

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

The European Standard EN 13555:2004 has the status of a British Standard

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PSE/2, Jointing materials and compounds, which has the responsibility to:

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**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
modes opératoires d'essai relatifs 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 27 October 2004.

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Management Centre: rue de Stassart, 36 B-1050 Brussels

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Foreword

This document (EN 13555:2004) 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of an identical text or by endorsement, at the latest by June 2005, and conflicting national standards shall be withdrawn at the latest by June 2005.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and 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 document specifies the design parameters of gaskets and gasket materials required by EN 1591-1 and provides the test procedures for establishing the values of these parameters for inclusion in ENV 1591-2.

The testing procedures given might be applicable to gaskets of other shapes and dimensions but this shall be indicated in the report.

Gaskets which are wholly based upon elastomers, or based upon elastomer with the inclusion of particulate fillers or particulate reinforcement, are beyond the scope of this document.

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.

EN 1092-1, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges*

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 — Dimensions of 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 method*

ENV 1591-2, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 2: Gasket parameters*

EN 1759-1, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, Class designated — Part 1: Steel flanges, NPS ½ to 24*

EN 1779, *Non-destructive testing — Leak testing — Criteria for method and technique selection*

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 — 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*

EN ISO 4287, *Geometrical products specification (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters (ISO 4287:1997)*

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

3 Notations

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]
e_G	gasket or sealing element thickness	[mm]
Δe_G	change in gasket or sealing element thickness	[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	the secant unloading modulus of the gasket	[MPa]
L_N	leakage rate class — subscript N indicates the maximum specific leakage rate for that leakage rate class	[mg s ⁻¹ m ⁻¹]
P_{QR}	ratio of gasket surface pressures after & before relaxation	—
Q	surface pressure	[MPa]
Q_A	gasket surface pressure at assembly	[MPa]
$Q_{\min(L)}$	the minimum level of surface pressure required for leakage rate class L on assembly	[MPa]
$Q_{\min(L)}$	the minimum level of surface pressure required for leakage rate class L after off-loading	[MPa]
$Q_{\max}$	the maximum surface pressure than can be safely imposed upon the gasket at the service temperature without damage	[MPa]

Concordance with EN 1591-1 and ENV 1591-2:

Q_A , the gasket surface pressure at assembly is the gasket stress at the load situation 0 and is defined by Q_0 in EN 1591-1 and ENV 1591-2.

Q_{smax} , the maximum surface pressure that can be safely imposed upon the gasket at the indicated temperature without damage is the $Q_{max,ref}$ defined in ENV 1591-2.

$Q_{smin(L)}$ corresponds the Q_I defined in EN 1591-1 and in ENV 1591-2.

4 List of gasket parameters

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

Table 1 — Gasket parameters and test procedures

Gasket parameter	Definition Clause	Test procedure(s) Clause
Q_{smax}	5.1	8.4
$Q_{min(L)}$	5.2	8.7
$Q_{smin(L)}$	5.4	8.7 and 8.8
P_{QR}	5.5	8.6
E_G	5.6	8.5
α_G	5.7	8.9

5 Definitions

5.1

Gasket parameter Q_{smax}

maximum gasket surface pressure that may be imposed on the gasket at the indicated temperatures without collapse or compressive failure of the gasket

5.2

Gasket parameter $Q_{min(L)}$

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

5.3

Tightness class L_N

tightness classes are defined in Table 2 in terms of specific leak rates. Additional, better tightness classes can be introduced as required by continuing the series

Table 2 — Tightness classes

Tightness classes	$L_{1,0}$	$L_{0,1}$	$L_{0,01}$
Specific leak rates [$\text{mg s}^{-1} \text{m}^{-1}$]	$\leq 1,0$	$\leq 0,1$	$\leq 0,01$

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, $\pi/2 (D_S + d_S)$.

5.4

Gasket parameter $Q_{smin(L)}$

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

5.5

Gasket parameter P_{QR}

a factor to allow for the effect on the imposed load of the relaxation of the gasket between the completion of bolt up and after long term experience of the service temperature

5.6

Gasket parameters E_G

the unloading moduli determined from the thickness recovery of the gasket between the initial compression surface pressure and unloading to a third of this initial surface pressure

5.7

Gasket parameter axial coefficient of thermal expansion α_G

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

5.8

Area of the gasket subjected to surface pressure, A_G

the area subjected to surface pressure by the flange facings is calculated from:

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

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

5.9

Ambient Temperature

the ambient laboratory temperature during the testing detailed in this document shall be $(23 \pm 5)^\circ\text{C}$ as recommended in ISO 554 but the temperature of the test platens at the start of all tests shall be $(23 \pm 2)^\circ\text{C}$

5.10

Test Temperatures

when testing is carried out at elevated temperature it is recommended, for reasons of uniformity, that the test temperature be selected from those shown below

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 °C per minute.

6 Test equipment

6.1 Design

Schematics of test rigs for compression, compression creep, and leakage 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. Figures B.1 and C.1 show the dimensions in the former case.

6.3 Surface finish of test platens

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

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

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 must be recorded.

This surface finish can be achieved by lathe turning with the following parameters:

- Helical pitch: 0,3 mm;
- Tool radius: 0,8 mm;
- Depth: 0,015 mm.

The recommended R_a values shall be checked before each test. Local errors shall not exceed twice the value of R_a (see EN ISO 4287).

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.

Experience has indicated that during hot compression tests, such as the Q_{smax} test, the use of stainless steel foils or shims of thickness of 0,05 mm thickness between the test gasket and the platens protects the flange surface finish because platen cleaning, with the inherent probability of damaging the platen surface finish, is eliminated. If there is any effect from the use of such foils it will be conservative.

Where foils are used the fact of their use shall be included in the test report issued. Foils shall not be re-used and shall not be used in sealing tests

6.4 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.

6.5 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.

6.6 Temperature

The rate of increase of temperature in all elevated temperature tests shall be 2 °C per minute

6.7 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 specimens

7.1 Number of specimens

At least two specimens for each type of test shall be tested, in order to check the repeatability of the results.

7.2 Procurement and identification of specimens

The gaskets to be tested shall be selected at random from production gaskets or shall be cut from sheet representative of normal production. In both cases 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 specimen 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 $(50 \pm 6) \%$ at ambient temperature.

