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Test Report

Customer:	Kukil Inntot Co., Ltd. 17 Tapgeol-gil, KOR - 689-871 Ulsan
Project number (amtec):	303 163
Report number:	303 163 1/a
Test procedure:	Gasket Testing BS 7531
Material:	Innosild KN1
Date:	August 24th, 2016
Pages:	5
Appendices:	12

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Test results are only relevant to the test objects submitted.

1. Subject of Investigation

The subject of investigation was a flat gasket of fibre material manufactured by Kukil Inntot Co., Ltd. which is named

- Innosild KN1.

The material composition of Innosild KN1 is aramid fibre, mineral fibre & inorganic fillers with a binder of Synthetic NBR Elastomers. The colour of the gasket is blue.

2. Goal of Investigation

The goal of the investigation was the determination of the following gasket characteristics according to BS 7531 (dated 2006):

- Compressibility,
- Residual stress,
- Gas Permeability.

3. Test Specimens

The dimensions of the test specimens were different for the 3 tests which were performed:

- Compressibility test (BS 7531): 4 x ∅ 6.4 mm,
- Residual stress test (BS 7531): ∅ 75 x 55 mm,
- Gas permeability test (BS 7531): DN40/PN40 (∅ 92 x 49 mm).

The thickness of the Kukil Innosild KN1 fibre gasket was 2 mm for compressibility test and for gas permeability test and 1.6 mm for the residual stress test.

4. Testing Equipment

The gasket tests were carried out on the following testing equipment:

	Test rig:	Serial number
Compressibility test:	Klinger	Ident-No. 010 317
Residual stress test:	Klinger	Ident-No. 010 317
Gas permeability test:	TEMES$_{fl.ai1}$	Ident-No. 010 181

Photos and the schematic view of the testing equipment are shown in **appendices 1 and 2**.

5. Test Procedure

5.1 Compressibility test

The test specimen is centred upon the anvil and a preload is applied and maintained constant for 15 s. Within the next 10 s the major load is applied. After further 60 s the load is decreased again to the original preload.

The gasket thickness is measured at the end of each dwell time under preload, major load und preload again. From these measurements the compressibility is calculated.

The preload is defined to 22.2 N and the major load is defined to 1112 N.

The compression expressed as percentage of the original thickness under preload shall be not less than 6% for all grades and not more than 14% for grades AX and AY.

5.2 Residual stress test

The residual stress is measured after 16 h at 300 °C from an initial gasket stress of 40 MPa. The test is performed in a hydraulic compression press used in the displacement controlled mode with an adjusted stiffness of 313 kN/mm.

The test procedure consists of loading the specimen until the initial load is applied, re-loading after 5 minutes dwell time, and heating of the test rig until the test temperature is reached. Then the temperature is held constant for a period of 16 hours. During the heating period and at elevated temperature the stiffness controlled mode of the equipment is activated. After the 16 hour period the remaining load being imposed by the press is noted.

The residual stress shall be not less than 25 MPa for grade X or 22 MPa for grade Y.

5.3 Gas permeability test

The gasket specimens were put centrically between the raised faces of the test platens and were compressed with a gasket stress of 32 MPa. Afterwards the test apparatus is pressurized up to 40 bar Nitrogen.

Two hours after pressurization the leak rate was measured by the pressure drop method using a very sensitive differential pressure unit. The leak rate can be calculated from the increase of the differential pressure during the measuring period under consideration of the mean gasket circumference.

For passing the permeability requirements of BS 7531 the specific leakage rate must be lower than 1 ml/min.

6. Results

6.1 Compressibility test

In **appendix 3** the results of the compressibility tests are listed. Three tests of the material Innosild KN1 were performed.

The average compressibility of the gasket sheet Innosild KN1 between preload and major load is 7.8% and therefore more than 6% and not more than 14% which is required for grade AX and AY sheet material.

Therefore the examined gasket material Innosild KN1 has passed **the compressibility requirements of BS 7531**.

6.2 Residual stress test

The results of the residual stress tests according BS 7531 are listed in **appendices 4 and 5**. Two specimens were examined. The initial gasket stress was set to 40 MPa, the test temperature was set to 300 °C.

During heating up and during the dwell time a creeping of the gasket could be recognized. The remaining gasket stress after a dwell time of 16 hours was measured to 23.1 MPa resp. 22.2 MPa.

Therefore the examined gasket material Innosild KN1 has passed **the residual stress requirements of BS 7531 for grade Y materials**.

