Experiences gained in the inspection of Q_{Smax}- and P_{QR}-values in accordance with EN 13555 as exemplified by PTFE-based Gaskets

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EN 13555 –
Gasket factors and testing procedures for applying the rules for designing flange connections with round flanges and gaskets – has been valid since February 2005.

It replaced the standard DIN 28090-1 "Static sealings for flange connections – part 1: Gasket factors and test procedures" of Sept. 1995.

In the past years, the company Klinger Dichtungstechnik has looked into this new standard intensively and has performed a large number of tests on a wide range of gasket materials in its in-house test lab.

An interim balance of our initial findings shows that testing the gasket factor Q_{Smax} (maximum surface stress) leads to reasonable results for many fibre-reinforced gaskets, but that for the results for PTFE gaskets doubt needs to be applied to the purposefulness of the test results.

The failure criterion defined in the standard is not clearly defined, and, depending on how the test results are interpreted, one can arrive at completely different results for the corresponding gasket factors.

The note provided in the standard, that determining Q_{Smax} on sheet materials can lead to an overvaluation of the functionality of gaskets, and hence all values for Q_{Smax} need to be confirmed by determining P_{QR} at the same temperature and surface stress, is also not very helpful, since the interpretation of the failure criterion for Q_{Smax} provides different values for Q_{Smax}.

The interpretation of Q_{Smax} by the engineer could lead to an overestimation of the load bearing capacity of the gasket, since the standard does not provide any note on the final state of the gasket after the test.

If one compares the maximun surface stress in compliance with EN 13555 to σ_{BO} according to DIN 28090-1, it is simple to identify the different testing concepts used for both standards.

In the definition according to DIN 28090-1, non-permitted relaxation of the gasket connection due to structural damage or gasket creeping are taken into account and the highest permitted, relative change in thickness in the compression test for gasket materials is clearly limited.

This concept leads to defined values for the maximum permitted surface stress of the gasket material in the operating state and differs basically to the Q_{Smax} value determined in accordance with EN 13555.

In the following, the terms according to EN 13555 and the determination of the gasket factors – Q_{Smax} and P_{QR} – are cited from the standard.

Test results and photos of the gaskets tested in accordance with EN 13555 show that the definition and determination of the gasket factors Q_{Smax} and P_{QR} for gaskets based on PTFE need to be reviewed, so that the user can determine easily and without doubt, which gasket material will function perfectly under the given operating conditions.

So long as EN 13555, published in February 2005, is still valid, Klinger recommends for safety reasons, the application of the values for the max. permitted surface stress σ_{BO} determined by the sealing calculation software KLINGER®expert 5.2.1, for the specific application for all Klinger gasket materials.

Gasket Parameters Notations according EN 13555

Gasket factor Q_{Smax} (EN 13555 – 5.1/8.1)

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

The determination of Q_{Smax} may for sheet material result in an over-estimation of the capability of the sheet and it is important that all values of Q_{Smax} for sheets are verified by conducting a test for P_{QR} at the same temperature and surface pressure as for the Q_{Smax} value.

Generation of Q_{Smax} (EN 13555 – 8.4.4)

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 QSmax 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 N/mm^2 based upon the original area of the gasket at ambient temperature and there is then a dwell period of 5 minutes. The temperature is the 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, based upon the original area of the gasket, is attained (see below for the exact value).

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 the standard 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.

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Gasket Parameters Notations according EN 13555

Gasket factor P_{QR} (EN 13555 – 5.5)

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.

Generation of P_{QR} (EN 13555 – 8.6.4)

The factor P_{QR} is the ratio of the residual and the original load 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 1.500 kN/mm for a Class designated flange. For this test the stiffness of the rig shall be 500, 1.000 or 1.500 kN/mm.

The test procedure consists of loading the test gasket at the defined rate (see 6.5) 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 hours 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.

Validity of the test results (EN 13555 – 8.4.5)

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).

KLINGER Determination of Q_{Smax} (EN 13555 – 8.4.4)

Material A

Deformation at different surface stresses

Temperature = 100°C

Q_{Smax} = 160 N/mm²

Gasket dimensions	before testing	after testing
Outer diameter	90 mm	105 mm
Inner diameter	50 mm	30 mm
Gasket thickness *)	2 mm	0.38 mm

*) measured at ambient temperature in dismantled stage

Diagram 1 Deformation of Material A at different surface stresses

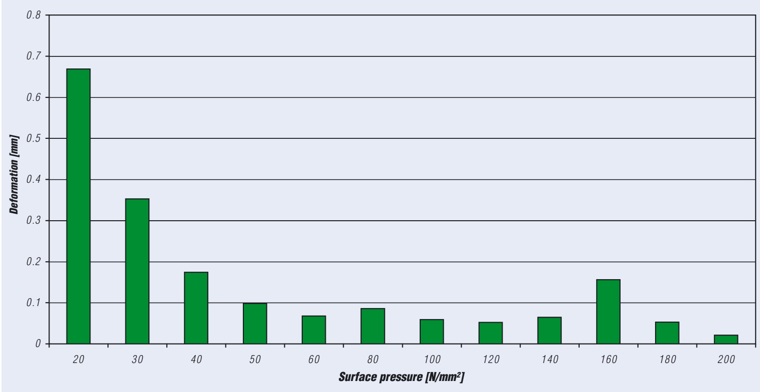


Figure 1: Photos of gasket Material A before testing and after testing at a surface pressure of 160 N/mm²

The surface stress of the load cycle prior to the failure of the gasket or the max. surface stress specified by the manufacturer applies as Q_{Smax}.