7.4 Dimensions of test gaskets

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

Table 3 — Test gasket dimensions

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)

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 stabilization 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 reported.

7.6 Influence of specimen dimensions

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

8 Test procedures

8.1 Testing Strategy

The two most important properties of a gasket are the ability to create a seal and the ability to maintain that 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 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 $Q_{\min(L)}$ are determined and in the latter case tests from which $Q_{\max}$, E_G and P_{QR} are determined.

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

8.2 Reference gasket thickness

The reference gasket thickness that should 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.

8.3 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 6.5 shall be included with the report specified in Section 9, see also 7.6.

8.4 Determination of Q_{smax}

8.4.1 Equipment required

See Clause 6.

8.4.2 Test gasket dimensions

See 7.4.

8.4.3 Pre-conditioning of test gaskets

See 7.3.

8.4.4 Generation of Q_{smax}

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 6.5, 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 6.6 until the required temperature is reached after which there is a dwell for 15 minutes.

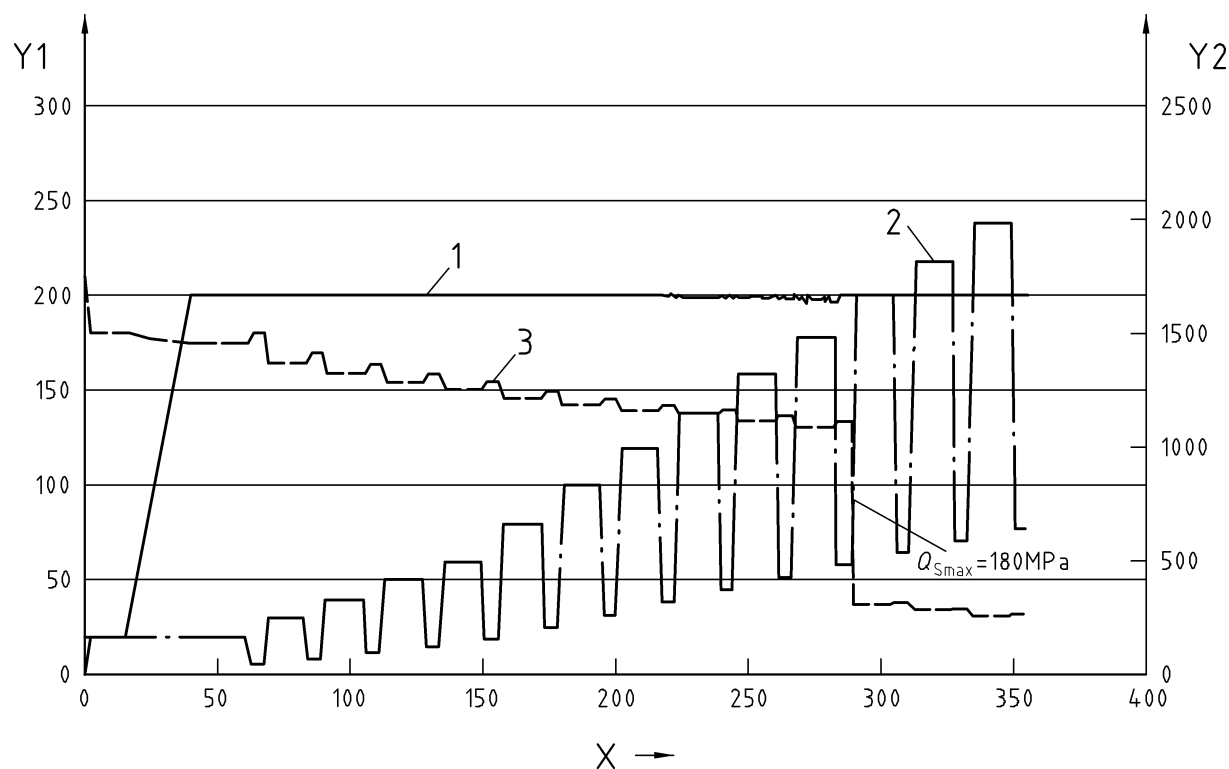
After this dwell the load on the gasket is decreased to one third of the previous value at the appropriate rate, see 6.5, based upon the original area of the gasket and held there for a dwell period of 5 minutes. It is then increased at the appropriate rate, see 6.5, based upon the original area of the 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. The value of Q_{smax} being taken at that gasket surface pressure value used before the successive thickness change exhibited an increase.

During this test regime the surface pressures that shall be used are indicated below:

Q [MPa]	20	30	40	50	60	80	100	120	140	160	and so on in steps of 20 MPa
$Q/3$ [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

