Experiences gained in the inspection of $Q_{S_{\text{max}}}$ - and $P_{QR}$-values in accordance with EN 13555 as exemplified by PTFE-based Gaskets
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”

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_{S_{max}} (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 purpose-
fulness 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 com-
pletely different results for the corres-
ponding gasket factors.

The note provided in the
standard, that determining Q_{S_{max}} on
sheet materials can lead to an over-
valuation of the functionality of
gaskets, and hence all values for Q_{S_{max}}
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_{S_{max}} provides different
values for Q_{S_{max}}.

The interpretation of Q_{S_{max}} by the
engineer could lead to an overestima-
tion 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 maximum
surface stress in compliance with
EN 13555 to \sigma_{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 relaxa-
tion 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 va-
ues for the maximum permitted sur-
face stress of the gasket material in the
operating state and differs basically to
the Q_{S_{max}} value determined in accor-
dance with EN 13555.

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

Test results and photos of
the gaskets tested in accor-
dance with EN 13555 show that
the definition and determination
of the gasket factors Q_{S_{max}} 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, pub-
lished in February 2005, is still
valid, Klinger recommends for
safety reasons, the application
of the values for the max. per-
mitted surface stress \sigma_{BO deter-
mined 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_{\text{Shmax}}**
(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_{\text{Shmax}} may for sheet material result in an overestimation of the capability of the sheet and it is important that all values of Q_{\text{Shmax}} for sheets are verified by conducting a test for P_{QR} at the same temperature and surface pressure as for the Q_{\text{Shmax}} value.

**Generation of Q_{\text{Shmax}}**
(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 Q_{\text{Shmax}} value for that temperature. The parameter Q_{\text{Shmax}} 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/mm² 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_{\text{Shmax}} being taken at that gasket surface pressure value used before the successive thickness change exhibited an increase.
### Gasket Parameters Notations according EN 13555

#### Gasket factor $P_{GR}$ (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 $P_{GR}$ (EN 13555 – 8.6.4)

The factor $P_{GR}$ 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 $P_{GR}$, the ratio of the residual load to the original load, is calculated.

For all gasket types, the $P_{GR}$ 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 $P_{GR}$ 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 $P_{GR}$ test at that surface pressure, as well as lower ones, and temperature (see 8.6.4).
**Determination of $Q_{\text{Smax}}$ (EN 13555 – 8.4.4)**

**Material A**

**Deformation at different surface stresses**

**Temperature = 100°C**

$Q_{\text{Smax}} = 160 \, \text{N/mm}^2$

<table>
<thead>
<tr>
<th>Gasket dimensions</th>
<th>before testing</th>
<th>after testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer diameter</td>
<td>90 mm</td>
<td>105 mm</td>
</tr>
<tr>
<td>Inner diameter</td>
<td>50 mm</td>
<td>30 mm</td>
</tr>
<tr>
<td>Gasket thickness (*)</td>
<td>2 mm</td>
<td>0.38 mm</td>
</tr>
</tbody>
</table>

*Measured at ambient temperature in dismantled stage.

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 $Q_{\text{Smax}}$.

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 $Q_{\text{Smax}}$ 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/mm$^2$.

The value for $Q_{\text{Smax}}$ at $T = 100 \, ^\circ\text{C}$ would therefore be indicated as 140 N/mm$^2$ 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.

The deformation of the original 2 mm thick gasket equates to 84% at a surface stress of 140 N/mm$^2$ 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/mm$^2$.

In order to estimate $Q_{\text{Smax}}$ more effectively, the deformation of highly compressible materials should also be tested at surface stresses of 5 N/mm$^2$ and 10 N/mm$^2$, 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 $Q_{\text{Smax}}$. 

**Table 1**

<table>
<thead>
<tr>
<th>Surface pressure (N/mm$^2$)</th>
<th>Total deformation (mm)</th>
<th>End thickness at $T = 100, ^\circ\text{C}$ (mm)</th>
<th>Deformation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.67</td>
<td>1.29</td>
<td>34</td>
</tr>
<tr>
<td>30</td>
<td>1.02</td>
<td>0.94</td>
<td>52</td>
</tr>
<tr>
<td>40</td>
<td>1.20</td>
<td>0.74</td>
<td>62</td>
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<tr>
<td>50</td>
<td>1.30</td>
<td>0.66</td>
<td>66</td>
</tr>
<tr>
<td>60</td>
<td>1.37</td>
<td>0.59</td>
<td>70</td>
</tr>
<tr>
<td>80</td>
<td>1.46</td>
<td>0.50</td>
<td>74</td>
</tr>
<tr>
<td>100</td>
<td>1.52</td>
<td>0.44</td>
<td>78</td>
</tr>
<tr>
<td>160</td>
<td>1.79</td>
<td>0.18</td>
<td>91</td>
</tr>
</tbody>
</table>