6.3 Gas permeability test

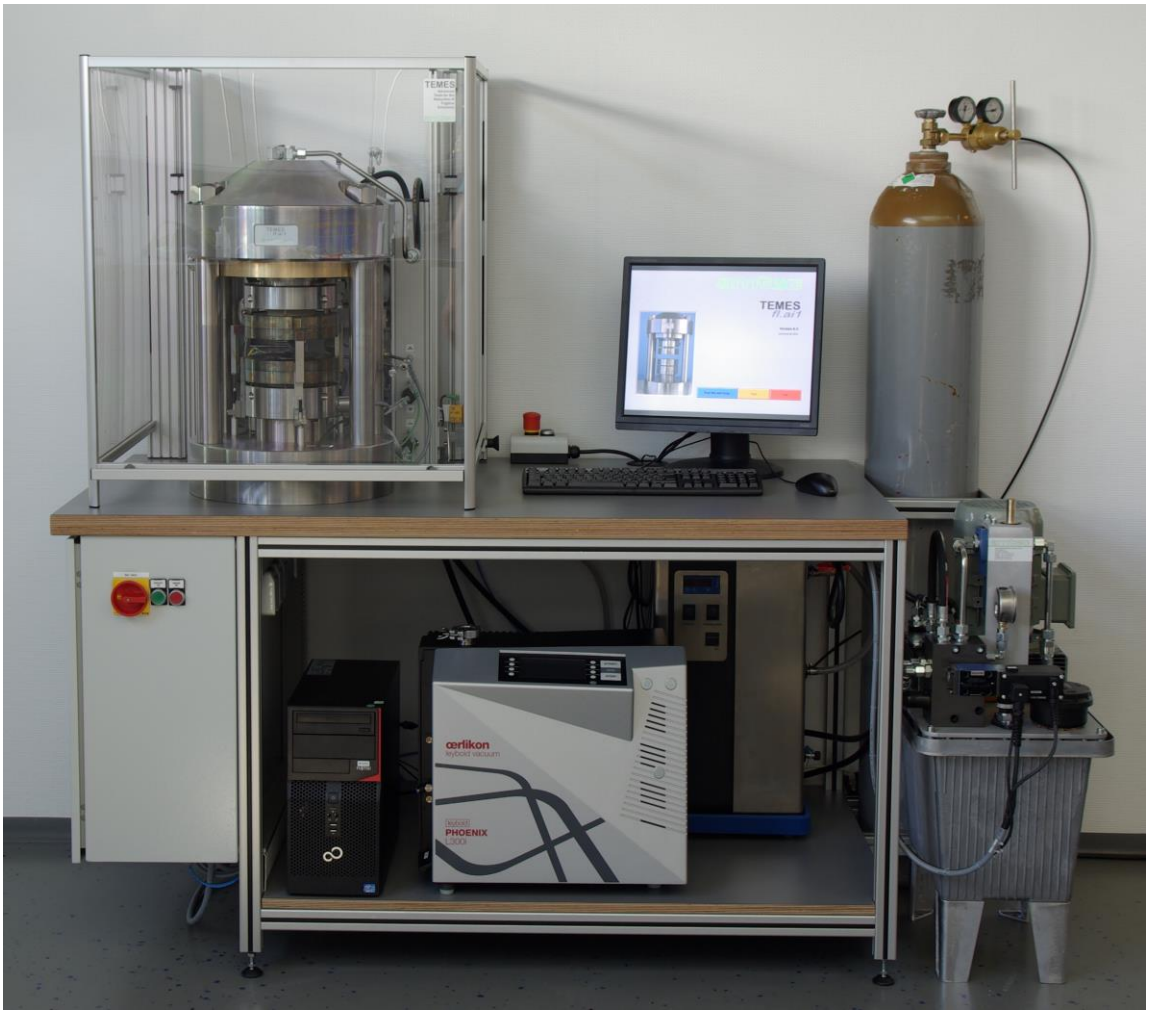
The results of the gas permeability tests according BS 7531 are listed in **appendices 6 to 8**. The gasket stress was set for all materials at 32 MPa, the test pressure level was 40 bar Nitrogen at each test.

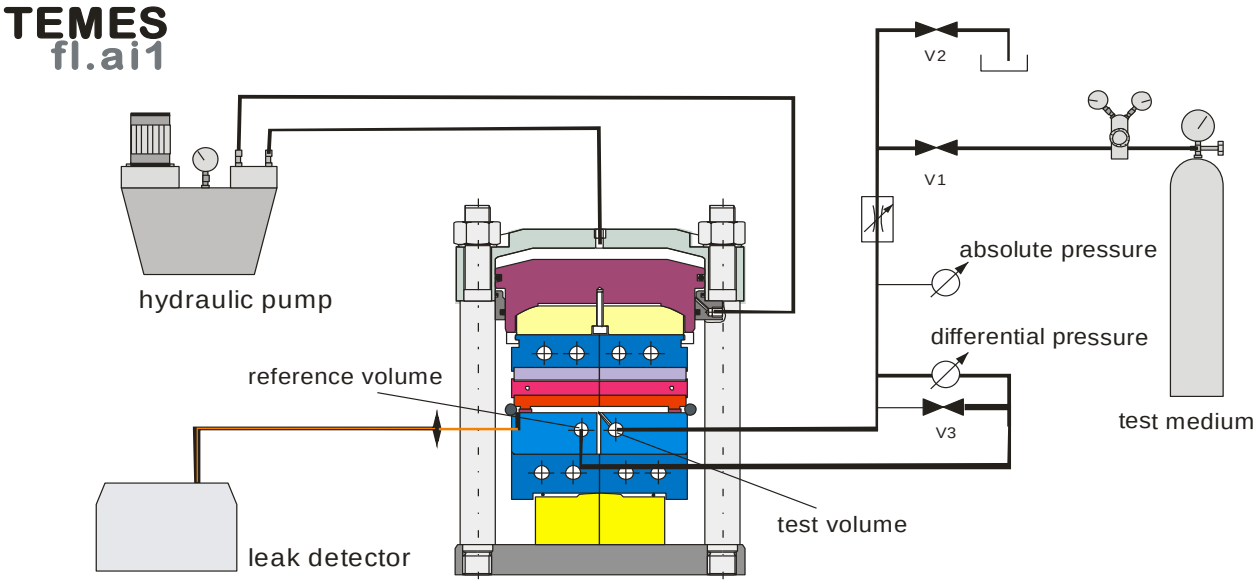
In all 3 tests performed with Innosild KN1 at ambient temperature, the recorded leak rates were lower than the limit of 1.0 ml/min defined in BS 7531. The lowest leak rate, measured with the test sample 16-268, was $3.0 \cdot 10^{-4}$ ml/min. The highest leak rate, measured with the test sample 16-265, was $1.6 \cdot 10^{-2}$ ml/min.

