BS EN 13555:2014

BSI Standards Publication

Flanges and their joints — Gasket parameters and test procedures relevant to the design rules for gasketed circular flange connections

National foreword

This British Standard is the UK implementation of EN 13555:2014. It supersedes BS EN 13555:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PSE/15/2, Flanges - Jointing materials and compounds.

A list of organizations represented on this committee can be obtained on request to its secretary.

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

ISBN 978 0 580 75691 7

ICS 23.040.60; 23.040.80

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

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2014.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 13555

April 2014

ICS 23.040.60; 23.040.80

Supersedes EN 13555:2004

English Version

Flanges and their joints - Gasket parameters and test procedures relevant to the design rules for gasketed circular flange connections

Brides et leurs assemblages - Paramètres de joints et procédures d'essai relatives aux règles de calcul des assemblages à brides circulaires avec joint

Flansche und ihre Verbindungen - Dichtungskennwerte und Prüfverfahren für die Anwendung der Regeln für die Auslegung von Flanschverbindungen mit runden Flanschen und Dichtungen

This European Standard was approved by CEN on 28 February 2014.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 13555:2014 E

Contents

Page

Foreword

This document (EN 13555:2014) has been prepared by Technical Committee CEN/TC 74 “Flanges and their joints”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2014, and conflicting national standards shall be withdrawn at the latest by October 2014.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13555:2004.

In comparison to EN 13555:2004 the following changes have been made:

a) in Clause 3 the list of definitions has been revised;

b) in Clause 4 the list of symbols has been revised;

c) a new sub-clause 6.3 with testing requirements for metal foils has been added;

d) sub-clause 6.4 on surface finish has been revised;

e) sub-clauses 7.2 and 7.3 on test gaskets have been revised;

f) Clause 8 including Figure 1a) to Figure 6 on testing procedures has been completely revised;

g) in Clause 9 the report details have been revised;

h) Annex F on relationship of gasket parameters in EN 13555 with those from PVRC method has been revised;

i) a new informative Annex G on determination of the sealing characteristics of strip sealing materials available in coil form has been added;

j) a new informative Annex H on the proposed method for the determination of the coefficient of static friction of gaskets has been added.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This document provides the test procedures to allow the generation of the gasket parameters to enable the design equations established in EN 1591-1 to be employed. The same test procedures may be used for "Type Testing" of gaskets and gasket materials. These procedures are not for routine quality control purposes.

1 Scope

This European Standard specifies the gasket parameters required by EN 1591-1 and provides the test procedures for establishing the values of these parameters.

Gaskets which are wholly based upon elastomers, or based upon elastomers with only the inclusion of particulate fillers or particulate reinforcement, as opposed to gaskets combining elastomers, fillers and fibrous reinforcement, are beyond the scope of this document.

NOTE The testing procedures given might be applicable to gaskets of other shapes and dimensions.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1092 (all parts), *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated*

EN 1514-1, *Flanges and their joints - Dimensions of gaskets for PN-designated flanges - Part 1: Non-metallic flat gaskets with or without inserts*

EN 1514-2, *Flanges and their joints - Gaskets for PN-designated flanges - Part 2: Spiral wound gaskets for use with steel flanges*

EN 1514-3, *Flanges and their joints - Dimensions of gaskets for PN-designated flanges - Part 3: Non-metallic PTFE envelope gaskets*

EN 1514-4, *Flanges and their joints - Dimensions of gaskets for PN-designated flanges - Part 4: Corrugated, flat or grooved metallic and filled metallic gaskets for use with steel flanges*

EN 1514-6, *Flanges and their joints - Dimensions of gaskets for PN-designated flanges - Part 6: Covered serrated metal gaskets for use with steel flanges*

EN 1514-7, *Flanges and their joints - Gaskets for PN-designated flanges - Part 7: Covered metal jacketed gaskets for use with steel flanges*

EN 1591-1, *Flanges and their joints - Design rules for gasketed circular flange connections - Part 1: Calculation*

EN 1759 (all parts), *Flanges and their joint - Circular flanges for pipes, valves, fittings and accessories, Class designated*

EN 12560-1, *Flanges and their joints - Gaskets for Class-designated flanges - Part 1: Non-metallic flat gaskets with or without inserts*

EN 12560-2, *Flanges and their joints - Dimensions of gaskets for Class-designated flanges - Part 2: Spiral wound gaskets for use with steel flanges*

EN 12560-3, *Flanges and their joints - Gaskets for Class-designated flanges - Part 3: Non-metallic PTFE envelope gaskets*

EN 12560-4, *Flanges and their joints - Gaskets for Class-designated flanges - Part 4: Corrugated, flat or grooved metallic and filled metallic gaskets for use with steel flanges*

EN 12560-5, *Flanges and their joints - Gaskets for Class-designated flanges - Part 5: Metallic ring joint gaskets for use with steel flanges*

EN 12560-6, *Flanges and their joints - Gaskets for Class-designated flanges - Part 6: Covered serrated metal gaskets for use with steel flanges*

EN 12560-7, *Flanges and their joints - Gaskets for Class-designated flanges - Part 7: Covered metal jacketed gaskets for use with steel flanges*

3 Terms and definitions

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

3.1
Q_{smax}
the maximum surface pressure that may be imposed on the gasket at the indicated temperatures without collapse or "crash", compressive failure, unacceptable intrusion into the bore or damage of the stressed area of the gasket such that failure was imminent

3.2
$Q_{min(L)}$
the minimum gasket surface pressure on assembly required at ambient temperature in order to seat the gasket into the flange facing roughness and close the internal leakage channels so that the tightness class is to the required level L for the internal test pressure

3.3
$Q_{smin(L)}$
the minimum gasket surface pressure required under the service pressure conditions, (i.e.) after off loading and at the service temperature, so that the required tightness class L is maintained for the internal test pressure

3.4
L_N
the tightness classes are defined in Table 1 in terms of specific leak rates. Additional, better, tightness classes can be introduced as required by continuing the series

Table 1 — Tightness classes

Tightness class L_N	$L_{1,0}$	$L_{0,1}$	$L_{0,01}$
Specific leak rate [mg s^{-1} m^{-1}]	≤ 1,0	≤ 0,1	≤ 0,01

3.5
P_{QR}
this factor to allows for the effect on the imposed load of the relaxation of the gasket between the completion of bolt up and long term experience of the service temperature

3.6
E_G
this is the unloading modulus of elasticity and it is determined from the thickness recovery of the gasket between the initial compression surface pressure and unloading to a third of this initial surface pressure

3.7
α_G
this is the coefficient of thermal expansion of the gasket under the service conditions of temperature and gasket surface pressure in the axial direction

3.8
Δe_{Gc}
this is the additional change in thickness of the gasket or sealing element due to creep between the completion of the loading and the end of the test period

3.9
μ_G
this is the static friction factor between the gasket and the flange facing during service conditions and under external loading

4 Symbols

For the purposes of this document, the following notations apply.

Where units are applicable, they are shown in brackets. Where units are not applicable, no indication is given.

α_G	the axial coefficient of thermal expansion of gasket	[K^{-1}]
μ_G	the static friction factor between the gasket and the flange facing	—
e_G	gasket or sealing element thickness	[mm]
Δe_{Gc}	change in gasket or sealing element thickness due to creep	[mm]
A_G	area of gasket subjected to surface pressure	[mm^2]
d	internal diameter of gasket	[mm]
d_S	internal diameter of area of gasket subjected to surface pressure	[mm]
D	external diameter of gasket	[mm]
D_S	external diameter of area of gasket subjected to surface pressure	[mm]
E_G	unloading modulus of elasticity of the gasket	[MPa]
L_N	tightness class — subscript N indicates the maximum specific leakage rate for that tightness class	[mg $s^{-1}m^{-1}$]
P_{QR}	creep relaxation factor, the ratio of the residual and initial surface pressures	—
Q	surface pressure	[MPa]
Q_A	gasket surface pressure at assembly prior to unloading	[MPa]
$Q_{min(L)}$	the minimum level of surface pressure required for leakage rate class L on assembly	[MPa]
$Q_{smin(L)}$	the minimum level of surface pressure required for leakage rate class L after off-loading	[MPa]
Q_{smax}	the maximum surface pressure that can be safely imposed upon the gasket at the service temperature without damage	[MPa]

Concordance with EN 1591-1:

Q_A, the gasket surface pressure at assembly is the gasket stress at the load situation 0 and is defined by Q_A in EN 1591-1.

5 List of gasket parameters

The gasket parameters relevant to the calculation procedures for the design of bolted flange connections as given in EN 1591-1 are shown in Table 2 together with the test procedures applicable for determining the value of the parameter in each case.

Table 2 — Gasket parameters and test procedures

Gasket parameter	Definition Subclause	Test procedure(s) Subclause
Q_{smax}	3.1	8.5
$Q_{min(L)}$	3.2	8.8
$Q_{smin(L)}$	3.3	8.8 and 8.9
L_N	3.4	8.8 and 8.9
P_{QR}	3.5	8.7
E_G	3.6	8.6
α_G	3.7	8.10
Δe_{Gc}	3.8	8.7
μ_G	3.9	8.11

6 Test equipment

6.1 Design

Schematics of test rigs for compression, creep relaxation, and tightness measurement are shown in informative Annexes A to D. Annex A is a generalised schematic with the other figures providing further detail for specific aspects of the tests.

6.2 Test platens

The test platens, and heater assembly where appropriate, shall be sufficiently rigid so that any load imposed on the gasket can be withstood and so that there is no platen deformation which results in gasket surface pressure variation. This rigidity aspect can also be important when gasket elastic recovery is being investigated.