**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/mm$^2$.
**Determination of P_{QR}**
(EN 13555 – 8.6.4)

**Material A**

<table>
<thead>
<tr>
<th>Stiffness of the test rig:</th>
<th>500 kN/mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial surface pressure:</td>
<td>160 N/mm²</td>
</tr>
<tr>
<td>Temperature:</td>
<td>100°C</td>
</tr>
<tr>
<td>Dwell period:</td>
<td>4 hours</td>
</tr>
<tr>
<td>Residual surface pressure:</td>
<td>107 N/mm²</td>
</tr>
<tr>
<td>Relaxation factor P_{QR}:</td>
<td>0.67</td>
</tr>
<tr>
<td>(≈ ratio of residual surface pressure to initial surface pressure)</td>
<td></td>
</tr>
</tbody>
</table>

End thickness of the gasket after testing: 0.20 mm

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 \(q_{\text{max}}\) 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 \(q_{\text{max}}\) 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 scheduled in the standard.

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 \(q_{\text{max}}\), 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 \(q_{\text{max}}\) determined by the sealing calculation software KLINGER® expert, for the given form of application for all Klinger gasket materials.

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**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.
**KLINGER®top-chem 2003**

**Deformation at different surface stresses**

**Temperature = 100°C**

$Q_{\text{Smax}} = 30 \text{ N/mm}^2$

<table>
<thead>
<tr>
<th>Gasket dimensions</th>
<th>before testing</th>
<th>after testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer diameter</td>
<td>90 mm</td>
<td>105 mm</td>
</tr>
<tr>
<td>Inner diameter</td>
<td>50 mm</td>
<td>30 mm</td>
</tr>
<tr>
<td>Gasket thickness *)</td>
<td>2 mm</td>
<td>0.45 mm</td>
</tr>
</tbody>
</table>

*) measured at ambient temperature in dismantled state

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For each load cycle, decrease in the gasket’s thickness must be recorded dependent on the surface stress. The value for $Q_{\text{Smax}}$ 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 $Q_{\text{Smax}}$ at $T = 100°C$ would therefore be indicated as 20 N/mm² in compliance with the standard.

In order to estimate $Q_{\text{Smax}}$ 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 $Q_{\text{Smax}}$.

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**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 $Q_{\text{Smax}}$. 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.

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**Table 3**

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

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

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

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

**Total deformation**

**Deformation**

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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.

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

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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.

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**In order to estimate** $Q_{\text{Smax}}$ **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.**

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

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

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

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KLINGER®­top-chem 2003
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

We see that the $P_{QR}$ factor of 0.65 at $T = 100°C$ alone still fails to confirm the $Q_{max}$ 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 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.

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 $Q_{max}$, 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.

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.

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 $\sigma_{BO}$ determined by the sealing calculation software KLINGER® expert, for the given form of application for all Klinger gasket materials.
Determination of $Q_{S\text{max}}$ (EN 13555 – 8.4.4)

For each load cycle, decrease in the gasket’s thickness must be recorded dependent on the surface stress. The value for $Q_{S\text{max}}$ 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 $Q_{S\text{max}}$ at $T = 100^\circ\text{C}$ would therefore be indicated as 200 N/mm$^2$ in compliance with the standard.

The deformation of the original 2.2 mm thick gasket equates to 72% at a surface stress of 200 N/mm$^2$ 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/mm$^2$.

In order to estimate $Q_{S\text{max}}$ more effectively, the deformation of highly compressible materials should also be tested at surface stresses of 5 N/mm$^2$ and 10 N/mm$^2$, 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 $Q_{S\text{max}}$.
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 $Q_{\text{max}}$ value of 200 N/mm$^2$ in the $P_{\text{QR}}$ values determined. Unfortunately it is not defined in the standard, which result of the $P_{\text{QR}}$-measurement confirms a $Q_{\text{max}}$ 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 scheduled in the standard.

A high $P_{\text{QR}}$ 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 $Q_{\text{max}}$, 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 $P_{\text{QR}}$ test.

The gasket factor $P_{\text{QR}}$ 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.

Due to the results of the tests performed, KLININGER 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 $Q_{\text{BO}}$ determined by the sealing calculation software KLININGER®expert, for the given form of application for all Klinger gasket materials.
Determination of $Q_{\text{Smax}}$ (EN 13555 – 8.4.4)

**KLINGER® top-chem 2000**

**Deformation at different surface stresses**

**Temperature = 200°C**

$Q_{\text{Smax}} = 140 \text{ N/mm}^2$

<table>
<thead>
<tr>
<th>Gasket dimensions</th>
<th>before testing</th>
<th>after testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer diameter</td>
<td>90 mm</td>
<td>94 mm</td>
</tr>
<tr>
<td>Inner diameter</td>
<td>50 mm</td>
<td>44 mm</td>
</tr>
<tr>
<td>Gasket thickness *)</td>
<td>2 mm</td>
<td>1.61 mm</td>
</tr>
</tbody>
</table>

*) measured at ambient temperature in dismantled stage

For each load cycle, decrease in the gasket’s thickness must be recorded dependent on the surface stress. The value for $Q_{\text{Smax}}$ 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/mm$^2$.