Failure is seen to occur when the values for the thickness decrease, dependent on the increase in the surface stress, increase so much, compared to the course of the previous values, that it can no longer be assumed that measurement value distributions are concerned.

For each load cycle, decrease in the gasket's thickness must be recorded dependent on the surface stress.

The value for Q_{Smax} is identified as the surface stress after which an increase in the change in the gasket's thickness occurs.

As can be seen from the Figure, this occurs at a surface stress of 160 N/mm².

The value for Q_{Smax} at T = 100°C would therefore be indicated as 140 N/mm² in compliance with the standard.

Specification of the end thickness and a visual evaluation of the tested gasket or information on the behaviour of the gasket on assembly (cold compression) or operation (hot compression) is unfortunately not scheduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

Table 1 Total deformation of gasket Material A at the corresponding surface pressures and relative end thicknesses

Surface pressure	Total deformation	End thickness at T = 100°C	Deformation
N/mm²	mm	mm	%
20	0.67	1.29	34
30	1.02	0.94	52
40	1.20	0.74	62
50	1.30	0.66	66
60	1.37	0.59	70
80	1.46	0.50	74
100	1.52	0.44	78
160	1.79	0.18	91

The deformation of the original 2 mm thick gasket equates to 84% at a surface stress of 140 N/mm² and the material extrudes strongly outwards and inwards at this load.

In our opinion, Gasket Material A is unsuitable for use at 100 °C and a surface stress of 140 N/mm².

In order to estimate Q_{Smax} more effectively, the deformation of highly compressible materials should also be tested at surface stresses of 5 N/mm² and 10 N/mm², which is unfortunately not scheduled in the standard.

This confirms that a visual evaluation of the gasket tested represents an indispensable additional criterion for determining Q_{Smax}.

Determination of P_{QR} (EN 13555 – 8.6.4)

Material A

Stiffness of the test rig: 500 kN/mm

Initial surface pressure: 160 N/mm²

Temperature: 100°C

Dwell period: 4 hours

Residual surface pressure: 107 N/mm²

Relaxation factor P_{QR}: 0.67
(= ratio of residual surface pressure to initial surface pressure)

End thickness of the gasket after testing: 0.20 mm

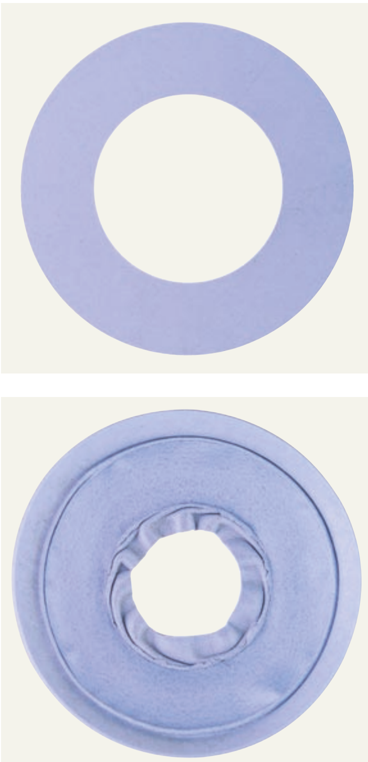
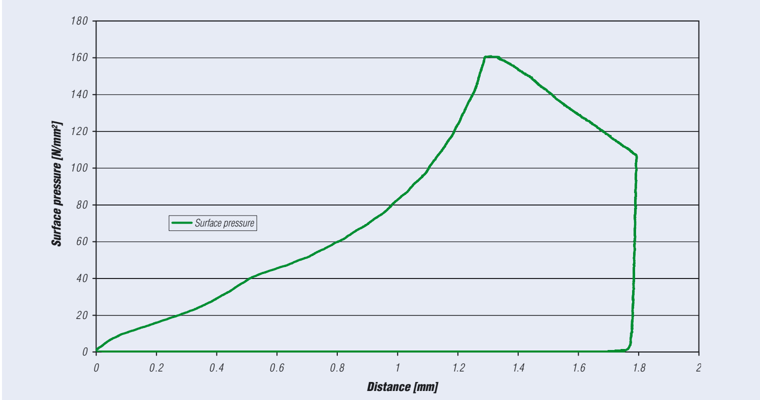


Figure 2: Photos of gasket Material A before and after the P_{QR}-test

The gasket factor P_{QR}, is a factor for taking the relaxation influence on the gasket load into account after torquing the bolts and the long-term affects of the operating temperature.

It is calculated by taking the ratio between the residual surface stress and the initial surface stress after a relaxation test in a press by way of route-controlled load control for a specific stiffness.
A stiffness of 500 kN/mm is typical for PN flanges.

Diagram 2 Deformation of gasket Material A during the P_{QR}-test



It is obvious that a gasket material in 2 mm thickness, which loses 90 % of its thickness under the given load, can indeed cause problems in application, although according to the testing standard it has not failed.
The material extrudes strongly outwards and inwards during testing.

We therefore see no confirmation of a Q_{Smax} value of 160 N/mm² in the P_{QR} values determined. Unfortunately it is not defined in the standard, which result of the P_{QR}-measurement confirms a Q_{Smax} value.

The specification of the end thickness, a visual evaluation as well as the indication of the gasket deformation according to which the initial surface stress was achieved, would also comprise useful information which unfortunately are not sceduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

A high P_{QR} value does not exclude failure of the gasket and can in no way replace a visual evaluation of the gasket tested.

As during the testing of Q_{Smax}, it was confirmed here that a visual evaluation of the tested gasket represents an indispensable, additional criterion for the estimation of the significance of the result of the P_{QR}-test.

Due to the results of the tests performed, KLINGER considers rapid revision of EN 13555 to be urgently necessary.