The dimensions of the test platen raised faces shall be as given in EN 1092-1 for a DN 40 / PN 40 gasket and EN 1759-1 for an NPS 4 CLASS 300 gasket.

For testing in tongue and groove geometries the test platens should be in accordance with EN 1092-1, Form C and Form D or EN 1759-1.

6.3 Metal Foils

Experience has shown that during hot compression tests, that is the P_{QR}, Q_{smax} and elevated temperature tightness tests, some gasket materials are likely to adhere badly enough to the test platens during the test to cause difficulty in the removal of the gasket after the completion of the test and damage the platen surface finish.

To avoid such damage, stainless steel foils or shims of thickness of 0,05 mm placed between the test gasket and the platens during P_{QR} and Q_{smax} tests may be used.

Where foils or shims are used the fact of their use shall be included in the test report.

Foils or shims shall not be re-used or used in tightness tests at any temperature nor in the Coefficient of Static Friction determination defined in 8.11 and provisionally detailed in Annex H.

NOTE A formal investigation into the effect of the use of foils during P_{QR} and Q_{smax} testing is planned to be carried out and, as a result, the next revision of this document might not continue to allow the use of foils or shims.

6.4 Surface finish

The platen surface finish shall be within the range specified by the relevant flange standards in the EN 1092 and EN 1759 series. For sheet materials where the standards are EN 1092-1 and EN 1759-1 the finish should be as specified below.

The surface finish of the test platens shall conform to the following:

$$3{,}2\ \mu m < R_a < 6{,}3\ \mu m$$

Exceptions to this range are acceptable where the gasket is intended for use with a surface finish outside of this range. In this case the surface finish used shall be recorded.

Before each test, the freedom from debris from the previous test and from scratch and impact damage to the surface finish of the platens shall be checked visually.

6.5 Measurement of gasket thickness

For those procedures where the gasket thickness has to be monitored during the test there shall be either three displacement transducers at 120° spacing around the circumference of the platens or one displacement transducer placed on the central line.

However, for a leak test, the use of an axial transducer is not recommended as it introduces a sealing complication to the rig design.

6.6 Loading

Any loading means may be used that allows the gasket to be loaded and unloaded at a required and consistent rate. The rate of loading and unloading to be used is fixed as:

0,5 MPa/s for all types of gasket except for PTFE based gaskets when 0,1 MPa/s shall be used.

The loading shall be recorded as a function of time.

6.7 Temperature

The rate of increase of temperature in all elevated temperature tests shall be 2 K / min.

6.8 Leakage measurement

EN 1779 gives the limits that can be achieved by various method of leakage measurement. The information given in that document shall be taken into account when selecting a measurement system.

For modern, high performance, sealing materials and gasket styles, the most appropriate method of measurement is very likely to be mass spectrometry.

7 Test gaskets

7.1 Number of gaskets

At least two gaskets for each type of test shall be tested.

NOTE More rigorous guidance on the number of repeat tests required for each test type will be available for the next revision of this document.

7.2 Procurement and identification of gaskets

The gaskets to be tested shall be selected at random from production gaskets or shall be cut from sheet representative of normal production. Prior to selection for test the gaskets or sheet shall have been stored in accordance with the recommendations of the manufacturer and the time since manufacture should be within any time limit set by the manufacturer.

Some basic checks shall be made in order to ensure that the gaskets or sheet are acceptable by the normal quality assurance criteria before the tests to this document are carried out. The results of these checks shall be recorded.

In all cases, full traceability to production shall be maintained.

7.3 Pre-conditioning of the gaskets

For every gasket type where the sealing element is not solid metal the gasket shall be conditioned as indicated below before any of the tests of this document are carried out.

The test gasket shall be held for at least 48 hours in air with a relative humidity of (50 ± 6) % at ambient temperature.

The required relative humidity can for example be generated and maintained by the use of a saturated solution of magnesium nitrate hexahydrate, $Mg(NO_3)_2\,6H_2O$. The test gaskets that are to be held at the required relative humidity should be stored above a saturated solution of the salt, containing an excess of the solid salt, in a glass container fitted with a ground glass lid and held in an area at ambient temperature.

The test gaskets shall be removed from the conditioning atmosphere no more than 30 min before the test is carried out.

7.4 Dimensions of test gaskets

The test gasket dimensions shall be either of those specified in Table 3.

Table 3 — Test gasket dimensions for Raised Face Flanges

Flange description	Raised face dimensions according to	Gasket dimensions according to
DN 40/PN 40	EN 1092–1	EN 1514–1 to 7 (according to the type of gasket)
NPS 4 CLASS 300	EN 1759–1	EN 12560–1 to 7 (according to the type of gasket)

For convenience for sheet materials the gasket dimensions are given below:

EN 1514–1: ID 49,0 mm OD 92,0 mm

EN 12560–1: ID 115,0 mm OD 148,0 mm

Where the intended service is in tongue and groove flanges, the test gasket size is specified in EN 1092-1 or in EN 1759-1, and the test shall be carried out with test platens which have a tongue and groove configuration.

Tolerance of the platens for tongue and groove configurations shall be as given below:

— Negative tolerance for tongue width,

— Positive tolerance for groove width.

If this mode of testing is used it shall be clearly stated in the report.

7.5 Measurement of test gaskets as received

The internal and external diameter of the gasket or sealing face shall be measured with an appropriate device such as micrometer, caliper or circometer (π tape) at ambient temperature.

Except where a circometer is used, the measurement shall be taken at not less than four positions around the gasket and the mean diameter shall be reported.

The mean values shall conform to the theoretical values within the tolerances given in the appropriate document or the supplier's information.

The as received thickness of the gasket or sealing element shall be measured by a micrometer or other suitable device with contact faces wide enough to provide a measurement without penetration. The value of the reference gasket thickness is obtained by measuring the gasket thickness under a 1 MPa surface pressure at ambient temperature and after a one minute stabilisation period. The measurements of thickness shall be taken at not less than four positions around the gasket or ring and the mean reported. The measured thickness shall be within the tolerances given in the appropriate document or the supplier's information if no document exists.

Where the gasket has centering or locating rings associated with the sealing element then the thickness of the rings shall also be measured and reported.

7.6 Influence of gasket dimensions

For gaskets the test results obtained are influenced by their thickness. For sheet materials the thickness of the gasket as a function of the surface pressure shall be recorded. This information is generated by the ambient temperature compression test, see 8.3.

8 Test procedures

8.1 General

For all the test procedures detailed in this European Standard the ambient laboratory temperature during the testing shall be (23 ± 5) °C and the temperature of the test platens at the start of all tests shall be (23 ± 2) °C

When testing is carried out at elevated temperature it is recommended, for reasons of uniformity, that the test temperature be selected from those in Table 4.

Table 4 — Recommended Elevated Temperature

T [°C]	50	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600
T [K]	323	373	398	423	448	473	498	523	548	573	623	673	723	773	823	873

In all cases the rate of increase of temperature shall be 2 K/min.

The surface pressure on gaskets shall be calculated using the area subjected to surface pressure by the flange facings as given below:

$$A_G = \frac{\pi}{4}\left(D_s{}^2 - d_s{}^2\right) \qquad (1)$$

Where the contact area between the test platen and the gasket is fixed by raised faces as part of the design of the test platens, or the gasket overlaps the contact area of the test platens, then the stressed area is calculated from the above with D_S being whichever is the smaller of the outside diameter of the gasket, D, the outside diameter of the platen contact region, or, where used, the outside diameter of the raised face and with d_S replaced by whichever is the greater of the inside diameter of the gasket, d, the inside diameter of the platen contact area or, where used, the inside diameter of the raised face

8.2 Testing Strategy

The two most important properties of a gasket are the ability to create and to maintain a seal. This is reflected in the testing carried out as the calculation method EN 1591-1 recognises these features. However, this means that the data generated is not only of value for use in the calculation method but that it is useful to aid the development of better gaskets.

There are two types of testing detailed in this document which reflect these properties. In the former case there are tests from which the values of $Q_{min(L)}$ and $Q_{smin(L)}$ are determined and in the latter case tests from which Q_{smax}, E_G and P_{QR}, Δe_{Gc} and μ_G are determined.

The determination of Q_{smax} may for sheet material result is an overestimation of the capability of the sheet and it is important that all values of Q_{smax} for sheet are verified by conducting a test for P_{QR} and Δe_{Gc} at the same temperature and surface pressure as for the Q_{smax} value.

8.3 Reference gasket thickness

The reference gasket thickness that shall be used in all tests is the thickness value determined at ambient temperature after the imposition of a surface pressure of 1 MPa for 1 minute.

8.4 Compression curve

It is often very useful to know the thickness of the gasket under a given surface pressure at ambient temperature. A curve of the compressed thickness as a function of the surface pressure with the gasket loaded at the rate specified in 6.6 shall be included as part of the report specified in Clause 9, see also 7.6.

8.5 Determination of Q_{smax}

8.5.1 Generation of Q_{smax}

For some soft gasket materials a sudden collapse or "crash" is seen when the loading on the gasket exceeds a certain value and that clearly can be taken as the Q_{smax} value under the conditions of the test. However, many soft gasket materials do not exhibit such a sudden effect and under loading on assembly will spread progressively but the sealing integrity will be likely to be maintained until the material fractures in the area under the load.

The test procedure consists of raising the temperature of the gasket to the required value under an initial surface pressure and then carrying out cyclic compression / recovery loadings on the gasket at progressively higher surface pressures until the gasket collapses or the maximum load of the test machine or the maximum surface pressure specified by the manufacturer is reached. For each loading cycle the thickness decrement per unit of surface pressure increase is recorded.