The value for $Q_{\text{Smax}}$ at $T = 200^\circ\text{C}$ would therefore be indicated as 120 N/mm$^2$ in compliance with the standard.

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

**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.

**The deformation of the original 2 mm thick gasket equates to 14.5% at a surface stress of 140 N/mm$^2$ and to 21% at 160 N/mm$^2$. 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/mm$^2$.

**Table 7**

<table>
<thead>
<tr>
<th>Surface pressure (N/mm$^2$)</th>
<th>Total deformation (mm)</th>
<th>End thickness at $T = 200^\circ\text{C}$ (mm)</th>
<th>Deformation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.05</td>
<td>1.95</td>
<td>2.5</td>
</tr>
<tr>
<td>30</td>
<td>0.06</td>
<td>1.94</td>
<td>3.0</td>
</tr>
<tr>
<td>40</td>
<td>0.08</td>
<td>1.92</td>
<td>4.0</td>
</tr>
<tr>
<td>50</td>
<td>0.10</td>
<td>1.90</td>
<td>5.0</td>
</tr>
<tr>
<td>60</td>
<td>0.12</td>
<td>1.88</td>
<td>6.0</td>
</tr>
<tr>
<td>80</td>
<td>0.15</td>
<td>1.85</td>
<td>7.5</td>
</tr>
<tr>
<td>100</td>
<td>0.18</td>
<td>1.82</td>
<td>9.0</td>
</tr>
<tr>
<td>140</td>
<td>0.29</td>
<td>1.71</td>
<td>14.5</td>
</tr>
</tbody>
</table>

**Figure 7:** Photos of gasket KLINGER® top-chem 2000 before testing and after testing at a surface pressure of 160 N/mm$^2$.

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 $Q_{\text{Smax}}$.

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.

Additional testing at surface stresses of 5 N/mm$^2$ and 10 N/mm$^2$ 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 $Q_{\text{Smax}}$.
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

---

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 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.

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.

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

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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 $Q_{BO}$ determined by the sealing calculation software KLINGER® expert, for the given form of application for all Klinger gasket materials.
Determination of $Q_{\text{Smax}}$
(EN 13555 – 8.4.4)

**KLINGER® top-chem 2005**

**Deformation at different surface stresses**

**Temperature = 175°C**

$Q_{\text{Smax}} = 30 \text{ N/mm}^2$

<table>
<thead>
<tr>
<th>Gasket dimensions</th>
<th>before testing</th>
<th>after testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer diameter</td>
<td>90 mm</td>
<td>97 mm</td>
</tr>
<tr>
<td>Inner diameter</td>
<td>50 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td>Gasket thickness *)</td>
<td>2 mm</td>
<td>1.35 mm</td>
</tr>
</tbody>
</table>

*) measured at ambient temperature in dismantled stage.

- For each load cycle, decrease in the gasket's thickness must be recorded dependent on the surface stress.
- The value for $Q_{\text{Smax}}$ 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 $Q_{\text{Smax}}$ at $T = 175^\circ\text{C}$ would therefore be indicated as 20 N/mm² in compliance with the standard.

**Table 9**

<table>
<thead>
<tr>
<th>Surface pressure [N/mm²]</th>
<th>Total deformation [%]</th>
<th>End thickness at $T = 175^\circ\text{C}$ [mm]</th>
<th>Deformation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.05</td>
<td>1.95</td>
<td>2.5</td>
</tr>
<tr>
<td>30</td>
<td>0.31</td>
<td>1.69</td>
<td>15.5</td>
</tr>
<tr>
<td>40</td>
<td>0.51</td>
<td>1.49</td>
<td>25.0</td>
</tr>
<tr>
<td>50</td>
<td>0.65</td>
<td>1.35</td>
<td>32.5</td>
</tr>
<tr>
<td>60</td>
<td>0.76</td>
<td>1.24</td>
<td>38.0</td>
</tr>
</tbody>
</table>

**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 $Q_{\text{Smax}}$.

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 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 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.

**Table 9**

<table>
<thead>
<tr>
<th>Surface pressure [N/mm²]</th>
<th>Total deformation [%]</th>
<th>End thickness at $T = 175^\circ\text{C}$ [mm]</th>
<th>Deformation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.05</td>
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<td>0.51</td>
<td>1.49</td>
<td>25.0</td>
</tr>
<tr>
<td>50</td>
<td>0.65</td>
<td>1.35</td>
<td>32.5</td>
</tr>
<tr>
<td>60</td>
<td>0.76</td>
<td>1.24</td>
<td>38.0</td>
</tr>
</tbody>
</table>

**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 $Q_{\text{Smax}}$.
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 $Q_{\text{max}}$ value of 30 N/mm² in the determined $P_{\text{QR}}$ 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 $P_{\text{QR}}$ 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 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.

A high $P_{\text{QR}}$ 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 $\sigma_{BO}$ 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

Subject to technical alterations.
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