So long as EN 13555, published in February 2005, is still valid, Klinger recommends for safety reasons, the application of the values for the max. permitted surface stress σ_{BO} determined by the sealing calculation software KLINGER®expert, for the given form of application for all Klinger gasket materials.

KLINGER Determination of Q_{Smax} (EN 13555 – 8.4.4)

KLINGER®top-chem 2003

Deformation at different surface stresses
Temperature = 100°C
Q_{Smax} = 30 N/mm²

Gasket dimensions	before testing	after testing
Outer diameter	90 mm	105 mm
Inner diameter	50 mm	30 mm
Gasket thickness *)	2 mm	0.45 mm

*) measured at ambient temperature in dismantled stage

Diagram 3 — Deformation of KLINGER®top-chem 2003 at different surface stresses

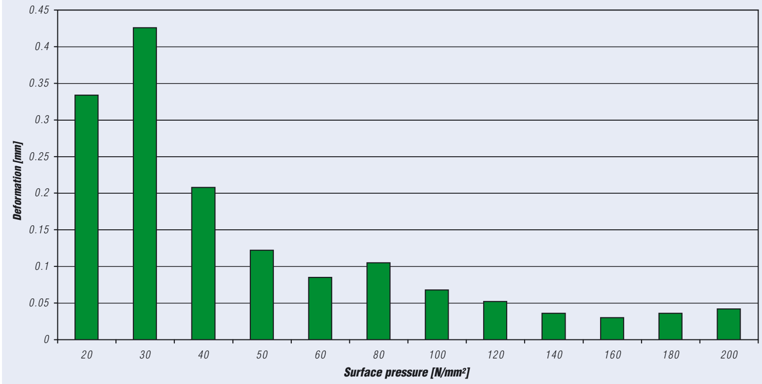


Figure 3: Photos of gasket KLINGER®top-chem 2003 before testing and after testing at a surface pressure of 200 N/mm²

The surface stress of the load cycle prior to the failure of the gasket or the max. surface stress specified by the manufacturer applies as Q_{Smax}.

Failure is seen to occur when the values for the thickness decrease, dependent on the increase in the surface stress, increase so much, compared to the course of the previous values, that it can no longer be assumed that measurement value distributions are concerned.

For each load cycle, decrease in the gasket's thickness must be recorded dependent on the surface stress.

The value for Q_{Smax} is identified as the surface stress after which an increase in the change in the gasket's thickness occurs.

As can be seen from the Figure, this occurs at a surface stress of 30 N/mm².

The value for Q_{Smax} at T = 100°C would therefore be indicated as 20 N/mm² in compliance with the standard.

Specification of the end thickness and a visual evaluation of the tested gasket or information on the behaviour of the gasket on assembly (cold compression) or operation (hot compression) is unfortunately not scheduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

Table 3 — Total deformation of KLINGER®top-chem 2003 at the corresponding surface pressures and relative end thicknesses

Surface pressure	Total deformation	End thickness at T = 100°C	Deformation
N/mm²	mm	mm	%
20	0.33	1.56	18
30	0.76	1.13	40
40	0.97	0.92	51
50	1.09	0.80	58
60	1.17	0.72	62
80	1.28	0.61	68
100	1.35	0.54	72
160	1.46	0.43	78
200	1.54	0.35	81

The deformation of the original 2 mm thick gasket equates to 81 % at a surface stress of 200 N/mm² and the material extrudes strongly outwards and inwards at this load.

In our opinion, KLINGER®top-chem 2003 is unsuitable for use at 100 °C and a surface stress of 200 N/mm².

In order to estimate Q_{Smax} more effectively, the deformation of highly compressible materials should also be tested at surface stresses of 5 N/mm² and 10 N/mm², which is unfortunately not scheduled in the standard.

This confirms that a visual evaluation of the gasket tested represents an indispensable additional criterion for determining Q_{Smax}.

Determination of P_{QR} (EN 13555 – 8.6.4)

KLINGER®top-chem 2003

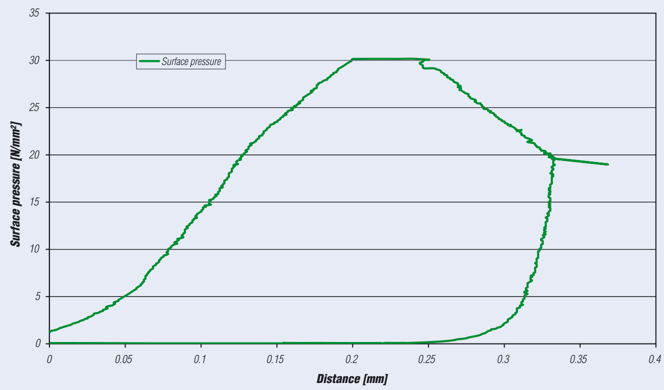
Stiffness of the test rig: 500 kN/mm
Initial surface pressure: 30 N/mm²
Temperature: 100°C
Dwell period: 4 hours
Residual surface pressure: 19.6 N/mm²
Relaxation factor P_{QR}: 0.65
(= ratio of residual surface pressure to initial surface pressure)
End thickness of the gasket after testing: 1.65 mm

Figure 4: Photos of gasket KLINGER®top-chem 2003 before and after the P_{QR}-test.

The gasket factor P_{QR}, is a factor for taking the relaxation influence on the gasket load into account after torquing the bolts and the long-term affects of the operating temperature.

It is calculated by taking the ratio between the residual surface stress and the initial surface stress after a relaxation test in a press by way of route-controlled load control for a specific stiffness.
A stiffness of 500 kN/mm is typical for PN flanges.