The examined gasket material Innosild KN1 has fulfilled **the permeability requirements of BS 7531**.

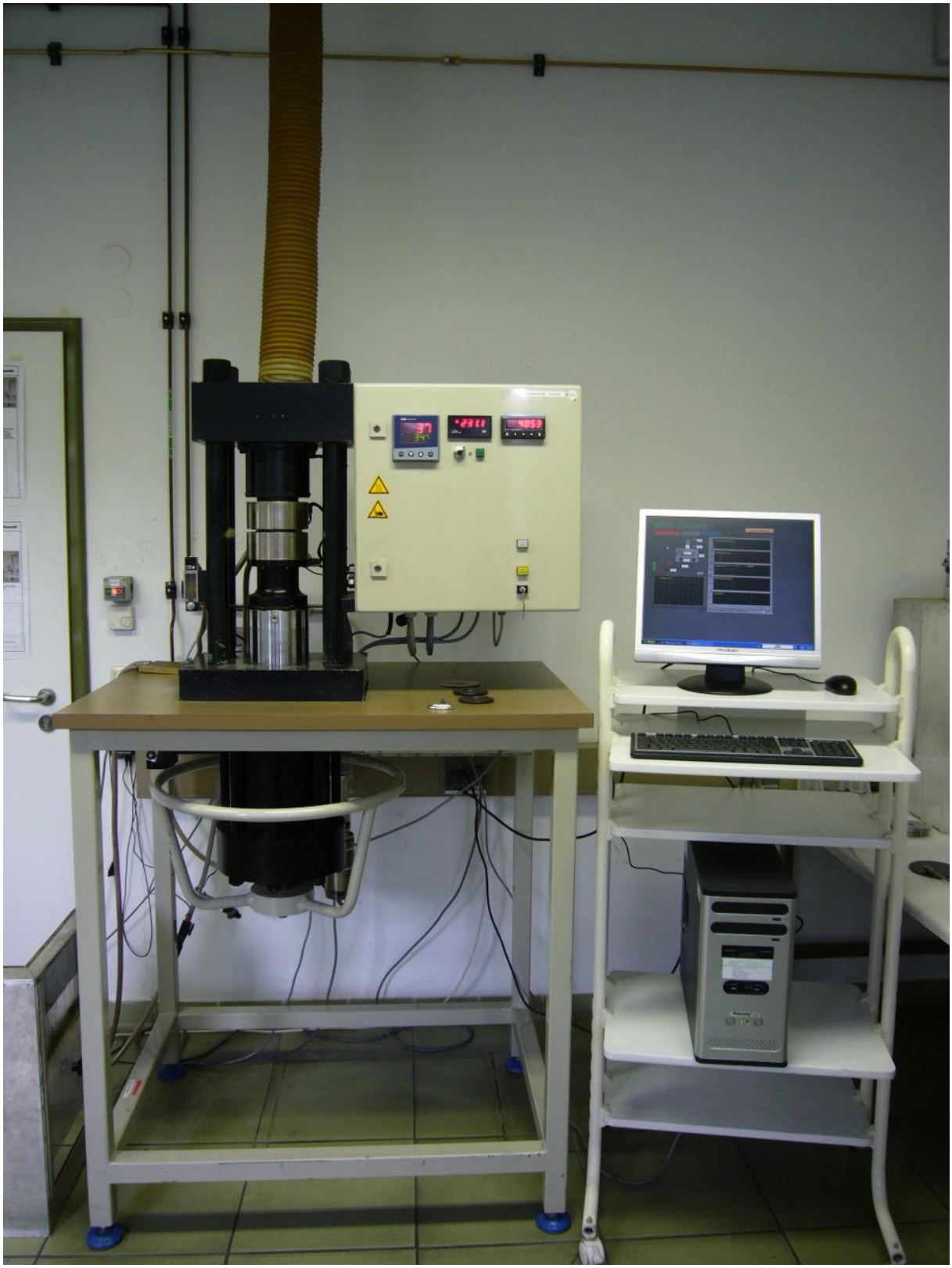
7. Photo documentation

In **appendices 9 to 12** photos of the tested gasket specimens Kukil Innosild KN1 for the different test procedures are presented.





