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Test Report

Customer:	Kukil Inntot Co., Ltd. 17 Tapgeol-gil, KOR - 689-871 Ulsan
Project number (amtec):	303 360
Report number:	303 360 3/a
Test procedure:	Shell Specification MESC SPE 85/300 (dated February 2016)
Material:	Insulation Gasket – K/# KINS-SA
Date:	May 15th, 2017
Pages:	14
Appendices:	29

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Test results are only relevant to the test objects submitted.

1. Subject of Investigation

The subject of investigation was an insulation gasket manufactured by Kukil Inntot Co., Ltd. which is named

- K/# KINS-SA.

The gaskets consist of a 3 mm glass fiber reinforced epoxy core with a PTFE-seal on both sides. The PTFE-seal is bonded in a groove on each side of the gasket. The dimensions of the PTFE-seal on front side is different than the dimension of the PTFE-seal at the back.

2. Goal of Investigation

The goal of the investigation was the determination of the following gasket characteristics according to the Shell Specification MESC SPE 85/300 (dated February 2016: Procedure and Technical Specification for Type Acceptance Testing (TAT) of Gaskets).

The Shell Specification MESC SPE 85/300 describes several testing procedures for the evaluation of the gasket compressibility and the tightness characteristics of the gasket material at ambient and elevated temperature.

In this project, 10 different tests were performed in respect of the Shell approval:

- Shell leakage test at ambient temperature (MESC SPE 85/300 - 3.3.2),
- Shell leakage test at 150 °C (MESC SPE 85/300 - 3.3.2),
- Compression test at ambient temperature (MESC SPE 85/300 - 3.3.4: EN 13555),
- Compression test at 150 °C (MESC SPE 85/300 - 3.3.4: EN 13555),
- Relaxation test at ambient temperature (MESC SPE 85/300 - 3.3.4: EN 13555),
- Relaxation test at 150 °C (MESC SPE 85/300 - 3.3.4: EN 13555),
- Leakage test (MESC SPE 85/300 - 3.3.4: EN 13555),
- Shell cycle test at 150 °C (MESC SPE 85/300 - 3.3.5),
- Hot Blow-Out test (MESC SPE 85/300 - 3.3.6: HOBT) and
- Electrical Isolation Test (MESC SPE 85/300 - 3.3.15).

The Electrical Isolation Test (MESC SPE 85/300 - 3.3.15) is not part of the accreditation.

3. Test Specimens

The dimensions of the test specimens for the different tests were 4" Class 300 and 3" Class 150 for the Hot Blowout Test.

Geometries of the PTFE sealing element of the Insulation Gasket K/# KINS-SA:

- Side a: Ø 137.2 mm x Ø 132.5 mm x 5.3 mm (4" Class 300),
  Side b: Ø 118.2 mm x Ø 113.4 mm x 5.3 mm (4" Class 300),
- Side a: Ø 112.1 mm x Ø 107.4 mm x 5.4 mm (3" Class 150),
  Side b: Ø 94.1 mm x Ø 89.5 mm x 5.4 mm (3" Class 150).

A visual examination of all test specimens was done prior and after testing. All test specimens are in accordance to the applicable design standard (MESC SPE 85/300 - 3.3.1).

4. Testing Equipment

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

- Multifunctional test rig TEMES$_{fl.ai1}$ No.: 010 181 and 010 629
- 4" Class 300 pair of flanges and Insulation tester Megger BM 21

Photos and the schematic view of the testing equipment TEMES$_{fl.ai1}$ and the Insulation testing device are shown in **appendices 1 and 2**.

4.1 Multifunctional Testing Equipment TEMES$_{fl.ai1}$

The servo-hydraulic press of the TEMES$_{fl.ai1}$ is capable of producing a load up to 1 MN. Gaskets up to 180 mm diameter can be tested.

Depending on the type of test, different components (e.g. heating platens for temperatures up to 450 °C, insulation and cooling platens, different flange face designs, etc.) can be used.

The load (gasket stress) is measured by a load cell on the bottom of the test rig, the gasket deformation is recorded by three displacement transducers and the temperature profile is controlled. LabView-Software is used for data logging and online evaluation. The entire test can be performed under software-control, thus automatic tests according to international standards or user defined procedures are possible.

Also, the simulation of different flange stiffnesses can be achieved within the equipment. In dependence on the gasket deformation, the gasket surface pressure is reduced automatically according to the nominal stiffness being simulated.

Due to the modular design, the above-described test rig can be modified to perform leakage tests. The platens for compression tests are replaced by platens for leakage tests, which are connected to a separate measurement device, see Appendix 1. The leak rate measurement principle is based on the pressure decay method. Using the differential pressure method leak rates down to approximately 1.0×10^{-4} mg/m/s can be measured. For higher tightness classes a leak detector can be used.

4.2 Insulation tester Megger BM 21

The BM21 is a compact, battery powered, high voltage D.C. insulation testers with resistance measurement capabilities to around 5 TΩ. The BM21 can be set to display leakage current instead of resistance and this mode of operation also allows higher resistances to be measured, possibly up to 500 TΩ. The instruments are microprocessor controlled and feature a large, clear LCD combining digital and analogue readings of insulation resistance. This instrument has test voltage positions of 500 V, 1000 V, 2500 V and 5000 V and an additional range with a variable output voltage of 25 V to 5000 V in 25 V steps.

5. Test Procedure

5.1 Fugitive Emission: Shell leakage test at ambient and elevated temperature (MESC SPE 85/300 - 3.3.2)

The Shell leakage test is carried out at ambient and at elevated temperature. For the tests at elevated temperature first the temperature is raised to the required test temperature under an initial gasket stress. Afterwards the gasket is compressed in steps of 100 MPa to a maximum gasket stress of 700 MPa at ambient and at elevated temperature. After reaching the first gasket stress level the test volume is pressurised with 51 bar at ambient temperature and 45.1 bar at 150 °C according to ASME B16.5-2003 - PT-Rating for Group 1.1 Materials. For the leakage measurement helium is used as test medium.

The leak rate can be classified in tightness classes:

- Class A: $\leq 1.78 \cdot 10^{-9}$ Pa·m³/s/mm,
- Class B: $\leq 1.78 \cdot 10^{-8}$ Pa·m³/s/mm.

Shell TAT recommends a maximum gasket stress of 620 MPa, which is equivalent to a maximum bolt stress of 361 MPa. The calculation of the gasket stress, which is calculated from the bolt stress, was done with an effective cross section area of 199 mm² per bolt referred to an average OD of 127.7 mm and average ID of 123 mm of the PTFE sealing element of Insulation Gasket.

5.2 Test Procedure EN 13555 (MESC SPE 85/300 - 3.3.4)

According to the European Standard EN 13555 the determination of the following gasket characteristics, which are necessary for the calculation according to EN 1591-1, was done:

- Maximum allowable gasket stress Q_{smax} (RT, 150 °C),
- Modulus of elasticity E_G (RT, 150 °C),
- Creep relaxation factor P_{QR} (160 MPa – RT, 150 °C),
- Change in gasket thickness due to creep Δe_{Gc} (160 MPa – RT, 150 °C),
- Minimum required gasket stress in assembly $Q_{min(L)}$ (40 bar) and
- Minimum required gasket stress in service $Q_{smin(L)}$ (40 bar).

5.2.1 Compression Test

The compression test can be carried out at ambient or at elevated temperature. For the tests at elevated temperature, the temperature of the gasket is first raised to the required test temperature under an initial gasket stress. Then cyclic compression and recovery loadings on the gasket at progressively higher surface pressures are carried out until the gasket collapses or the maximum load of the test machine or the maximum gasket stress specified by the manufacturer is reached.

The gasket stress of the loading cycle prior to collapse is taken to be the maximum allowable gasket stress at ambient temperature $Q_{smax}(RT)$ or the maximum allowable gasket stress at the test temperature $Q_{smax}(T)$.

The unloading cycles of the Q_{smax} test allow the generation of values of the modulus of elasticity E_G. An E_G value is determined for each gasket stress level of the different unloading cycles. The E_G value is also dependent on the test temperature level.

5.2.2 Creep Relaxation Test

The factor P_{QR} is the ratio of the residual and the initial gasket stress from a relaxation test. The test is performed by using the stiffness simulated control mode. The load will be decreased according to the creeping of the gasket and the nominal set point for stiffness simulation. A stiffness of 500 kN/mm is typical for a PN designated flange and 1500 kN/mm for a Class designated flange. For this test the stiffness of the rig shall be 500, 1000 or 1500 kN/mm.

The test procedure consists of loading the test gasket until the initial load is achieved. The load is then held constant for 5 minutes. Next, the temperature of the test rig is raised until the test temperature is reached and the temperature is held constant for a period of 4 hours. During the heating period and at elevated temperature the stiffness controlled mode of the equipment is activated. After the 4 hour period the remaining load after relaxation is noted and P_{QR}, the ratio of the residual load to the initial load, and the deflection Δe_{Gc} are calculated.

5.2.3 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 internal gas pressure of 40 bar.

The procedure therefore consists of loading to 20 MPa, holding the load and measuring the leak rate and then raising the gasket stress to 40 MPa. The load is then held whilst the leak rate is measured. In the next step the load is reduced to 20 MPa and the leak rate is measured. Then measurements are done for the next loading - unloading cycle at 60 MPa and 20 MPa and so on until either the 160 MPa loading - unloading cycle is completed or the value of Q_{smax} would have been exceeded.

The test gas used for this test is helium.

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.

5.3 HOTT: Shell cycle test at 150 °C (MESC SPE 85/300 – 3.3.5)

In the leakage test at elevated temperature the gasket is compressed with a gasket stress of 620 MPa. After heating up to 150 °C the specimen was pressurized with 45.1 bar helium (in accordance to ASME B16.5-2003 - PT-Rating for Group 1.1 Materials), no load compensation of the internal pressure is done.

After one hour the test rig is cooled down to ambient temperature. The thermal cycle is repeated three times. During the last thermal cycle, the pressure loss shall not exceed 1 bar.

5.4 Hot Blow-Out test (HOBT1), (MESC SPE 85/300 – 3.3.6)

The HOBT1 test can be performed in a fixture joint (NPS 3 in., ASME class 150) or in a hydraulic test rig, in which the rigidity of the flange can be simulated. In the amtec lab the HOBT1 tests are carried out in hydraulic testing equipment.

The HOBT1 test procedure consists of different steps, which may be described as follows:

1. The gasket is compressed to the required gasket stress of 302.1 MPa (43,815.9 psi).

2. The gasket is left undisturbed for 5 minutes before it is reloaded up to 302.1 MPa (43,815.9 psi). During this period it creeps and relaxes according to the defined rigidity of the test rig.

3. The gasket is left undisturbed for 30 minutes before the test temperature 150 °C (302 °F) is applied with an increasing rate of 1.7 K/min (3 °F/min). During this period the gasket is therefore left to creep and relax according to the defined rigidity of the test rig (780 kN/mm / 4,400.00 lb/in).

4. After the 30 minutes waiting period, the specified helium pressure is applied to the test rig. Because of the increasing internal pressure, the gasket stress is decreasing. For most PTFE based materials, this may lead to the sudden blow-out of the gasket, in which case, the blow-out temperature, the actual internal pressure and the gasket stress are recorded.

5.5 Electrical Isolation Test (MESC SPE 85/300 - 3.3.15)

The Electrical Isolation Test according to Shell Specification MESC SPE 85/300 ensures that gasket, insulation sleeves and washer kit adhere to the requirements for AC and DC electrical isolation when installed in a flange arrangement.

In the electrical isolation test an isolation gasket with isolation sleeves and washers is mounted in a 4" Class 300 flange.

The electrical isolation resistance is measured from every bolt to flange and from flange to flange with a voltage of 1500 V DC. There is a dwell time of one minute at each measurement point. After one minute the resistance value is taken.
The minimum resistance for the flange to flange measurement is 100 MΩ. The minimum average resistance of the bolt to flange measurement is 100 MΩ.

6. Results

All test results of the gasket material Insulation Gasket K/# KINS-SA are summarized in **appendices 3 to 6**.

6.1 Fugitive Emission: Shell leakage test at ambient and elevated temperature (MESC SPE 85/300 - 3.3.2)

In the Shell leakage test at ambient temperature the gasket was compressed in 8 steps from 100 MPa to 700 MPa. The detected leak rate at 100 MPa gasket stress at an internal pressure of 51 bar was $1.5 \cdot 10^{-7}$ Pa·m³/s/mm, see **appendix 7**. The leak rate was decreasing with increasing gasket stress up to 700 MPa. The leak rate at a gasket stress of 620 MPa, which is equivalent to a bolt stress of 361 MPa, was $1.1 \cdot 10^{-8}$ Pa·m³/mm/s, which is below the Tightness Class B.

For the maximum gasket surface stress of 700 MPa the leak rate was $1.0 \cdot 10^{-8}$ Pa·m³/s/mm, which is also lower than the Tightness Class B.

In the Shell leakage test at 150 °C the gasket was compressed in 7 steps from 200 MPa to 700 MPa. The leak rate at 200 MPa gasket stress at an internal pressure of 45.1 bar was $1.2 \cdot 10^{-7}$ Pa·m³/s/mm, see appendix 7. The leak rate was decreasing with increasing gasket stress up to 500 MPa. With an increasing gasket stress up to 700 MPa the leak rate was nearly constant at a low level. The leak rate at a gasket stress of 620 MPa, which is equivalent to a bolt stress of 361 MPa, was $6.4 \cdot 10^{-10}$ Pa·m³/mm/s, which is below the Tightness Class A.

For the maximum gasket surface stress of 700 MPa the leak rate was $7.6 \cdot 10^{-10}$ Pa·m³/s/mm, which is lower than the Tightness Class A.