Diagram 4 Deformation of KLINGER®top-chem 2003 during the P_{QR}-test



We see that the P_{QR} factor of 0.65 at T = 100 °C alone still fails to confirm the Q_{Smax} of 30 N/mm². On visual evaluation, it was possible to determine that the gasket material does hardly extrude outwards and inwards and that no unusual thickness decrease occurs.

In our opinion, a correct interpretation of the P_{QR} value is only feasible after this additional information has been provided.

The specification of the end thickness, a visual evaluation as well as the indication of the gasket deformation according to which the initial surface stress was achieved, would also comprise useful information which unfortunately are not sceduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

A high P_{QR} value does not exclude failure of the gasket and can in no way replace a visual evaluation of the gasket tested.

As during the testing of Q_{Smax}, it was confirmed here that a visual evaluation of the tested gasket represents an indispensable, additional criterion for the estimation of the significance of the result of the P_{QR}-test.

Due to the results of the tests performed, KLINGER considers rapid revision of EN 13555 to be urgently necessary.

So long as EN 13555, published in February 2005, is still valid, Klinger recommends for safety reasons, the application of the values for the max. permitted surface stress σ_{BO} determined by the sealing calculation software KLINGER®expert, for the given form of application for all Klinger gasket materials.

KLINGER Determination of Q_{Smax} (EN 13555 – 8.4.4)

KLINGER®soft-chem

Deformation at different surface stresses

Temperature = 100°C

Q_{Smax} = 200 N/mm²

Gasket dimensions	before testing	after testing
Outer diameter	90 mm	101 mm
Inner diameter	50 mm	35 mm
Gasket thickness *)	2.2 mm	0.56 mm

*) measured at ambient temperature in dismantled stage

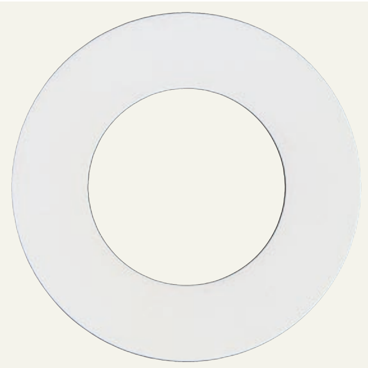
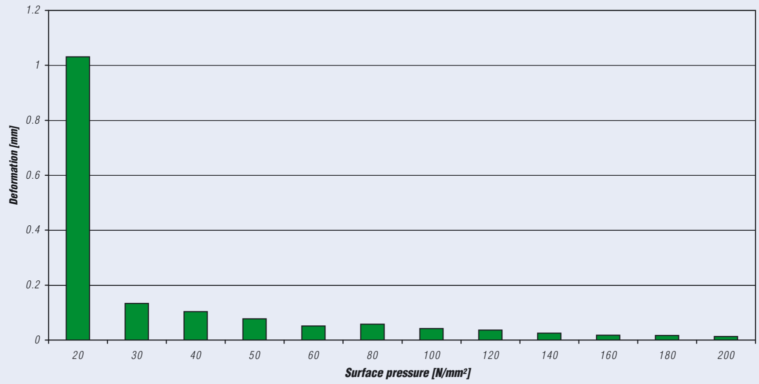


Figure 5: Photos of gasket KLINGER®soft-chem before testing and after testing at a surface pressure of 200 N/mm²

The surface stress of the load cycle prior to the failure of the gasket or the max. surface stress specified by the manufacturer applies as Q_{Smax}.

Failure is seen to occur when the values for the thickness decrease, dependent on the increase in the surface stress, increase so much, compared to the course of the previous values, that it can no longer be assumed that measurement value distributions are concerned.

Diagram 5 Deformation of KLINGER®soft-chem at different surface stresses



For each load cycle, decrease in the gasket's thickness must be recorded dependent on the surface stress.

The value for Q_{Smax} is identified as the surface stress after which an increase in the change in the gasket's thickness occurs.

As can be seen from the Figure, this does not occur at any surface stress.

The value for Q_{Smax} at T = 100°C would therefore be indicated as 200 N/mm² in compliance with the standard.

Specification of the end thickness and a visual evaluation of the tested gasket or information on the behaviour of the gaskets on assembly (cold compression) or operation (hot compression) is unfortunately not scheduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

Table 5 Total deformation of KLINGER®soft-chem at the corresponding surface pressures and relative end thicknesses

Surface pressure	Total deformation	End thickness at T = 100°C	Deformation
N/mm²	mm	mm	%
20	1.05	1.15	48
30	1.20	1.00	55
40	1.30	0.90	59
50	1.38	0.82	63
60	1.42	0.78	65
80	1.47	0.73	67
100	1.51	0.69	68
160	1.57	0.63	71
200	1.59	0.61	72

The deformation of the original 2,2 mm thick gasket equates to 72 % at a surface stress of 200 N/mm² and the material extrudes strongly outwards and inwards at this load.

In our opinion, KLINGER®soft-chem is unsuitable for use at 100 °C and a surface stress of 200 N/mm².

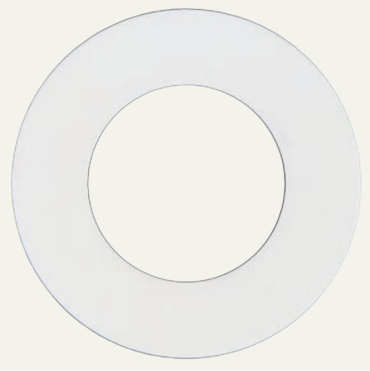
In order to estimate Q_{Smax} more effectively, the deformation of highly compressible materials should also be tested at surface stresses of 5 N/mm² and 10 N/mm², which is unfortunately not scheduled in the standard.