Testing Equipment TEMES*fl.ai1* (1000 kN)



Testing Equipment KLINGER Dichtungstechnik

Compressibility test
Kukil Innosild KN1 13.3x0x1.92 mm
Test number: 16-352

Thickness under pre-load	1.890 mm
Thickness under load	1.738 mm
Impression	0.152 mm
Compressibility	8.0%

Compressibility test
Kukil Innosild KN1 13.3x0x1.92 mm
Test number: 16-353

Thickness under pre-load	1.901 mm
Thickness under load	1.753 mm
Impression	0.148 mm
Compressibility	7.8%

Compressibility test
Kukil Innosild KN1 13.3x0x1.93 mm
Test number: 16-354

Thickness under pre-load	1.912 mm
Thickness under load	1.765 mm
Impression	0.146 mm
Compressibility	7.6%

Residual stress test (BS 7531)

Innosild KN1
74.66x54.65x1.64 mm
Test number: 16-516

Test parameters

Initial gasket stress:	40	MPa
Time at RT:	00:05	hh:mm
Test temperature T_P:	300	°C
Time at T_P:	16:00	hh:mm
Stiffness C:	313	kN/mm

Test results

Residual stress of the jointing	23.1	MPa

Residual stress test (BS 7531)

Innosild KN1
74.62x54.53x1.63 mm
Test number: 16-518

Test parameters

Initial gasket stress:	40	MPa
Time at RT:	00:05	hh:mm
Test temperature T_P:	300	°C
Time at T_P:	16:00	hh:mm
Stiffness C:	313	kN/mm

Test results

Residual stress of the jointing	22.2	MPa

Gas permeability test (BS 7531)

Innosild KN1
91.54x48.71x1.9 mm
Test number: 16-263

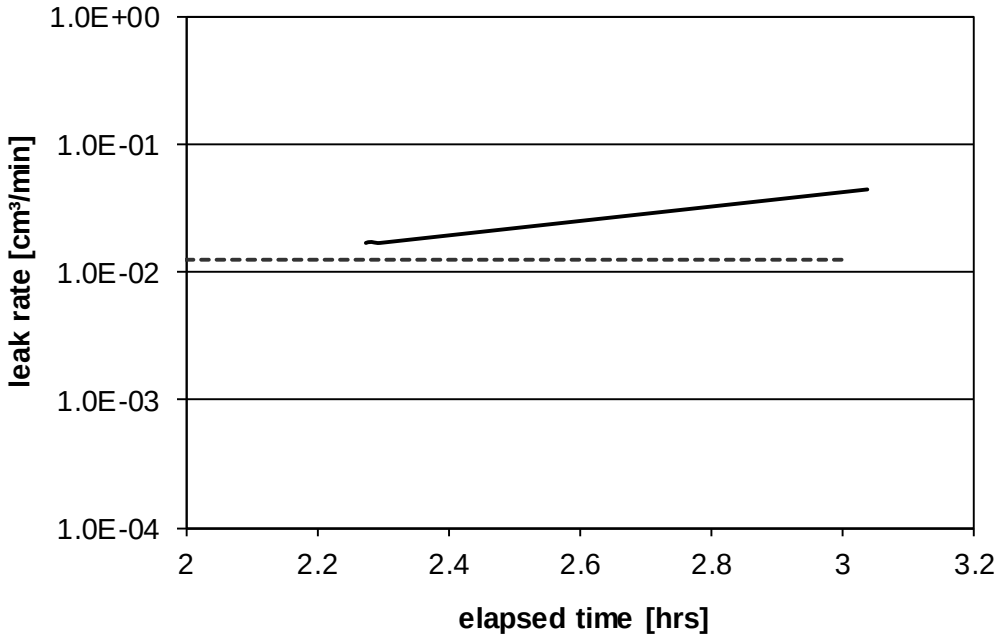
Test parameters

Initial gasket stress σ:	32	MPa
Internal pressure p:	40	bar
Test temperature T_P:	23	°C
Dwell time:	2:00	hh:mm
Measuring time:	1:00	hh:mm

Test results

Leak rate λ:	1.24E-02	cm³/min
	1.21E-03	mg/m/s

Leak rate acc. BS 7531 permissible



Gas permeability test (BS 7531)