The surface pressure of the loading cycle prior to collapse is taken to be the Q_{smax} value for that temperature. The parameter Q_{smax} for sheet materials is very thickness dependent and the values determined are only relevant for the thicknesses of gaskets tested.

In the context of the above the term collapse is defined as when the thickness decrement per unit of surface pressure increase rises sharply above the trend set by the previous values to the extent that it cannot be considered to be just a consequence of the inherent variation around the trend.

The test procedure is illustrated in Figure 1a and gaskets as specified in 7.4 should be used. The test can be carried out either at ambient or any required elevated temperature. It is recommended that a minimum of three temperatures be used; ambient and one at the top end of the possible temperature range shall always be used. The gasket is initially loaded at the appropriate rate of increase, see 6.6, to 20 MPa based upon the original area of the gasket at ambient temperature and there is then a dwell period of 5 minutes. The temperature is then raised at the rate specified in 6.7 until the required temperature is reached after which there is a dwell for 15 minutes.

After this dwell the load on the gasket is decreased to one third of the previous value at the appropriate rate, see 6.6, based upon the original area of the gasket and held there for a dwell period of 5 minutes. It is then increased at the appropriate rate, see 6.6, based upon the original area of the gasket, until a higher gasket surface pressure, see below for the exact value, based upon the original area of the gasket, is attained.

Then, after a dwell period of 5 minutes, this cyclic procedure is repeated until the gasket surface pressure reaches the value of the maximum load of the test machine or the maximum surface pressure specified by the manufacturer is reached or the gasket is seen to have collapsed.

The thickness decrement per unit of surface pressure increase relative to the previous thickness at the end of each cycle is plotted as shown in Figure 1b. For some of the soft gasket materials a sudden "crash" is observed which is taken to indicate that Q_{smax} has been exceeded. The value of Q_{smax} shall be taken as the gasket surface pressure value used before the successive thickness change exhibited an increase.

Where no collapse is observed and the gasket shows no signs of distress or damage then Q_{smax} can be reported as being the maximum stress imposed.

Where no collapse is observed but the gasket shows signs of distress or damage then further testing is required in order to determine a value for Q_{smax}. The extra testing involves carrying out P_{QR}, 8.7, tests at 500 KN/mm as indicated in Figure 2 and then an inspection of the test gasket for bore intrusion and damage

For the purposes of determination of the Q_{smax} value when there is no collapse but there is damage or distress of the test gasket, the P_{QR} test gasket indicated in Figure 2 shall be of the PN 40/DN 40 dimensions.

If the gasket inner bore reduces below 43,1 mm for a PN 40 DN 40 gasket then Q_{smax} shall be assumed to have been exceeded. A metal gauge shall be used to assess whether the inner bore diameter is less than the 43,1 mm value. Unacceptable intrusion has occurred when, without any force being applied, the gauge cannot fit inside the gasket after testing.

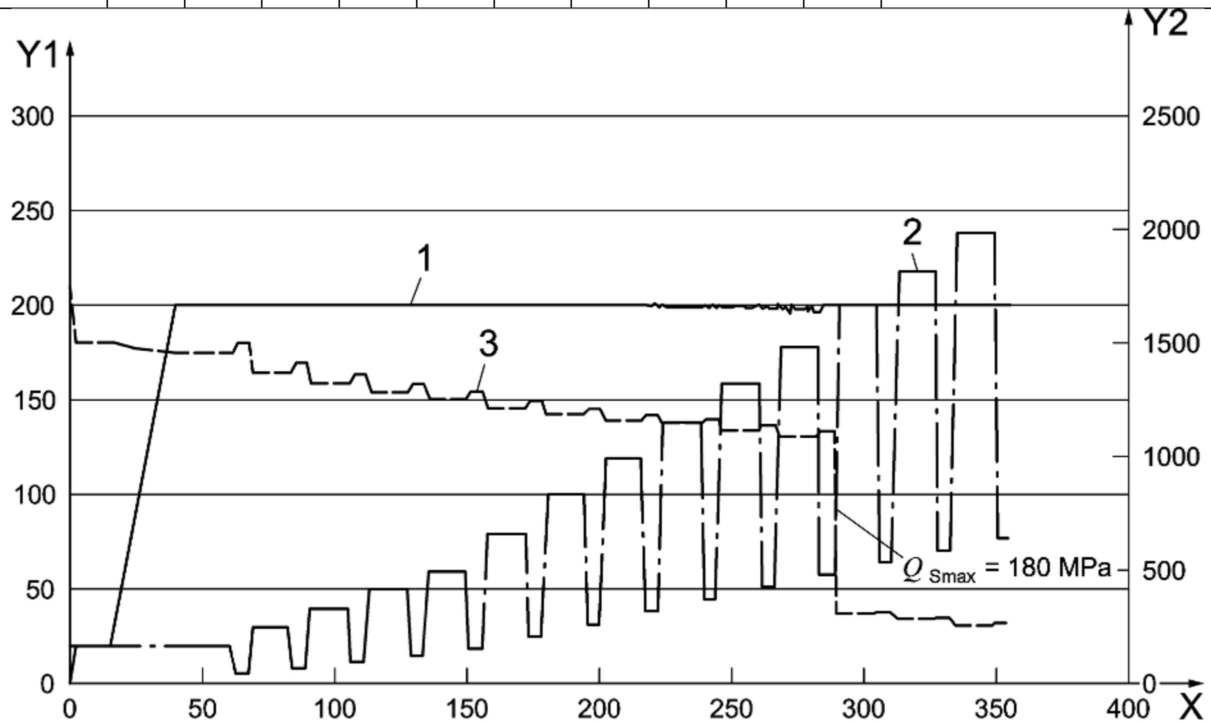
Where there is no collapse during the test procedure of Figure 1a and there is no unacceptable bore intrusion after the P_{QR} test as determined with the gauge as indicated above then the stressed faces of the test gasket shall be inspected for cracking. Where none is observed the gasket shall be taken to have a Q_{smax} value higher than the surface stress imposed during the P_{QR} test.

For spiral wound gaskets to EN 1514-2 the Q_{smax} value is defined as the stress just less than is sufficient to compress the sealing element to the thickness of the guide ring or either ring buckling or sealing element implosion occurs. For spiral wound gaskets to EN 12560-2 the Q_{smax} value is just the load at which ring buckling or sealing element implosion occurs.

During this test regime the surface pressures that shall be used are indicated in Table 5.

Table 5 — Surface pressures

Q_{Ai} [MPa]	20	30	40	50	60	80	100	120	140	160	and so on in steps of 20 MPa
Q_{Ai}/3 [MPa]	6,7	10	13,3	16,7	20	26,7	33,3	40	46,7	53,3	and so on in steps of 6,7 MPa



Key

1 temperature [°C];

2 gasket surface pressure [MPa]

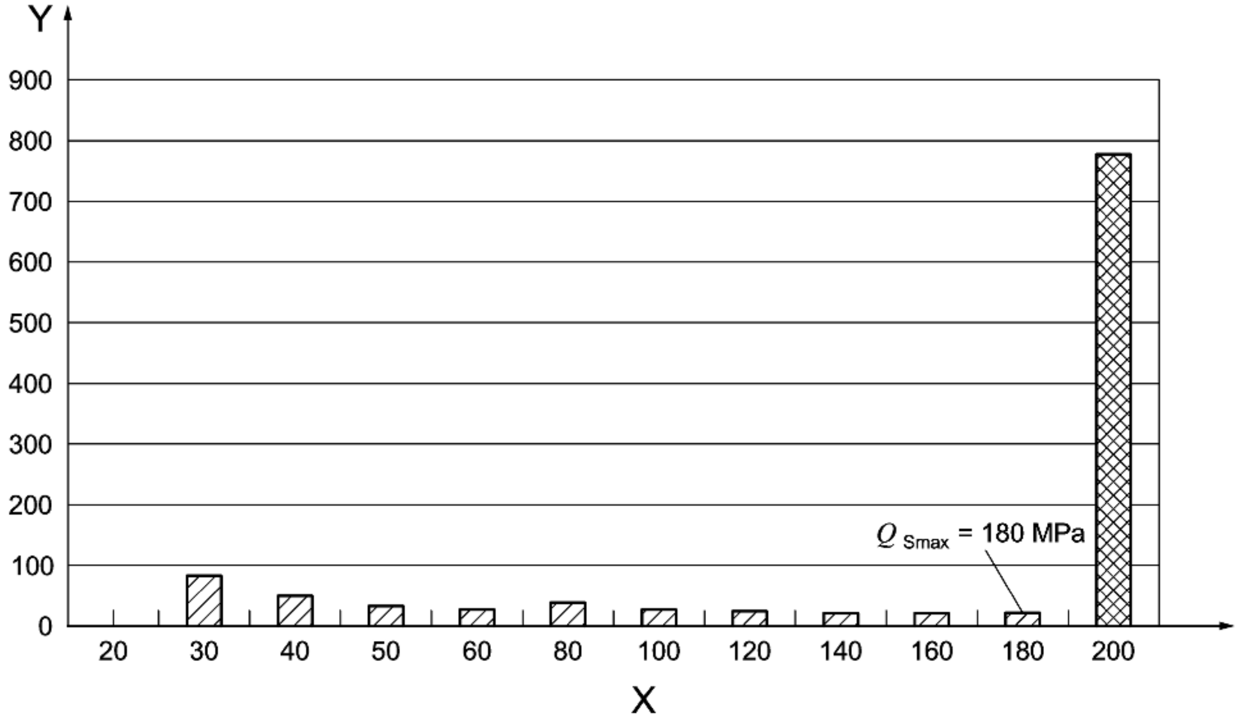
3 gasket thickness [µm]