This confirms that a visual evaluation of the gasket tested represents an indispensable additional criterion for determining Q_{Smax}.

Determination of P_{QR} (EN 13555 – 8.6.4)

KLINGER®soft-chem

Stiffness of the test rig: 500 kN/mm
Initial surface pressure: 200 N/mm²
Temperature: 100°C
Dwell period: 4 hours
Residual surface pressure: 187.9 N/mm²
Relaxation factor P_{QR}: 0.94
(= ratio of residual surface pressure to initial surface pressure)
End thickness of the gasket after testing: 0.20 mm



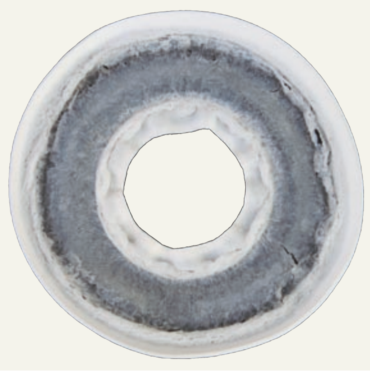
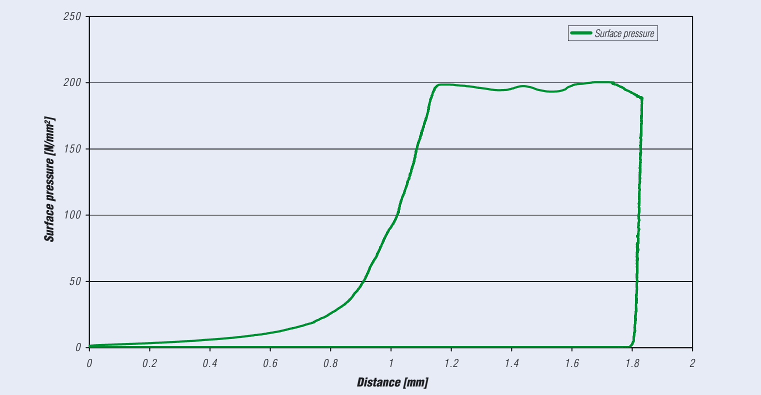


Figure 6: Photos of gasket KLINGER®soft-chem before and after the P_{QR}-test

The gasket factor P_{QR}, is a factor for taking the relaxation influence on the gasket load into account after torquing the bolts and the long-term affects of the operating temperature.

It is calculated by taking the ratio between the residual surface stress and the initial surface stress after a relaxation test in a press by way of route-controlled load control for a specific stiffness.
A stiffness of 500 kN/mm is typical for PN flanges.

Diagram 6 Deformation of KLINGER®soft-chem during the P_{QR}-test



It is obvious that a gasket material in 2 mm thickness, which loses more than 90 % of its thickness under the given load, can indeed cause problems in application, although according to the testing standard it has not failed.

The material extrudes strongly outwards and inwards during testing.

We therefore see no confirmation of a Q_{Smax} value of 200 N/mm² in the P_{QR} values determined. Unfortunately it is not defined in the standard, which result of the P_{QR}-measurement confirms a Q_{Smax} value.

The specification of the end thickness, a visual evaluation as well as the indication of the gasket deformation according to which the initial surface stress was achieved, would also comprise useful information which unfortunately are not sceduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

A high P_{QR} value does not exclude failure of the gasket and can in no way replace a visual evaluation of the gasket tested.

As during the testing of Q_{Smax}, it was confirmed here that a visual evaluation of the tested gasket represents an indispensable, additional criterion for the estimation of the significance of the result of the P_{QR}-test.

Due to the results of the tests performed, KLINGER considers rapid revision of EN 13555 to be urgently necessary.

So long as EN 13555, published in February 2005, is still valid, Klinger recommends for safety reasons, the application of the values for the max. permitted surface stress σ_{BO} determined by the sealing calculation software KLINGER®expert, for the given form of application for all Klinger gasket materials.

Determination of Q_{Smax} (EN 13555 – 8.4.4)

KLINGER®top-chem 2000

Deformation at different surface stresses
Temperature = 200°C
Q_{Smax} = 140 N/mm²

Gasket dimensions	before testing	after testing
Outer diameter	90 mm	94 mm
Inner diameter	50 mm	44 mm
Gasket thickness *)	2 mm	1.61 mm

*) measured at ambient temperature in dismantled stage

Diagram 7 – Deformation of KLINGER®top-chem 2000 at different surface stresses

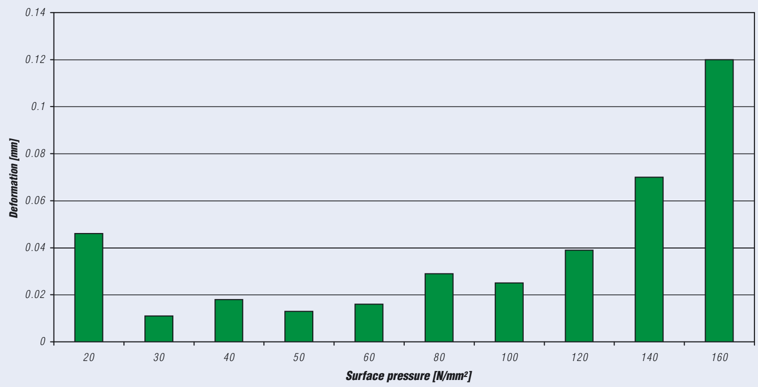


Figure 7: Photos of gasket KLINGER®top-chem 2000 before testing and after testing at a surface pressure of 160 N/mm²

The surface stress of the load cycle prior to the failure of the gasket or the max. surface stress specified by the manufacturer applies as Q_{Smax}.