Innosild KN1
91.5x48.7x1.9 mm
Test number: 16-265

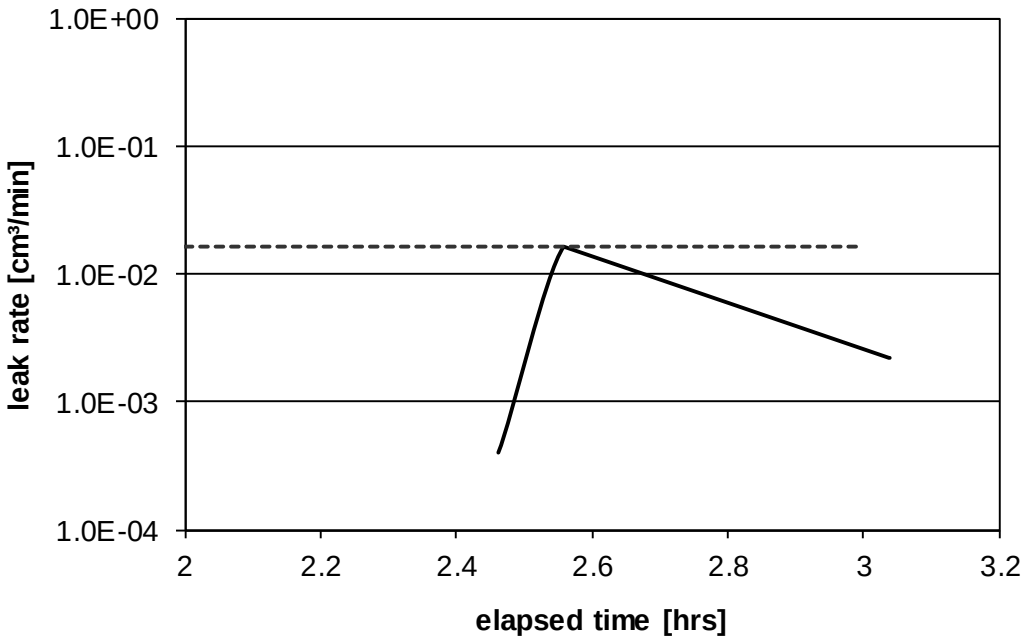
Test parameters

Initial gasket stress σ:	32	MPa
Internal pressure p:	40	bar
Test temperature T_P:	23	°C
Dwell time:	2:00	hh:mm
Measuring time:	1:00	hh:mm

Test results

Leak rate λ:	1.63E-02	cm³/min
	1.58E-03	mg/m/s

Leak rate acc. BS 7531 permissible



Gas permeability test (BS 7531)

