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D-PL-12008-01-00

Test Report

Customer:	Kukil Inntot Co., Ltd. 17 Tapgeol-gil, KOR - 689-871 Ulsan
Project number (amtec):	303 360
Report number:	303 360 2/a
Test procedure:	Shell Specification MESC SPE 85/300 (dated February 2016)
Material:	Insulation Gasket – K/# KINS-HA
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-HA.

The gaskets consist of a 6.7 mm resp. 7.0 mm thick metal core laminated with glass fiber reinforced epoxy on both sides and a PTFE-seal on both sides. The PTFE-seal is bonded in a groove on each side of the gasket.

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).

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.

Geometry of the PTFE sealing element of the Insulation Gasket K/# KINS-HA:
- Ø 131.3 mm x Ø 126.3 mm x 9.1 mm (4" Class 300)
- Ø 99.8 mm x Ø 95.0 mm x 9.2 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).

Within all tests a variation of nearly 0.5 mm of the thickness of the PTFE sealing element could be measured prior testing.

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 $1.0x10^{-4}$ 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 568.1 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 OD of 131.3 mm and ID of 126.3 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 5 MPa, holding the load and measuring the leak rate and then raising the gasket stress to 10 MPa. The load is then held whilst the leak rate is measured. In the next step the load is reduced to 5 MPa and the leak rate is measured. Then measurements are done for the next loading - unloading cycle at 20 MPa, 10 MPa, and 5 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 617 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 302.8 MPa (43,917.427 psi).

2. The gasket is left undisturbed for 5 minutes before it is reloaded up to 302.8 MPa (43,917.427 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-HA 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 $1.2 \cdot 10^{-8}$ Pa·m³/s/mm, see **appendix 7**. The leak rate was nearly constant with increasing gasket stress up to 700 MPa. The leak rate at a gasket stress of 570 MPa, which is equivalent to a bolt stress of 361 MPa, was $1.7 \cdot 10^{-8}$ Pa·m³/mm/s, which is below the Tightness Class B.

For the maximum gasket surface stress of 700 MPa the leak rate was $1.5 \cdot 10^{-8}$ 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 8 steps from 100 MPa to 700 MPa. The leak rate at 100 MPa gasket stress at an internal pressure of 45.1 bar was $6.7 \cdot 10^{-9}$ Pa·m³/s/mm, see appendix 7. The leak rate was decreasing with increasing gasket stress up to 300 MPa and with higher gasket stress nearly constant at a very low level. The leak rate at a gasket stress of 570 MPa, which is equivalent to a bolt stress of 361 MPa, was $5.0 \cdot 10^{-10}$ Pa·m³/mm/s, which is below the Tightness Class A.

For the maximum gasket surface stress of 700 MPa the leak rate was $8.8 \cdot 10^{-10}$ Pa·m³/s/mm, which is also 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-HA 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 a load of 360 MPa or 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 RT is set to 500 MPa.

In both compression tests at 150 °C no damage of the gasket specimen can be recognized until a load of 500 MPa or 460 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 up to 200 MPa. With a gasket stress above 200 MPa the modulus of elasticity E_G stays at a constant level in the first test and increases steadily until the maximum load in the second test.

The modulus of elasticity E_G at elevated temperature at 150 °C increases steadily up to a gasket stress of 180 MPa with increasing gasket stress. With a gasket stress above 180 MPa the modulus of elasticity E_G decreases with increasing gasket stress.

The modulus of elasticity E_G at 150 °C is higher than the modulus of elasticity E_G at ambient temperature.

With all compression tests the PTFE sealing element was totally compressed into the groove (block situation) up to a gasket stress level of 100 MPa.

6.2.2 Creep Relaxation Tests

In appendix 3 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 1.00 (160 MPa, RT, 500 kN/mm) and 1.00 (160 MPa, 150 °C, 500 kN/mm). The deflection Δe_{Gc} of the gasket Insulation Gasket K/# KINS-HA at RT are 2 µm and in tests at 150 °C are 1 µm.

A very good repeatability of the double test is noticeable.

6.2.3 Leakage Tests

The tightness behaviour of the gasket material Insulation Gasket K/# KINS-HA 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 19 MPa or 20 MPa, respectively. Therefore the minimum gasket stress in assembly for the tightness class $L_{0.01}$ is set to $Q_{min(0.01)}$ = 20 MPa. The lowest tightness class which could be reached was $L_{0.001}$; therefore a gasket stress of 32 MPa resp. 31 MPa is necessary.

The leak rate is decreasing with an increasing gasket stress up to 60 MPa. With a gasket stress above 60 MPa the leak rate stays nearly at the same level. The lowest leak rate which could be measured was $1.3 \cdot 10^{-4}$ mg/m/s at 160 MPa in test 17-239.

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 60 MPa is $Q_{smin(0.01)}$ = 10 MPa in both tests.

A good repeatability of the double test is noticeable.

6.3 HOTT: Shell cycle test at 400 °C (MESC SPE 85/300 – 3.3.5)

For the Shell cycle test at elevated temperature the Insulation Gasket K/# KINS-HA was compressed initially with 617 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, therefore the pressure loss is less than 0.1 bar. The gasket material Insulation Gasket K/# KINS-HA 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-HA 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-HA 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-HA has passed the Hot Blow-Out test at a temperature of 150 °C with an initial gasket stress of 302.8 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-HA 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 619.49 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-HA 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 8.1 GΩ.