6.2 EN 13555 (MESC SPE 85/300 - 3.3.4)

All tests according to EN 13555 with the material Insulation Gasket K/# KINS-SA were performed twice; they are listed in appendices 3 and 4. All gasket characteristics which are necessary for the use of the flange calculation code EN 1591-1 are summarized in these tables.

6.2.1 Compression tests

In appendix 3 the results of the compression tests with loading and unloading cycles are given, the gasket characteristics are

- the maximum allowable gasket stress Q_{smax} (RT),
- the modulus of elasticity E_G (RT),
- the maximum allowable gasket stress Q_{smax} (150 °C) and
- the modulus of elasticity E_G (150 °C).

Compression tests were performed at ambient temperature and at elevated temperature at 150 °C. According to EN 13555 loading and unloading cycles were carried out to determine the deformation behaviour of the gasket material. The compression curves and the corresponding graphs of the modules of elasticity for the different test temperature levels are shown in **appendices 8 to 11.**

In both compression tests at ambient temperature no collapse of the gasket specimens can be recognized until the maximum load of the testing equipment of 500 MPa resp. 400 MPa is reached. Also in the diagrams of the modules of elasticity no distinctive feature is visible which would indicate a damage of the gasket material.

The maximum allowable gasket stress Q_{smax} at RT is set to 500 MPa.

In both compression tests at 150 °C no damage of the gasket specimen can be recognized until the maximum load of the testing equipment of 500 MPa is reached. Also in the diagrams of the modules of elasticity no distinctive feature is visible which would indicate a damage of the gasket material.

The maximum allowable gasket stress Q_{smax} at 150 °C is set to 500 MPa.

The modulus of elasticity E_G at ambient temperature increases steadily with increasing gasket stress.

The modulus of elasticity E_G at elevated temperature at 150 °C increases steadily with increasing gasket stress up to 150 MPa. At higher gasket stress levels the modulus of elasticity E_G decreases again.

In all tests most of the compression could be measured at a gasket stress level below 100 MPa.

6.2.2 Creep Relaxation Tests

In appendix 4 the gasket characteristics of the creep relaxation tests for one gasket stress, two temperatures and one stiffness levels are listed:

- creep relaxation factor P_{QR} (160 MPa, RT, 500 kN/mm) and
- creep relaxation factor P_{QR} (160 MPa, 150 °C, 500 kN/mm).

In total 4 creep relaxation tests were performed. The initial gasket stress level was set to 160 MPa, the temperature was assessed to RT and 150 °C. For the stiffness the typical value for a PN designated flange (500 kN/mm) was chosen.

The results of all creep relaxation tests are given in **appendices 12 to 15**. The creep relaxation factors P_{QR} are 0.94 resp. 0.9 (160 MPa, RT, 500 kN/mm) and 0.99 resp. 0.84 (160 MPa, 150 °C, 500 kN/mm). The maximum deflection Δe_{Gc} of the gasket Insulation Gasket K/# KINS-SA at RT is 28 µm and in tests at 150 °C is 47 µm.

6.2.3 Leakage Tests

The tightness behaviour of the gasket material Insulation Gasket K/# KINS-SA was examined in two leakage tests at 40 bar helium. In appendix 4 the determined gasket characteristics

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

are listed for both tests in dependence on the tightness class L.

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 than $1.0 \cdot 10^{-3}$ mg/m/s, for lower leak rates the signal of the helium leak detector was taken for the calculation of the leak rate.

The graphical presentation of the leakage curves are shown in **appendix 16**. The tightness class $L_{0.01}$ was reached when the gasket stress raised above 45 MPa or 84 MPa, respectively. Therefore the minimum gasket stress in assembly for the tightness class $L_{0.01}$ should be set to $Q_{min(0.01)}$ = 84 MPa. The lowest tightness class which could be reached was $L_{0.0001}$ in test 17-244; therefore a gasket stress of 139 MPa.

The leak rate is decreasing with an increasing gasket stress up to 160 MPa. The lowest leak rate which could be measured was $7.4 \cdot 10^{-5}$ mg/m/s at 160 MPa in test 17-244.

During the unloading cycles the leak rate is increasing again, but the gasket is tighter as during the first loading to a defined gasket stress level. In all unloading curves no drastic increase of the leak rate (or sudden blow-out) is observed.

The minimum gasket stress in service for the tightness class $L_{0.01}$ for an initial gasket surface pressure Q_A of 100 MPa is $Q_{smin(0.01)}$ = 60 MPa resp. 20 MPa in both tests.

6.3 HOTT: Shell cycle test at 150 °C (MESC SPE 85/300 – 3.3.5)

For the Shell cycle test at elevated temperature the Insulation Gasket K/# KINS-SA was compressed initially with 620 MPa. After heating up to 150 °C, the specimen was pressurized with 45 bar helium. During the thermal cycles in the leakage test at 150 °C, nearly no pressure drop could be measured, see **appendix 17**.

During the last thermal cycle no pressure loss could be measured. The gasket material Insulation Gasket K/# KINS-SA has passed the Shell requirement of a pressure drop less than 1 bar.

6.4 Hot Blow-Out test (HOBT1), (MESC SPE 85/300 – 3.3.6)

One Hot Blow-Out test with the material K/# KINS-SA has been carried out for the measure of its margin of safety against blow-out.

In **appendices 18 and 19** the results and the diagrams of the HOBT test of K/# KINS-SA are shown.

During pressurization with Helium the gasket decreases again. With a maximum pressure of 180 bar and a dwell time of 2 x 15 minutes no Blow-Out could be recognized.

The gasket material K/# KINS-SA has passed the Hot Blow-Out test at a temperature of 150 °C with an initial gasket stress of 302.1 MPa and an internal pressure of 180 bar.

6.5 Electrical Isolation Test (MESC SPE 85/300 - 3.3.15)

In the electrical isolation test according to Specification MESC SPE 85/300 the flange isolation gasket kit K# KINS-SA was mounted in a 4" Class 300 flange with hydraulic spanners to a bolt load of 67.08 kN which means a total load of 536.64 kN and a gasket surface stress of 579.9 MPa, see **appendix 20**.

After that the electrical isolation resistance was measured from each bolt to the bottom flange and from top to bottom flange with a voltage of 1500 V DC for 1 minute each.

The results of the measurements with the flange isolation kit K# KINS-SA are shown in appendix 6. The average value of the bolt to flange measurements was > 1.52 TΩ. The value of the flange to flange measurement was 16.3 GΩ.

Therefore the electrical isolation resistance is higher than the minimum resistance of 100 MΩ and the Insulation Gasket K# KINS-SA has passed the electrical isolation test according to the Shell Specification MESC SPE 85/300.

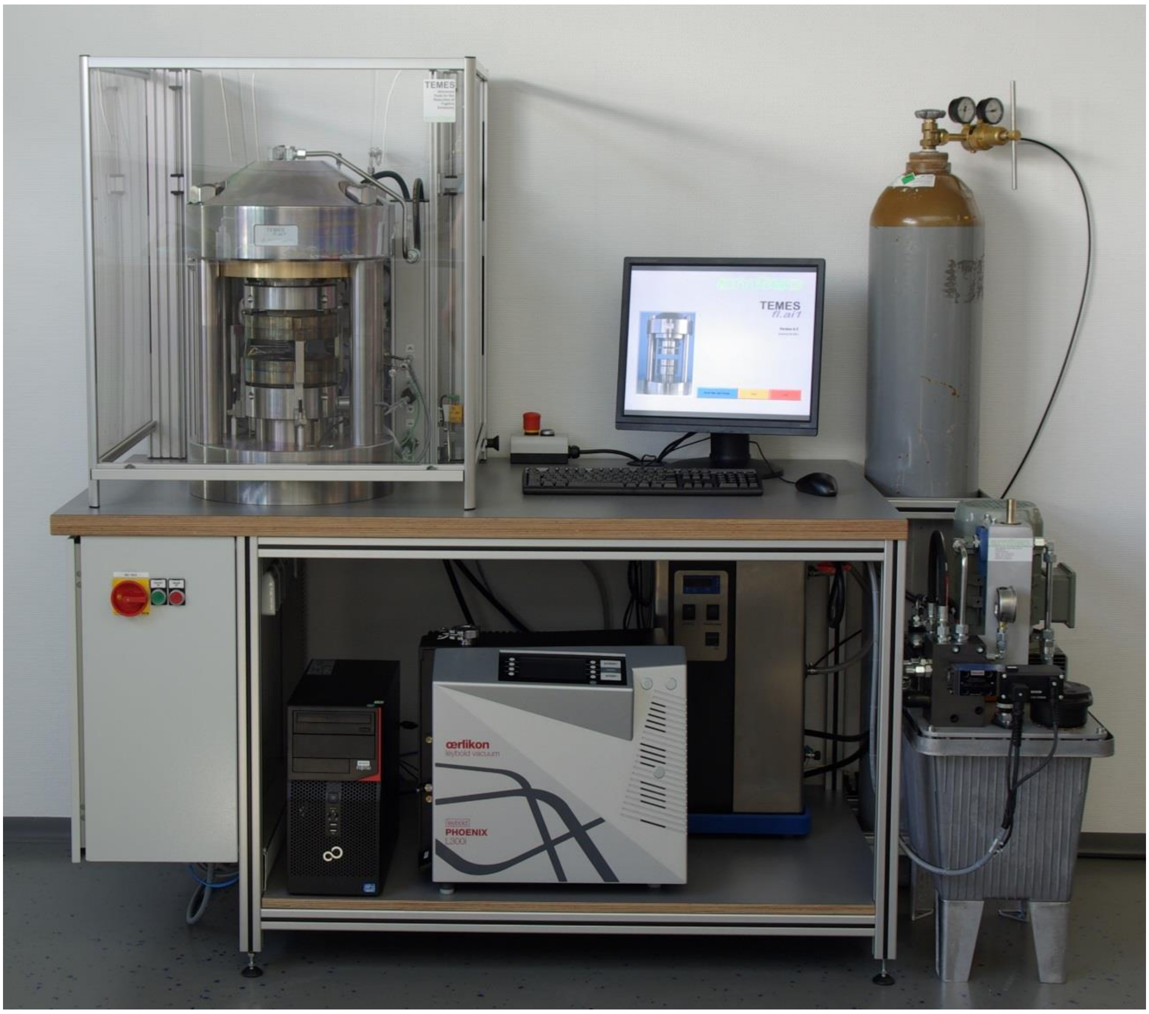
6.6 Gasket adhesion (MESC SPE 85/300 – 3.3.13)

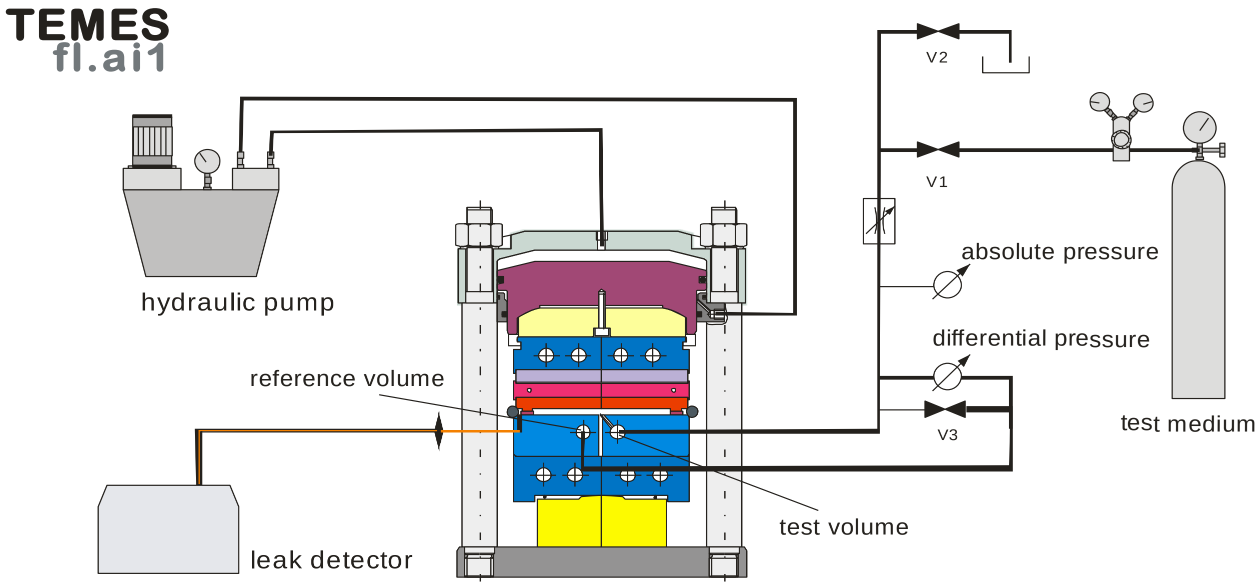
In **appendix 21** photos of the adjacent flanges after tests at ambient temperature with the gasket specimens Insulation Gasket K/# KINS-SA are represented. The gasket does not stick on the flange.

The gasket adhesion could be considered as acceptable.

7. Photo documentation

In **appendices 22 to 29** photos of the tested gasket specimens Insulation Gasket K/# KINS-SA for the different test procedures are presented.





Testing Equipment TEMES$_{fl.ai1}$ (1000 kN)

Isolation Testing Device Megger BM21

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

Manufacturer: Kukil Inntot Co., Ltd.