X time [min]

Y1 temperature [°C]; gasket surface pressure [MPa]

Y2 gasket thickness [µm]

Figure 1a — Test procedure for the determination of Q_{smax} and the generation of values of E_G



Key

X gasket surface pressure [MPa]

Y thickness decrement per unit of surface pressure increase [µm/MPa]

Figure 1b — Determination of Q_{smax}

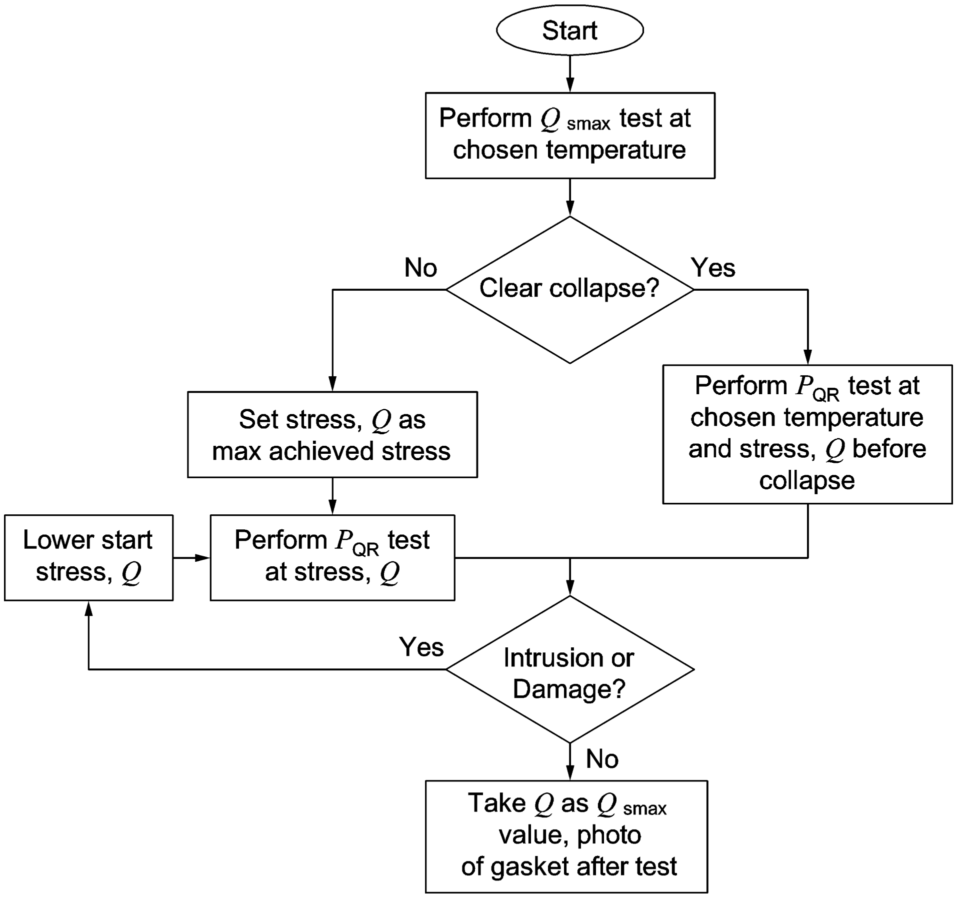


Figure 2 — Test Procedure for the determination of Q_{smax}

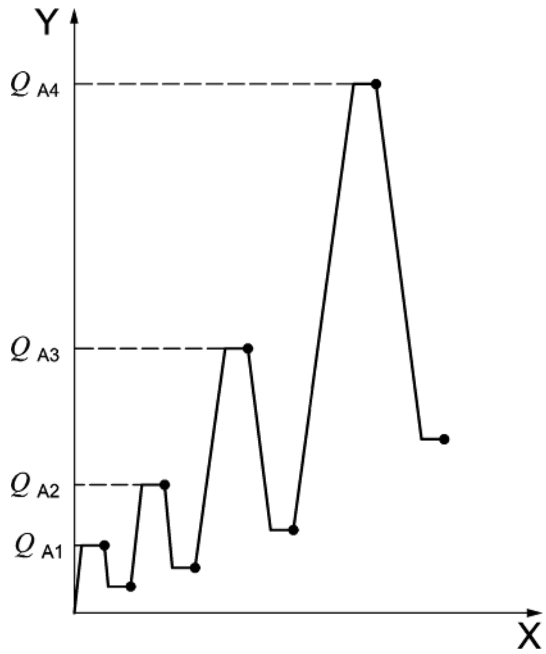
8.6 Determination of the values of E_G

8.6.1 Generation of E_G from the data generated for the Q_{smax} test

The unloading cycles of the Q_{smax} test allow the generation of values of E_G as shown in Figure 4. The value of E_G varies with the surface pressure on the gasket with the exact form of the relationship depending upon the style of gasket being tested.

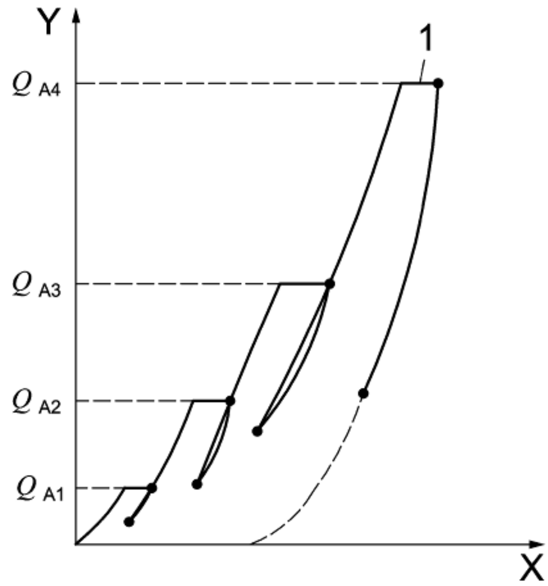
In the determination of E_{Gi}, the thickness of the gasket at the stress Q_{Ai}, see Figure 3b, used in the calculation of the strain is the one at the start of the offloading.

The value of the thicknesses used in the calculation of the modulus of elasticity shall be reported together with the E_G value as required in Clause 9.



Key
X time
Y gasket surface pressure

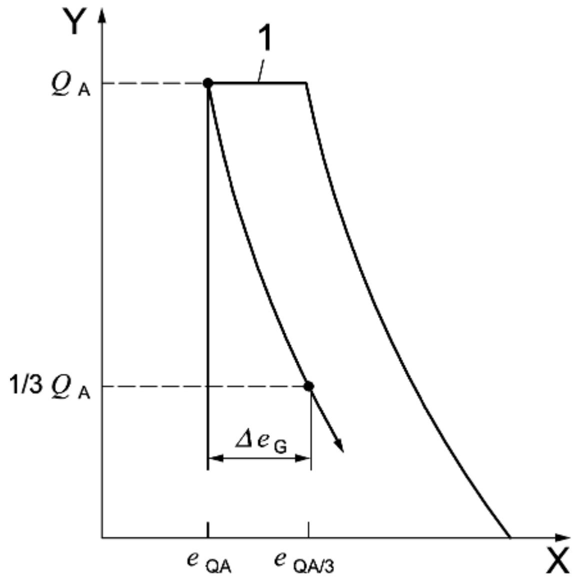
a) Loading scheme



Key
1 creep
X gasket deflection
Y gasket surface pressure

b) Thickness Recovery curve

Figure 3 — Loading scheme and thickness recovery curve



Key
1 creep
X gasket thickness
Y gasket surface pressure

NOTE $E_G = \frac{2}{3} Q_A \times \frac{e_{Q_A}}{\Delta e_G}$

Figure 4 — Determination of E_G in the case of gasket creep

8.7 Determination of P_{QR} and Δe_{Gc}

The factor P_{QR} is the ratio of the residual and the original loads from a relaxation test in a compression press used in the displacement controlled mode with a known stiffness. The factor Δe_{Gc} is the additional deflection of the gasket associated to the load loss occurring during this relaxation test performed under controlled stiffness. A stiffness of 500 kN/mm is typical for a PN designated flange and 1 500 kN/mm for a Class designated flange. For this test the stiffness of the rig for this test shall be 500, 1 000 or 1 500 kN /mm.

The test procedure consists of loading the test gasket at the defined rate (see 6.6) until the required loading and surface pressure is reached. The loading is then held for 5 min, at this stage the gasket thickness is recorded as the original gasket thickness after which the temperature of the rig is raised at the rate specified in 6.7 until the required temperature is reached. The temperature is then held constant for a period of 4 hours. After the 4 hour period the remaining load being imposed by the press and the final gasket thickness are recorded. P_{QR} is then calculated as the ratio of the residual load to the original load, and Δe_{Gc} is the difference between the original and final gasket thicknesses. The gasket condition after each test shall be reported.

For all gasket types, the P_{QR} and Δe_{Gc} tests carried out shall include tests at the values of Q_{smax} determined from the cyclic loading test of 8.5.1. In general, values for P_{QR} and Δe_{Gc} shall be determined at three levels of stress at each of three temperatures within the temperature range and stress range encompassing the likely service conditions and at each of the levels of stiffness specified above.