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

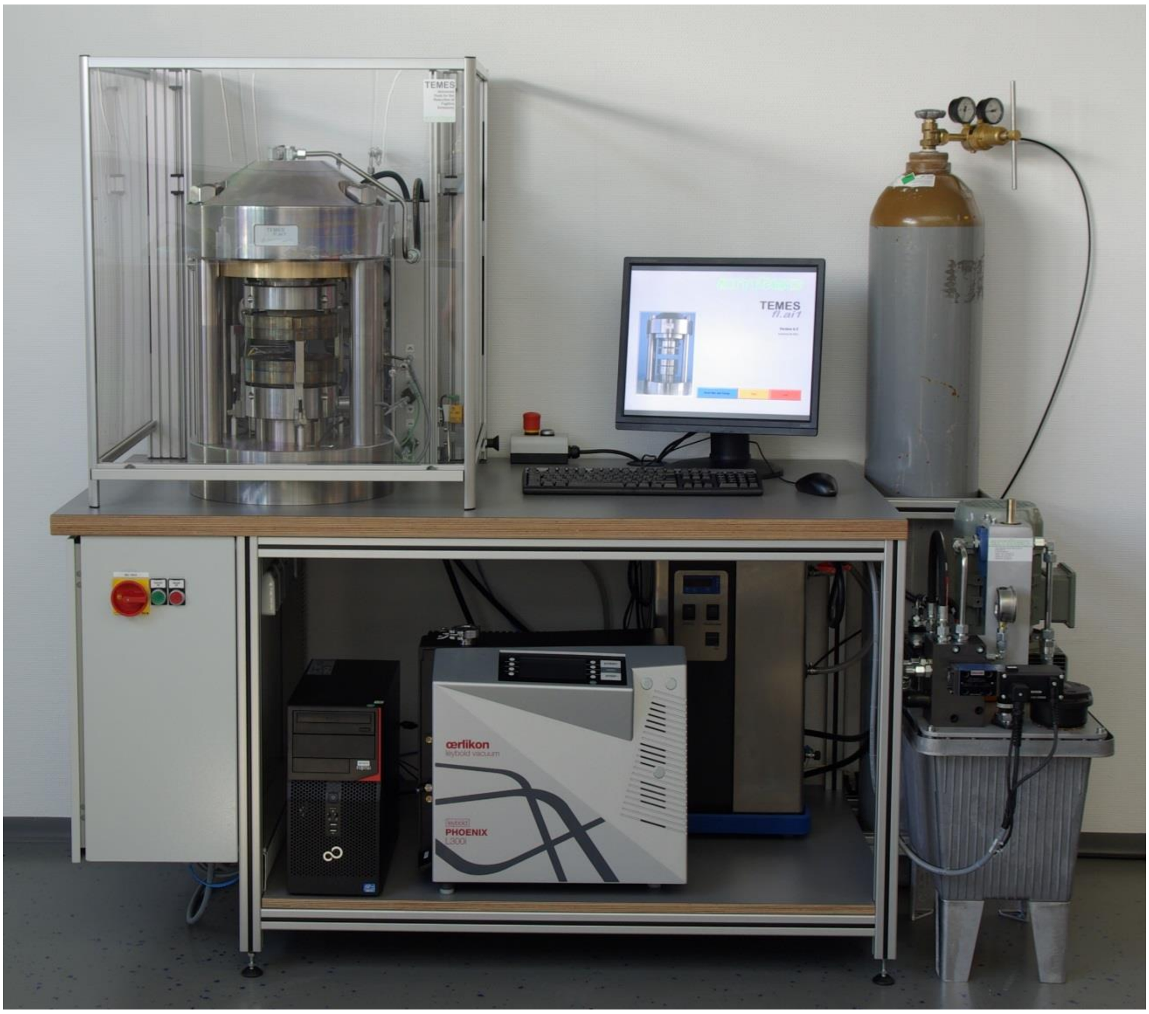
6.6 Gasket adhesion (MESC SPE 85/300 – 3.3.13)

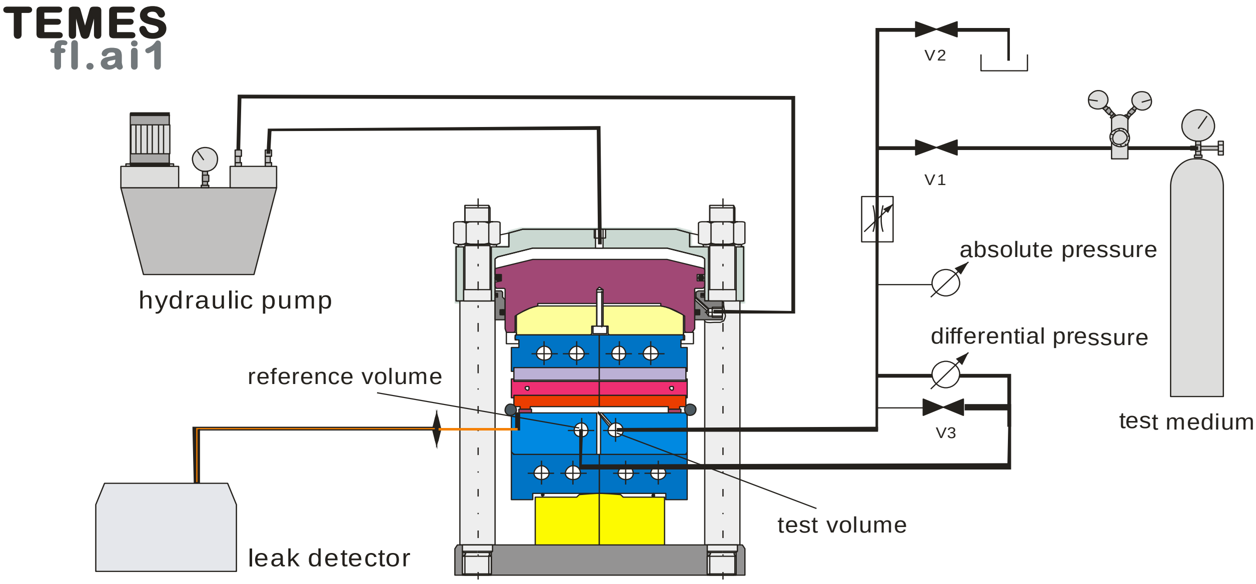
In **appendix 21** photos of the adjacent flanges after tests at ambient temperature with the gasket specimens Insulation Gasket K/# KINS-HA are represented. The gasket does not stick on the flange.

