



Test Report

Customer: SGL CARBON GmbH
Werner-von-Siemens-Str. 18
DE – 86405 Meitingen

Project number (amtec): 304 833
Report number: 304 833 1/-

Test procedure: Gasket Testing EN 13555 (dated April 2021)
- Leakage test

Material: SIGRAFLEX® HOCHDRUCK V20011Z3I

Date: April 25th, 2022
Pages: 5
Appendices: 4

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Test results are only relevant to the test objects submitted.

1. Subject of Investigation

The following documents and samples were submitted to amtec.

The subject of investigation was a flat gasket from SGL CARBON GmbH which is customer named:

- SIGRAFLEX® HOCHDRUCK V20011Z3I

SIGRAFLEX® HOCHDRUCK V20011Z3I is a multilayer high-strength graphite sealing sheet comprising 0.5 mm thick layers of high-purity SIGRAFLEX graphite foil and 0.05 mm thick stainless steel foils.

Samples receipt: January 10th, 2022.

2. Goal of Investigation

The goal of the investigation was the determination of the following gasket characteristics according to the European Standard EN 13555 (dated April 2021) which are necessary for calculation procedures according EN 1591-1 (dated April 2014):

- minimum required gasket stress in assembly $Q_{\min(L)}$ (40 bar)
- minimum required gasket stress in service $Q_{s\min(L)}$ (40 bar)

Deviant from the standard Hydrogen was used a test medium for the leakage tests.

3. Test Specimens

The dimensions of the test specimens were DN40/PN40 with an OD of 92 mm and an ID of 49 mm. The gasket thickness was 2 mm.

4. Testing Equipment

The gasket tests were carried out on the following testing equipment in the laboratory of amtec:

Leakage test: TEMES_{fl.ai1} Ident-No. 010 599

A photo and the schematic view of the testing equipment are shown in **appendix 1**.

5. Test Procedure EN 13555

5.1 Leakage Test

The leakage test procedure consists of loading and unloading the gasket in a cyclic manner with measurement of the leak rate at several effective gasket stress levels with an internal gas pressure of 40 bar.

The procedure therefore consists of loading to 10 MPa, holding the load and measuring the leak rate, and then raising the gasket stress to 20 MPa. The load is then held whilst the leak rate is measured. In the next step the load is reduced to 10 MPa and the leak rate is measured. Then measurements are done for the next loading-unloading cycle at 40 MPa, 20 MPa, 10 MPa and so on until either the 160 MPa loading-unloading cycle is completed or the value of Q_{smax} is exceeded.

The test gas used for this test is Hydrogen 5.0.

From the generated leakage curve the minimum required gasket stress in assembly $Q_{min(L)}$ and the minimum required gasket stress in service $Q_{smin(L)}$ as a result of the gasket surface pressure prior to the unloading Q_A can be evaluated for different tightness classes L.

6 Results

Test date: March 12th to March 16th, 2022.

In **appendix 2** all test results of the gasket tests with SIGRAFLEX® HOCHDRUCK V20011Z3I are listed. The following gasket characteristics are summarized in these tables:

- minimum required gasket stress in assembly $Q_{\min(L)}$
- minimum required gasket stress in service $Q_{\min(L)}$ in dependence on the gasket surface pressure prior to the unloading Q_A

6.1 Leakage Tests

The tightness behavior of the gasket material SIGRAFLEX® HOCHDRUCK V20011Z3I was examined in leakage tests with Hydrogen at 40 bar.

For the determination of the leak rate two different measurement devices were used in parallel. The pressure drop method with a differential pressure was used for the leak tightness evaluation for leak rates higher $1.0 \cdot 10^{-3} \text{ mg}/(\text{s}\cdot\text{m})$. For lower leak rates the signal of the leak detector was taken for the calculation of the leak rate.

The graphical presentation of the leakage curves are shown in **appendix 3**.

With an internal pressure of 40 bar the tightness class $L_{0.01}$ was reached when the gasket stress was raised above 26 MPa. The minimum gasket stress in assembly for the tightness class $L_{0.01}$ is $Q_{\min(0.01)} = 26 \text{ MPa}$. The highest tightness class which could be reached was $L_{0.00001}$, therefore a gasket stress of 138 MPa resp. 137 MPa is necessary.