NOTE The relationship between Δe_{Gc} and P_{QR} is given below:

$$\Delta e_{Gc[K,Q_I,T]} = \frac{A_G \times Q_I \times \left(1 - P_{QR[K,Q_I,T]}\right)}{K} \quad (2)$$

where:

— K is the stiffness of the test rig used for the test [in N/mm];

— T is the temperature (during the test) used for the test [in ° C];

— Q_I is the initial gasket contact pressure [in MPa].

8.8 Determination of $Q_{min(L)}$ and $Q_{smin(L)}$

8.8.1 General

The test gas shall be helium.

For gasket styles for which there is a maximum surface pressure that shall not be exceeded the value of Q_{smax} for ambient temperature shall be known before $Q_{min(L)}$ or $Q_{smin(L)}$ can be determined. The test procedure consists of loading and unloading the gasket in a cyclic manner with measurement of the leak rate at the effective surface pressures indicated in Table 6 with an internal gas pressure of 40 bar.

The specific leak rate shall be obtained by dividing the measured leak rate by the arithmetic mean of the inner and outer gasket peripheries subjected to surface pressure from the flange facings, π/2 (D_S + d_S).

Table 6 — The loading and unloading surface pressures to be used at 40 bar in the determination of $Q_{min(L)}$ and $Q_{smin(L)}$

Load to this effective surface pressure MPa	**Unload to these effective surface pressures** MPa
5	No unloading
10	5
20	10, 5
40	20, 10, 5
60	20, 10, 5
80	40, 20, 10, 5
100	40, 20, 10, 5
120	No unloading
140	No unloading
160	80, 40, 20, 10, 5

The procedure therefore consists of loading to 5 MPa, holding the load and measuring the leak rate after the leak rate has stabilised and then raising the loading to 10 MPa. The load is then held whilst the leak rate is measured and then the load is reduced to 5 MPa and the leak rate is measured. Then measurements are done at 20 MPa followed by 10 MPa and 5 MPa and so on until either the 160 MPa loading — unloading cycle is completed or the value of Q_{smax} would have been exceeded had the next loading point be used.

The measurement of the leakage rate shall continue until stabilisation has occurred. Stabilisation of the leakage rate can be considered to have been achieved when the change in leakage rate over 20 min is 2 % or less.

During at least the unloading from 10 MPa down to 5 MPa, but ideally at all times, a safety screen should be in place around the test platens. During this unloading the leakage should be measured with a mass flowmeter and only if it is stable and below 10^{-3} mg/ (m·s) should a mass spectrometer be used.

The gasket surface pressure shall be increased and decreased at the rate given in 6.6 and the gas pressure increased at a slow uniform rate.

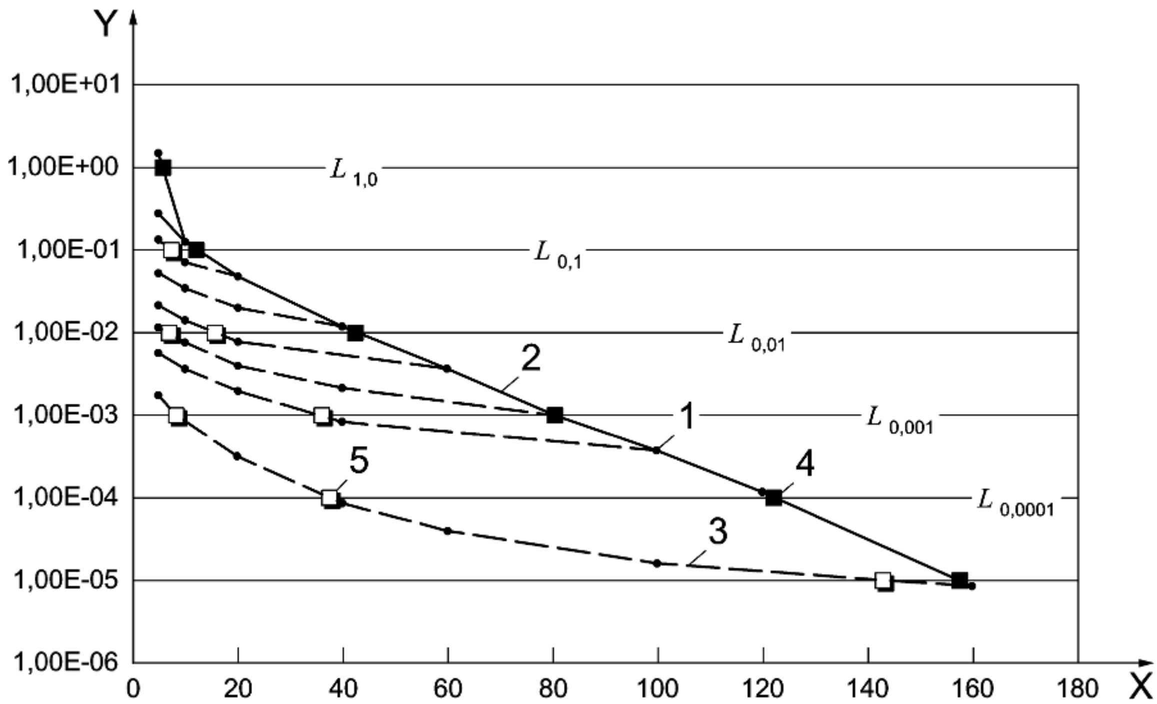
The effective surface pressure level is calculated from the following:

$$Q = Q_A - [(p \times (\pi / 4) \times d_S^{\ 2}) / A_G] \quad (3)$$

EN 1779 indicates the measurement limits that various methods of leak measurement can achieve.

Figure 5 illustrates the data obtained from a gasket tested with an internal pressure of 40 bar. The measured leakage rate shall be plotted against the effective stress, the stress after allowance for the end thrust. It can be seen that the leakage rates for unloading cycles follow a different trend from those of the loading cycles; this is due to the stress level that was experienced prior to the unloading. This latter situation simulates actual service and hence the unloading lines provide the values of $Q_{smin(L)}$, at ambient temperature and the loading line provides the $Q_{min(L)}$ values. From this figure the values $Q_{min(L)}$ and $Q_{smin(L)}$ at ambient temperature for the required value of L shall be obtained by interpolation between points either side of the value of L of interest. In Figure 5 these values for the gasket tested are indicated as solid or hollow rectangles.

The values of $Q_{min(L)}$ and $Q_{smin(L)}$ shall not be obtained by smoothing the data by curve fitting or similar techniques and then picking the values of $Q_{min(L)}$ or $Q_{smin(L)}$ from that smoothed curve.



Key

1 measurement point

2 loading

3 unloading

4 $Q_{min(L)}$

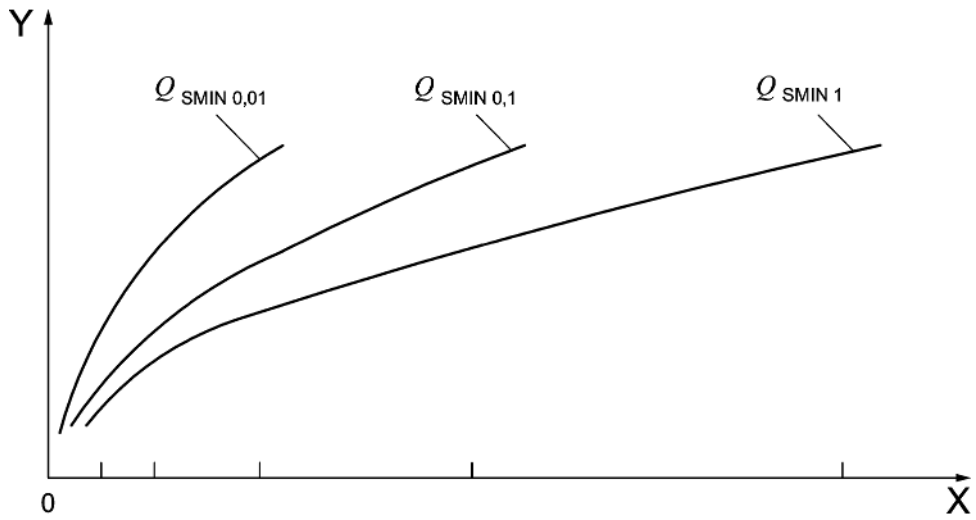
5 $Q_{smin(L)}$

X effective gasket surface pressure [in MPa]

Y leakage rate [in mg/(m·s)]

Figure 5 — Leakage rate as a function of gasket stress (for an internal pressure of 40 bar in this case)

Extra data may be obtained with other service relevant internal gas pressures, for example with 10 bar and 80 bar, but the pressures used shall be indicated in the test report. In these cases reduced loading and unloading schemes may be used by omitting some of the points indicated in Table 6. This data allows the generation of curves of the variation of tightness to a given class to be plotted as a function of internal pressure, see Figure 6.



Key

X gas pressure [in Bar]

Y effective gasket surface pressure [in MPa]

Figure 6 — $Q_{smin(L)}$ as a function of both internal pressure and tightness class

The sealing characteristics of ring type joints and lens gaskets can be determined by the above method provided that platens of the appropriate profile and surface finish, 0,4 µm < Ra < 1,6 µm, are used. Due to the contact area complication of these gasket types the applied load rather than the applied stress shall be reported.

8.8.2 Leakage diagram

For each sealing test reported a leakage diagram as given in Figure 5 shall be included with the report of Clause 9.

8.9 Determination of $Q_{smin(L)}$ at elevated temperatures

NOTE There is currently little experience in the determination of these parameters and the subsequent paragraphs contain some practical advice.

Where a determination is required that takes into account long term heat ageing effects the apparatus and method given in Annex F may be of assistance.