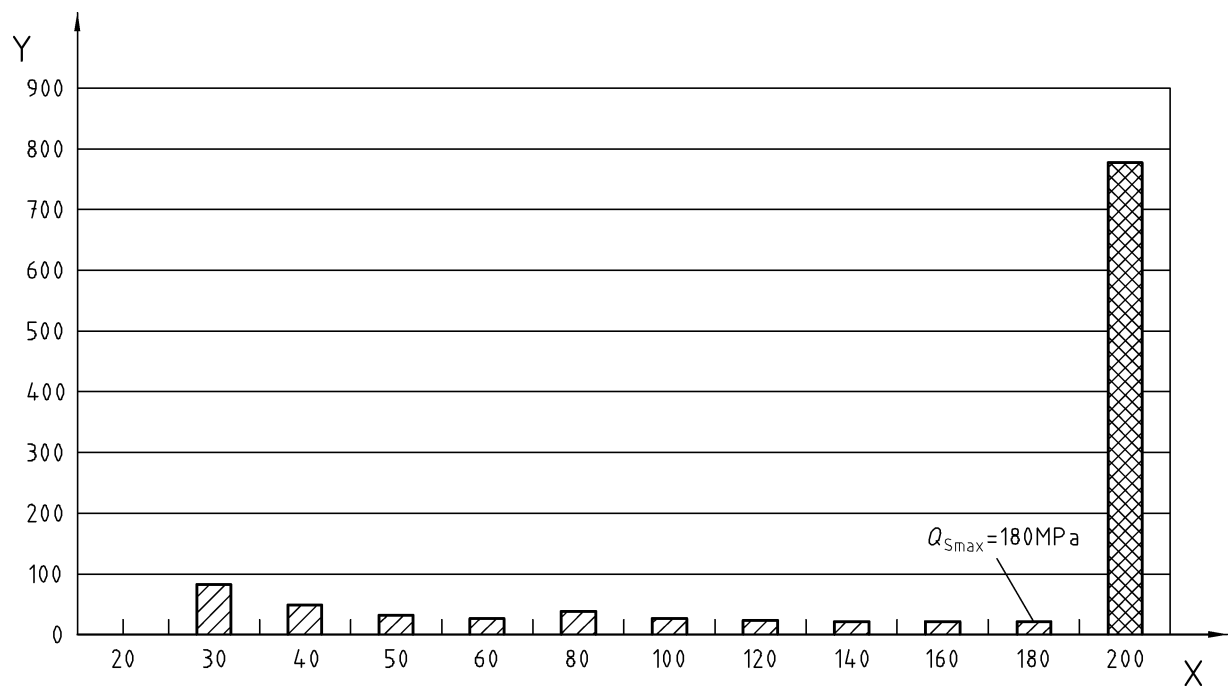


Key

- 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}

8.4.5 Validity of the test results

For some gasket materials within the scope of this document the value of Q_{smax} will be overestimated by this test procedure. The value of Q_{smax} shall be confirmed as satisfactory by conducting a P_{QR} test at that surface pressure, as well as lower ones, and temperature (see 8.6.4).

8.5 Determination of the values of E_G

8.5.1 Equipment required

See Clause 6.

8.5.2 Test gasket dimensions

See 7.4.

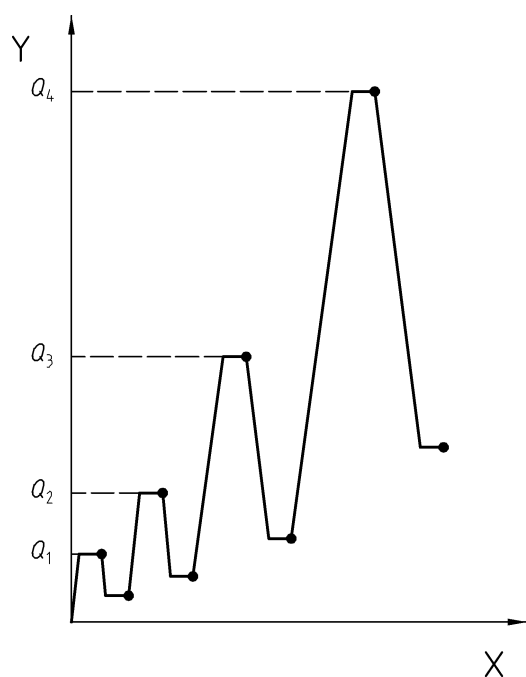
8.5.3 Pre-conditioning of test gaskets

See 7.3.

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

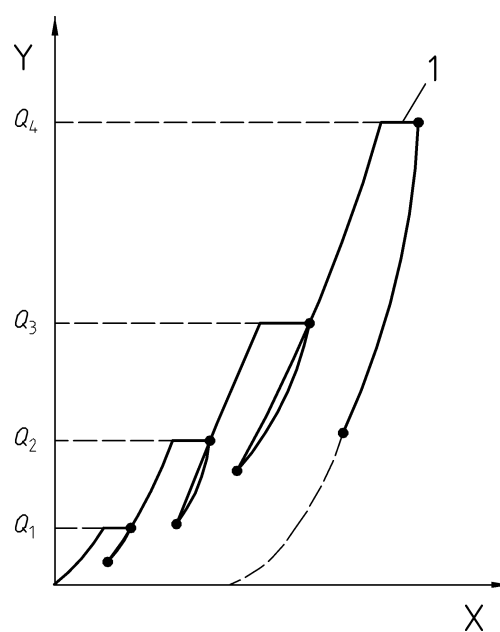
The unloading cycles of the Q_{smax} test allow the generation of values of E_G as shown in Figure 3. The value of E_G varies with the surface pressure on the gasket with the exact form of the relationship depending upon the style of gasket being tested.

In the determination of E_G , the thickness of the gasket at the stress Q_N , $N = 1$ to 4, see Figure 2b, used in the calculation of the strain is the one at the start of the off loading.



Key
 X Time
 Y Gasket stress Q

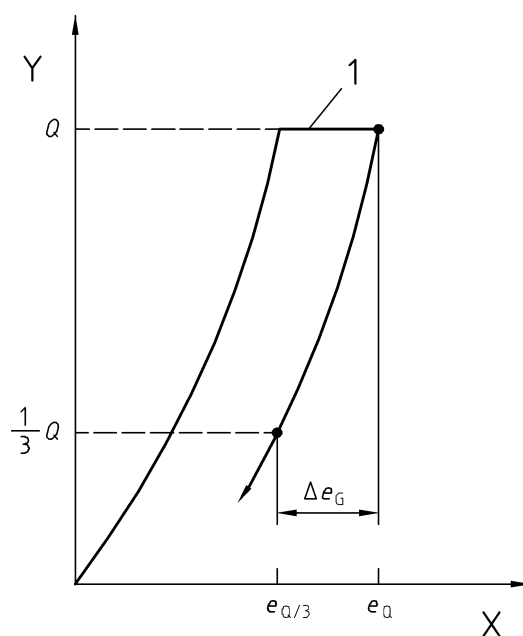
Figure 2a — Loading scheme



Key
 1 Creep
 X Gasket thickness change (including creep)
 Y Gasket stress

Figure 2b — Compression curve

Figure 2 — Loading scheme and resulting compression curve



Key
 1 Creep
 X Gasket thickness change (including creep)
 Y Gasket stress

NOTE $E_G = \frac{2}{3} Q \times \frac{e_Q}{\Delta e_G}$

Figure 3 — Determination of E_G in the case of gasket creep

8.6 Determination of P_{QR}

8.6.1 Equipment required

See Clause 6.

8.6.2 Test gasket dimensions

See 7.4.

8.6.3 Pre-conditioning of test gaskets

See 7.3.

