



Test Report


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

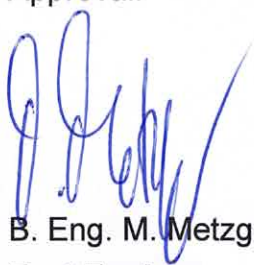
Project number (amtec): 304 833
Report number: 304 833 4/-

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

Material: SIGRAFLEX UNIVERSAL PRO V20010C2IP

Date: May 13th, 2022
Pages: 5
Appendices: 6

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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 UNIVERSAL PRO V20010C2IP

SIGRAFLEX UNIVERSAL PRO V20010C2IP is an adhesive-free graphite sealing sheet made from flexible graphite foil with one or two tanged stainless steel reinforcements. The sealing sheet is impregnated to reduce leakage and improve handling.

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 $Q_{\min(L)}$ (16 bar and 40 bar)
- minimum required gasket stress in service $Q_{\min(L)}$ (16 bar and 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 16 bar and 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: February 22nd to May 13th, 2022.

In **appendix 2** all test results of the gasket tests with SIGRAFLEX UNIVERSAL PRO V20010C2IP 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 UNIVERSAL PRO V20010C2IP was examined in leakage tests with Hydrogen at 16 bar and 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 **appendices 3 and 4**.

With an internal pressure of 16 bar the tightness class $L_{0.01}$ was reached when the gasket stress raised above 12 MPa resp. 13 MPa. The minimum gasket stress in assembly for the tightness class $L_{0.01}$ is $Q_{\min(0.01)} = 13 \text{ MPa}$. The highest tightness class which could be reached was $L_{0.000001}$, therefore a gasket stress of 91 MPa resp. 102 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 $1.5 \cdot 10^{-7} \text{ mg}/(\text{s}\cdot\text{m})$.

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.

With an internal pressure of 40 bar the tightness class $L_{0.01}$ was reached when the gasket stress raised above 24 MPa resp. 25 MPa. The minimum gasket stress in assembly for the tightness class $L_{0.01}$ is $Q_{\text{min}(0.01)} = 25$ MPa. The highest tightness class which could be reached was $L_{0.000001}$, therefore a gasket stress of 120 MPa resp. 121 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 $1.5 \cdot 10^{-7}$ mg/(s·m).