Product: **K/# KINS-SA**

Maximum allowable Gasket Stress Q_{smax} [MPa]

T [°C]	25	25	150	150
Q_{smax} [MPa]	500	500	500	500
Test #	17-208	17-221	17-220	17-229

Modulus of Elasticity E_G [MPa]

Q [MPa] \ T [°C]	25		25		150		150	
	E_G [MPa]	e_G [mm]	E_G [MPa]	e_G [mm]	E_G [MPa]	e_G [mm]	E_G [MPa]	e_G [mm]
0		4.860		5.270		4.920		5.210
1		4.682		4.647		4.564		4.576
20	410	3.829	316	3.792	717	3.236	762	3.330
30	1055	3.675	998	3.646	1102	3.153	1208	3.220
40	1954	3.564	2047	3.514	2027	3.122	2118	3.158
50	2856	3.472	2920	3.405	3988	3.113	3844	3.144
60	3749	3.398	3779	3.322	7541	3.108	6437	3.137
80	5883	3.298	6084	3.227	20218	3.104	15916	3.130
100	7792	3.236	8681	3.175	47652	3.101	29580	3.126
120	10096	3.198	10715	3.129	98535	3.099	46035	3.123
140	12153	3.168	13206	3.089	180000*	3.098	80451	3.121
160	14507	3.138	17627	3.072	180000*	3.096	82805	3.119
180	16548	3.111	24759	3.066	180000*	3.095	124268	3.117
200	18919	3.090	33609	3.063	180000*	3.094	129337	3.115
220	22965	3.077	39967	3.061	180000*	3.093	151838	3.114
240	25895	3.068	46481	3.059	180000*	3.091	107956	3.112
260	30942	3.062	54481	3.057	180000*	3.089	112020	3.110
280	36060	3.058	60578	3.056	180000*	3.088	113529	3.109
300	41485	3.056	66269	3.055	180000*	3.087	98401	3.107
320	47808	3.055	73056	3.054	152712	3.085	93125	3.105
340	52735	3.053	84275	3.054	162233	3.084	84623	3.103
360	58501	3.052	96277	3.053	123037	3.082	79077	3.101
380	64290	3.051	105801	3.053	109725	3.081	78433	3.100
400	69437	3.050	112895	3.052	101244	3.079	72387	3.098
420	74784	3.049			87781	3.077	66617	3.096
440	81182	3.048			82648	3.075	66178	3.095
460	88079	3.048			78464	3.074	64908	3.093
480	90173	3.046			72197	3.072	62556	3.091
500	96622	3.046			66809	3.070	58444	3.089
Test #	17-208		17-221		17-220		17-229	

* E-Modulus could not be determined, recovery of the gasket near the resolution limit of the displacement ransducer

Table 2: Data Sheet for Gasket Characteristics (EN 13555)

Manufacturer: Kukil Inntot Co., Ltd.

Product: **K/# KINS-SA**

Creep-/Relaxation Factor P_{QR} [-]
Change in gasket thickness due to creep Δe_{GC} [µm]

C = 500 kN/mm	Q [MPa] \ T [°C]	25	25	150	150
	160	0.94	0.90	0.99	0.84
	Δe_{GC} [µm]	19	28	1	47
	Versuch	17-240	17-243	17-249	17-250

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

p [bar] \ L	10	1	0.1	0.01	0.001	0.0001	0.00001	0.000001
40	20	27	35	45	65	139	-	-
Test #	17-244							
40	20	45	64	84	126	-	-	-
Test #	17-251							

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	0.0001	0.00001	0.000001
	40	20	20	27	-	-	-	-	-
	60	20	20	20	30	-	-	-	-
	80	20	20	20	21	57	-	-	-
	100	20	20	20	20	54	-	-	-
	160	20	20	20	20	51	135	-	-
	Test #	17-244							

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	0.0001	0.00001	0.000001
	40	20	20	-	-	-	-	-	-
	60	20	20	-	-	-	-	-	-
	80	20	20	28	-	-	-	-	-
	100	20	20	20	60	-	-	-	-
	160	20	20	20	31	93	-	-	-
	Test #	17-251							

Table 3: Data Sheet for Gasket Characteristics (Shell)

Manufacturer: Kukil Inntot Co., Ltd.

Product: **K/# KINS-SA**

Shell leakage test at ambient temperature

Test pressure:	51	bar
Shell required gasket stresss level:	620	MPa
Leakage rate:	1.11E-08	Pa·m³/s/mm
Shell tightness class:	B	
test no.	17-297	

Shell leakage test at elevated temperature

Test pressure:	45	bar
Shell required gasket stresss level:	620	MPa
Leakage rate:	6.40E-10	Pa·m³/s/mm
Shell tightness class:	A	
test no.	17-281	

Shell cycle test at 150 °C

Test pressure:	45	bar
Initial gasket stresss level:	620	MPa
Pressure drop in last cycle:	< 0.1	bar
Requirements:	passed	
test no.	17-277	

Hot Blow-Out test (HOBT1)

Test pressure:	180	bar
Initial gasket stress level:	301	MPa
Temperature:	150	°C
Requirements	passed	
test no.	17-300	

Kukil Insulation Kit K# KINS-SA 17-225 303360

geometries

gasket	Insulation Kit K# KINS-SA	
manufacture	Kukil	
OD gasket PTFE	127.7	mm
ID gasket PTFE	123	mm
gasket thickness	5.5	mm
washers 1	steel washers	
number of washers	16	
washers 2	G-10	
number of washers	16	
sleeves	G-10	
number of sleeves	8	
OD raised faces flange	155	mm
number of bolts	8	

gauge

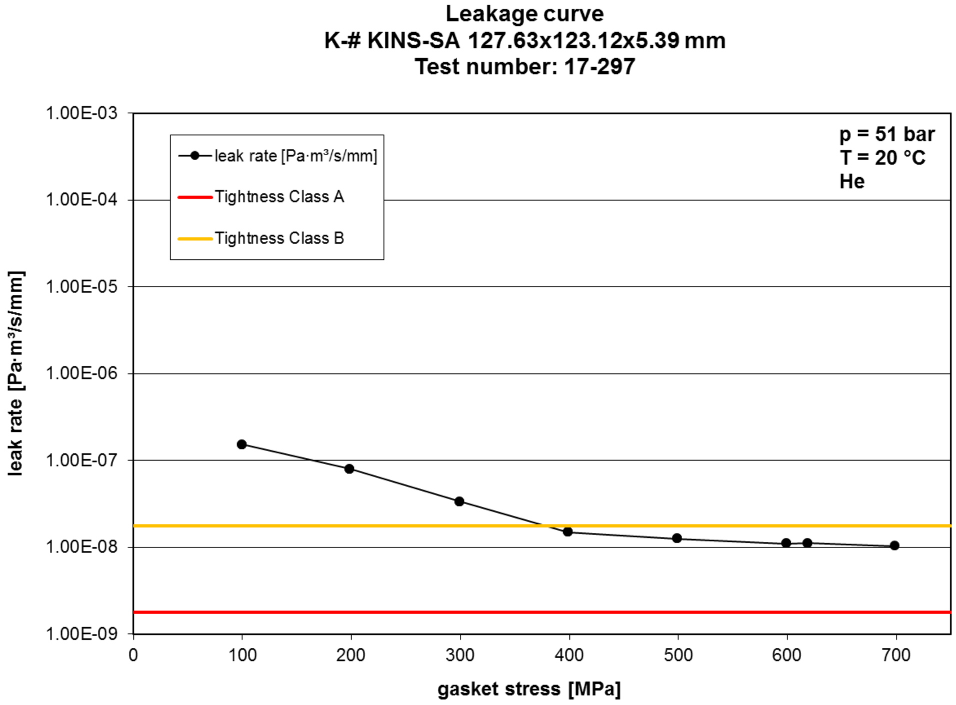
type	Megger BM21
identification	NEWK-WA 860

isolation test

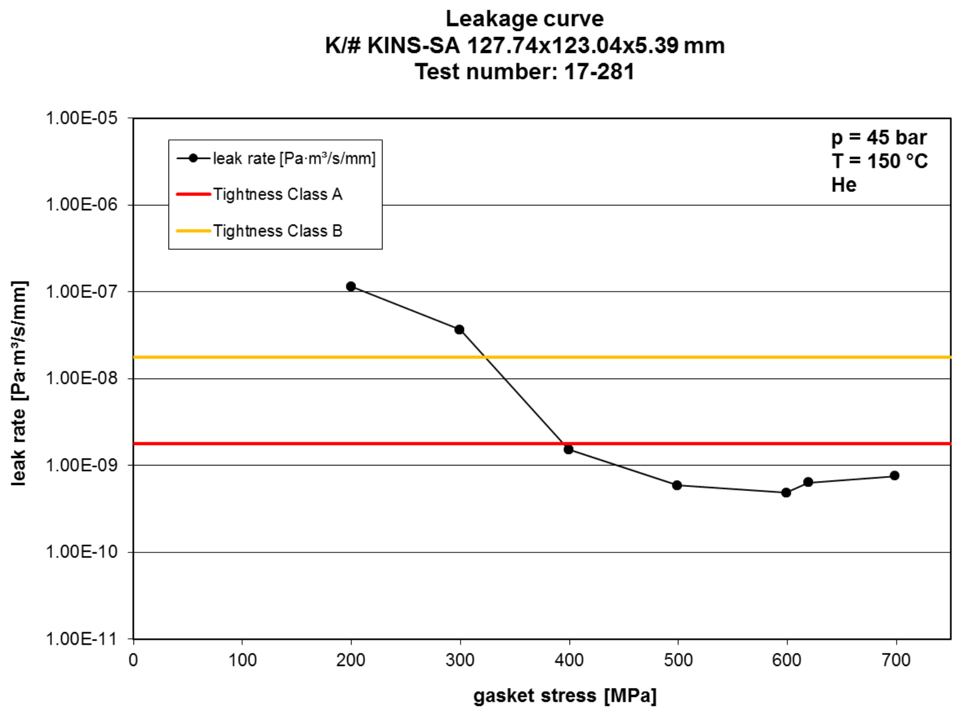
measuring time	60	s
measuring voltage	1500	VDC
minimum insulation resistance	**100**	**MΩ**

measuring data

flange to bolt		
1	> 1.52	TΩ
2	> 1.52	TΩ
3	> 1.52	TΩ
4	> 1.52	TΩ
5	> 1.52	TΩ
6	> 1.52	TΩ
7	> 1.52	TΩ
8	> 1.52	TΩ
average	**> 1.52**	**TΩ**
flange to flange	**16.3**	**GΩ**