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-HA 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-HA**

Maximum allowable Gasket Stress Q_{smax} [MPa]

T [°C]	25	25	150	150
Q_{smax} [MPa]	500	500	500	500
Test #	17-110	17-180	17-132	17-193

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		9.510		9.360		9.410		9.240
1		9.439		9.213		9.338		9.149
20	671	7.681	781	7.433	830	7.216	1012	7.048
30	1422	7.417	1676	7.256	1951	7.097	1918	7.007
40	2560	7.303	2570	7.160	4080	7.079	3586	6.987
50	4229	7.258	3281	7.092	13369	7.072	8295	6.973
60	6414	7.235	3955	7.042	27168	7.068	15318	6.965
80	13022	7.222	5653	6.982	65472	7.067	37593	6.963
100	22744	7.215	9338	6.959	116973	7.065	68801	6.961
120	31989	7.209	15953	6.952	140474	7.064	93769	6.958
140	38873	7.204	26601	6.947	152474	7.062	126726	6.957
160	44188	7.199	41506	6.943	170518	7.060	136876	6.955
180	48033	7.196	56112	6.940	156305	7.058	154029	6.954
200	52453	7.192	65909	6.937	137855	7.056	137876	6.952
220	52556	7.189	73066	6.935	118637	7.054	122503	6.950
240	54309	7.185	83926	6.933	116002	7.052	119193	6.947
260	56448	7.182	91598	6.931	103308	7.050	115479	6.946
280	56694	7.179	104257	6.930	95843	7.047	111553	6.943
300	56613	7.175	111636	6.928	89573	7.044	105021	6.941
320	56978	7.172	117190	6.926	87185	7.042	104823	6.940
340	58381	7.169	123577	6.925	83439	7.040	94621	6.937
360	59014	7.167	124884	6.923	81493	7.037	90825	6.935
380			130816	6.922	78414	7.035	89962	6.933
400			134692	6.921	76482	7.032	88363	6.930
420			136426	6.919	74741	7.030	84987	6.928
440			138982	6.918	73541	7.027	81837	6.926
460			139570	6.917	71992	7.025	82576	6.924
480			145602	6.916	70372	7.022		
500			146801	6.915	70633	7.020		
Test #	17-110		17-180		17-132		17-193	

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	1.0	1.0	1.0	1.0
	Δe_{GC} [µm]	2	2	1	1
	Versuch	17-205	17-236	17-201	17-266

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

Manufacturer: Kukil Inntot Co., Ltd.

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

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

L / p [bar]	10	1	0.1	0.01	0.001	0.0001	0.00001	0.000001
40	10	13	15	20	32	-	-	-
Test #	17-234							
40	10	12	15	19	31	-	-	-
Test #	17-239							

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

	L / Q_A [MPa]	10	1	0.1	0.01	0.001	0.0001	0.00001	0.000001
p = 40 bar	20	5	5	6	12	-	-	-	-
	40	5	5	6	11	27	-	-	-
	60	5	5	5	10	27	-	-	-
	80	5	5	5	10	26	-	-	-
	100	5	5	5	10	26	-	-	-
	160	5	5	5	9	25	-	-	-
	Test #	17-234							

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

	L / Q_A [MPa]	10	1	0.1	0.01	0.001	0.0001	0.00001	0.000001
p = 40 bar	20	5	5	6	12	-	-	-	-
	40	5	5	6	11	27	-	-	-
	60	5	5	5	10	27	-	-	-
	80	5	5	5	10	26	-	-	-
	100	5	5	5	9	25	-	-	-
	160	5	5	5	8	24	-	-	-
	Test #	17-239							

Table 3: Data Sheet for Gasket Characteristics (Shell)

Manufacturer: Kukil Inntot Co., Ltd.

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

Shell leakage test at ambient temperature

Test pressure:	51 bar
Shell required gasket stresss level:	570 MPa
Leakage rate:	1.71E-08 Pa·m³/s/mm
Shell tightness class:	B
test no.	17-195

Shell leakage test at elevated temperature

Test pressure:	45 bar
Shell required gasket stresss level:	570 MPa
Leakage rate:	4.95E-10 Pa·m³/s/mm
Shell tightness class:	A
test no.	17-197

Shell cycle test at 150 °C

Test pressure:	45 bar
Initial gasket stresss level:	617 MPa
Pressure drop in last cycle:	< 0.1 bar
Requirements:	passed
test no.	17-258

Hot Blow-Out test (HOBT1)

Test pressure:	180 bar
Initial gasket stress level:	302.1 MPa
Temperature:	150 °C
Requirements	passed
test no.	17-299

Kukil Insulation Kit K# KINS-HA 17-227

geometries

gasket	Insulation Kit K# KINS-HA	
manufacture	Kukil	
OD gasket PTFE	130.4	mm
ID gasket PTFE	126.1	mm
gasket thickness	8.1	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