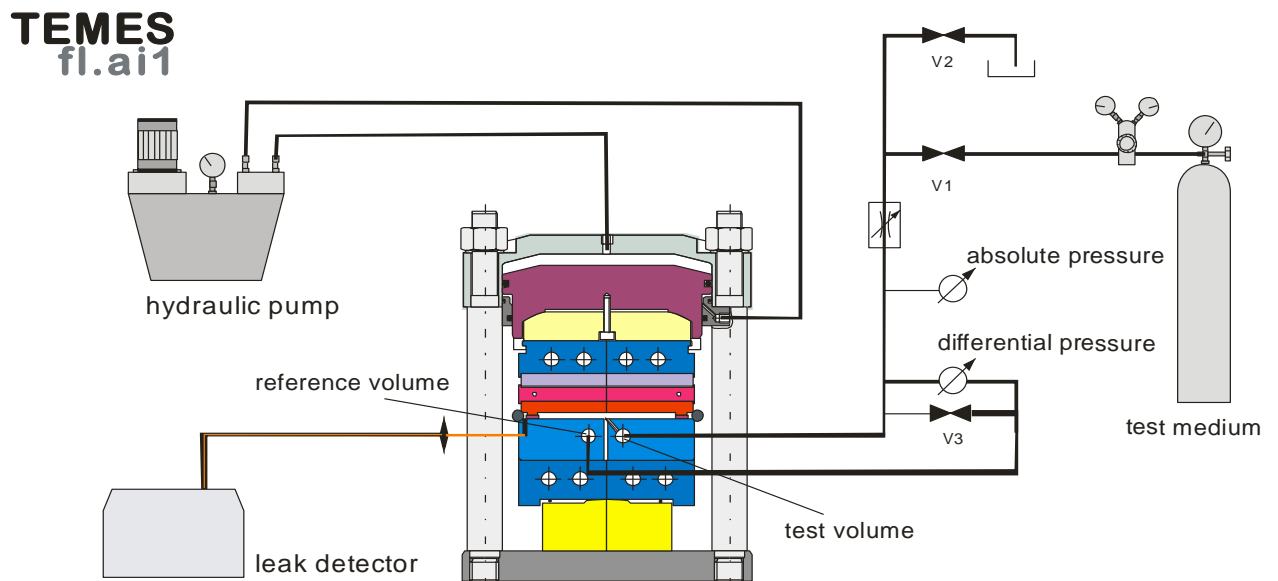
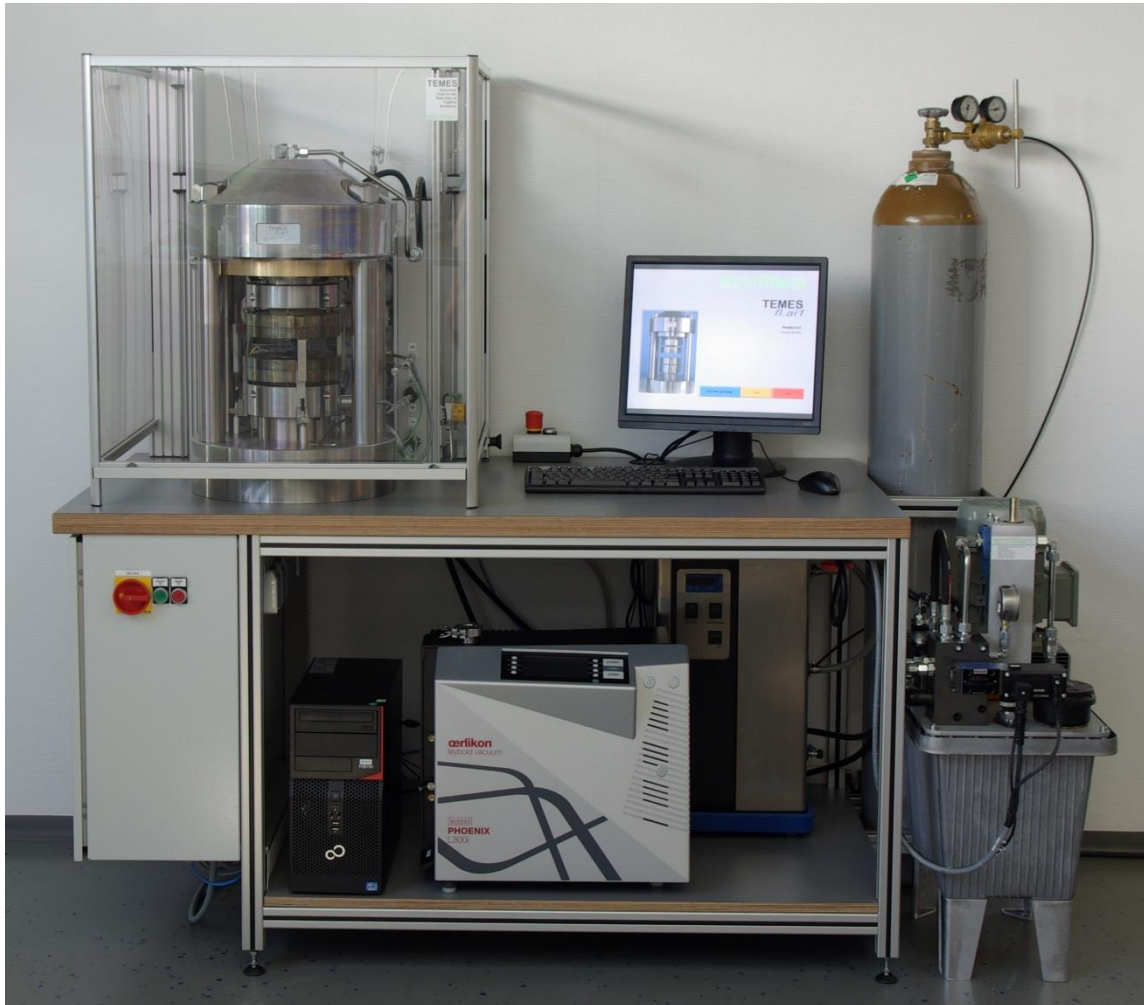
During the unloading cycles the leak rate increases again, but the gasket is clearly tighter than during the first loading to these lower, defined gasket stress levels. For all unloading cycles no drastic increase of the leak rate could be observed.

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 **appendices 5 and 6** photos of the tested gasket specimens SIGRAFLEX UNIVERSAL PRO V20010C2IP are presented.