8.6.4 Generation of P_{QR}

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. A stiffness of 500 KN/mm is typical for a PN designated flange and 1500 KN/mm for a Class designated flange. For this test the stiffness of the rig for this test shall be 500, 1000 or 1500 KN / mm.

The test procedure consists of loading the test gasket at the defined rate (see 6.5) until the required loading and surface pressure is reached. The loading is then held for 5 minutes after which the temperature of the test rig is raised at the rate specified in section 6.6 until the required temperature is reached. Then the temperature is held constant for a period of 4 hours. After the 4 hour period the remaining load being imposed by the press is noted and P_{QR} , the ratio of the residual load to the original load, is calculated.

For all gasket types, the P_{QR} tests carried out must include tests at the values of Q_{smax} determined from the cyclic loading test of 8.4.4. In general a value for P_{QR} 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.

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

8.7.1 Equipment required

See Clause 6.

8.7.2 Test gasket dimensions

See 7.4.

8.7.3 Pre-conditioning of gaskets

See 7.3.

8.7.4 Generation of $Q_{min(L)}$ and $Q_{smin(L)}$

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 5 with an internal gas pressure of 40 bar:

**Table 4 — The loading and unloading surface pressures to be used
in the determination of $Q_{\min(L)}$ and $Q_{s\min(L)}$**

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

The procedure therefore consists of loading to 10 MPa, holding the load and measuring the leak rate after the leak rate has stabilised and then raising the loading to 20 MPa. The load is then held whilst the leak rate is measured and then the load is reduced to 10 MPa and the leak rate is measured. Then measurements are done at 40 MPa, 20 MPa and 10 MPa and so on until either the 160 MPa loading — unloading cycle is completed or the value of $Q_{s\max}$ would have been exceeded had the next loading point be used.

For each load step the time for leak rate stabilisation is likely to be about 2 hours with about 5 hours for an unloading point.

The gasket surface pressure shall be increased and decreased at the rate given in 6.5 and the gas pressure increased at a slow uniform rate.

The test gas used for this test shall be helium.

The effective surface pressure level is calculated from the following:

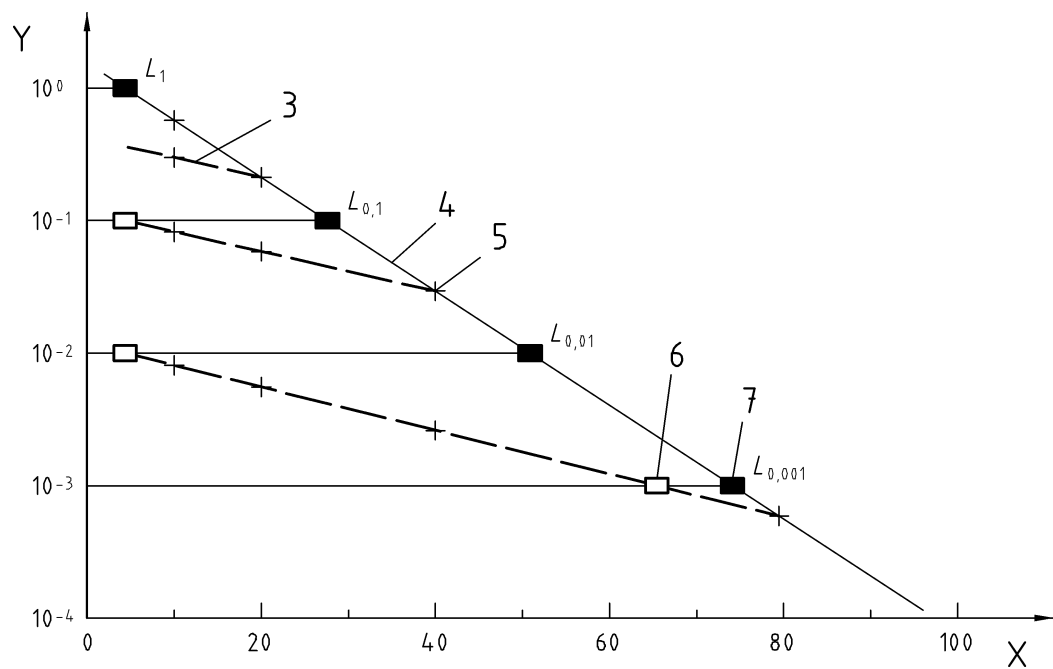
$$Q = Q_A - [(p \times (\pi/4) \times d_s^2)/A_G] \quad (3)$$

NOTE For safety reasons the effective gasket surface pressure, the surface pressure after end thrust allowance, should be higher than twice the internal pressure (e.g. $Q > 8$ MPa for 40 bar internal pressure).

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

Figure 4 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 $Q_{s\min(L)}$, at ambient temperature and the loading line provides the $Q_{\min(L)}$ values. From this figure the values $Q_{\min(L)}$ and $Q_{s\min(L)}$ 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 4 these values for the gasket tested are indicated as solid or hollow rectangles.

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

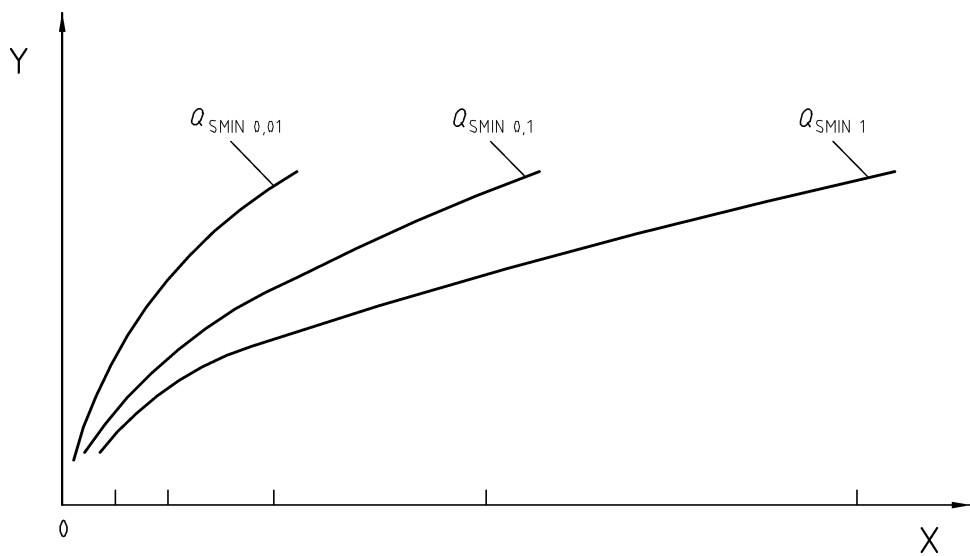


Key

- 3 Unloading
- 4 Loading
- 5 Measurement point
- 6 $Q_{smin}(L)$
- 7 $Q_{min}(L)$
- X Effective gasket stress [MPa]
- Y Leakage rate [mg/(m · s)]