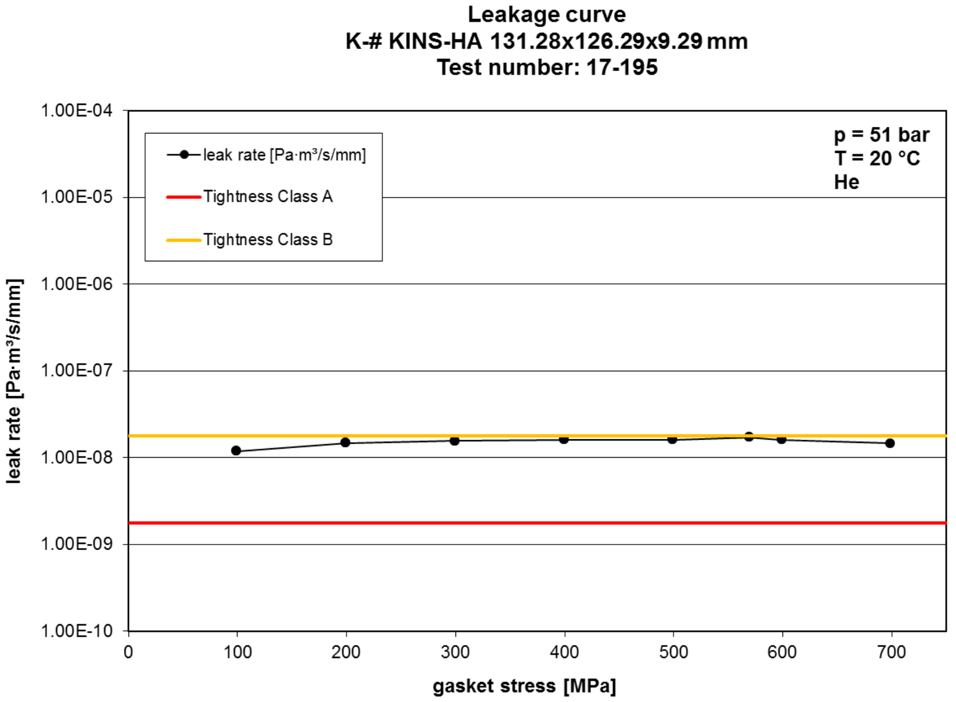
isolation test

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

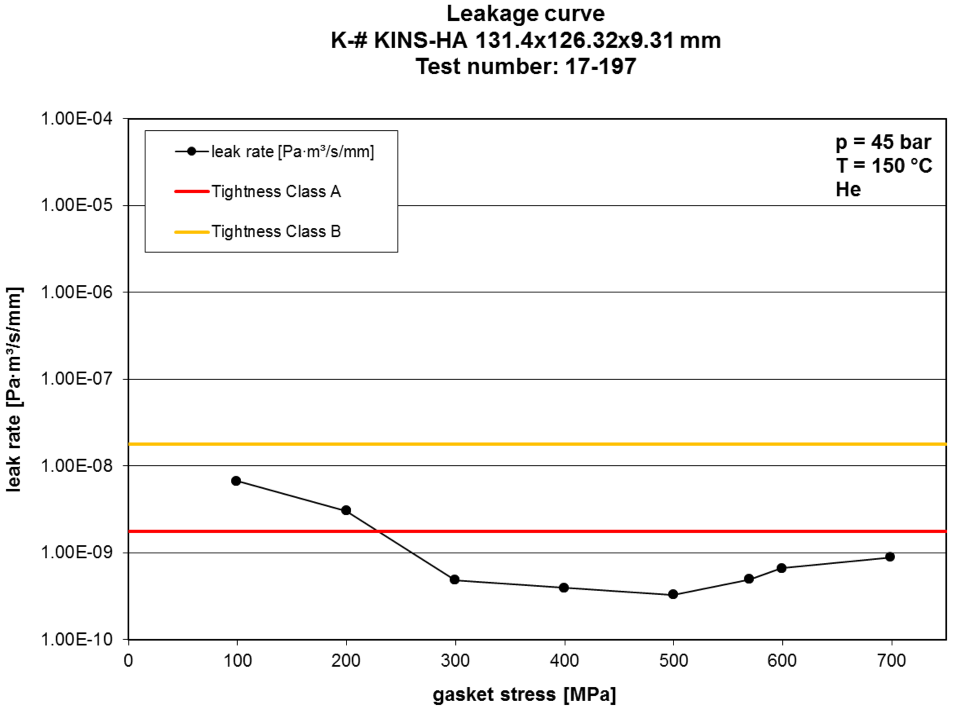
measuring data

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	**8.1**	**GΩ**

The insulation resistance of the gasket is <u>higher</u> than the minimum required value and <u>satisfys</u> the requirements of the SPE85-300.