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

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

Manufacturer: SGL
 Product: SIGRAFLEX UNIVERSAL PRO V20010C2IP

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
	16	10	10	10	12	20	39	64	91
test no.	22-306								
16	10	10	10	13	19	40	69	102	-
test no.	22-361								

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

p = 16 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	10	-	-	-	-
40	10	10	10	10	10	36	-	-	-	
60	10	10	10	10	10	11	-	-	-	
80	10	10	10	10	10	10	29	-	-	
100	10	10	10	10	10	10	18	65	-	
160	10	10	10	10	10	10	10	24	-	
test no.	22-306									

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

p = 16 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	10	19	-	-	-
40	10	10	10	10	10	37	-	-	-	
60	10	10	10	10	10	12	-	-	-	
80	10	10	10	10	10	10	36	-	-	
100	10	10	10	10	10	10	27	-	-	
160	10	10	10	10	10	10	10	26	-	
test no.	22-361									

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	12	24	37	60	89	120
test no.	22-165								
40	10	10	13	25	39	62	93	121	-
test no.	22-170								

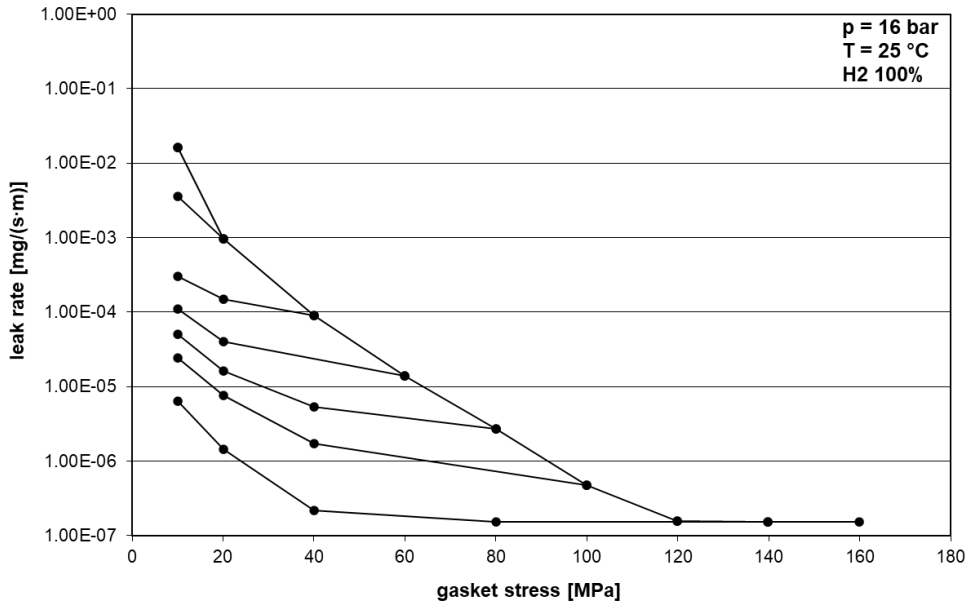
Minimum required Gasket Stress in Operation $Q_{smin(L)}$ [MPa]

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	10	20	-	-	-	-	
60	10	10	10	10	10	59	-	-	-	
80	10	10	10	10	10	19	-	-	-	
100	10	10	10	10	10	13	47	-	-	
160	10	10	10	10	10	10	16	37	-	
test no.	22-165									

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

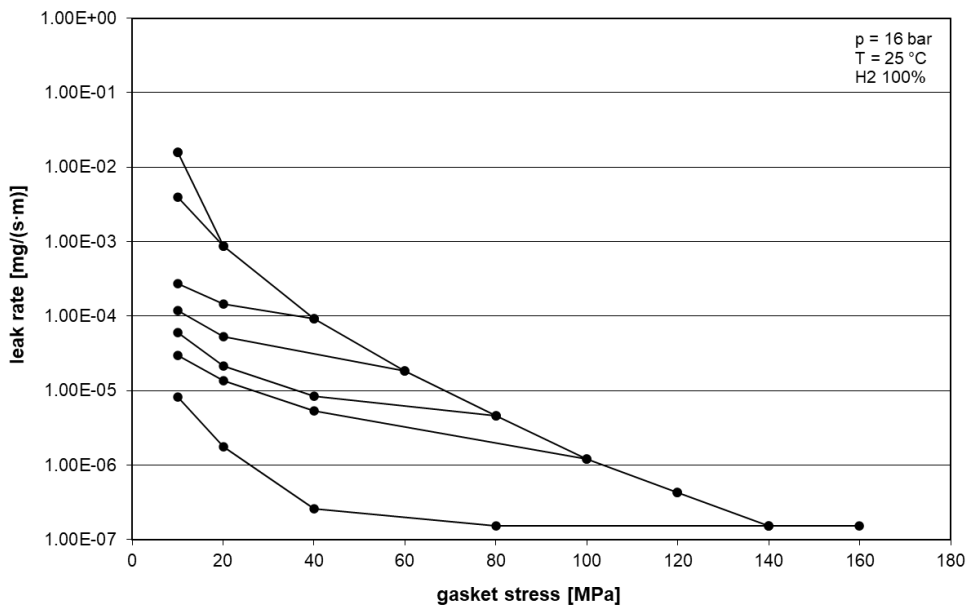
p = 40 bar	Q_A [MPa] \ L	10	1	0.1	0.01	0.001	1.00E-04	1.00E-05	1.00E-06	1.00E-07
		20	10	10	10	-	-	-	-	-
40	10	10	10	10	36	-	-	-	-	
60	10	10	10	10	10	-	-	-	-	
80	10	10	10	10	10	25	-	-	-	
100	10	10	10	10	10	16	72	-	-	
160	10	10	10	10	10	10	18	38	-	
test no.	22-170									