The leak rate decreases with an increasing gasket stress up to 160 MPa. The lowest leak rate which could be measured at 160 MPa was $2.4 \cdot 10^{-6} \text{ mg}/(\text{s}\cdot\text{m})$ in test 22-212.

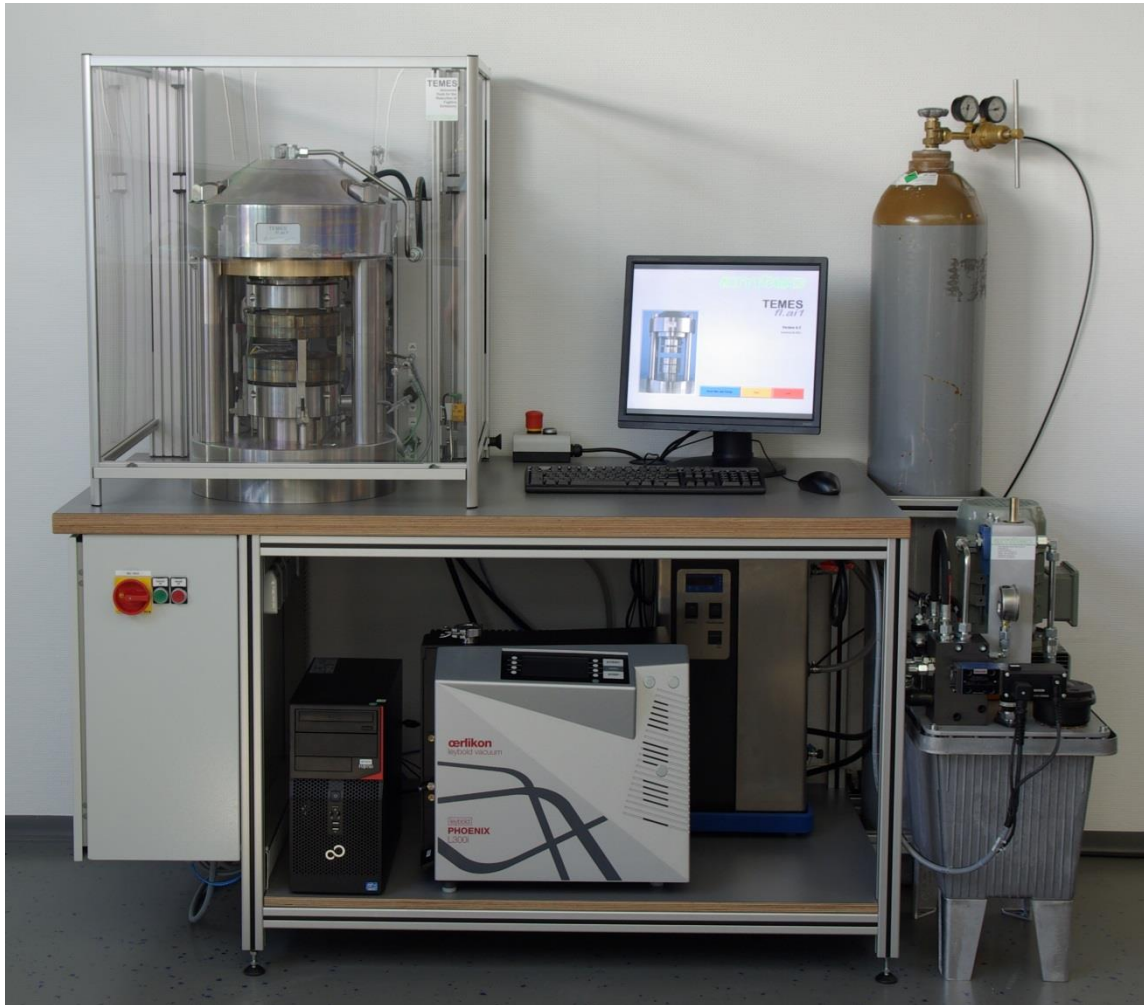
During the unloading cycles the leak rate increases again, but the gasket is clearly tighter than during the first loading to these lower, defined gasket stress levels. For all unloading cycles no drastic increase of the leak rate could be observed.