Innosild KN1
91.42x48.62x1.9 mm
Test number: 16-268

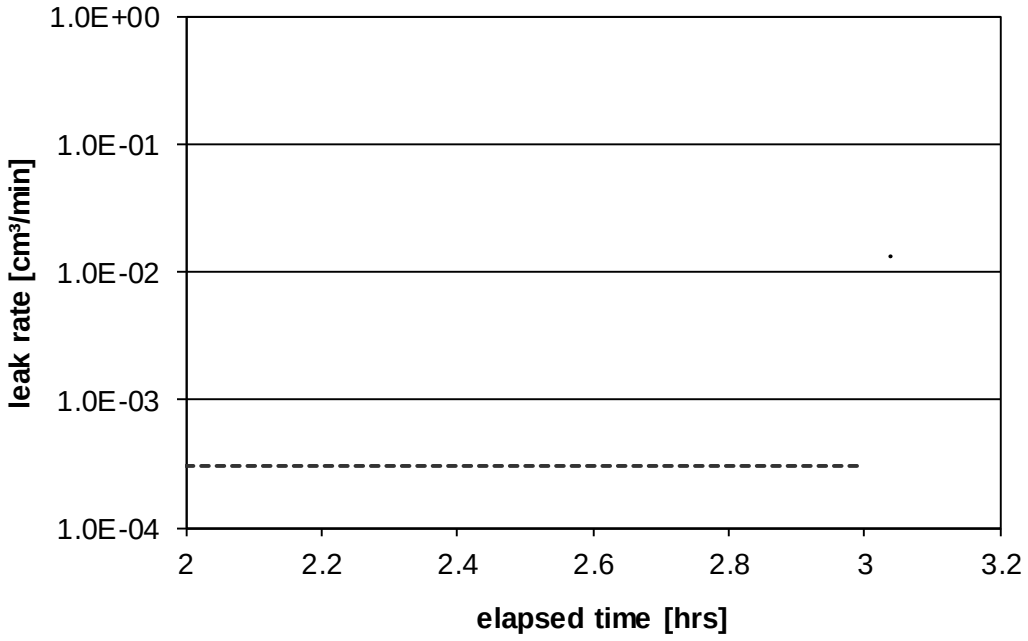
Test parameters

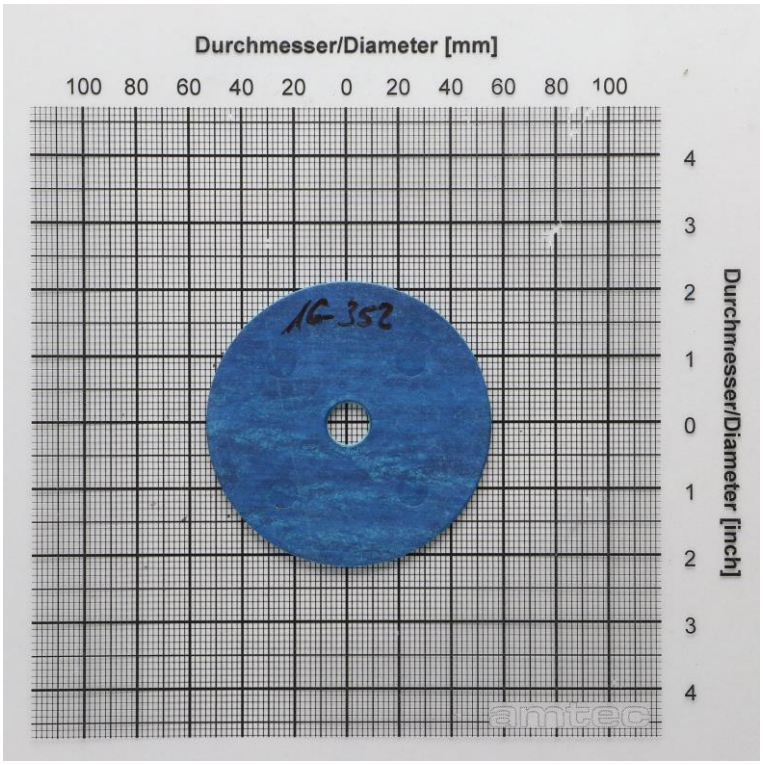
Initial gasket stress σ:	32	MPa
Internal pressure p:	40	bar
Test temperature T_P:	23	°C
Dwell time:	2:00	hh:mm
Measuring time:	1:00	hh:mm

Test results

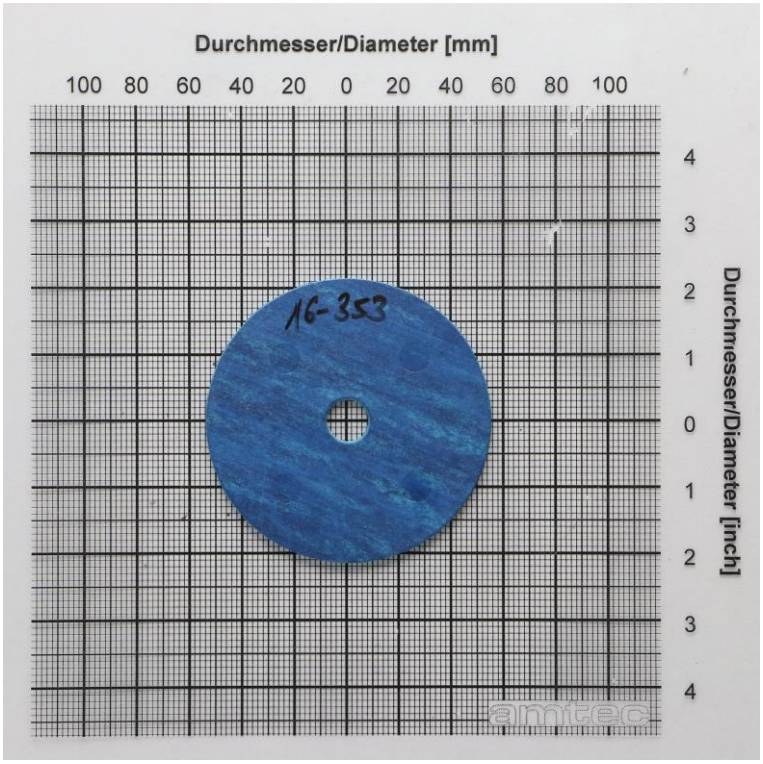
Leak rate λ:	3.03E-04	cm³/min
	2.95E-05	mg/m/s