Figure 4 — Leakage rate as a function of gasket stress (for an internal pressure of 40 bar in this case)

Extra data should be obtained with other relevant internal gas pressures, for example with 10 bar and 80 bar. 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, Figure 5.



Key

- X Internal pressure [bar]
- Y Effective gasket surface pressure

Figure 5 — $Q_{smin}(L)$ as a function of both internal pressure and leakage rate class

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

There is currently little experience in the determination of these parameters but where a determination is required the apparatus and method given in Annex G may be of assistance.

8.9 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.

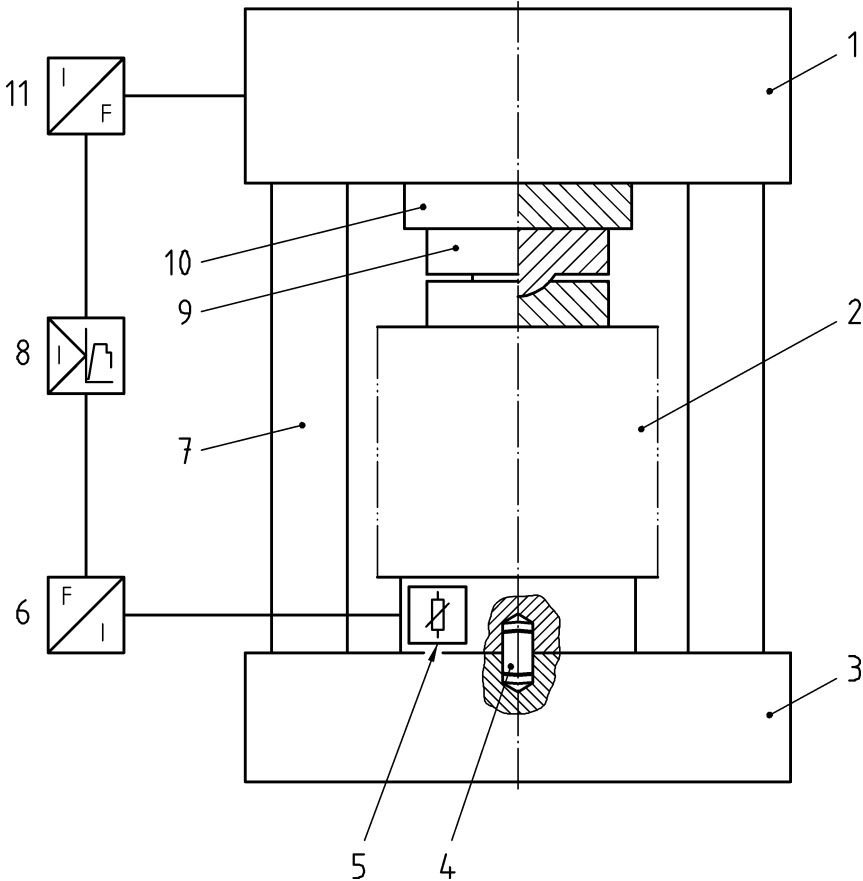
9 Report details

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

- a) Type, description and nominal sizes of the tested product;
- b) Lot number and production date;
- 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 before and 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 single 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) Quality assurance test parameters as specified in EN XXXX for the gasket type in question
- j) Curve of compressed thickness as function of surface pressure (see 8.3) at ambient temperature;
- k) Details of non-standard test platens (see 7.4);
- l) Any deviations from this standard such as special testing conditions agreed on with customer;
- m) 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
- n) Graphical representations of the values as a function of time or other relevant variable;
- o) If stainless steel foil of 0,05 mm thickness is used during the determination of Q_{smax} then the use of foil shall be noted in the report.

Annex A
(informative)