Leakage curve
 SIGRAFLEX UNIVERSAL PRO 92.09x49.36x2.08 mm
 Test number: 22-306



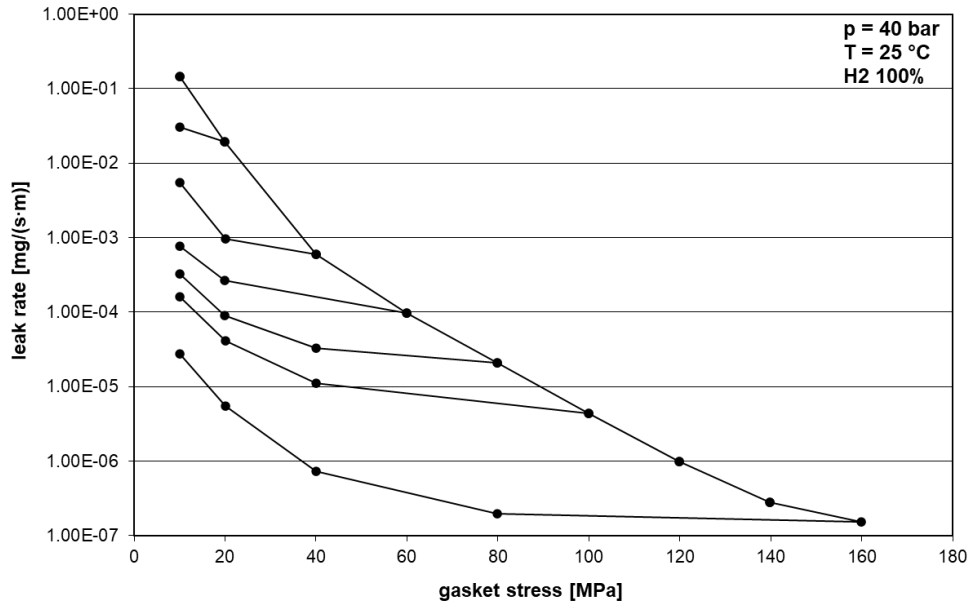
Leakage Test 16 bar according to EN 13555

Leakage curve
 Sigraflex Universal Pro 92.1x49.36x2.07 mm
 Test number: 22-361



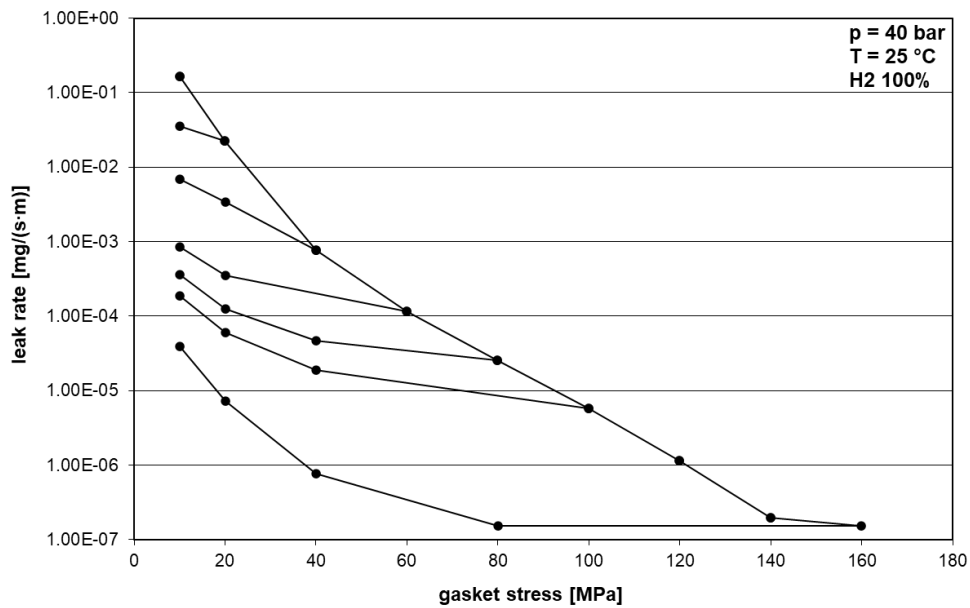
Leakage Test 16 bar according to EN 13555