Leak rate acc. BS 7531 permissible leakage value at lower resolution limit

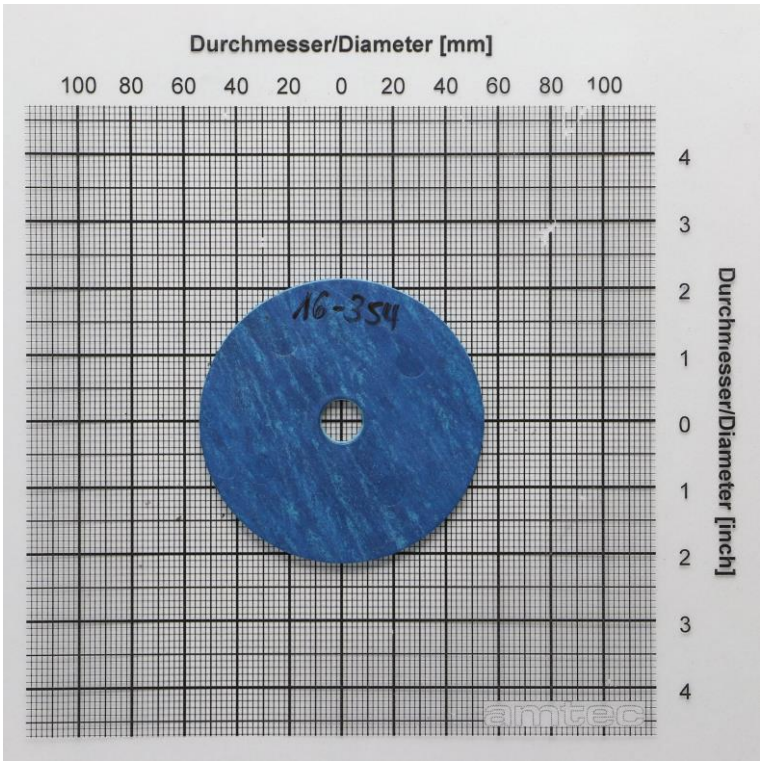




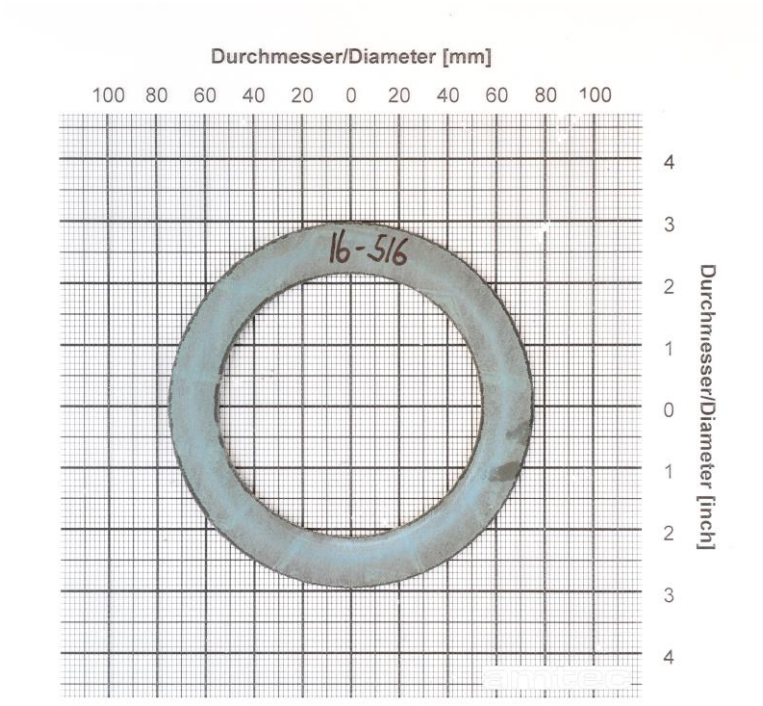
Compressibility test – 16-352



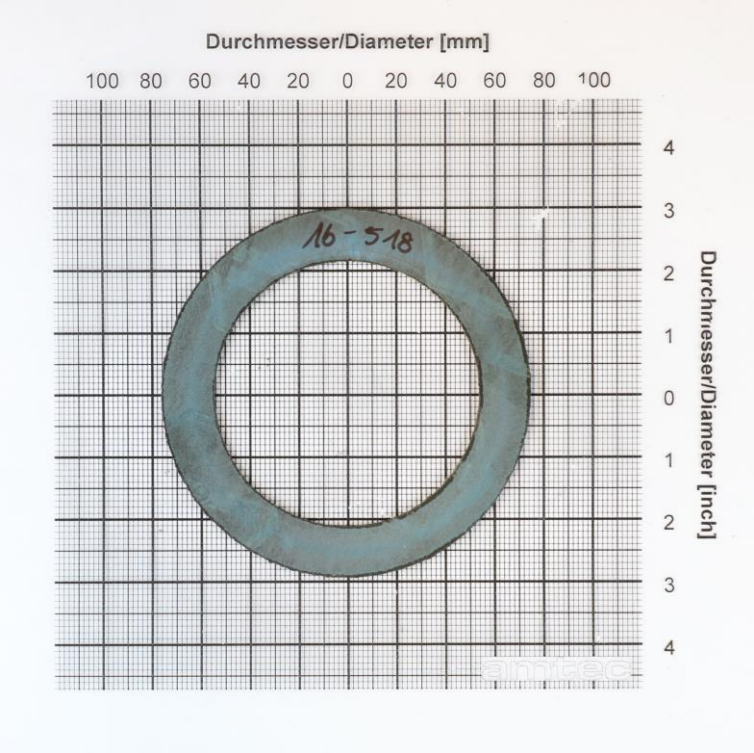
Compressibility test – 16-353



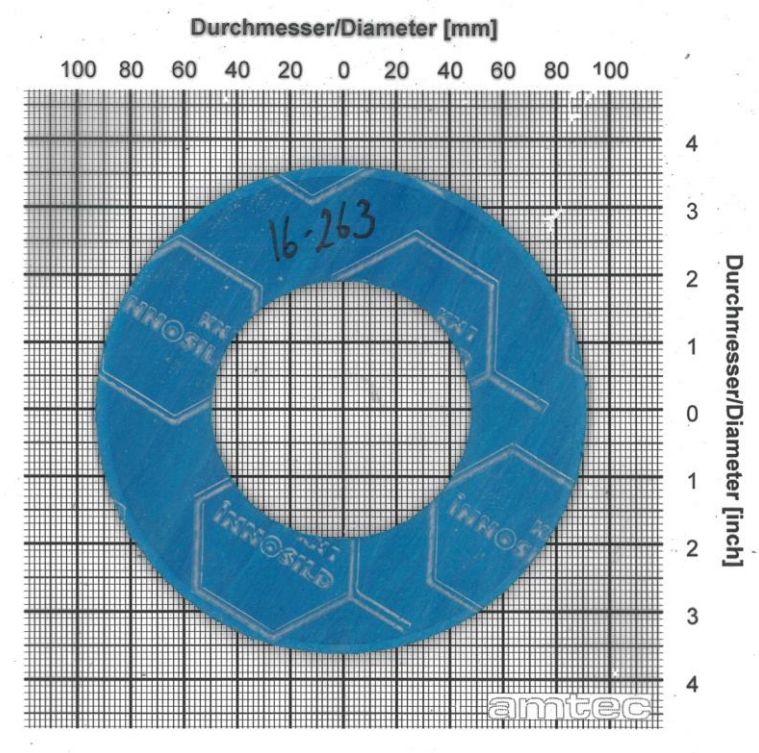