Generalised test rig schematic

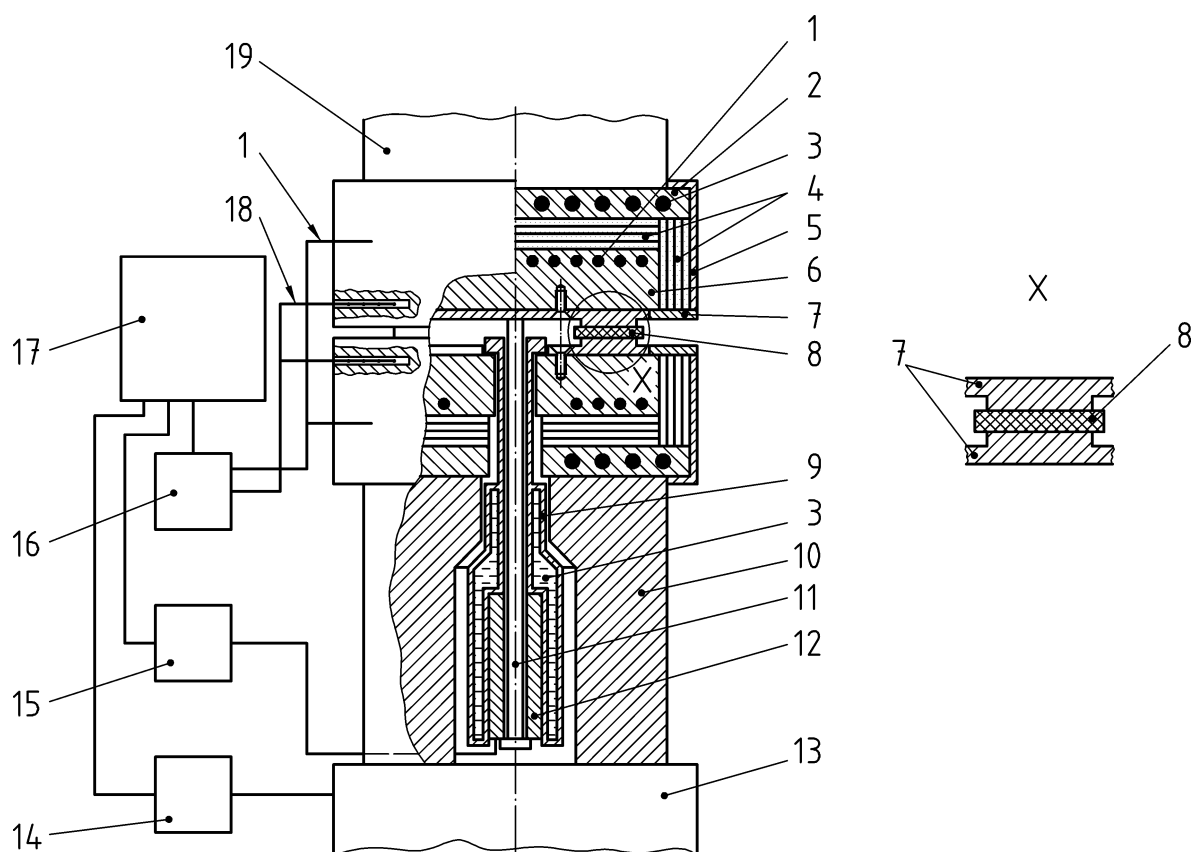


Key		
1, 3 and 7	Reaction frame	8 Load control
2	Test cell	9 Alignment ball joint
4	Location device	10 Hydraulic cylinder
5 and 6	Load cell and measurement	11 Hydraulics control

Figure A.1 — Generalised test rig schematic

Annex B (informative)

Test rig schematic for compression and compression creep tests



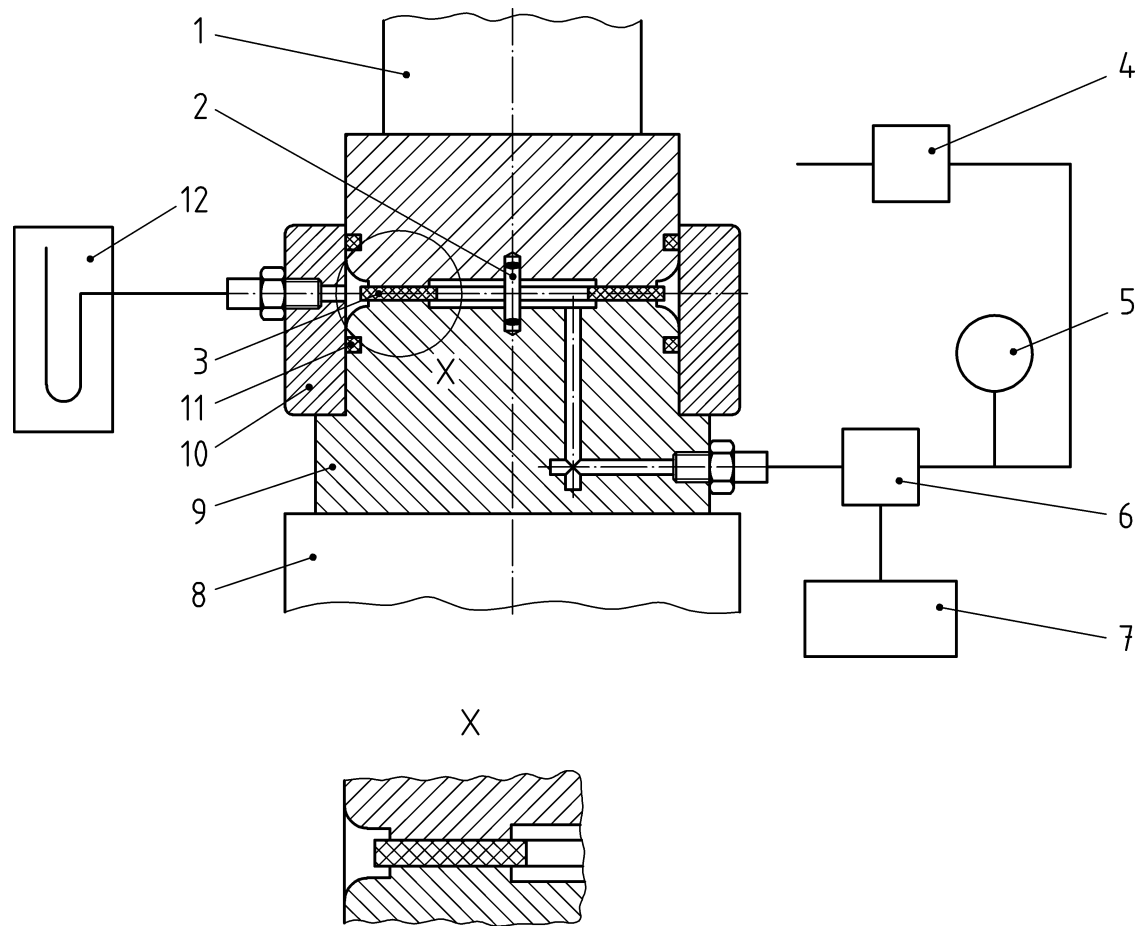
Key

- | | |
|--|-----------------------------|
| 1 Heaters | 10 Spacer block |
| 2 Cooling block | 11 Measuring pin |
| 3 Coolant passages | 12 Displacement transducer |
| 4 Thermal insulation | 13 Load cell |
| 5 Casing | 14 Force measurement |
| 6 Heating block | 15 Displacement measurement |
| 7 Exchangeable test plates of steel according to EN 10263-4 material number 1.7035,8 | 16 Heater control |
| 8 Test specimen | 17 Test controller |
| 9 Locator | 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