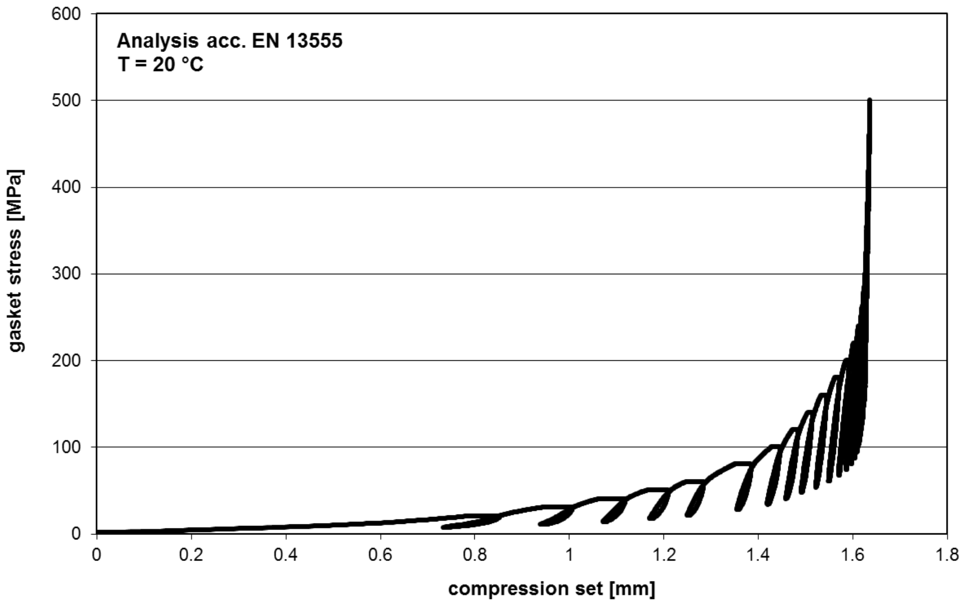


Shell leakage test (RT) according MESC SPE 85/300 - 3.3.2

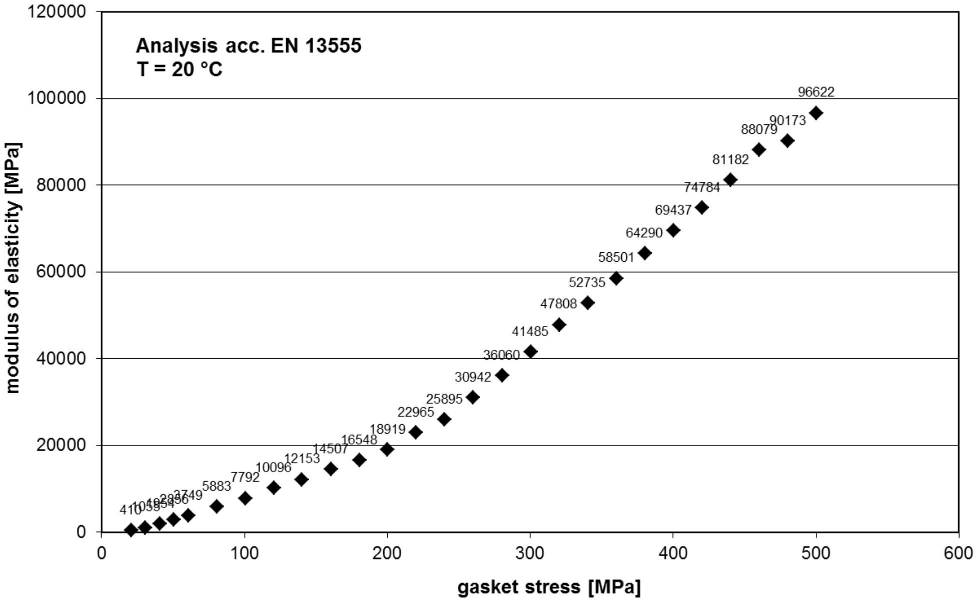


Shell leakage test (150 °C) according MESC SPE 85/300 - 3.3.2

Compression curve
K/# KINS-SA 118.2x113.4x4.682 mm
Test number: 17-208

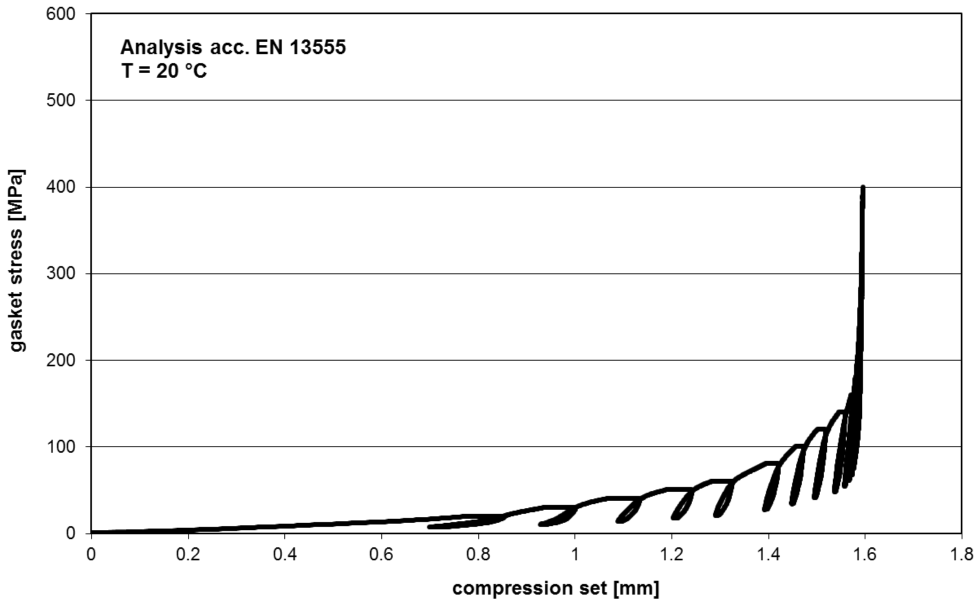


Modulus of elasticity
K/# KINS-SA 127.71x122.97x4.682 mm
Test number: 17-208

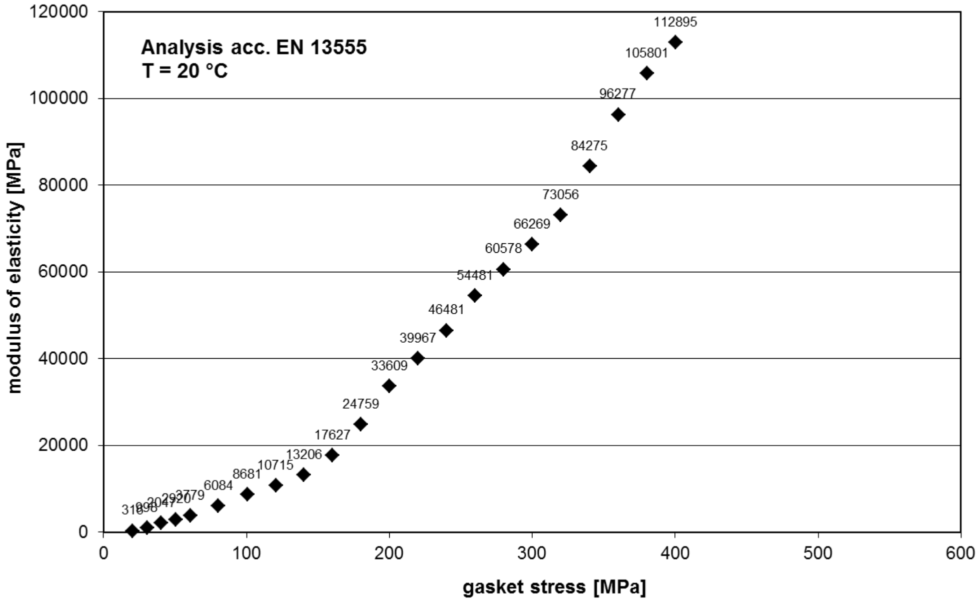


Compression Test (RT) according EN 13555

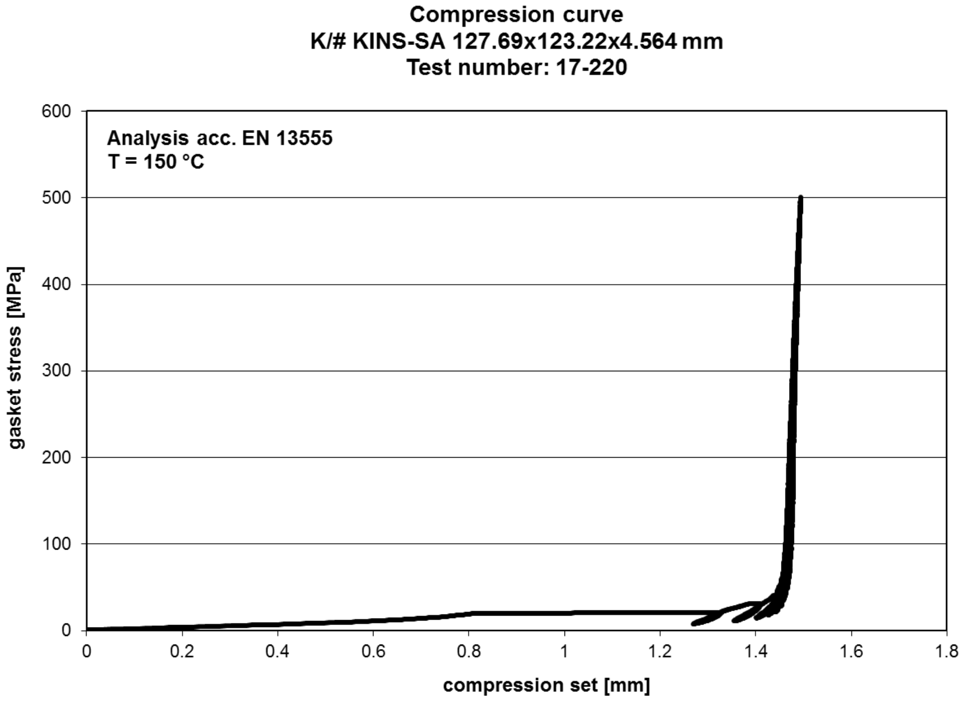
Compression curve
K/# KINS-SA 127.85x123.01x4.647 mm
Test number: 17-221

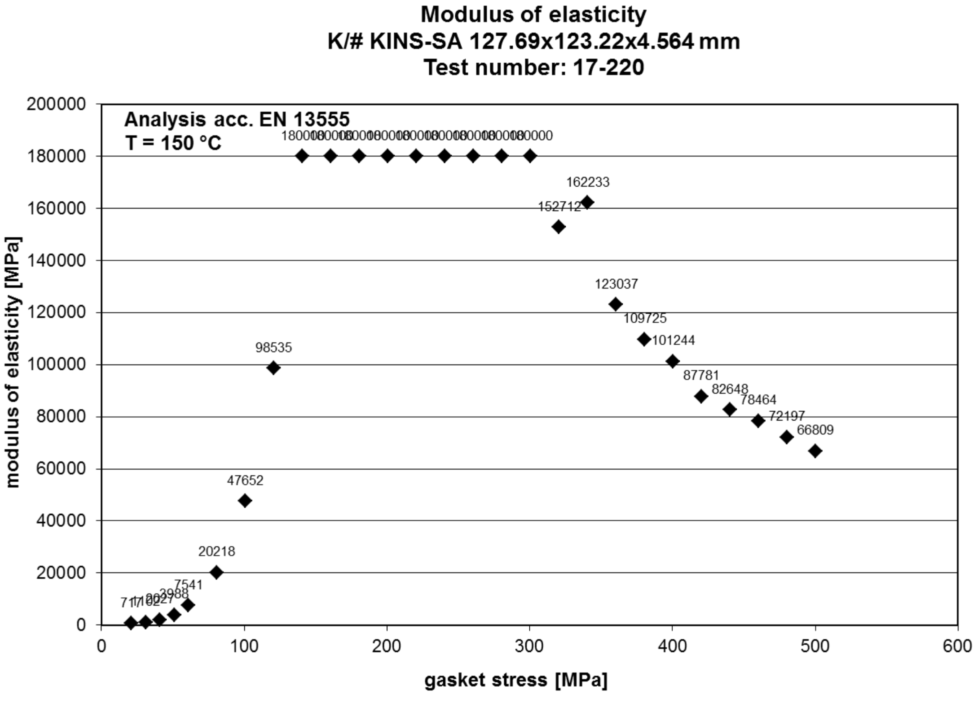


Modulus of elasticity
K/# KINS-SA 127.85x123.01x4.647 mm
Test number: 17-221



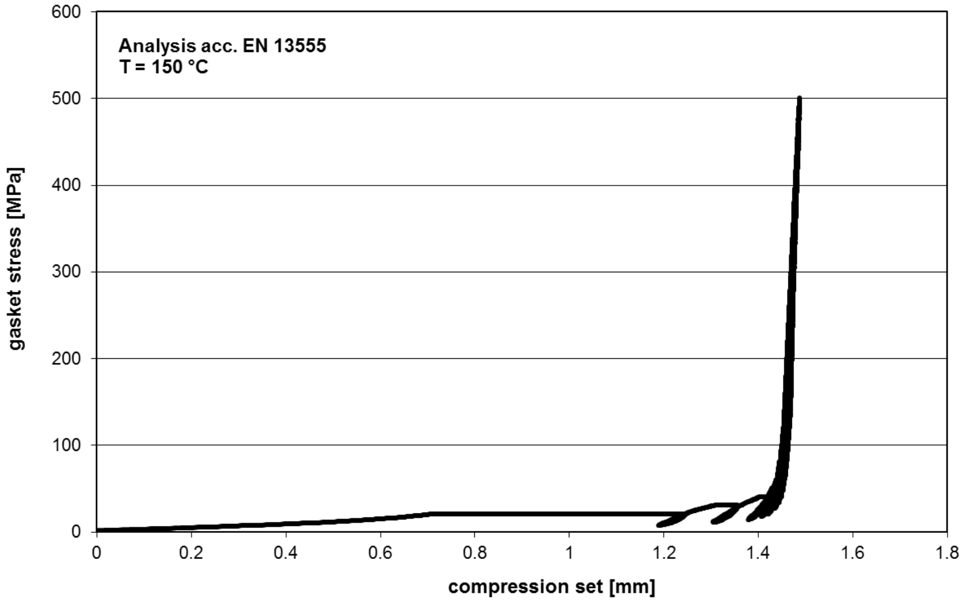
Compression Test (RT) according EN 13555



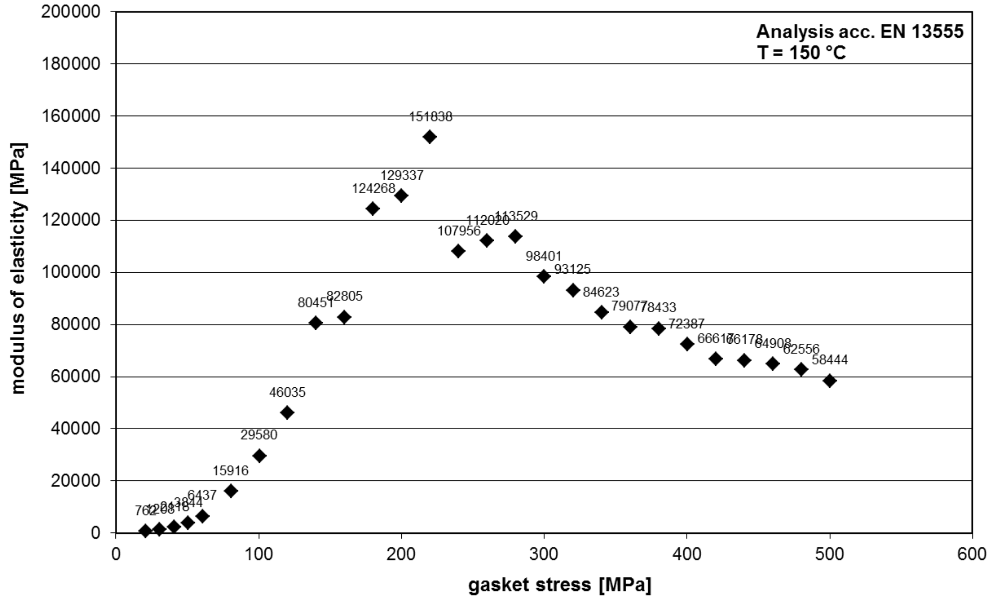


Compression Test at 150 °C according EN 13555

Compression curve
K/# KINS-SA 127.75x123.01x4.576 mm
Test number: 17-229



Modulus of elasticity
K/# KINS-SA 127.75x123.01x4.576 mm
Test number: 17-229



Compression Test at 150 °C according EN 13555

Creep relaxation test (EN 13555)