Where elevated temperature testing of material that do not suffer any heat ageing is of interest then the use of metal bellows has been proven to be satisfactory and elastomeric "O" rings capable of service to 300 °C are available.

The use of the differential pressure method of leakage measurement may be preferable over mass spectrometry for elevated temperature testing and, in particular, the pressure increase method with an external chamber.

8.10 Determination of axial coefficient of thermal expansion

For gaskets made from standard materials such as metals, the required value can be obtained from texts on the properties of materials.

However, most gaskets are made of other than metal alone so that their coefficients will have to be determined. For such gaskets there is currently no method available for the measurement of this parameter under compression. In these circumstances the use of the thermal expansion coefficient for the metal of the flange is recommended.

8.11 Determination of the coefficient of static friction

A proposed test procedure for the coefficient of static friction is given in Annex H.

NOTE It is planned that this procedure will be evaluated and refined, if necessary, prior to a method for the determination being included in the next revision of this standard.

9 Report details

The report shall be issued as a complete document and shall contain the following:

a) Type, description and nominal sizes of the tested gaskets;

b) Dimensions of the gaskets;

c) Thickness of material or sealing element;

d) Name of test laboratory;

e) Date of test;

f) Name of tester;

g) Shape and dimensions of the specimen after testing, and any visible changes of the tested specimen, e.g. cracks, faults, delaminations, bubbles, high deformations;

h) Construction details and type of the sealing components in the case of semi-metallic gaskets (e.g. grooved metal gaskets with unsintered PTFE facing, spiral wound gasket with exfoliated graphite filler);

i) The ambient temperature compression curve as required in 8.4;

j) Details of non-standard test platens (see 7.4);

k) Any deviations from this standard such as special testing conditions agreed on with customer;

l) Determined gasket factors and gasket properties together with the testing conditions (gasket stress, temperature testing time etc. Single and mean values (in the case of multiple tests) of the test results are to be reported;

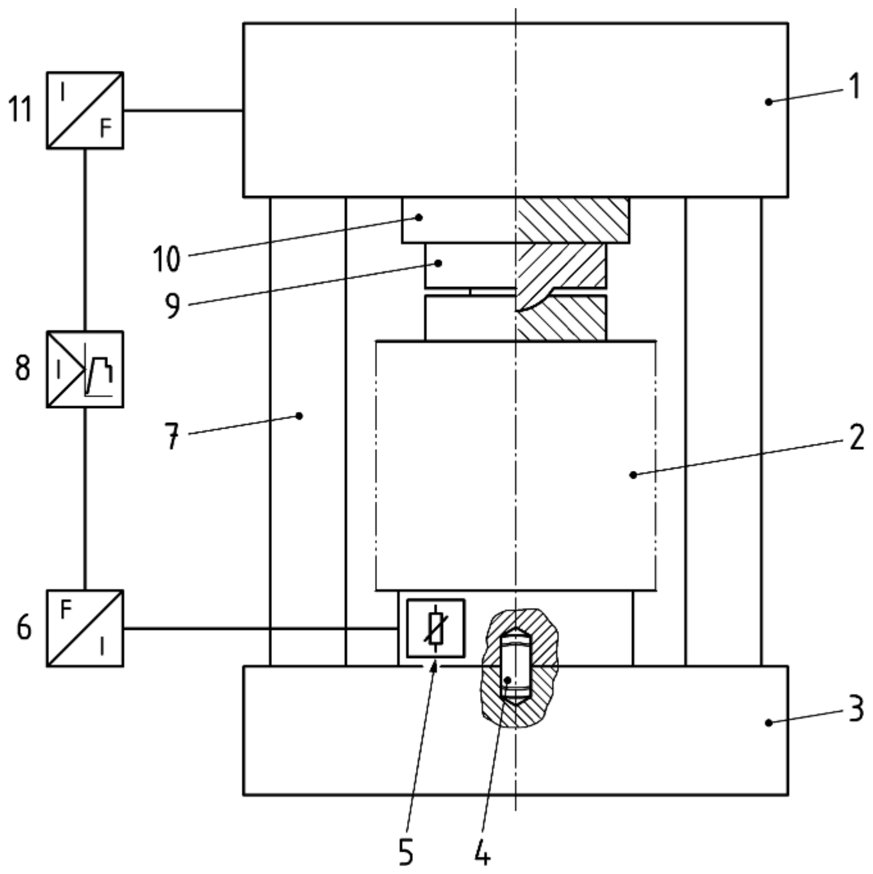
In the case of E_G, the value of the thickness at the start of the unloading, that is after any creep that occurred during the dwell, at each level of stress shall be reported as well as the E_G value:

m) The ambient temperature leakage diagrams as required in 8.8.2;

n) Photos of the gaskets after the tests carried out during the subjective determination of the value of Q_{smax} as required in 8.5.1.

Annex A
(informative)

Generalised test rig schematic



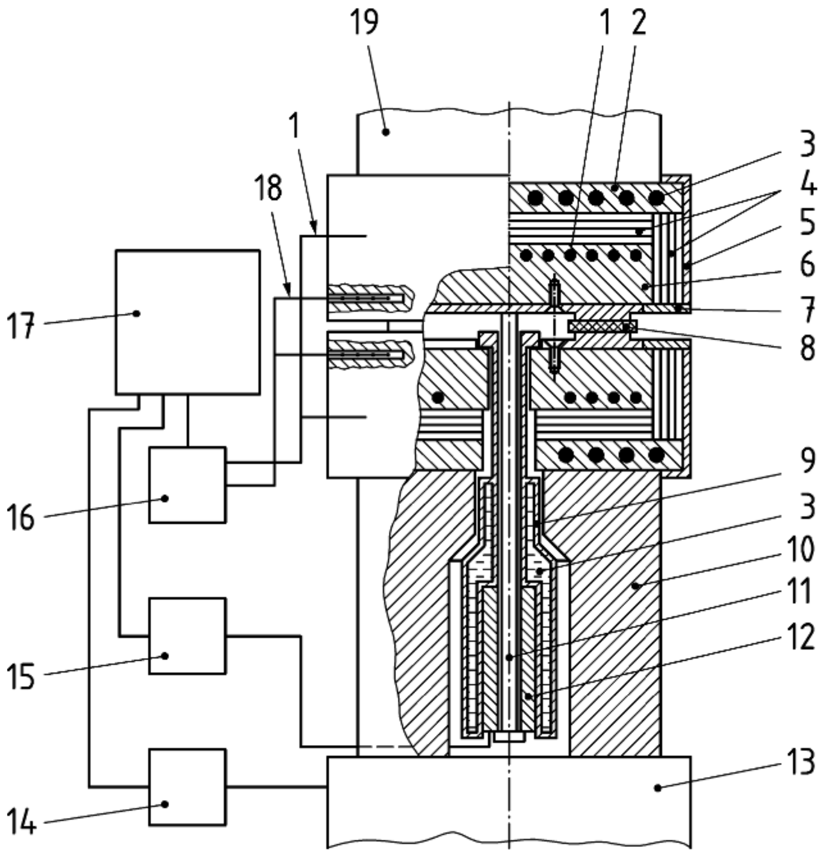
Key

1, 3 and 7	reaction frame
2	test cell
4	location device
5 and 6	load cell and measurement
8	load control
9	alignment ball joint
10	hydraulic cylinder
11	hydraulics control

Figure A.1 — Generalised test rig schematic

Annex B
(informative)