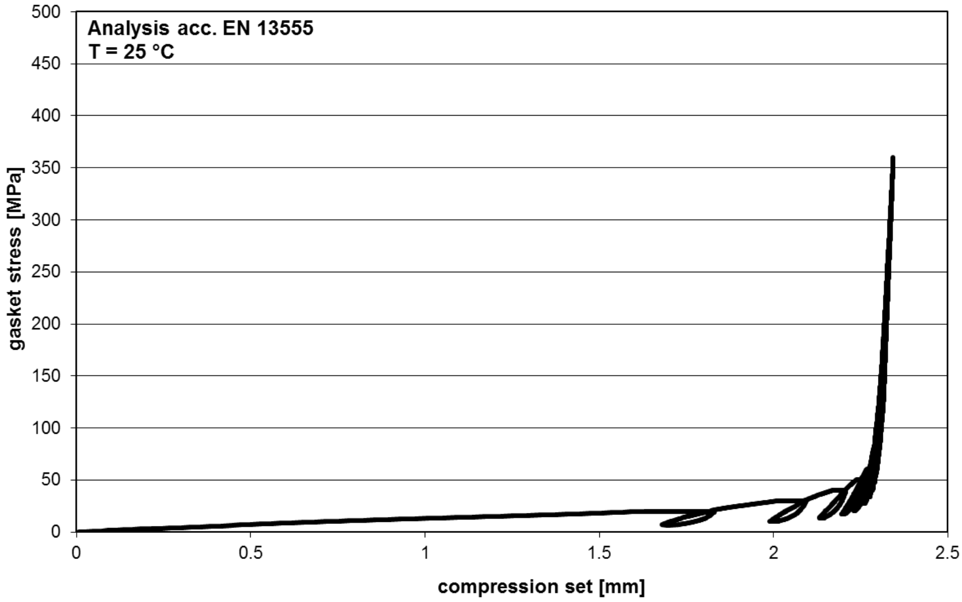


Shell leakage test (RT) according MESC SPE 85/300 - 3.3.2

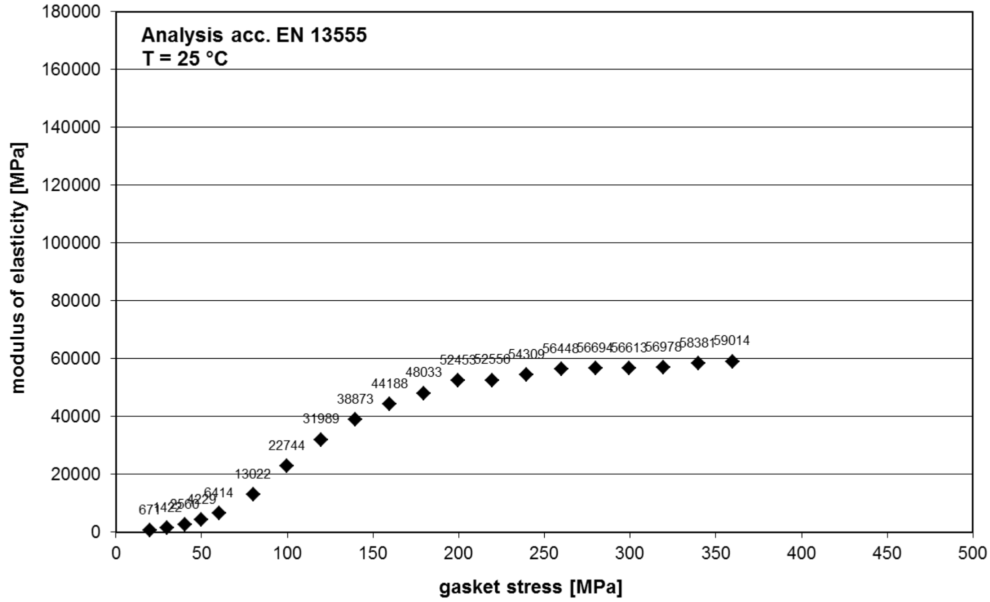


Shell leakage test (150 °C) according MESC SPE 85/300 - 3.3.2

Compression curve
K/# KINS-HA 131.34x126.48x9.51 mm
Test number: 17-110

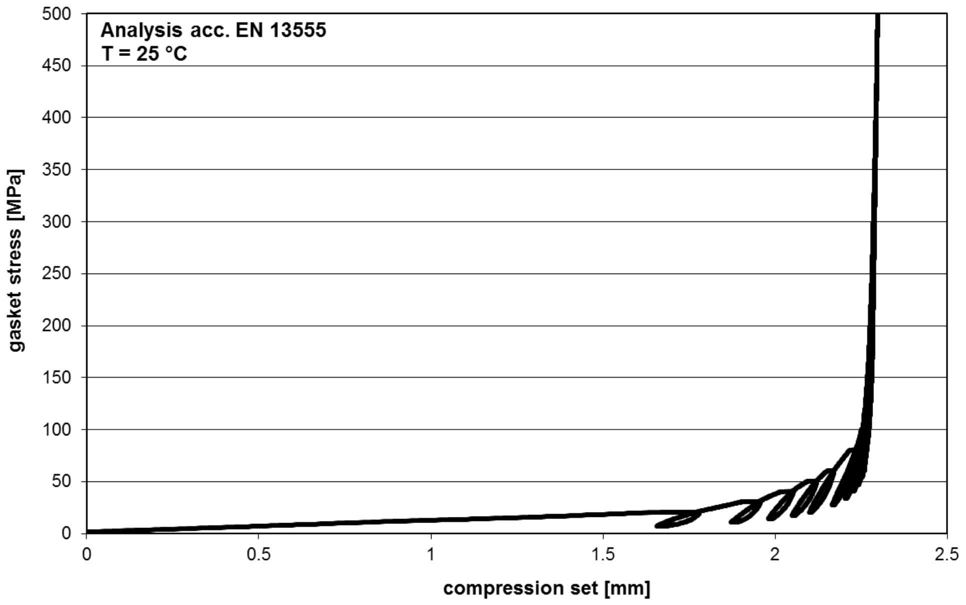


Modulus of elasticity
K/# KINS-HA 131.34x126.48x9.51 mm
Test number: 17-110

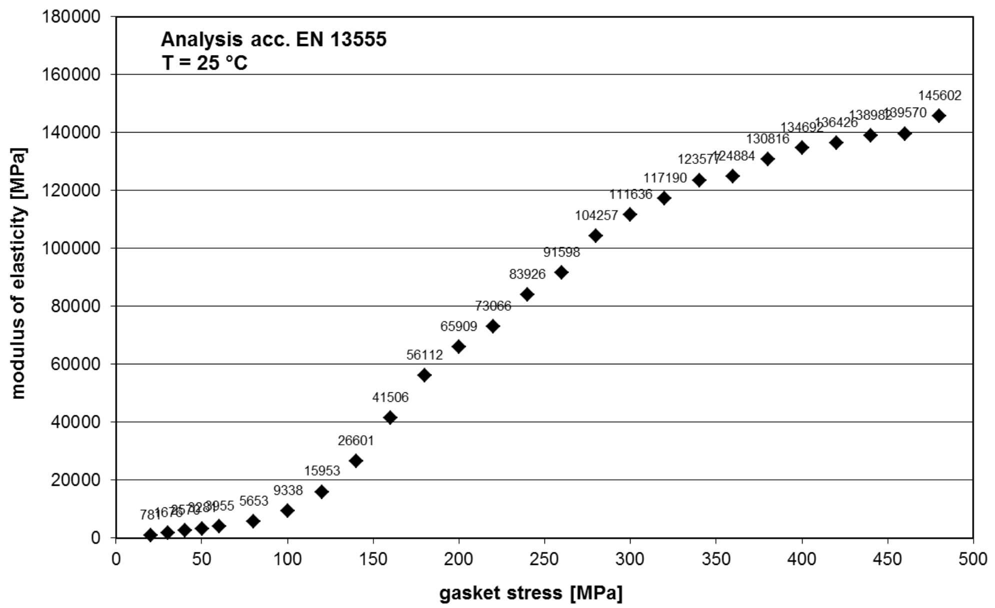


Compression Test (RT) according EN 13555

Compression curve
K/# KINS-HA 131.39x126.32x9.213 mm
Test number: 17-180

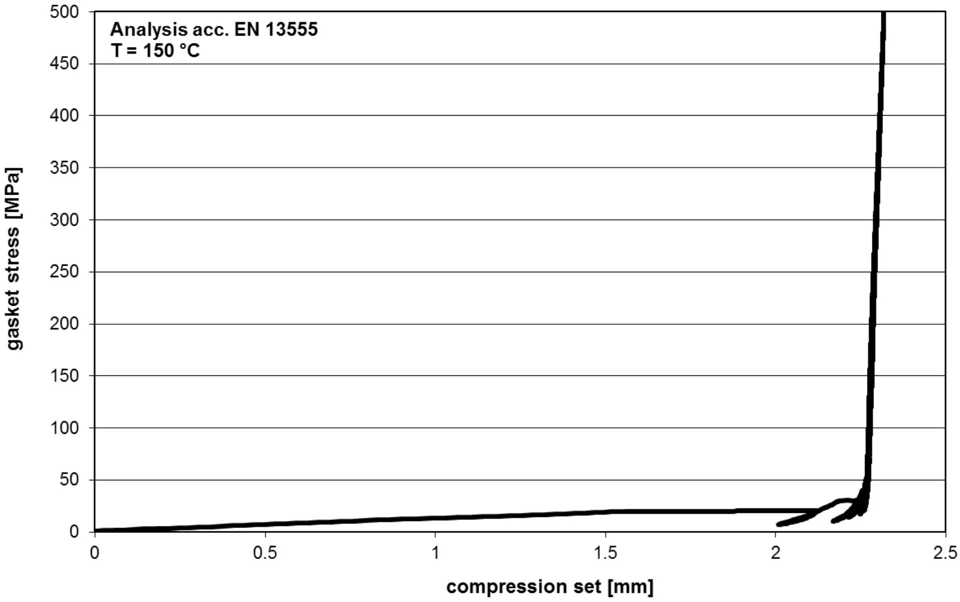


Modulus of elasticity