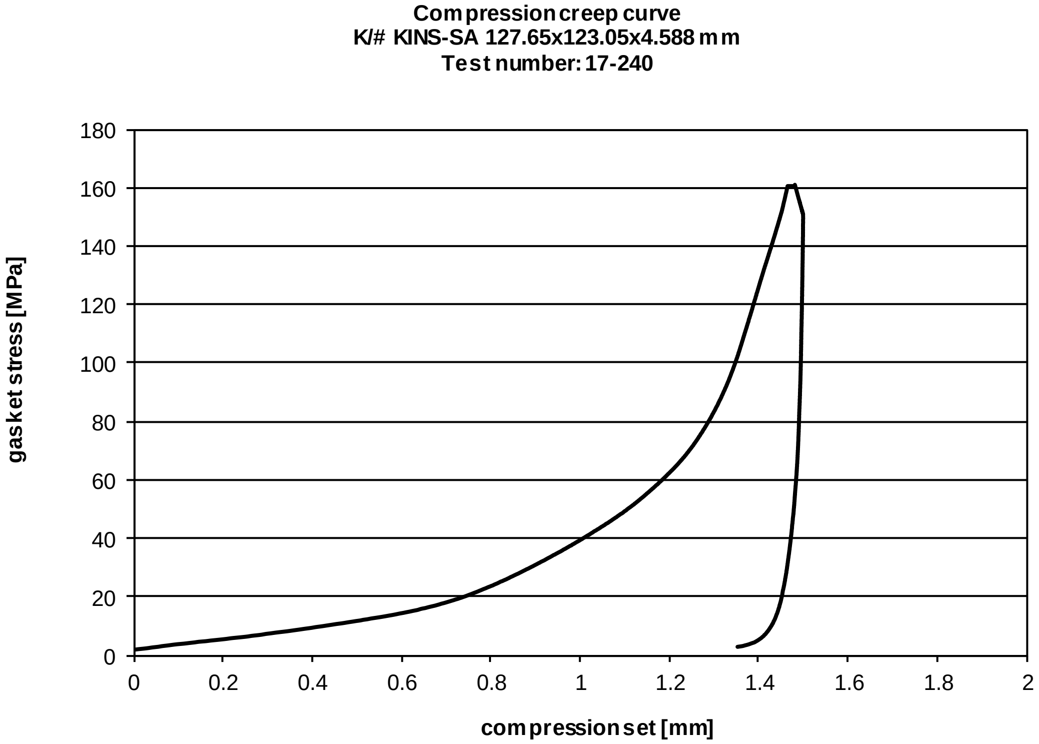
K/# KINS-SA
127.65x123.05x4.588 mm
Test number: 17-240

Test parameters

Initial gasket stress Q_i:	160.5	MPa
Test temperature T_P:	20	°C
Time at T_P:	4:00	hh:mm
Stiffness C:	500	kN/mm

Test results

Remaining gasket stress Q_r:	150.8	MPa
Relaxation factor P_{QR} (T_P):	0.94	
Deflection Δe_{Gc}:	19	µm



Creep relaxation test (EN 13555)

K/# KINS-SA
127.66x123.21x4.971 mm
Test number: 17-243

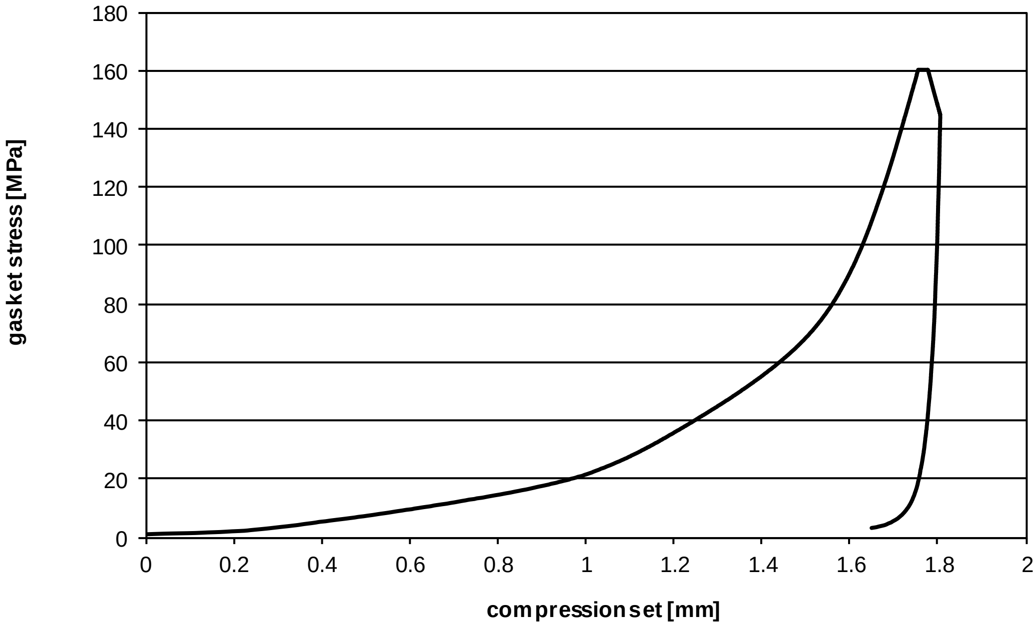
Test parameters

Initial gasket stress Q_i:	160.2	MPa
Test temperature T_P:	20	°C
Time at T_P:	3:59	hh:mm
Stiffness C:	500	kN/mm

Test results

Remaining gasket stress Q_r:	144.8	MPa
Relaxation factor P_{QR} (T_P):	0.90	
Deflection Δe_{Gc}:	28	µm

Compression creep curve
K/# KINS-SA 127.66x123.21x4.971 mm
Test number: 17-243



Creep relaxation test (EN 13555)

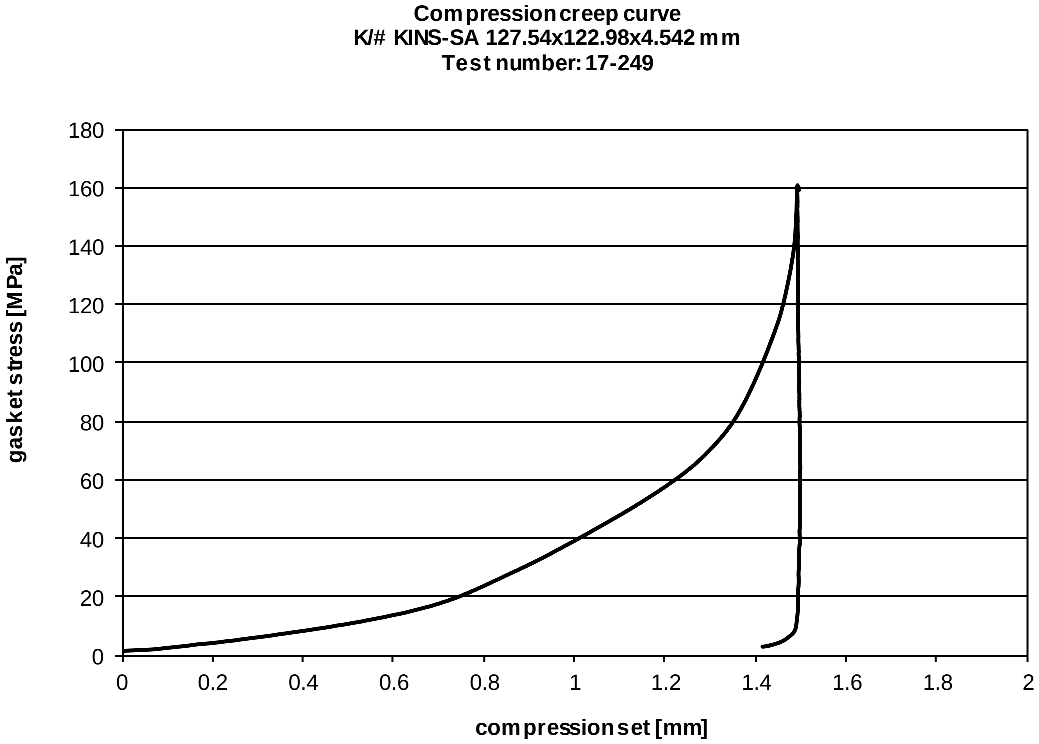
K/# KINS-SA
127.54x122.98x4.542 mm
Test number: 17-249

Test parameters

Initial gasket stress Q_i:	160.3	MPa
Test temperature T_P:	150	°C
Time at T_P:	4:00	hh:mm
Stiffness C:	500	kN/mm

Test results

Remaining gasket stress Q_r:	159.3	MPa
Relaxation factor P_{QR} (T_P):	0.99	
Deflection Δe_{Gc}:	1	µm



Creep relaxation test (EN 13555)

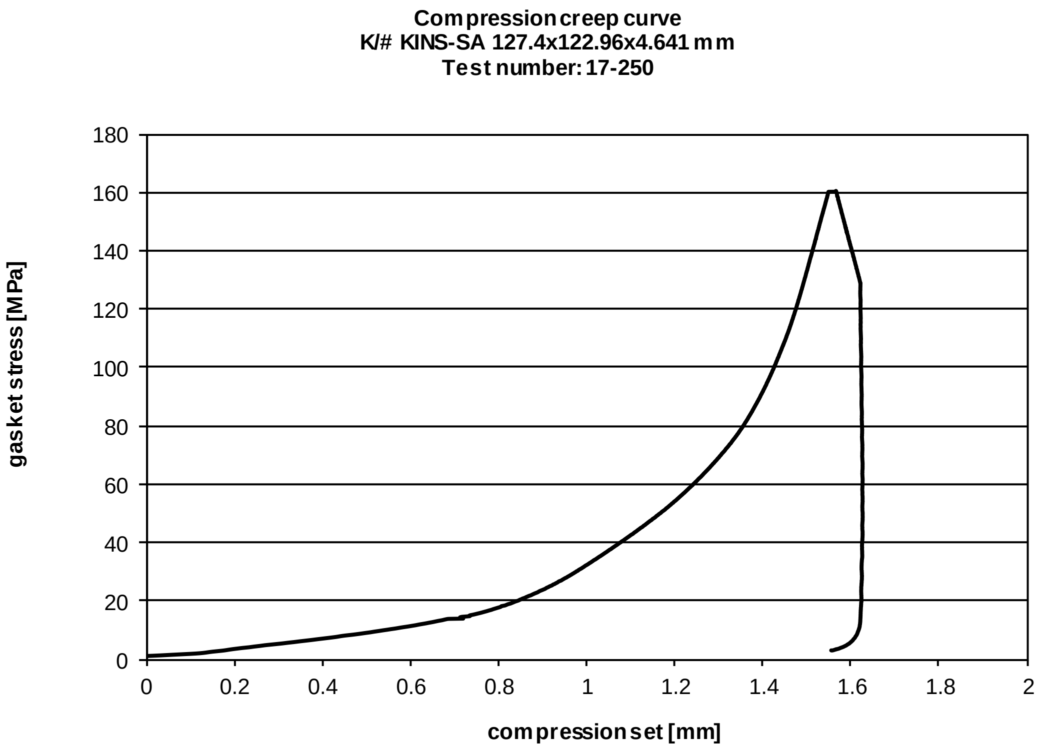
K/# KINS-SA
127.4x122.96x4.641 mm
Test number: 17-250

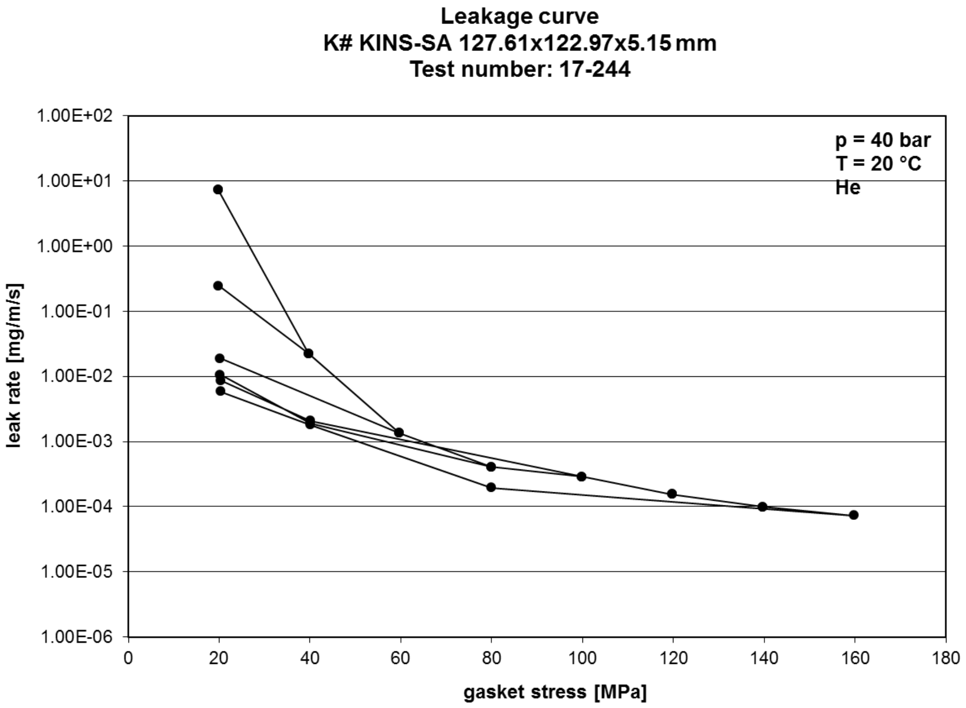
Test parameters

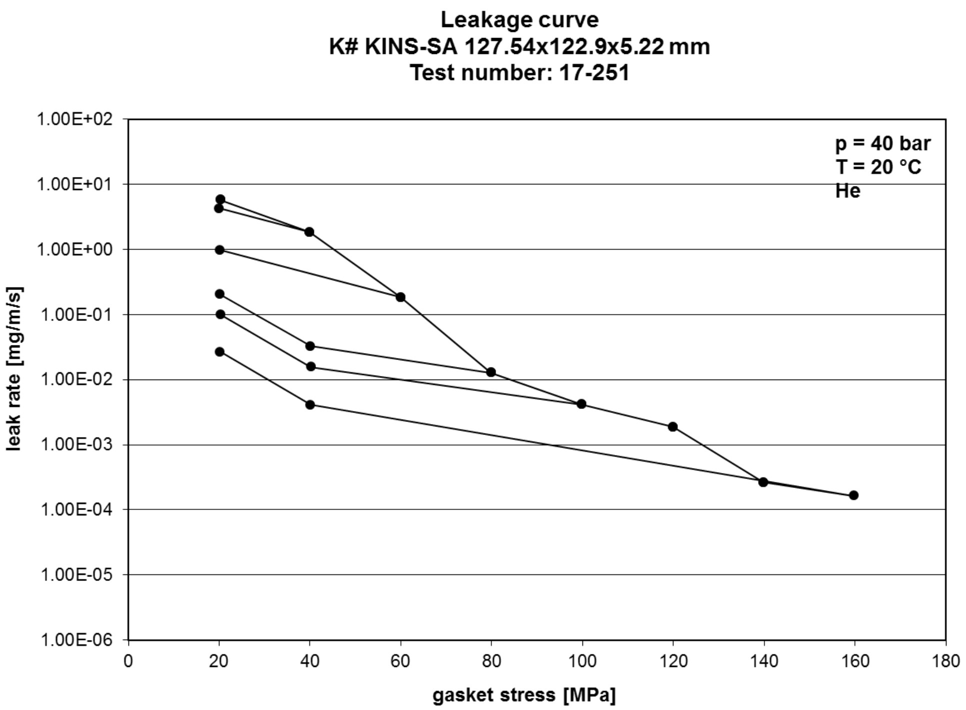
Initial gasket stress Q_i:	160.2	MPa
Test temperature T_P:	150	°C
Time at T_P:	4:00	hh:mm
Stiffness C:	500	kN/mm