The minimum gasket stress in service for the tightness class L_{0.01} for an initial gasket surface pressure Q_A of 60 MPa is $Q_{\text{min}(0.01)} = 10$ MPa.

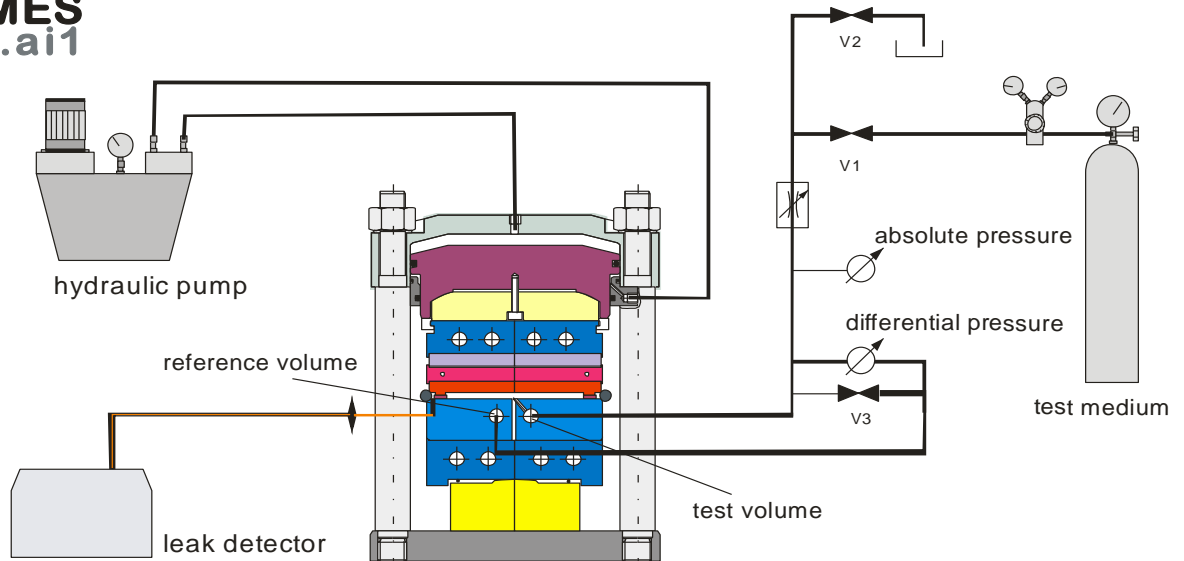
A good repeatability of the double tests is noticeable

7. Photo documentation

In **appendix 4** photos of the tested gasket specimens SIGRAFLEX® HOCHDRUCK V20011Z3I are presented.



TEMES
 fl.ai1



Testing Equipment TEMES_{fl.ai1} (1000 kN)

Table 1: Data Sheet for Gasket Characteristics (EN 13555)

Manufacturer: SGL

Product: SIGRAFLEX® HOCHDRUCK V20011Z3I - 2 mm

Minimum required Gasket Stress in Assembly $Q_{\min(L)}$ [MPa]

p [bar] \ L	10	1	0,1	0,01	0,001	1,00E-04	1,00E-05	1,00E-06	1,00E-07
40	10	10	10	26	51	93	138	-	-
test no.	22-211								
40	10	10	10	26	51	92	137	-	-
test no.	22-212								