K/# KINS-HA 131.39x126.32x9.213 mm
Test number: 17-180

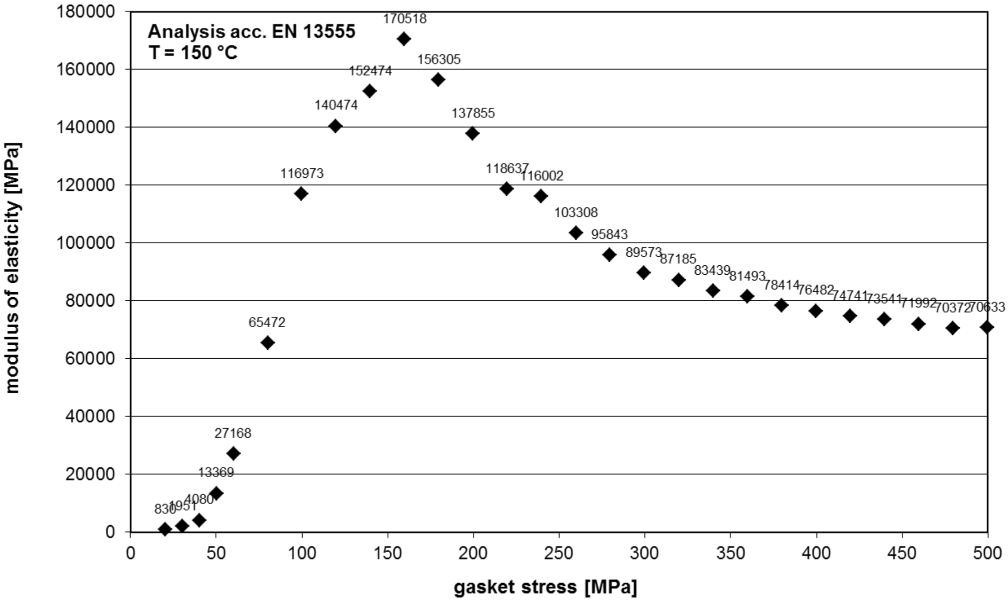


Compression Test (RT) according EN 13555

Compression curve
K/# KINS-HA 131.3x126.21x9.338 mm
Test number: 17-132

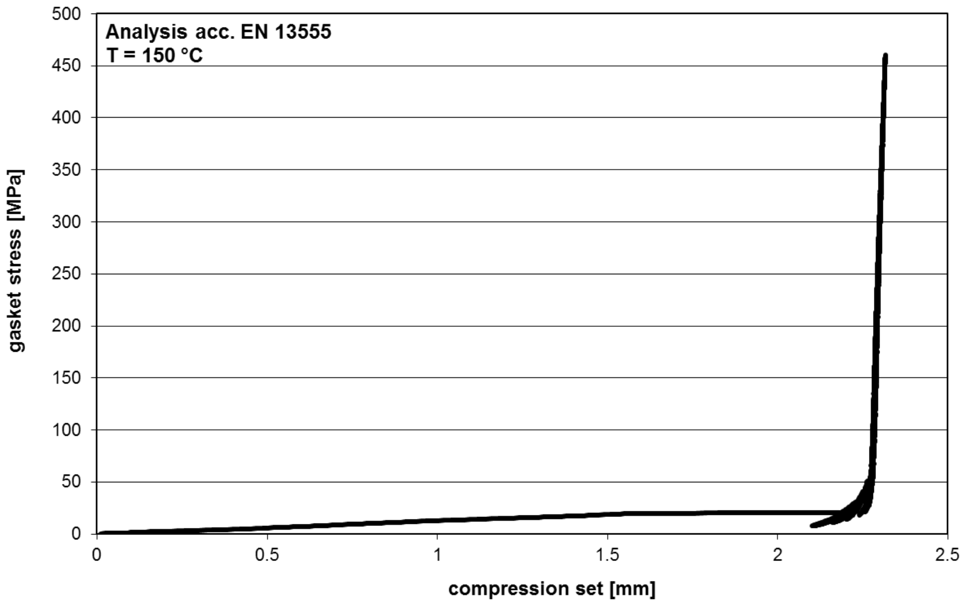


Modulus of elasticity
K/# KINS-HA 131.3x126.21x9.338 mm
Test number: 17-132

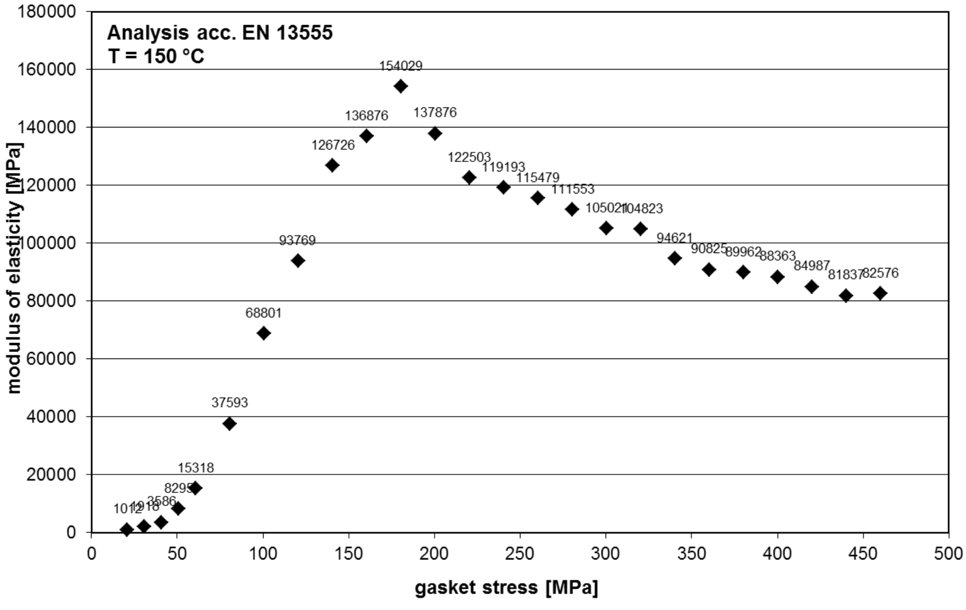


Compression Test at 150 °C according EN 13555

Compression curve
K/# KINS-HA 131.33x126.43x9.24 mm
Test number: 17-193



Modulus of elasticity
K/# KINS-HA 131.33x126.43x9.24 mm
Test number: 17-193



Compression Test at 150 °C according EN 13555

Creep relaxation test (EN 13555)