Test results

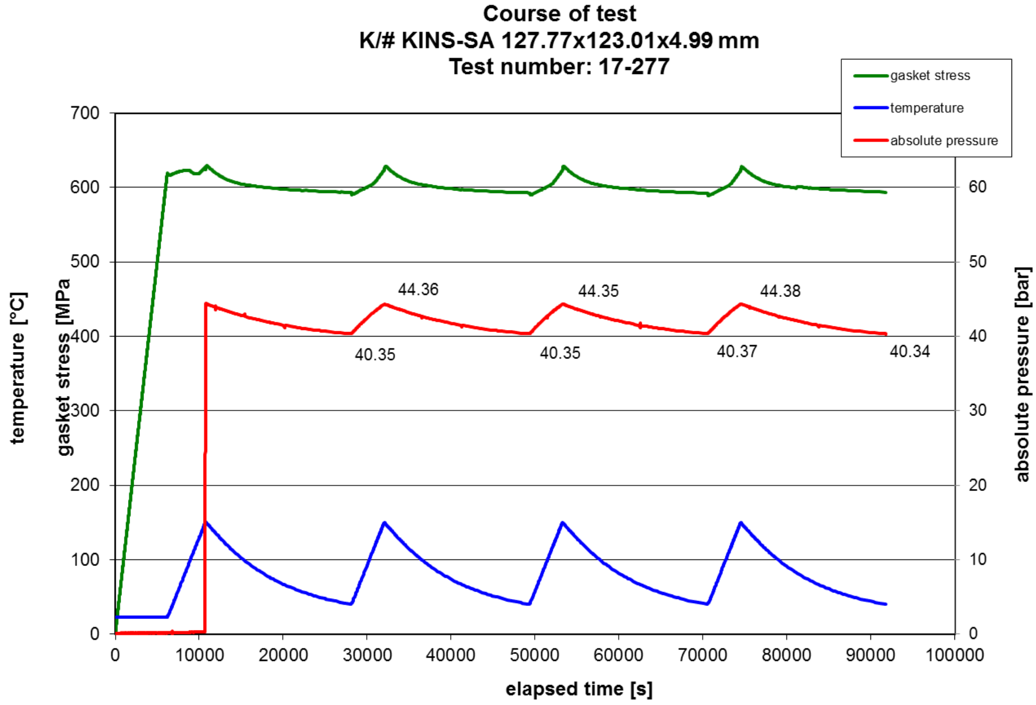
Remaining gasket stress Q_r:	133.8	MPa
Relaxation factor P_{QR} (T_P):	0.84	
Deflection Δe_{Gc}:	47	µm







Leakage Test according EN 13555



Shell cycle test at 150 °C according MESC SPE 85/300 - 3.3.5

Hot Blow-Out Test HOBT

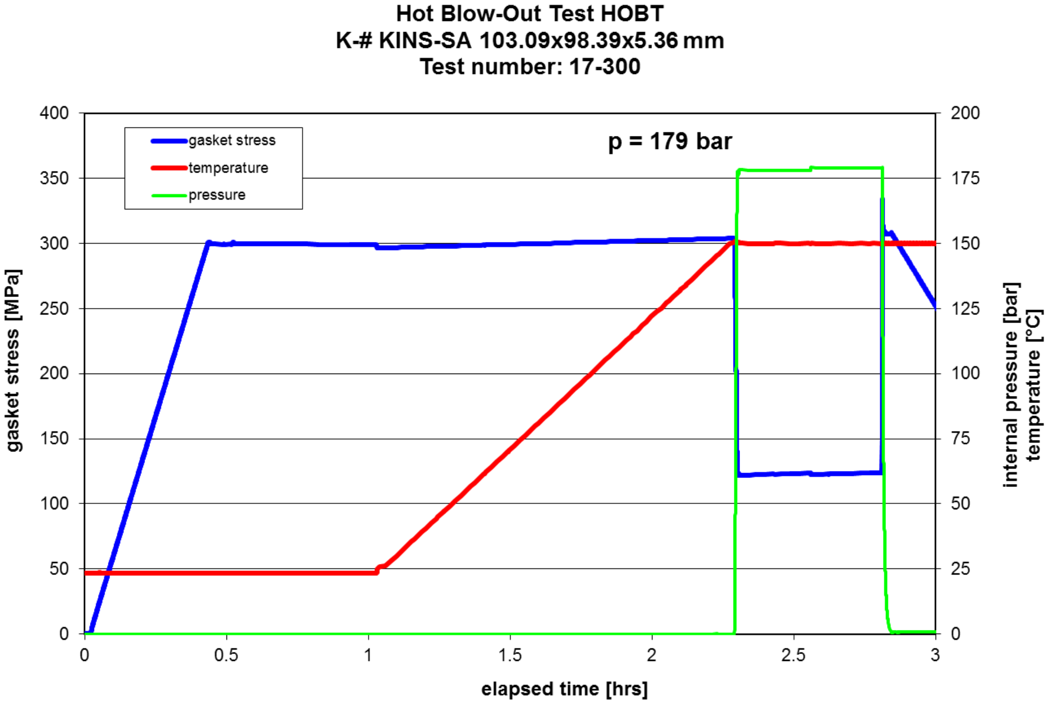
K-# KINS-SA
103.09x98.39x5.36 mm
Test number: 17-300

Test parameters

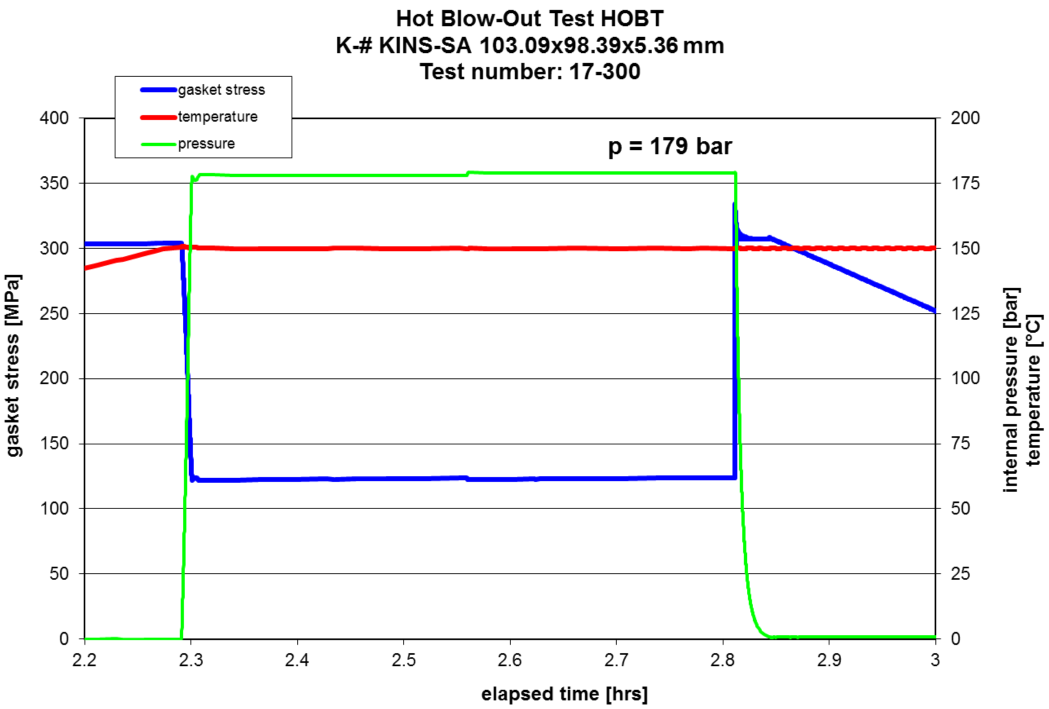
Nominal initial gasket stress:	43820	psi	302.1	MPa
Nominal pressure:	2611	psi	180	bar

Test results

Initial gasket thickness:	0.2110	in	5.36	mm
Final gasket thickness:	0.1201	in	3.05	mm
Initial gasket stress:	43660	psi	301.0	MPa
Actual test pressure:	2592	psi	179	bar
Gasket stress S_g:	43981	psi	303.2	MPa
Gasket temperature T_g:	302	°F	150	°C



HOBT1 - MESC SPE 85/300 - 3.3.6



HOBT1 - MESC SPE 85/300 - 3.3.6

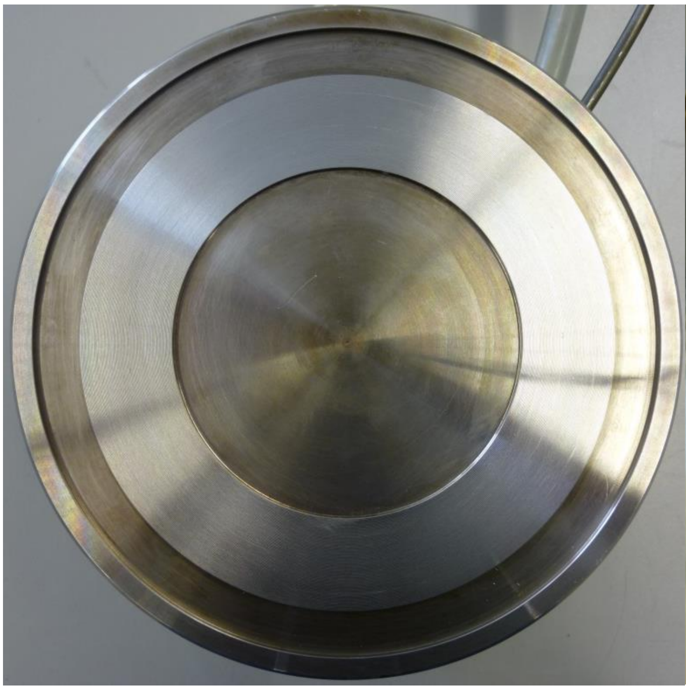
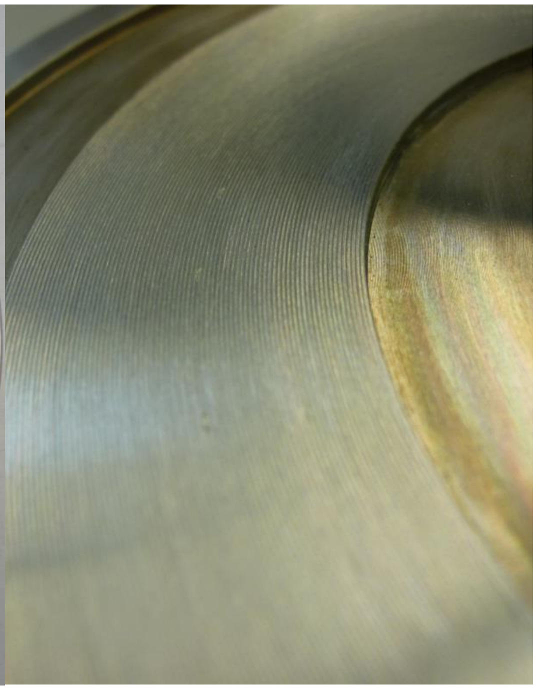
Kukil Insulation Kit K# KINS-SA 17-225