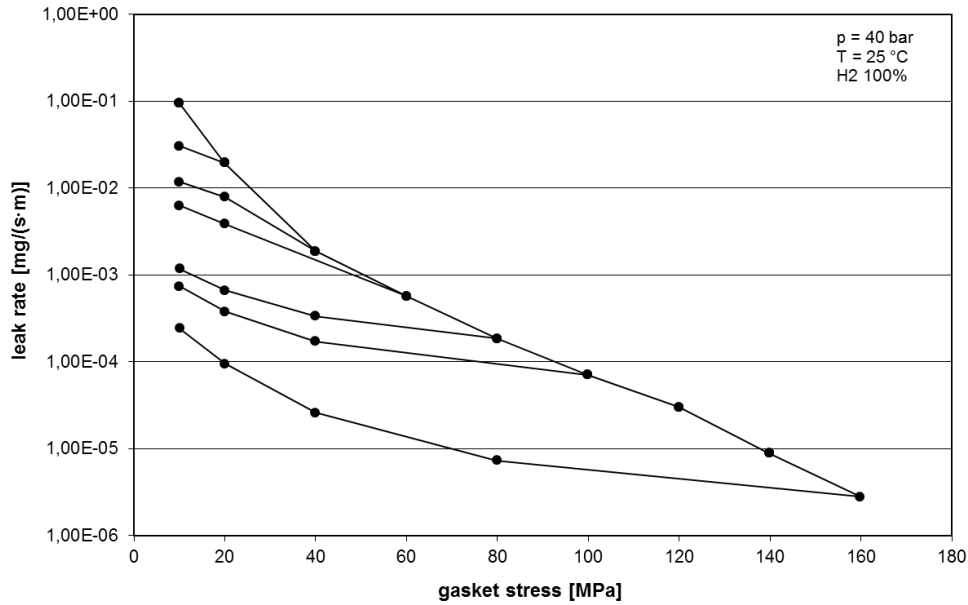
Minimum required Gasket Stress in Operation $Q_{\min(L)}$ [MPa]

$p = 40$ bar	Q_A [MPa] \ L	10	1	0,1	0,01	0,001	1,00E-04	1,00E-05	1,00E-06	1,00E-07
	20	10	10	10	-	-	-	-	-	-
40	10	10	10	14	-	-	-	-	-	-
60	10	10	10	10	47	-	-	-	-	-
80	10	10	10	10	13	-	-	-	-	-
100	10	10	10	10	10	78	-	-	-	-
160	10	10	10	10	10	19	70	-	-	-
test no.	22-211									

Minimum required Gasket Stress in Operation $Q_{\min(L)}$ [MPa]

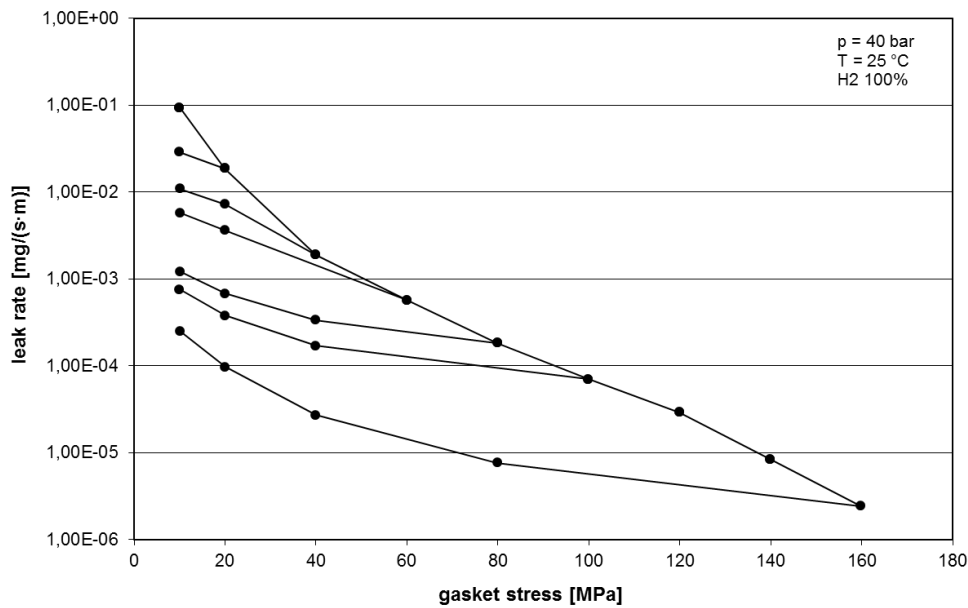
$p = 40$ bar	Q_A [MPa] \ L	10	1	0,1	0,01	0,001	1,00E-04	1,00E-05	1,00E-06	1,00E-07
	20	10	10	10	-	-	-	-	-	-
40	10	10	10	12	-	-	-	-	-	-
60	10	10	10	10	47	-	-	-	-	-
80	10	10	10	10	14	-	-	-	-	-
100	10	10	10	10	10	75	-	-	-	-
160	10	10	10	10	10	20	71	-	-	-
test no.	22-212									