Leakage curve
Sigraflex Universal Pro 92.1x49.39x1.969 mm
Test number: 22-165

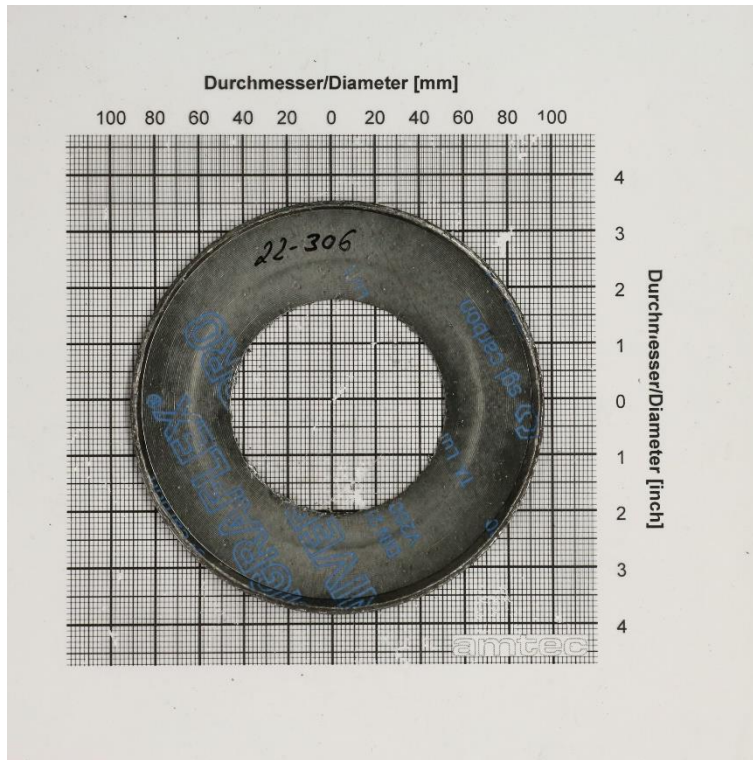


Leakage Test 40 bar according to EN 13555

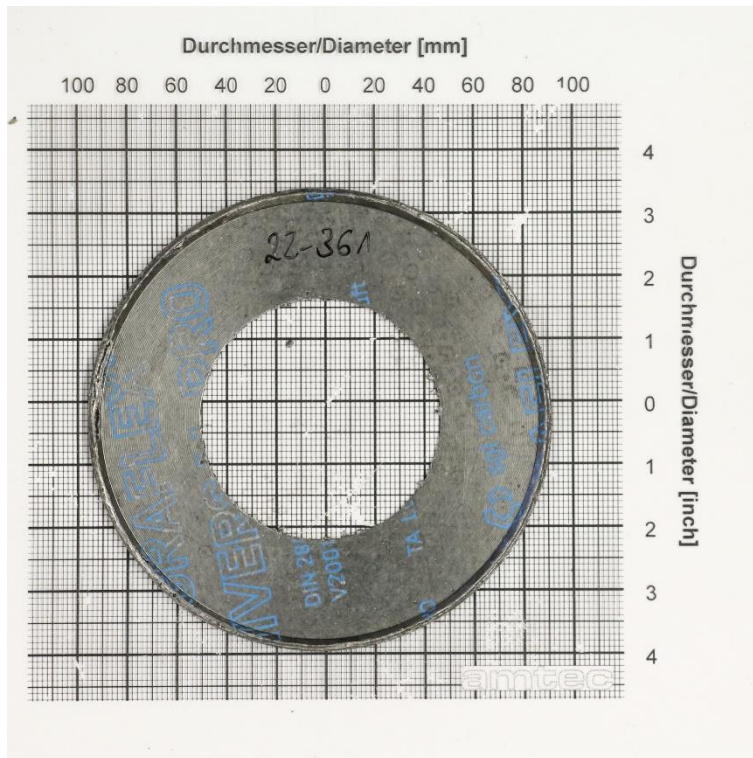
Leakage curve
Sigraflex Universal Pro 92.05x49.39x1.964 mm
Test number: 22-170