geometries

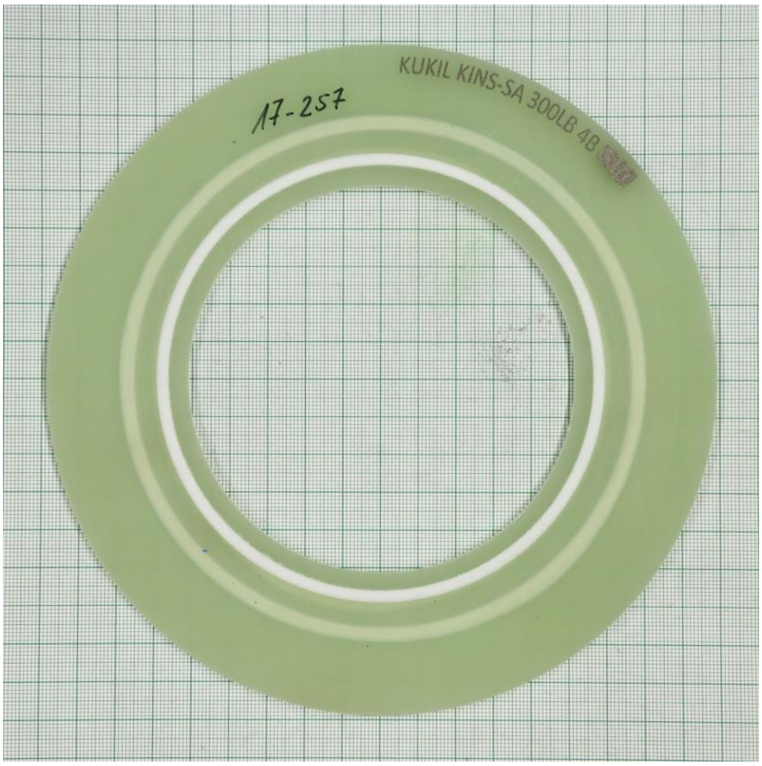
bolts	8	-
OD gasket	127.7	mm
ID gasket	123.0	mm
mean gasket circumference contact area	393.8	mm
gasket area	925.4	mm²
gasket contact area	925.4	mm²
OD raised faces flange (4" Class 300)	155	mm

calculation of gasket stress

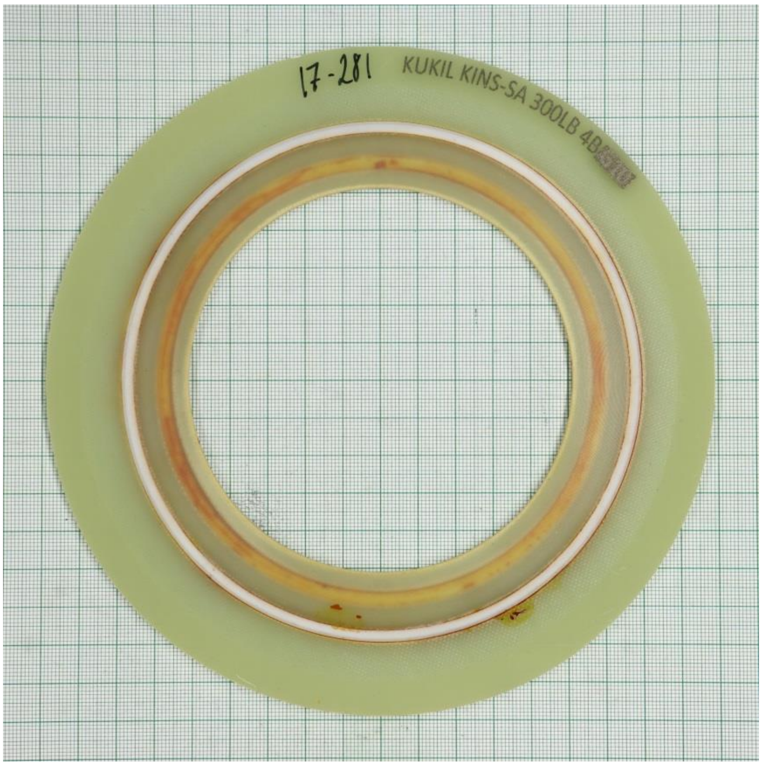
hydraulic spanners - No.	GS 3/1	-
pressure	430	bar
force per bolt	67.1	kN
force total	536.6	kN
gasket stress	579.9	MPa

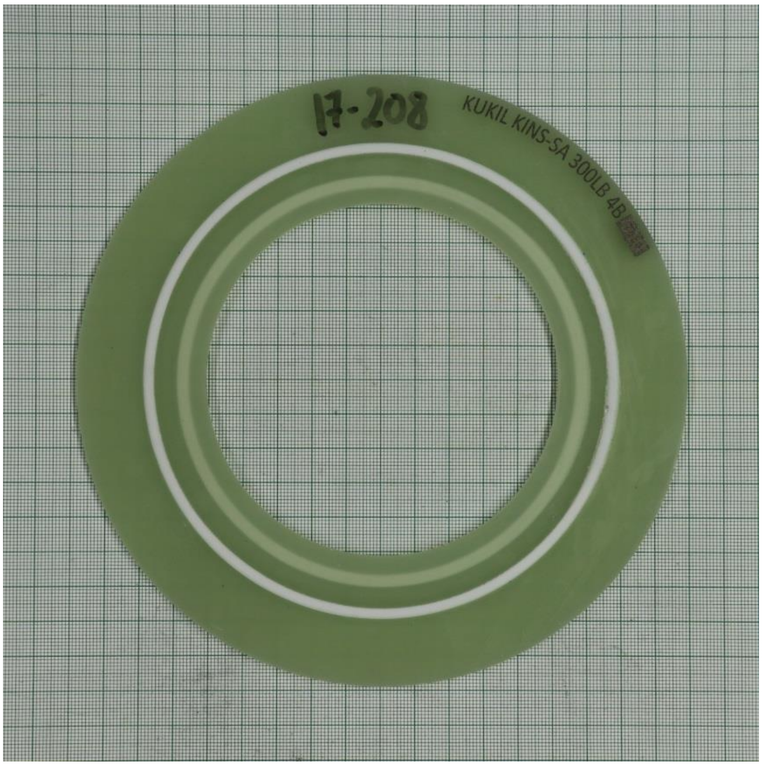
Top flange gasket adhesion

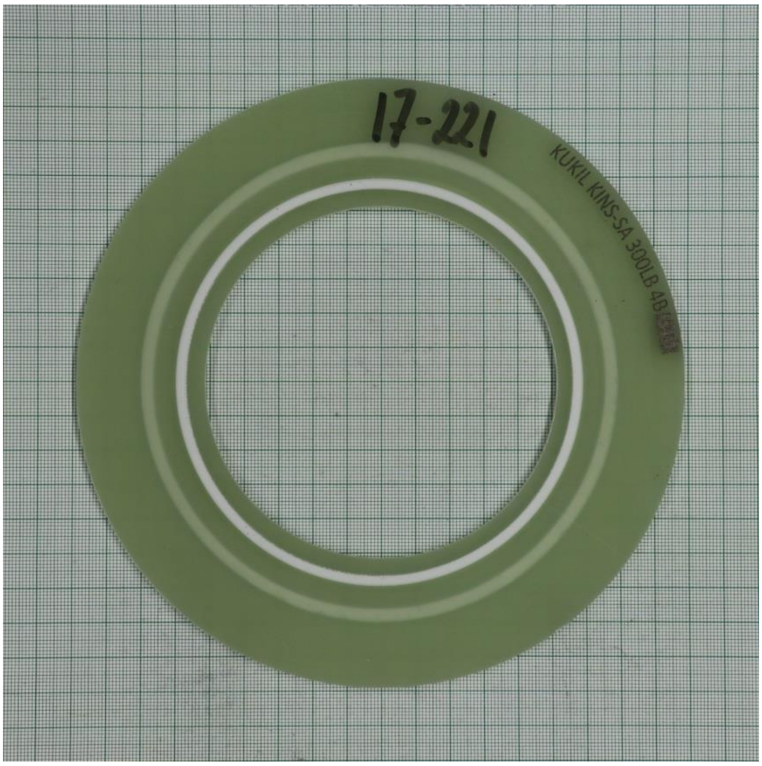
Shell leakage test (RT) according MESC SPE 85/300 - 3.3.2



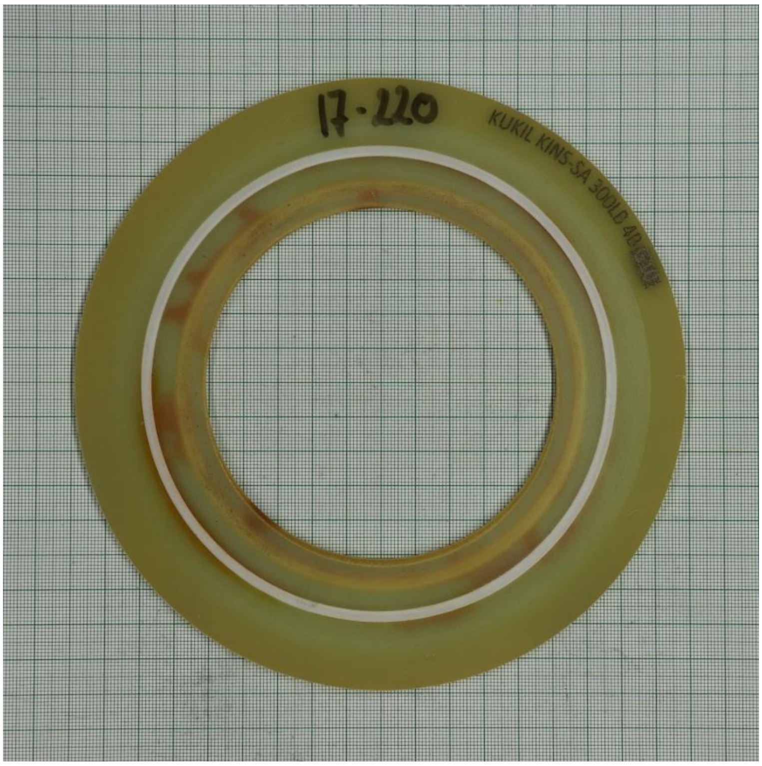
Shell leakage test (T) according MESC SPE 85/300 - 3.3.2



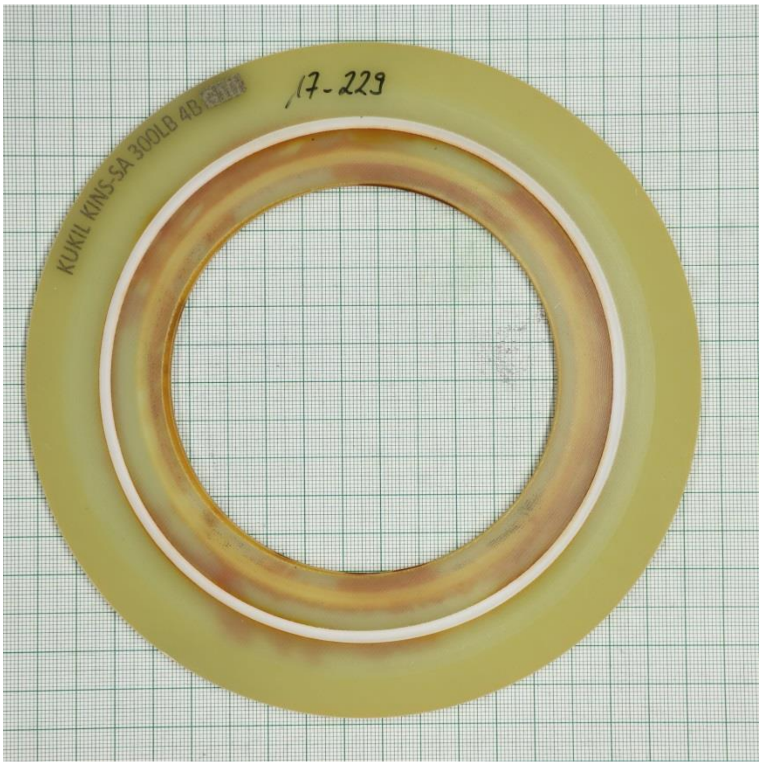
Compression Test at RT (EN 13555)



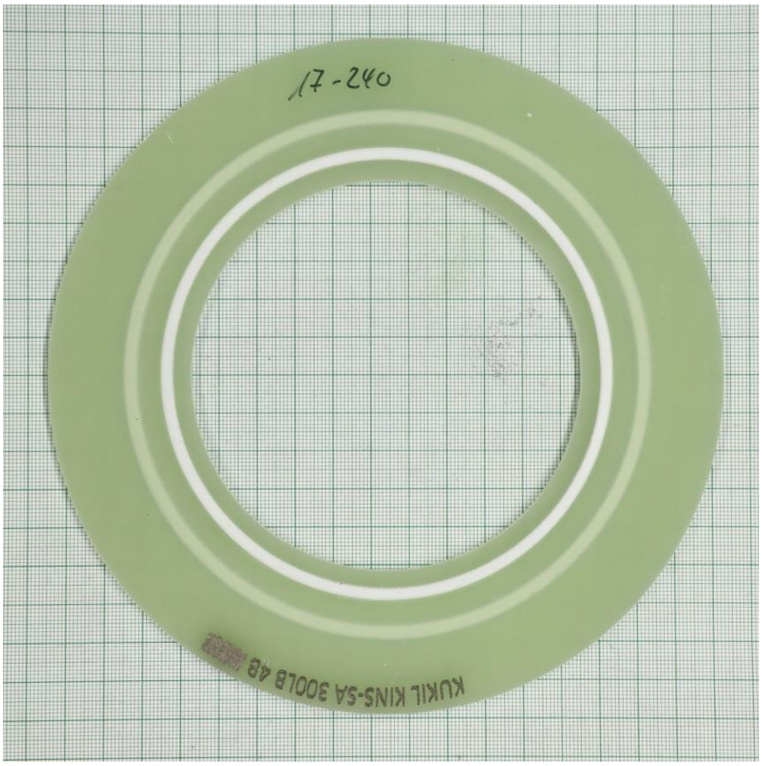
Compression Test at RT (EN 13555)