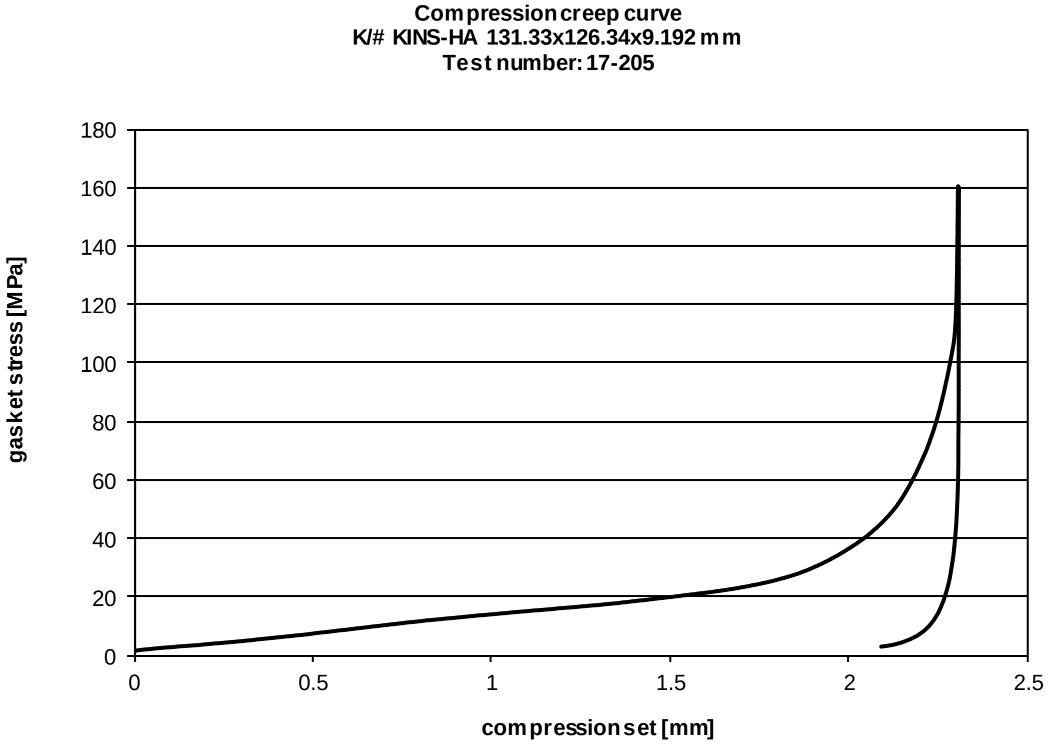
K/# KINS-HA
131.33x126.34x9.192 mm
Test number: 17-205

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:	159.7	MPa
Relaxation factor P_{QR} (T_P):	1.00	
Deflection Δe_{Gc}:	2	µm



Creep relaxation test (EN 13555)

K/# KINS-HA
131.23x126.24x8.962 mm
Test number: 17-236

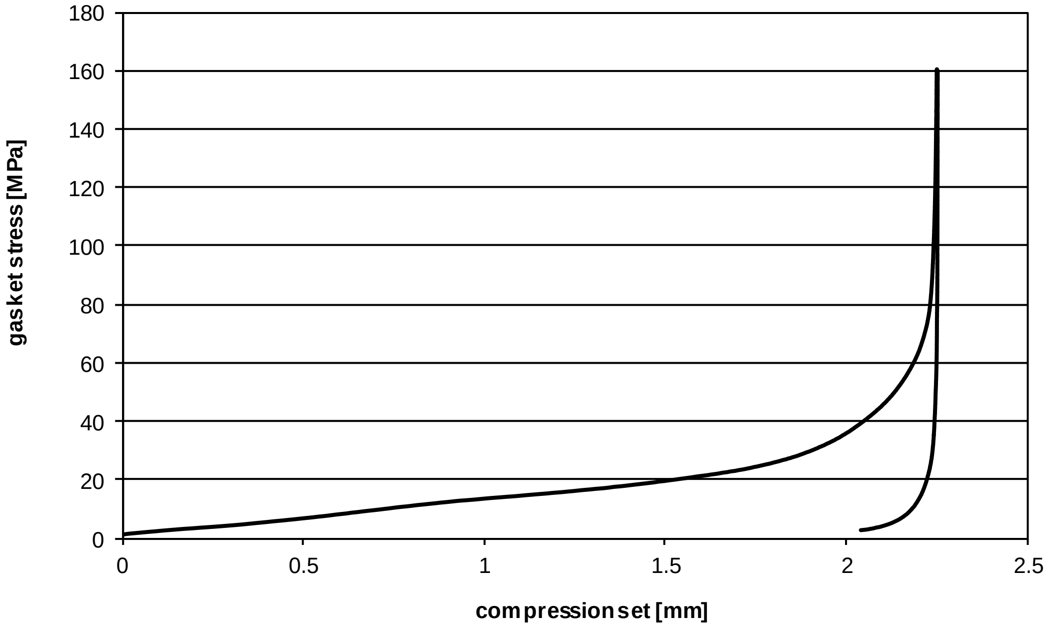
Test parameters

Initial gasket stress Q_i:	160.2	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:	159.7	MPa
Relaxation factor P_{QR} (T_P):	1.00	
Deflection Δe_{Gc}:	2	µm

Compression creep curve
K/# KINS-HA 131.23x126.24x8.962 mm
Test number: 17-236



Creep relaxation test (EN 13555)