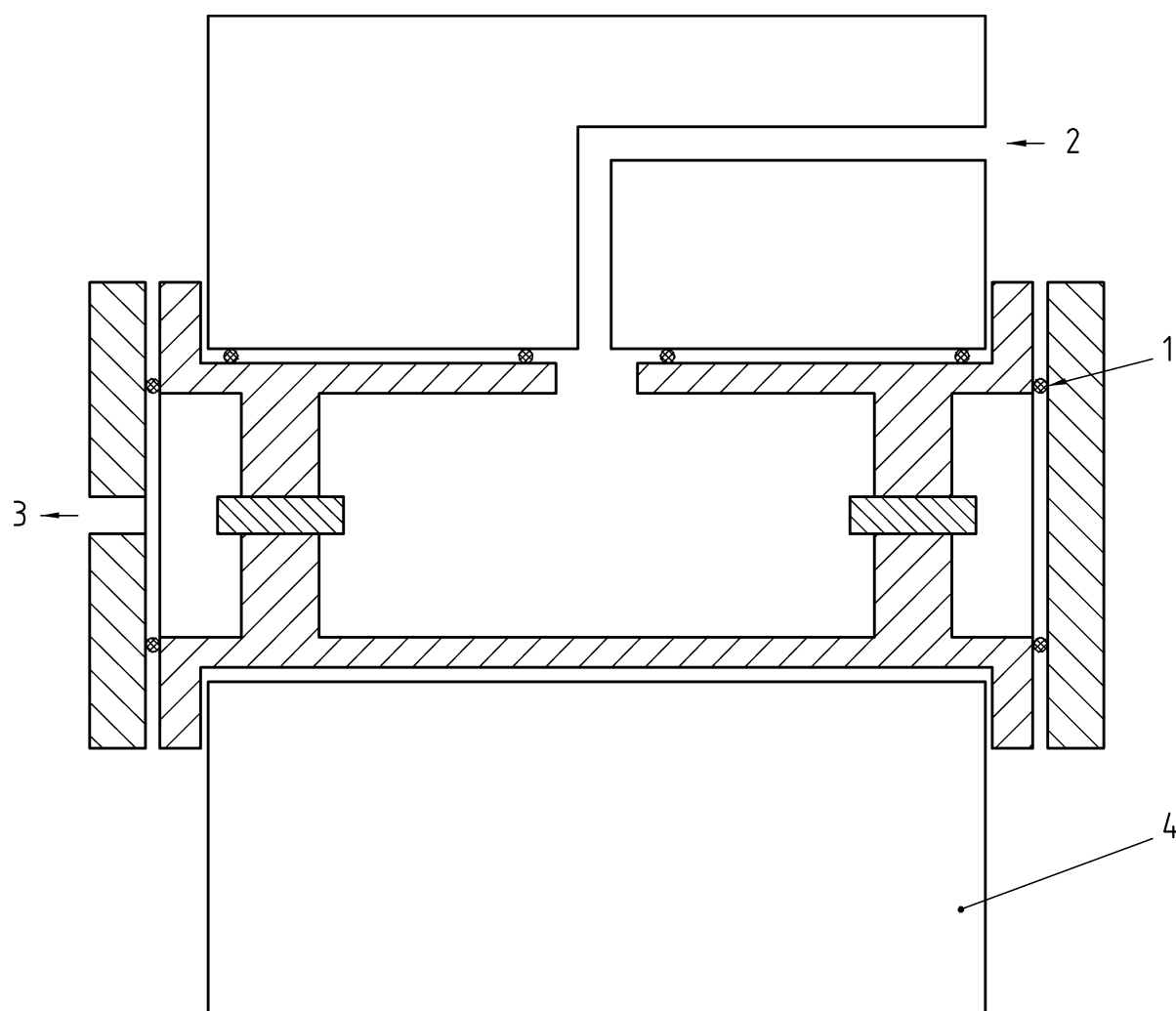


- Key**
- | | | | |
|---|----------------------|----|--------------------|
| 1 | Hydraulic cylinder | 7 | Flow rate recorder |
| 2 | Location device | 8 | Load cell |
| 3 | Test gasket | 9 | Spacer block |
| 4 | Pressure controller | 10 | Leakage collector |
| 5 | Pressure measurement | 11 | O ring |
| 6 | Mass flow meter | 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 $Q_{\text{sm}(L)}$ 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 $Q_{\text{sm}(L)}$ 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.

The reasons are:

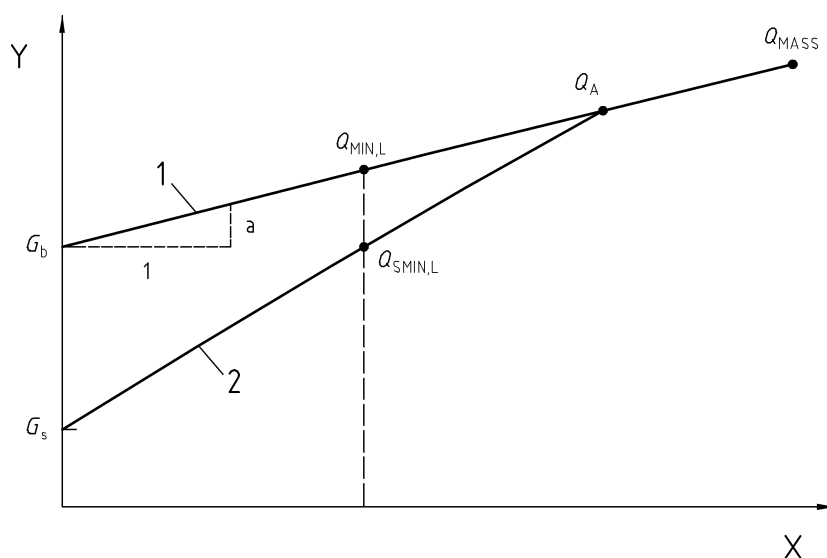
- limited knowledge about the quantitative relation between the leakage rate in the test and the large number of influencing factors;
- limited knowledge about the background of flow theory and how to transfer test results to the service conditions;
- strong influence of assembly technique and factors such as bolt friction.

For the assessment of leakage rates in service conditions leakage rate monitoring during service is necessary.