Failure is seen to occur when the values for the thickness decrease, dependent on the increase in the surface stress, increase so much, compared to the course of the previous values, that it can no longer be assumed that measurement value distributions are concerned.

For each load cycle, decrease in the gasket's thickness must be recorded dependent on the surface stress.

The value for Q_{Smax} is identified as the surface stress after which an increase in the change in the gasket's thickness occurs.

As can be seen from the Figure, an extremely small increase in the change in the gasket's thickness of a few hundredths of a millimetre takes place at a surface stress of 140 N/mm².

The value for Q_{Smax} at T = 200°C would therefore be indicated as 120 N/mm² in compliance with the standard.

Specification of the end thickness and a visual evaluation of the tested gasket or information on the behaviour of the gaskets on assembly (cold compression) or operation (hot compression) is unfortunately not scheduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

Table 7 – Total deformation of KLINGER®top-chem 2000 at the corresponding surface pressures and relative end thicknesses

Surface pressure	Total deformation	End thickness at T = 200°C	Deformation
N/mm²	mm	mm	%
20	0.05	1.95	2.5
30	0.06	1.94	3.0
40	0.08	1.92	4.0
50	0.10	1.90	5.0
60	0.12	1.88	6.0
80	0.15	1.85	7.5
100	0.18	1.82	9.0
140	0.29	1.71	14.5

The deformation of the original 2 mm thick gasket equates to 14,5 % at a surface stress of 140 N/mm² and to 21 % at 160 N/mm².
The material hardly extrudes outwards and inwards at this load.

In our opinion, KLINGER®top-chem 2000 is suitable for use at 200 °C and a surface stress of 140 N/mm².

Additional testing at surface stresses of 5 N/mm² and 10 N/mm² is not required for this extremely durable gasket material.

This confirms that a visual evaluation of the gasket tested represents an indispensable additional criterion for determining Q_{Smax}.

Determination of P_{QR} (EN 13555 – 8.6.4)

KLINGER®top-chem 2000

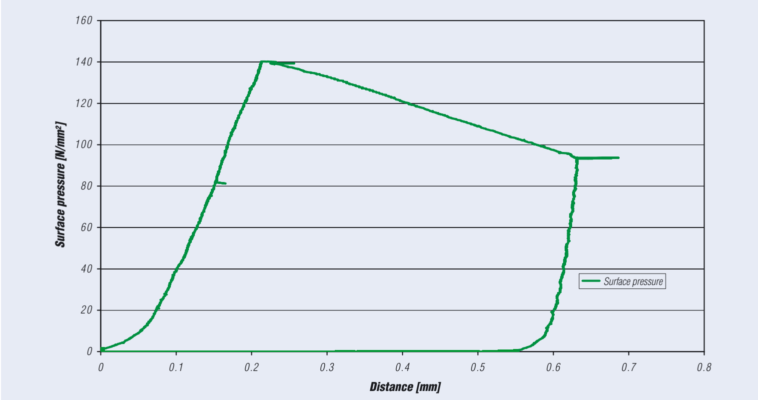
Stiffness of the test rig: 500 kN/mm
Initial surface pressure: 140 N/mm²
Temperature: 200°C
Dwell period: 4 hours
Residual surface pressure: 93.4 N/mm²
Relaxation factor P_{QR}: 0.67
(= ratio of residual surface pressure to initial surface pressure)
End thickness of the gasket after testing: 1.55 mm

Figure 8: Photos of gasket KLINGER®top-chem 2000 before and after the P_{QR}-test

The gasket factor P_{QR}, is a factor for taking the relaxation influence on the gasket load into account after torquing the bolts and the long-term affects of the operating temperature.

It is calculated by taking the ratio between the residual surface stress and the initial surface stress after a relaxation test in a press by way of route-controlled load control for a specific stiffness.
A stiffness of 500 kN/mm is typical for PN flanges.

Diagramm 8 — Deformation of KLINGER®top-chem 2000 during the P_{QR}-test



The end thickness of the gasket after testing at a surface stress of 140 N/mm² at a temperature of 200°C equates to 1.55 mm. P_{QR} = 0.67.

We see that the P_{QR} factor of 0.67 at T = 200 °C alone still fails to confirm the Q_{Smax} of 140 N/mm².

During visual evaluation, it could be determined that the gasket material does hardly extrude outwards and inwards and that no unusual thickness decrease occurs.

In our opinion, a correct interpretation of the P_{QR} value is only feasible after this additional information has been taken into account.

The specification of the end thickness, a visual evaluation as well as the indication of the gasket deformation according to which the initial surface stress was achieved, would also comprise useful information which unfortunately are not sceduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

A high P_{QR} value does not exclude failure of the gasket and can in no way replace a visual evaluation of the gasket tested.

Due to the results of the tests performed, KLINGER considers rapid revision of EN 13555 to be urgently necessary.

So long as EN 13555, published in February 2005, is still valid, Klinger recommends for safety reasons, the application of the values for the max. permitted surface stress σ_{BO} determined by the sealing calculation software KLINGER®expert, for the given form of application for all Klinger gasket materials.