Test rig schematic for compression and compression creep tests



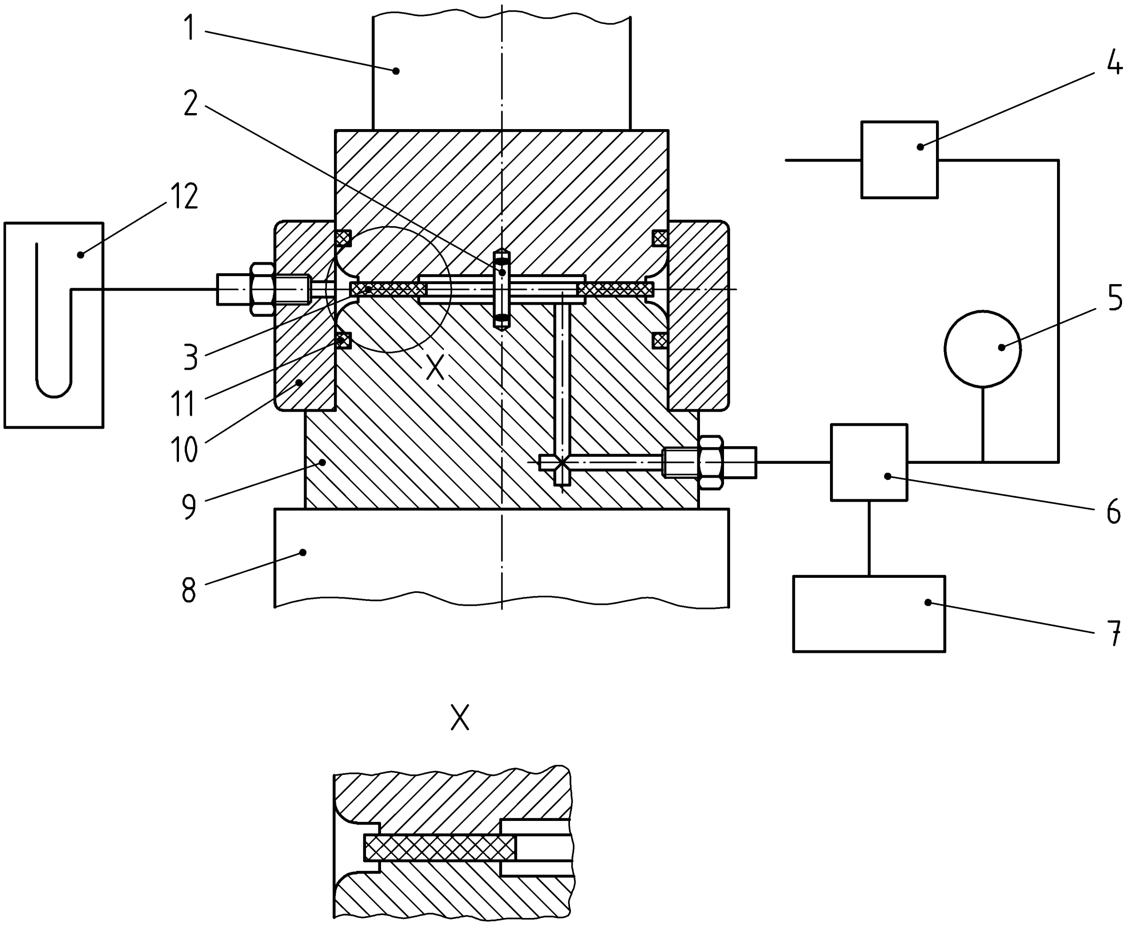
Key

1 heaters
2 cooling block
3 coolant passages
4 thermal insulation
5 casing
6 heating block
7 exchangeable test plates of steel according to EN 10263–4 material number 1.7035
8 test specimen
9 locator
10 spacer block
11 measuring pin
12 displacement transducer
13 load cell
14 force measurement
15 displacement measurement
16 heater control
17 test controller
18 temperature measurement
19 hydraulic cylinder

Figure B.1 — Test rig schematic for compression, compression creep and creep relaxation tests

Annex C
(informative)

Test rig schematic for ambient temperature leakage measurement



Key

1 hydraulic cylinder

2 location device

3 test gasket

4 pressure controller

5 pressure measurement

6 mass flow meter

7 flow rate recorder

8 load cell

9 spacer block

10 leakage collector

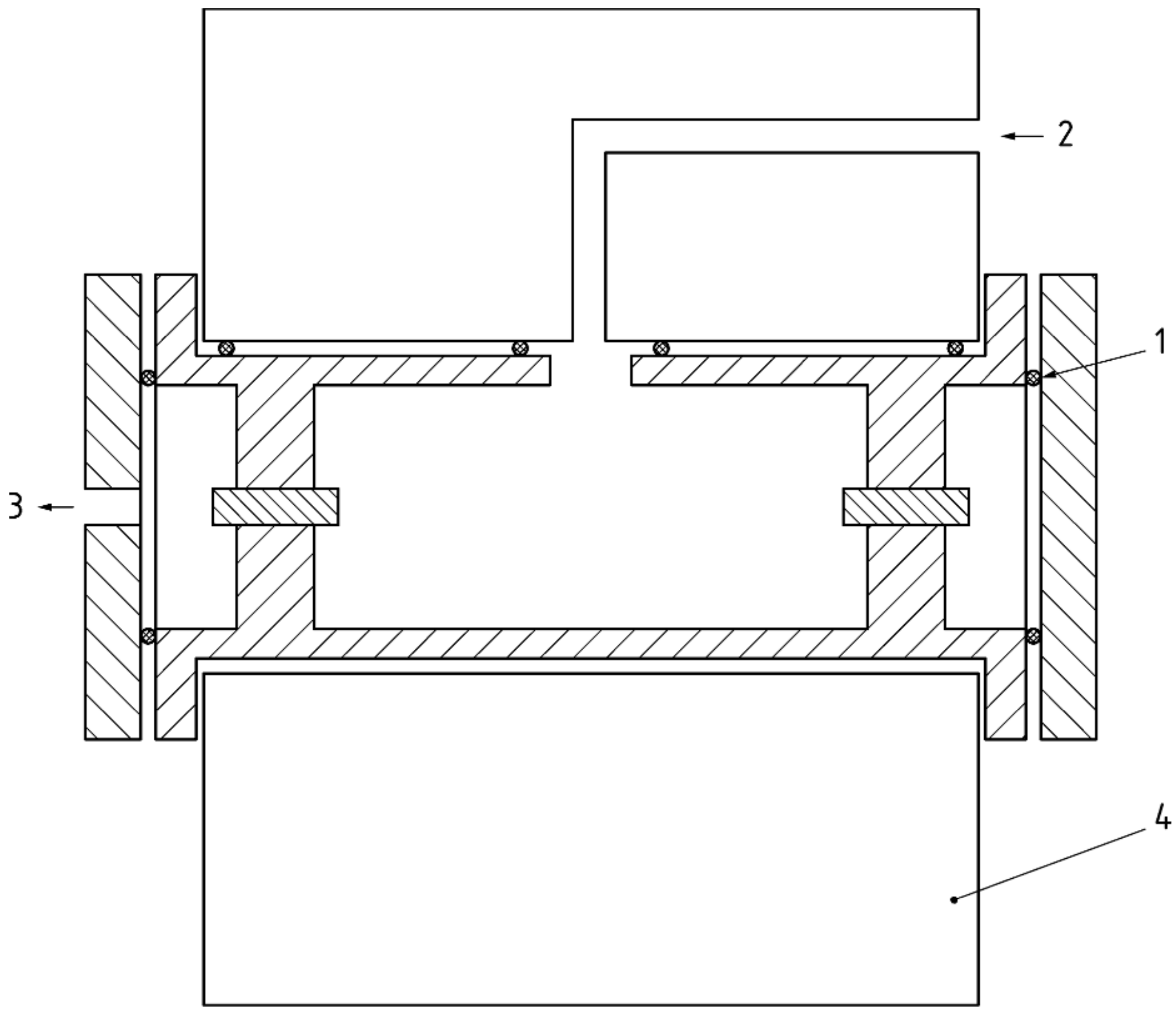
11 O-ring

12 gas burette

Figure C.1 — Test rig schematic for ambient temperature leakage measurement

Annex D
(informative)

Schematic of leakage rig allowing use of interchangeable face plate



Key

1 O-ring seals

2 test gas in

3 leakage out

4 face plates fixed outside of test area

Figure D.1 — Schematic of leakage rig allowing use of interchangeable face plate

Annex E
(informative)

Transferability of measured leakage rates to service conditions

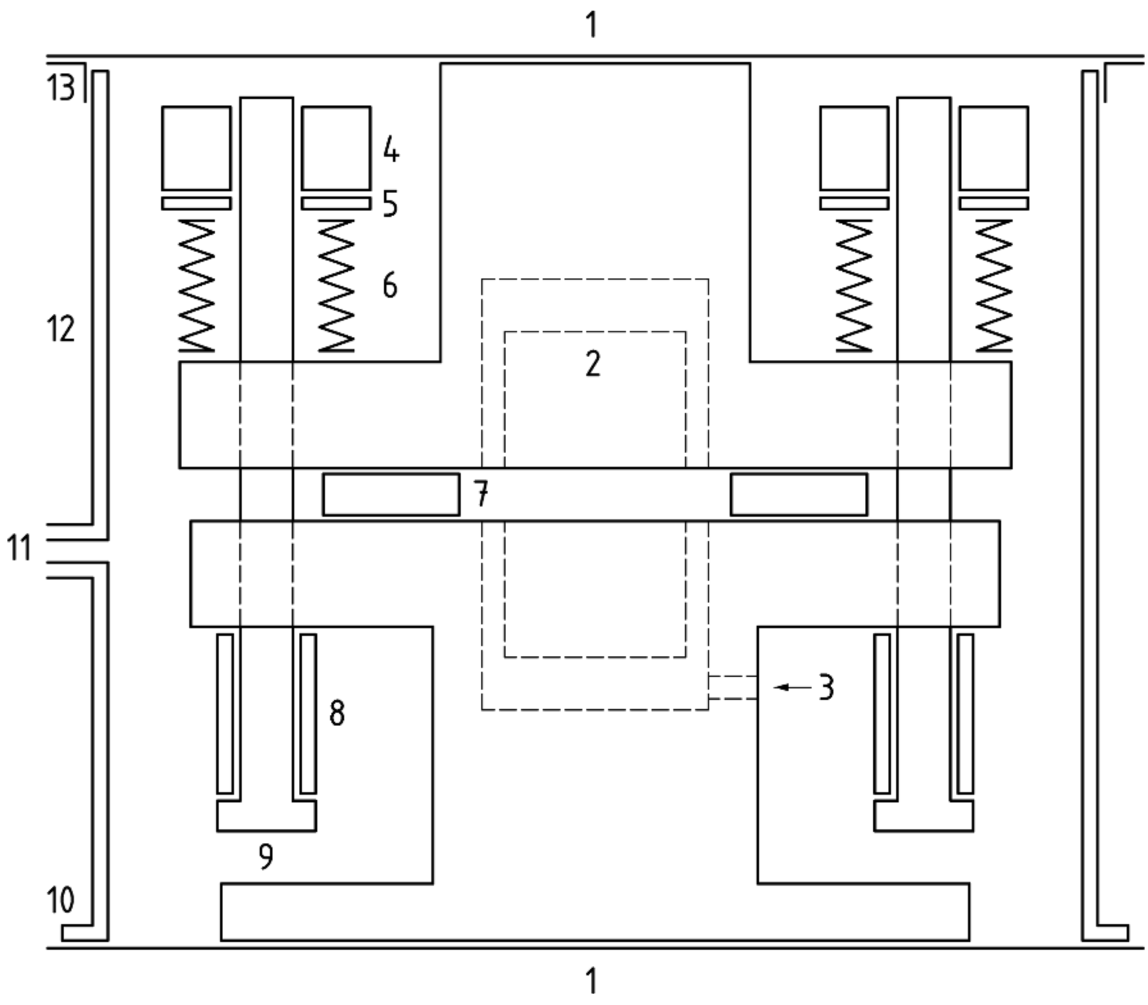
The procedure of determination of the values of $Q_{smin(L)}$ as indicated in the body of this document allows the required assembly surface pressure for a given level of leakage rate to be determined more precisely than previously possible.