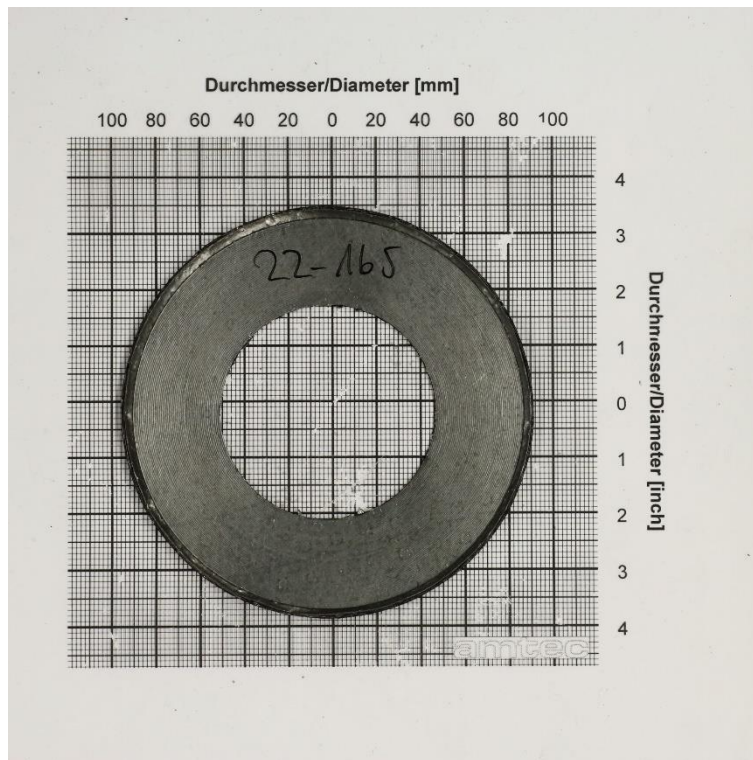
Leakage Test 40 bar according to EN 13555



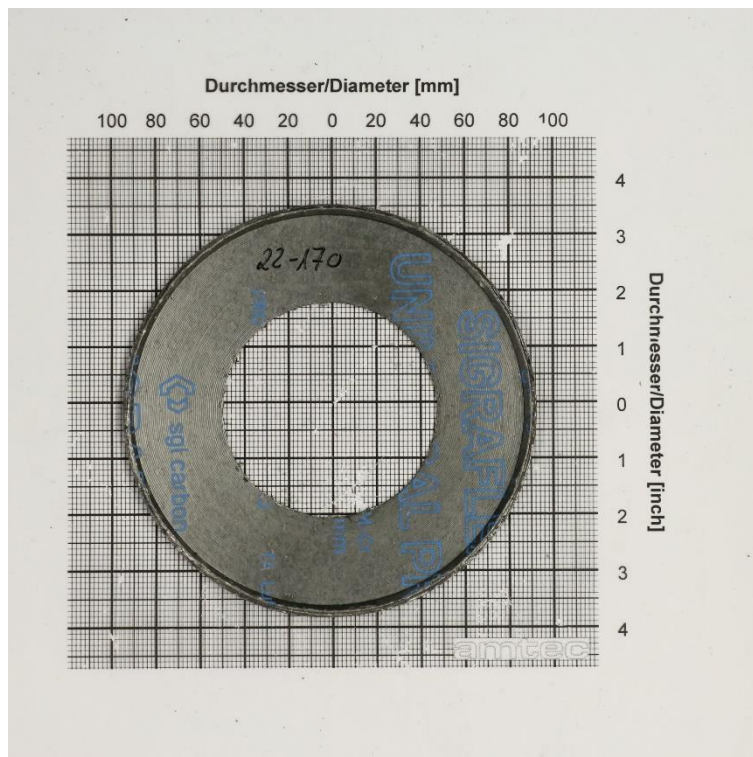
Leakage Test – 16 bar (EN 13555)



Leakage Test – 16 bar (EN 13555)



Leakage Test – 40 bar (EN 13555)



Leakage Test – 40 bar (EN 13555)