KLINGER Determination of Q_{Smax} (EN 13555 – 8.4.4)

KLINGER®top-chem 2005

Deformation at different surface stresses

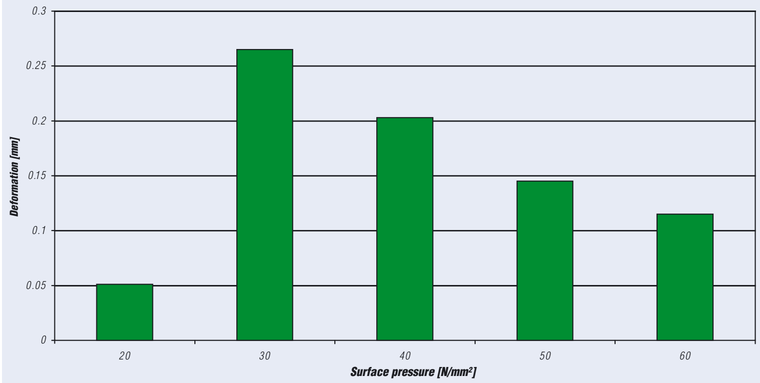
Temperature = 175°C

Q_{Smax} = 30 N/mm²

Gasket dimensions		
	before testing	after testing
Outer diameter	90 mm	97 mm
Inner diameter	50 mm	40 mm
Gasket thickness *)	2 mm	1.35 mm

*) measured at ambient temperature in dismantled stage

Diagram 9 — Deformation of KLINGER®top-chem 2005 at different surface stresses



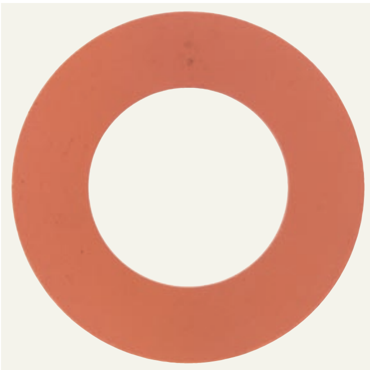


Figure 9: Photos of gasket KLINGER®top-chem 2005 before testing and after testing at a surface pressure of 60 N/mm²

The surface stress of the load cycle prior to the failure of the gasket or the max. surface stress specified by the manufacturer applies as Q_{Smax}.

Failure is seen to occur when the values for the thickness decrease, dependent on the increase in the surface stress, increase so much, compared to the course of the previous values, that it can no longer be assumed that measurement value distributions are concerned.

For each load cycle, decrease in the gasket's thickness must be recorded dependent on the surface stress.

The value for Q_{Smax} is identified as the surface stress after which an increase in the change in the gasket's thickness occurs.

As can be seen from the Figure, this occurs at a surface stress of 30 N/mm².

The value for Q_{Smax} at T = 175°C would therefore be indicated as 20 N/mm² in compliance with the standard.

Specification of the end thickness and a visual evaluation of the tested gasket or information on the behaviour of the gasket on assembly (cold compression) or operation (hot compression) is unfortunately not scheduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

Table 9 — Total deformation of KLINGER®top-chem 2005 at the corresponding surface pressures and relative end thicknesses

Surface pressure	Total deformation	End thickness at T = 175°C	Deformation
N/mm²	mm	mm	%
20	0.05	1.95	2.5
30	0.31	1.69	15.5
40	0.51	1.49	25.0
50	0.65	1.35	32.5
60	0.76	1.24	38.0

The deformation of the original 2 mm thick gasket equates to 15,5 % at a surface stress of 30 N/mm² and to 38 % at 60 N/mm².
The material extrudes outwards and inwards at this load.

In our opinion, KLINGER®top-chem 2005 is suitable for use at 175 °C and a surface stress of 30 N/mm².

Additional testing at surface stresses of 5 N/mm² and 10 N/mm² is not required for this durable gasket material.

This confirms that a visual evaluation of the gasket tested represents an indispensable additional criterion for determining Q_{Smax}.

KLINGER®

Determination of P_{QR} (EN 13555 – 8.6.4)

KLINGER®top-chem 2005

Stiffness of the test rig: 500 kN/mm
Initial surface pressure: 30 N/mm²
Temperature: 175°C
Dwell period: 4 hours
Residual surface pressure: 22.3 N/mm²
Relaxation factor P_{QR}: 0.74
(= ratio of residual surface pressure to initial surface pressure)
End thickness of the gasket after testing: 2.02 mm

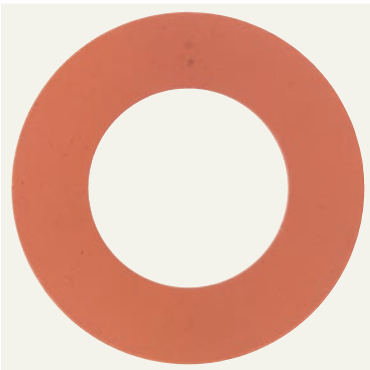
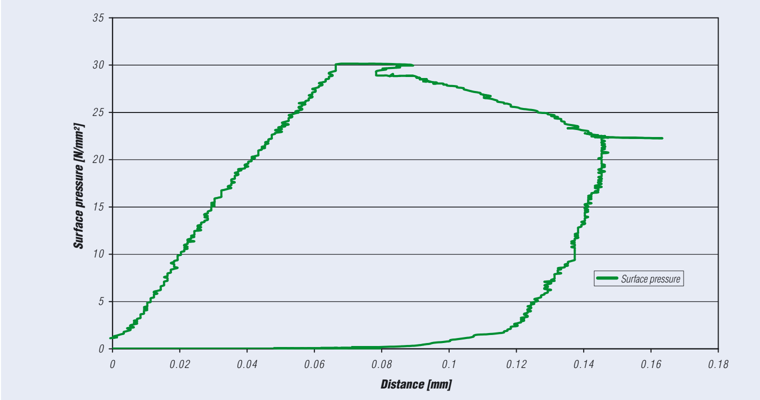


Figure 10: Photos of gasket KLINGER®top-chem 2005 before and after the P_{QR}-test

The gasket factor P_{QR}, is a factor for taking the relaxation influence on the gasket load into account after torquing the bolts and the long-term affects of the operating temperature.