However, the determination of the values of $Q_{smin(L)}$ as indicated in the body of this document does not allow the calculation of the leakage rates of bolted flanged joints in real service conditions.

For detailed information why such calculations are currently not possible, see EN 1591-1:2013, Annex I.

Annex F
(informative)

The measurement of the sealing parameter $Q_{smin(L)}$ after long term service simulating exposure to elevated temperature



Key

1 hydraulic test machine platen
2 heater cartridge
3 gas input point
4 nut
5 washer
6 disc washers
7 gasket
8 extension collar
9 bolt
10 gasketed seal
11 sampling point
12 cylindrical enclosure
13 bellows seal

Figure F.1 — The measurement of sealing parameters of heat aged gaskets

Discussion of the apparatus shown above

For materials that may alter with exposure to the simultaneous effects of temperature and pressure, this parameter shall be measured over periods which are a significant proportion of the likely service life of the gasket.

To determine the values of $Q_{\text{smin(L)}}$ at temperatures above ambient a different test rig is needed from that of Annex C. This is because it is not practical to conduct, in a such a compression press, tests of the necessary length of time to simulate the effects on a gasket which happen during service.

In order to make this practical test rig such as the above is required. This concept is intended for guidance only until such time as a totally researched and developed scheme can replace it. It is envisaged that the testing shall be carried out with an internal pressure of 40 bar and with Q_{smax} as the maximum surface pressure on the gasket.

Such a test rig may be constructed from an appropriately sized pair of flanges, of very high pressure class so that they are very thick and thus flange rotation is not a problem, loaded via a bolting system that is very elastic. The elastic bolting system is very important so that the gasket load remains constant irrespective of the creep and relaxation of the gasket.

One of the pair of flanges is blanked off and the other is welded to a short length of pipe with a base plate so that, when assembled, the rig stands safely on the base. The length of pipe shall be provided with locating lugs so that carrying handles can be inserted to allow easy and safe movement of the rig when at elevated temperature. The rig shall be internally heated rather than heated in an oven so that service conditions are more closely simulated. The rig can be heated via cartridge heaters or similar inside a block of suitable material rigidly secured inside the rig so that the heating was uniform without any local hot spots. Provision has to be made for the entry of the test gas.

Once the gasket has been at the required temperature for the required period of time the test rig can be transferred to the hydraulic press used for the ambient temperature work and the load transferred to the press. Once that has been done the bolts can be removed. The test gasket will then be at the required temperature after extended temperature exposure and will be under a hydraulically imposed load. The testing method as indicated in 8.8 for ambient temperature testing can then be carried out.

After the rig described above has been positioned in the hydraulic press a chamber such as shown above 13 is positioned around the rig and sealed as shown in above. The leakage rate from the heat aged gasket, whilst at temperature and hydraulically loaded, can then be determined by an appropriate method, for instance, currently the “flushing” method. Then, by the test procedure indicated previously for the ambient temperature test, the variation of leakage rate with hydraulic load and internal pressure can be determined and processed to provide the required sealing parameters.

Annex G
(informative)

Determination of the sealing characteristics of strip sealing materials available in coil form

Definition of Gasket Tape

A gasket tape is a sealing element with finite width and thickness but undefined length which is individually cut. A gasket tape forms a seal by connecting its two ends by a valid method.

Calculation of A_G

A gasket tape does not necessarily have compression independent dimensions. For calculation of A_G (see 8.1, 3rd paragraph) the uncompressed dimensions D_S and d_S are used.

Dimensions of test gaskets

Modification of 7.4:

Using a circular template of rigid material with an outer diameter of 110 mm the test specimen is formed on the test plate placing centred. For the testing of Q_{smax}, E_G and P_{QR} the ends may be butt jointed, overlapped or joined by the intended proprietary method.

For the leakage test for obtaining $Q_{min(L)}$, and $Q_{smin(L)}$ the joint is to be conducted as specified by the manufacturer.

Prior to test the template is removed.

Gasket Parameter Q_{smax}

Modification of 8.5:

Some types of tapes are designed to become wider during compression. The failure mode of a reduced d_S is therefore not applicable to such types of gasket tapes.

Report Details

Modification of Clause 9:

The following shall be added to the report:

a) Whether overlap used for leakage testing;

b) If the gasket tape has an adhesive strip for fixation on to the test platens.

Annex H
(informative)

Proposed method for the determination of the coefficient of static friction, μ_G, of gaskets

This factor is required in order to estimate the capability of the bolted flanged joint to counterbalance the acting shear forces and torsion moments. In bolted flanged joints with floating type of gasket, the effect of these kinds of external loads can be constrained only by friction between the gasket and the flange surfaces.

The standard testing equipment described in Clause 6 can be used for this proposed test method when used in conjunction with an extra heated platen, see Figure H.1. The extra heated platen, which can be moved in a radial direction using a hydraulic tensioner, is inserted between the two original platens with a gasket either side of the extra platen. For the determination of the coefficient of static friction the radial load that causes the commencement of radial movement is required. By measuring the axial load which is applied on the gaskets and the centre platen and the also the hydraulic force required to initiate the radial movement of the gaskets the static friction factor can be determined.

<u>Test procedure:</u>

— Apply initial gasket surface pressure (e.g. 20 MPa);

— Apply test temperature as appropriate for the gasket type;

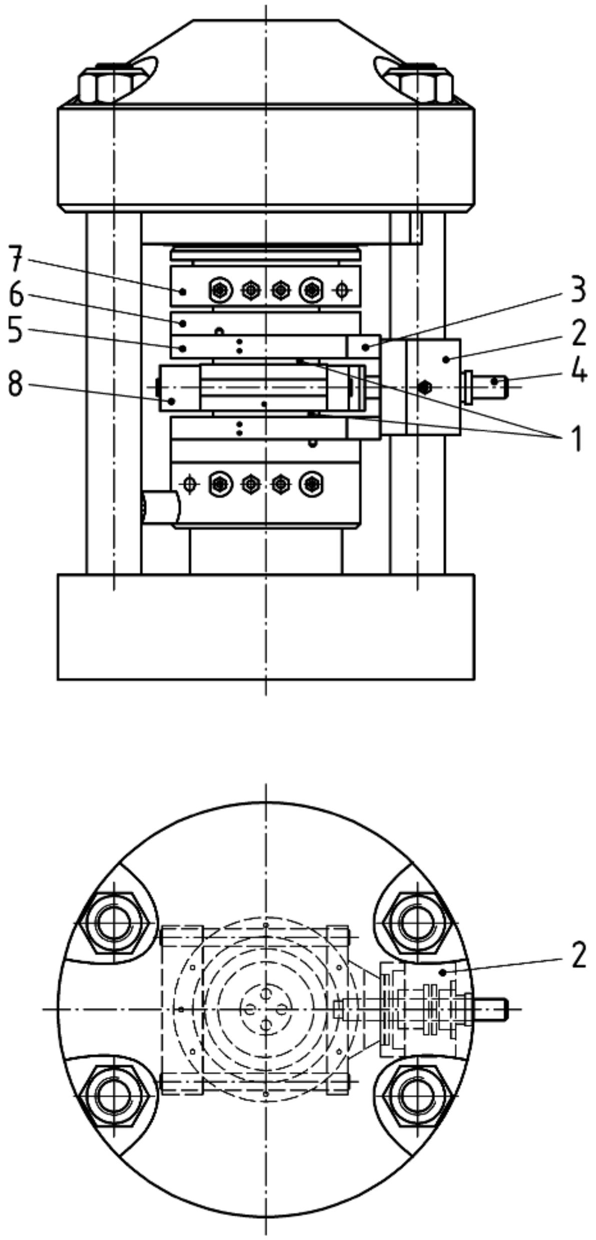
— Maintain the temperature and gasket surface pressure for four hours;

— Reduce gasket surface pressure to minimum required gasket surface pressure $Q_{smin(L)}$ (e.g. 5 MPa);

— Use the hydraulic tensioner to create a radial force that just moves the intermediate plate (radial break out);

— Determine the static friction coefficient from:

$\mu_G = (F_{rad\ break\ out}) / (2 \cdot F_{ax})$



Key

1 specimen

2 hydraulic tensioner

3 fixture pulling tool

4 tension rod

5 test platen

6 heating platen

7 cooling platen

8 heatable intermediate platen

Figure H.1 — Experimental setup for friction tests

Bibliography

[1] EN 1591-2, *Flanges and their joints - Design rules for gasketed circular flange connections - Part 2: Gasket parameters*

[2] EN 1779, *Non-destructive testing - Leak testing - Criteria for method and technique selection*

[3] EN 10263-4, *Steel rod, bars and wire for cold heading and cold extrusion - Part 4: Technical delivery conditions for steels for quenching and tempering*

[4] EN 14772, *Flanges and their joints - Quality assurance inspection and testing of gaskets in accordance with the series of standards EN 1514 and EN 12560*

[5] EN ISO 4287, *Geometrical product specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters (ISO 4287)*

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™