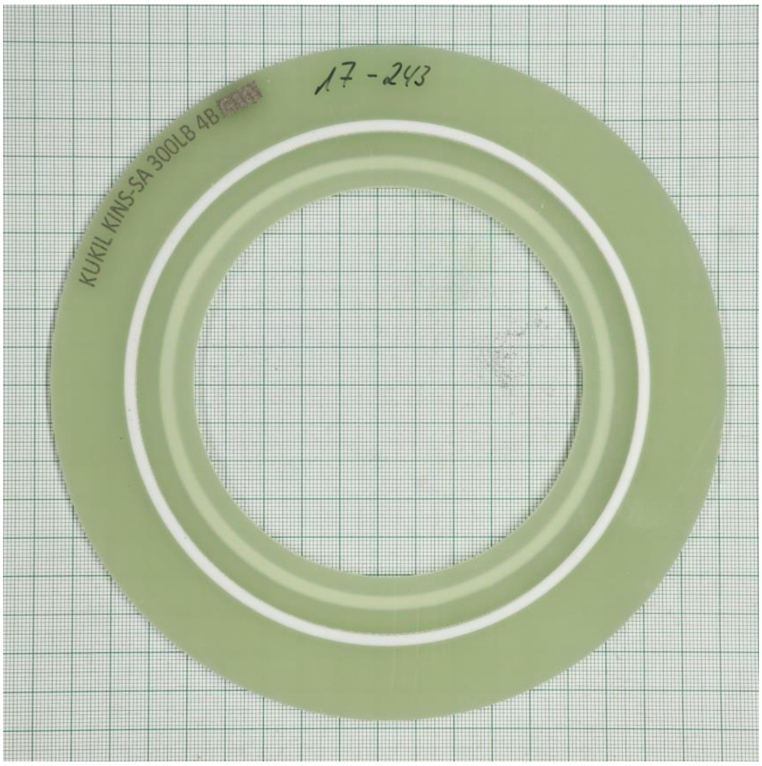
Compression Test at 150 °C (EN 13555)



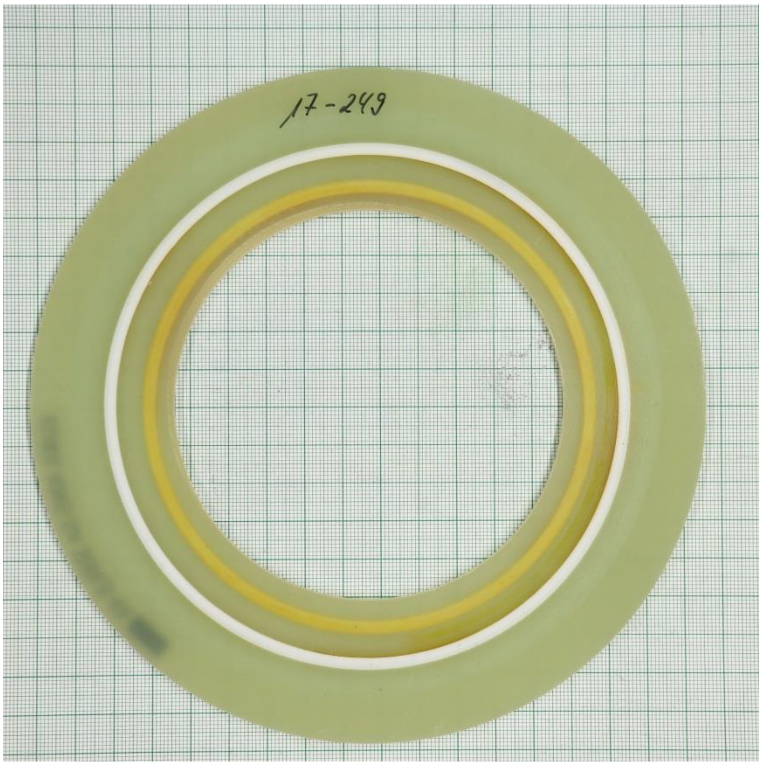
Compression Test at 150 °C (EN 13555)



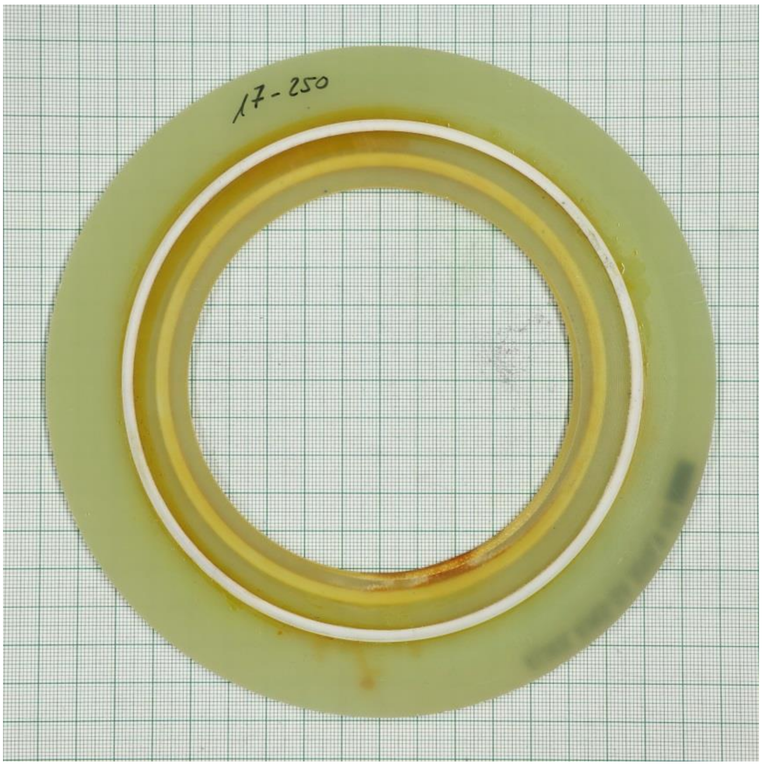
Creep Relaxation Test at 160 MPa - RT (EN 13555)



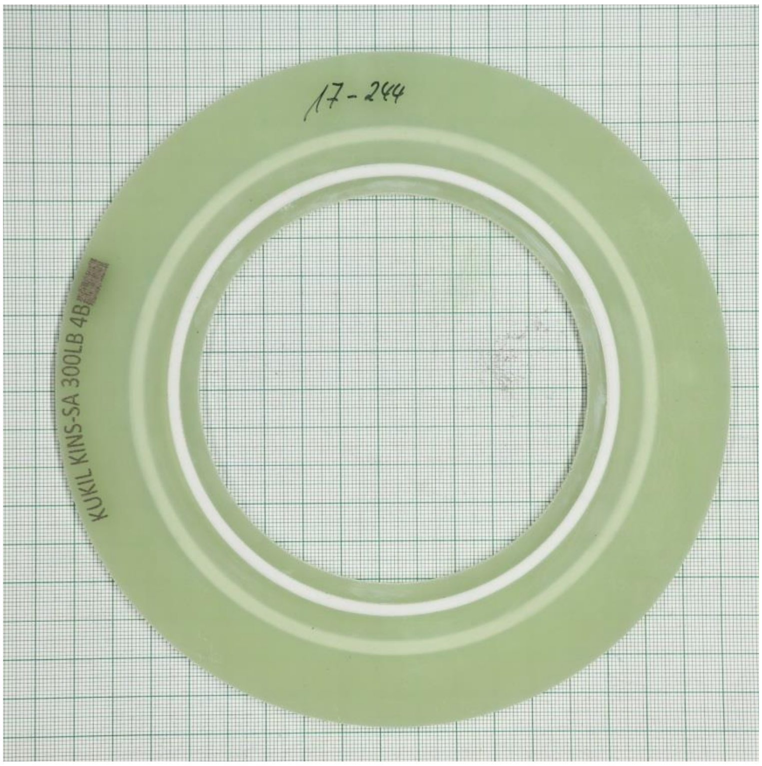
Creep Relaxation Test at 160 MPa - RT (EN 13555)



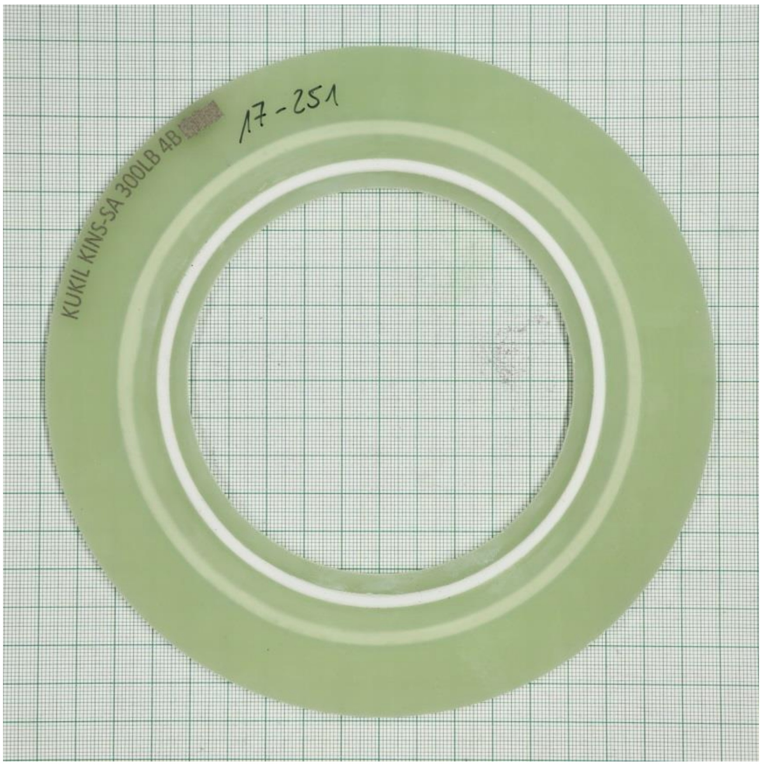
Creep Relaxation Test at 160 MPa - 150 °C (EN 13555)



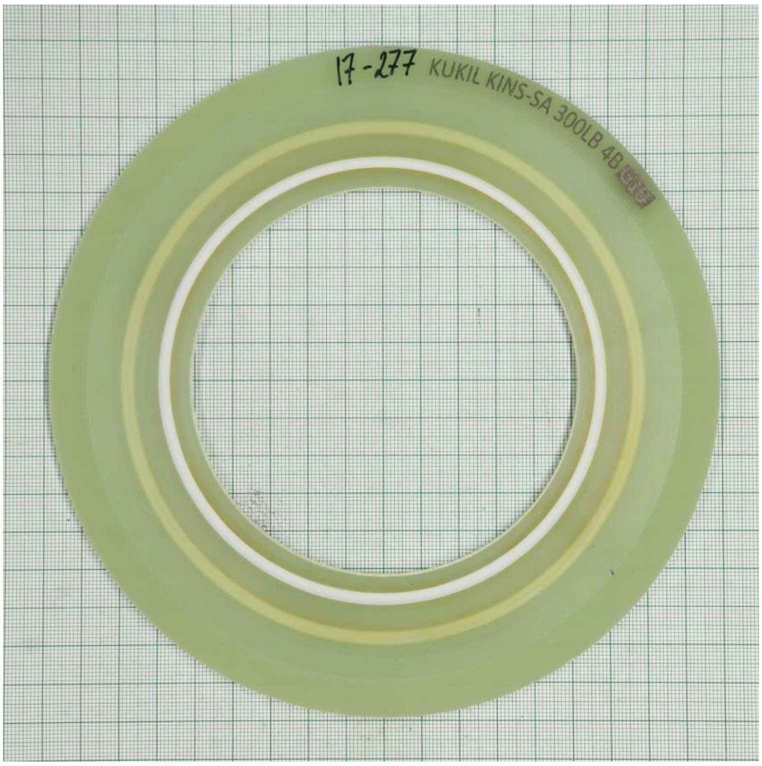
Creep Relaxation Test at 160 MPa – 150 °C (EN 13555)



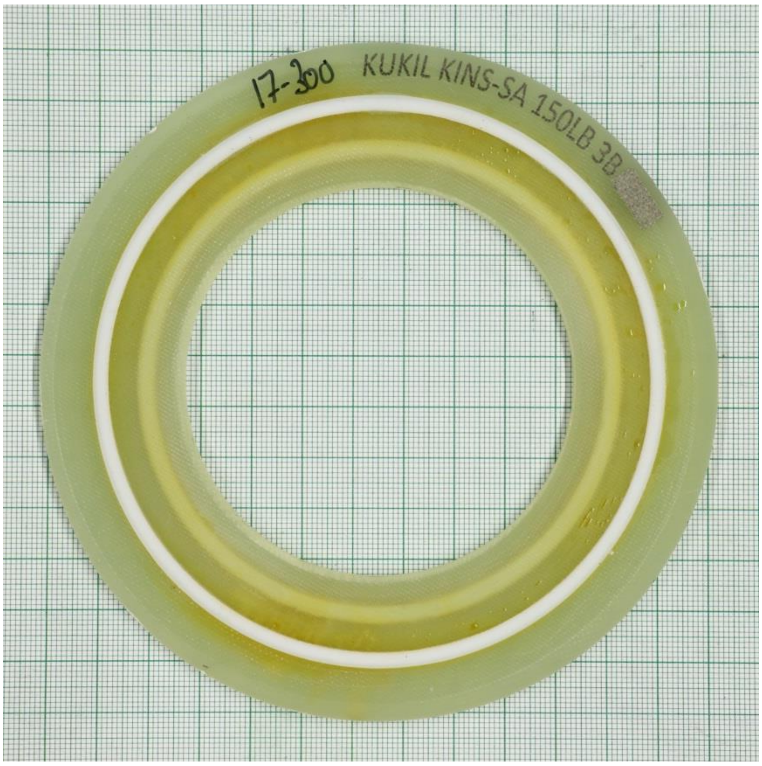
Leakage Test at RT (EN 13555)



Leakage Test at RT (EN 13555)



Shell cycle test (T) according MESC SPE 85/300 - 3.3.5



HOBT1 - MESC SPE 85/300 - 3.3.6

Shell electrical isolation test according MESC SPE 85/300 - 3.3.15
Insulation Gasket K/# KINS-SA (after test)

Shell electrical isolation test according MESC SPE 85/300 - 3.3.15
Insulation Gasket K/# KINS-SA (insulation gasket kit)