It is calculated by taking the ratio between the residual surface stress and the initial surface stress after a relaxation test in a press by way of route-controlled load control for a specific stiffness.
A stiffness of 500 kN/mm is typical for PN flanges.

Diagram 10 Deformation of KLINGER®top-chem 2005 during the P_{QR}-test



At a surface stress of 30 N/mm² and a temperature of 175°C, this gasket material will not cause problems in application assuming it has been fitted correctly.

We therefore see no confirmation of a Q_{Smax} value of 30 N/mm² in the determined P_{QR} value of 0.74 at T = 175 °C.

During visual evaluation, it could be determined that the gasket material does hardly extrude outwards and inwards and that also the thickness decrease is very low.

In our opinion, a correct interpretation of the P_{QR} value is only feasible after this additional information has been taken into account.

The specification of the end thickness, a visual evaluation as well as the indication of the gasket deformation according to which the initial surface stress was achieved, would also comprise useful information which unfortunately are not sceduled in the standard.

With this additional information, an essentially better evaluation of whether the gasket material selected is suitable or not for this load, would be possible.

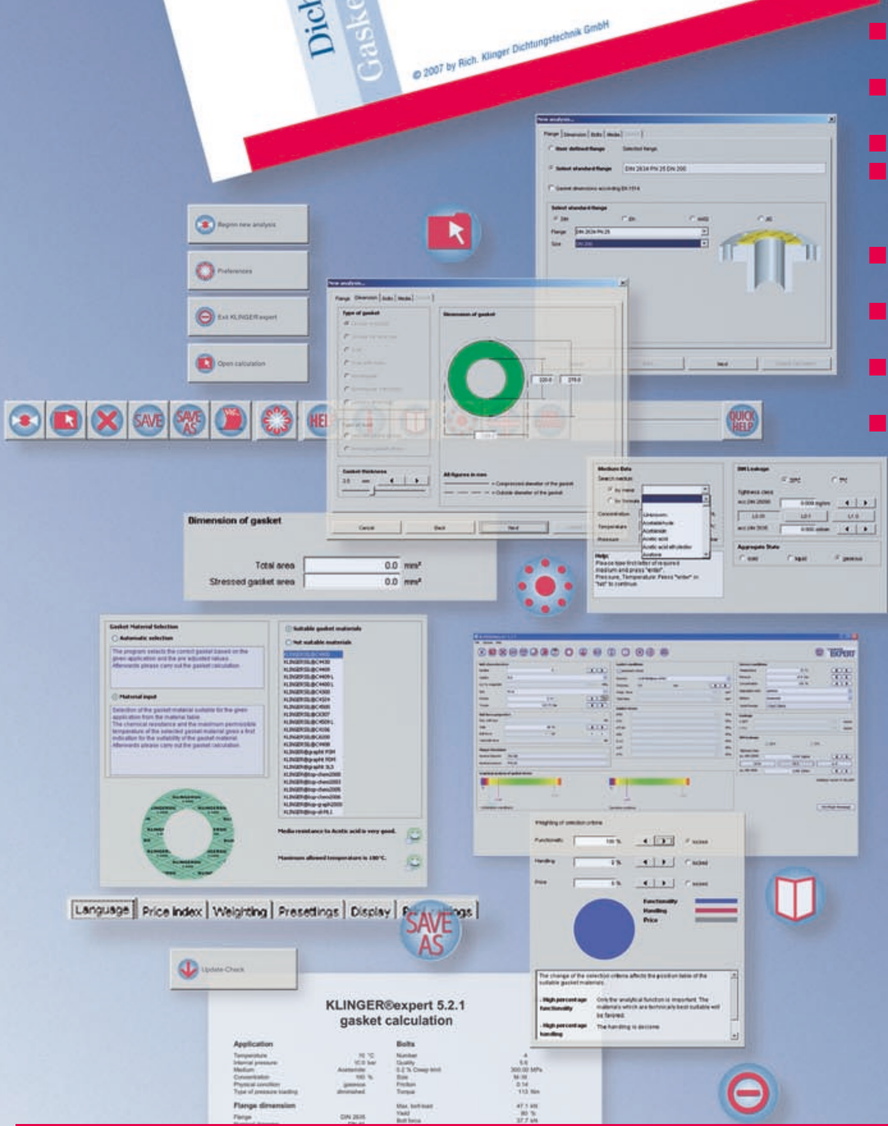
A high P_{QR} value does not exclude failure of the gasket and can in no way replace a visual evaluation of the gasket tested.

Due to the results of the tests performed, KLINGER considers rapid revision of EN 13555 to be urgently necessary.

So long as EN 13555, published in February 2005, is still valid, Klinger recommends for safety reasons, the application of the values for the max. permitted surface stress σ_{BO} determined by the sealing calculation software KLINGER®expert, for the given form of application for all Klinger gasket materials.

KLINGERexpert® 5.2.1 Powerful Sealing Calculation

- ***Easy, self-explaining flange selection***
- ***Graphical analysis of gasket stresses***
- ***QuickHelp Function***
- ***Product documentation of the sealing materials included on the CD***
- ***Step by Step selection to the most suitable gasket material***
- ***Solution proposal of the program at calculation problems***
- ***Keeps itself updated automatically (Internet-connection required)***
- ***Available in many different languages***



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Rich. Klinger Dichtungstechnik GmbH & Co KG
Am Kanal 8-10
A-2352 Gumpoldskirchen, Austria
Tel ++43 (0) 2252/62599-137
Fax ++43 (0) 2252/62599-296
e-mail: marketing@klinger.co.at
http://www.klinger.co.at