Leakage curve
Sigraflex Hochdruck 92.07x49.37x2.035 mm
Test number: 22-211

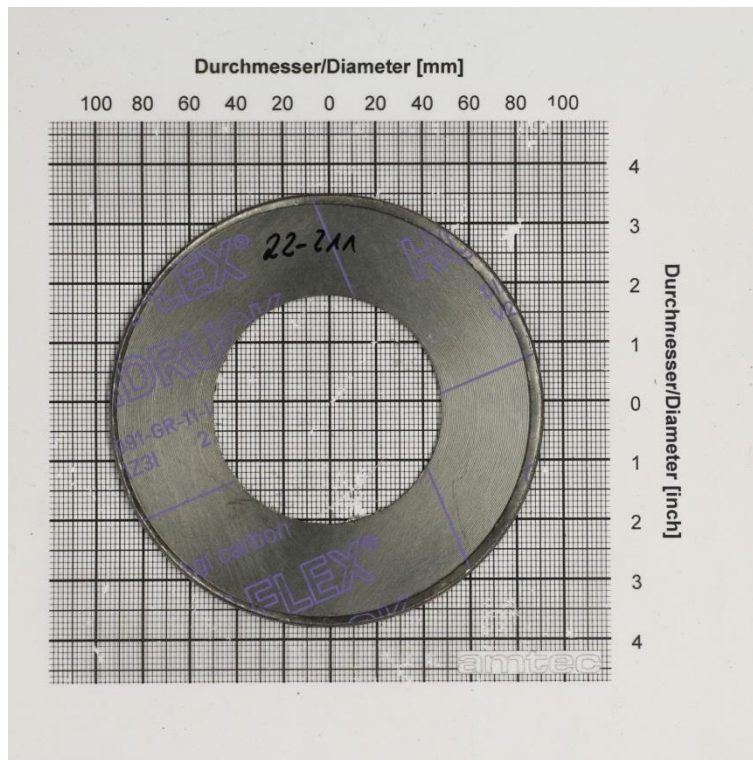


Leakage Test 40 bar according to EN 13555

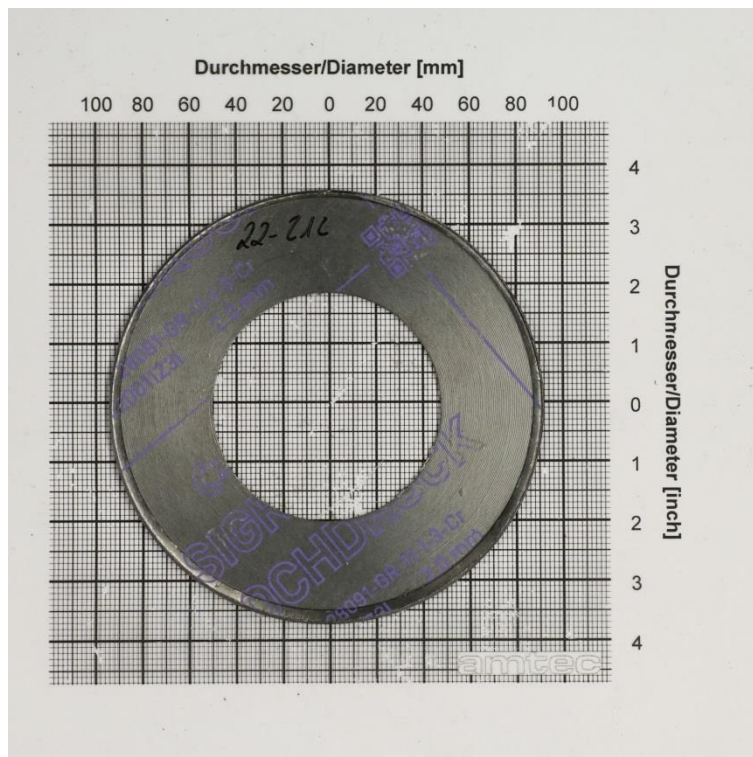
Leakage curve
Sigraflex Hochdruck 92.1x49.32x2.026 mm
Test number: 22-212



Leakage Test 40 bar according to EN 13555



Leakage Test – 40 bar (EN 13555)



Leakage Test – 40 bar (EN 13555)