Annex F (informative)

Relationship of gasket parameters of this standard with those from PVRC method

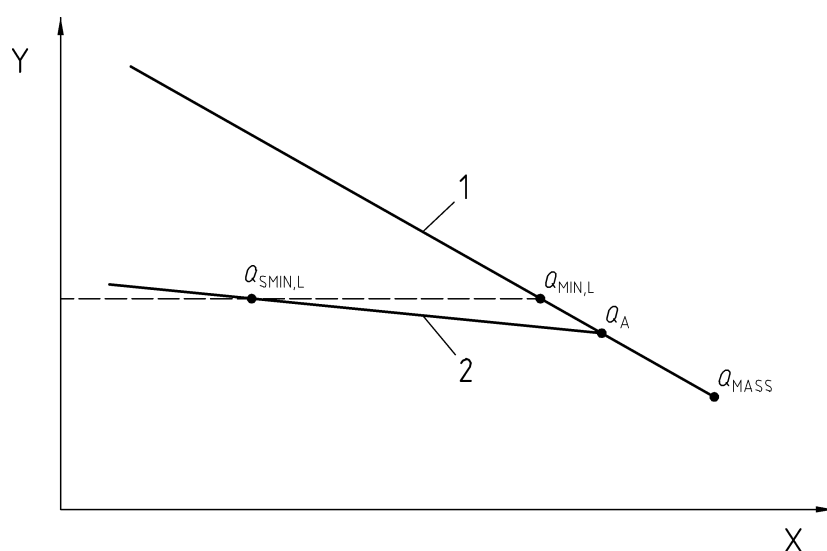
Figure F.1 clearly illustrates the similarity between PVRC ROTT test with its Part A and Part B sections and the method of this standard as indicated by Figure 4.



Key

- 1 Assembly line
- 2 Working line
- X Log tightness parameter
- Y Log gasket stress

Figure F.1a — PVRC ROTT (for all internal pressures)



Key

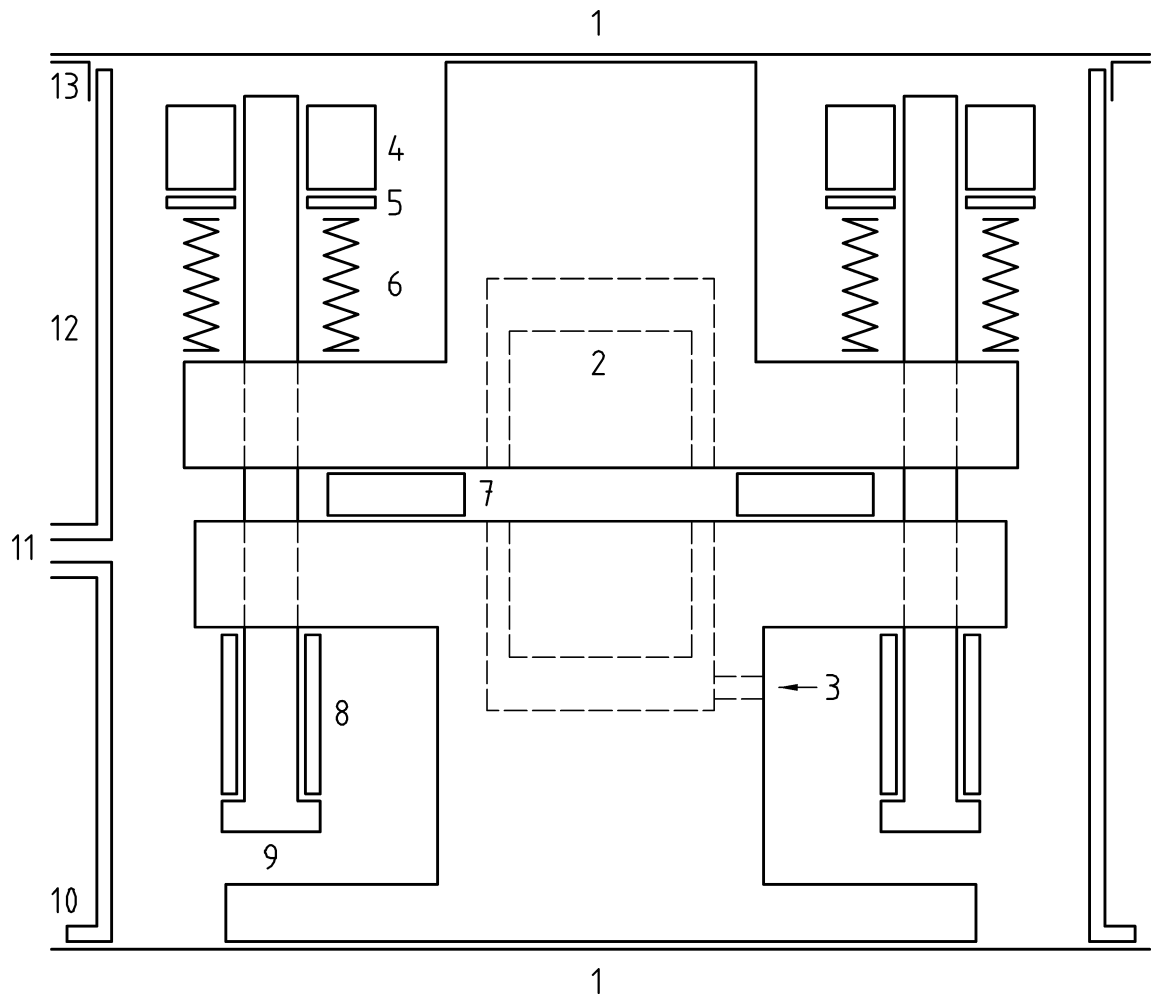
- 1 Assembly line
- 2 Working line
- X Gasket stress
- Y Log leakage rate class

Figure F.1b — EN 13555 (for a given internal pressure)

Figure F.1 — Comparison of the PVRC and this standard's gasket parameters

Annex G
(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 | 8 | Extension collar |
| 2 | Heater cartridge | 9 | Bolt |
| 3 | Gas input point | 10 | Gasketed seal |
| 4 | Nut | 11 | Sampling point |
| 5 | Washer | 12 | Cylindrical enclosure |
| 6 | Disc washers | 13 | Bellows Seal |
| 7 | Gasket | | |

Figure G.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 $Q_{smin(L)}$ 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 a low cost 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 would 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 can 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 8.6.4 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.

Bibliography

- [1] 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*

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