Compressibility test – 16-354



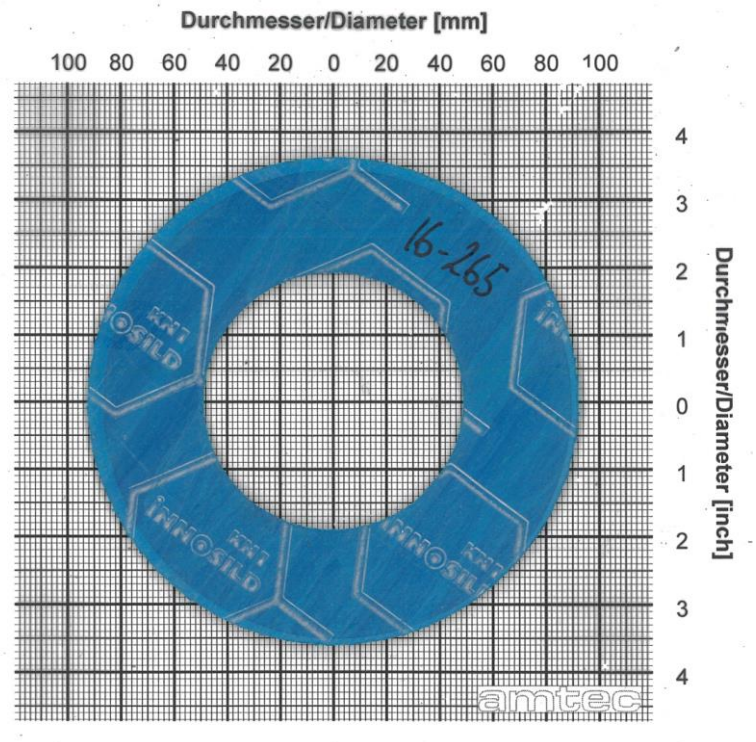
Residual stress test at 300 °C – 16-516



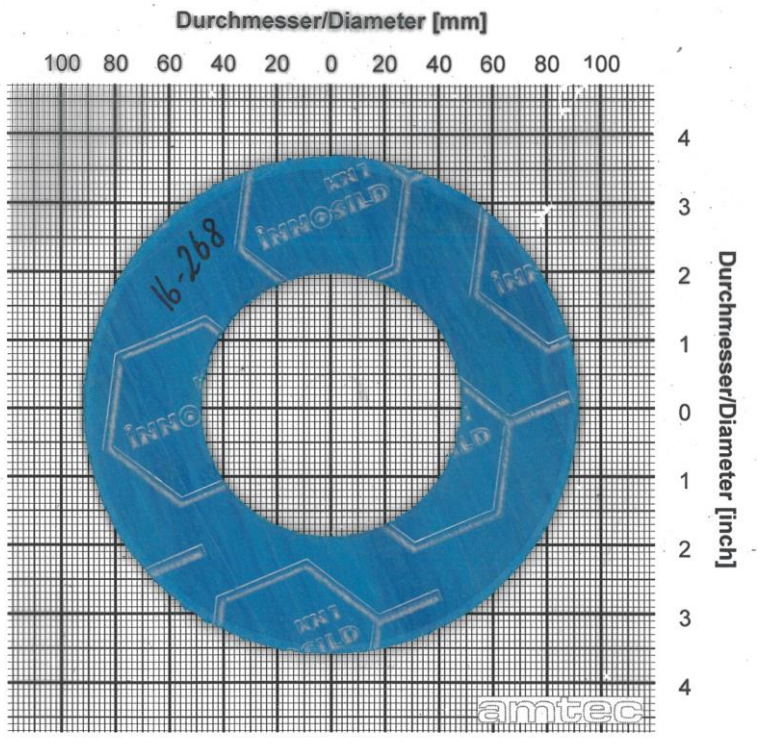
Residual stress test at 300 °C – 16-518



Gas permeability test at RT – 16-263



Gas permeability test at RT – 16-265



Gas permeability test at RT – 16-268