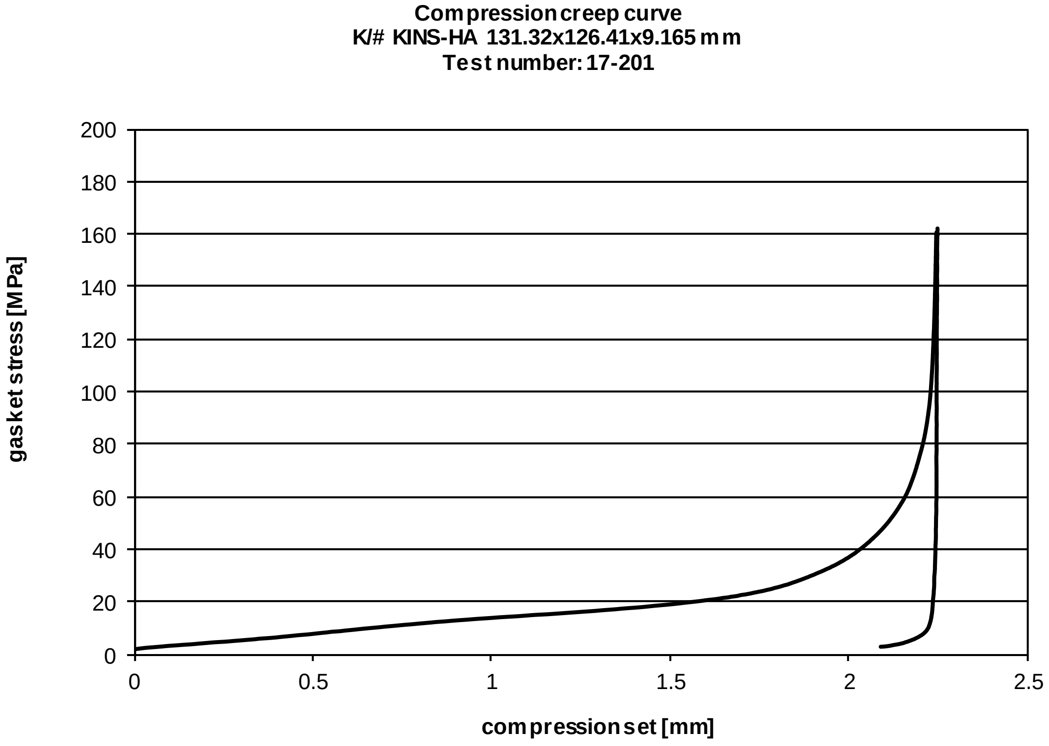
K/# KINS-HA
131.32x126.41x9.165 mm
Test number: 17-201

Test parameters

Initial gasket stress Q_i:	160.4	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:	160.3	MPa
Relaxation factor P_{QR} (T_P):	1.00	
Deflection Δe_{Gc}:	1	µm



Creep relaxation test (EN 13555)

K/# KINS-HA
131.27x126.15x9.271 mm
Test number: 17-266

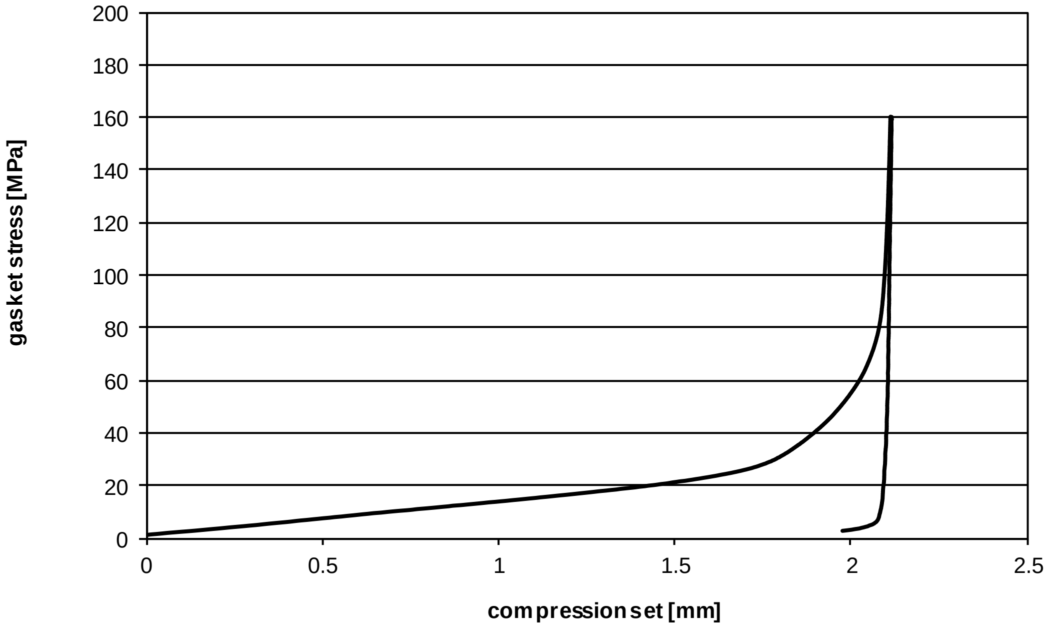
Test parameters

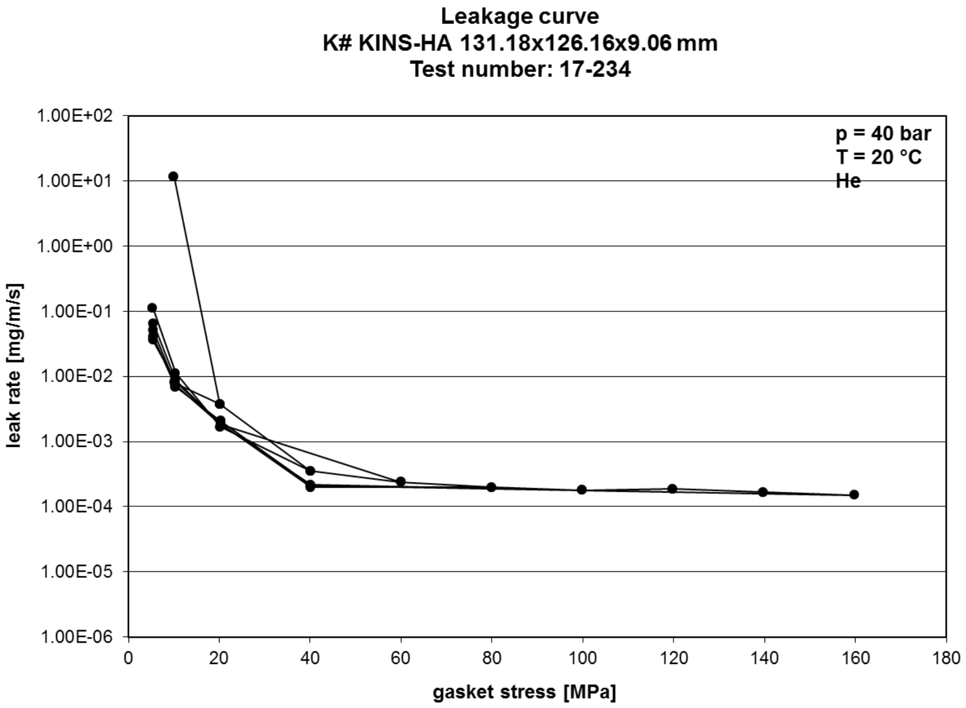
Initial gasket stress Q_i:	160.2	MPa
Test temperature T_P:	150	°C
Time at T_P:	4:00	hh:mm
Stiffness C:	500	kN/mm

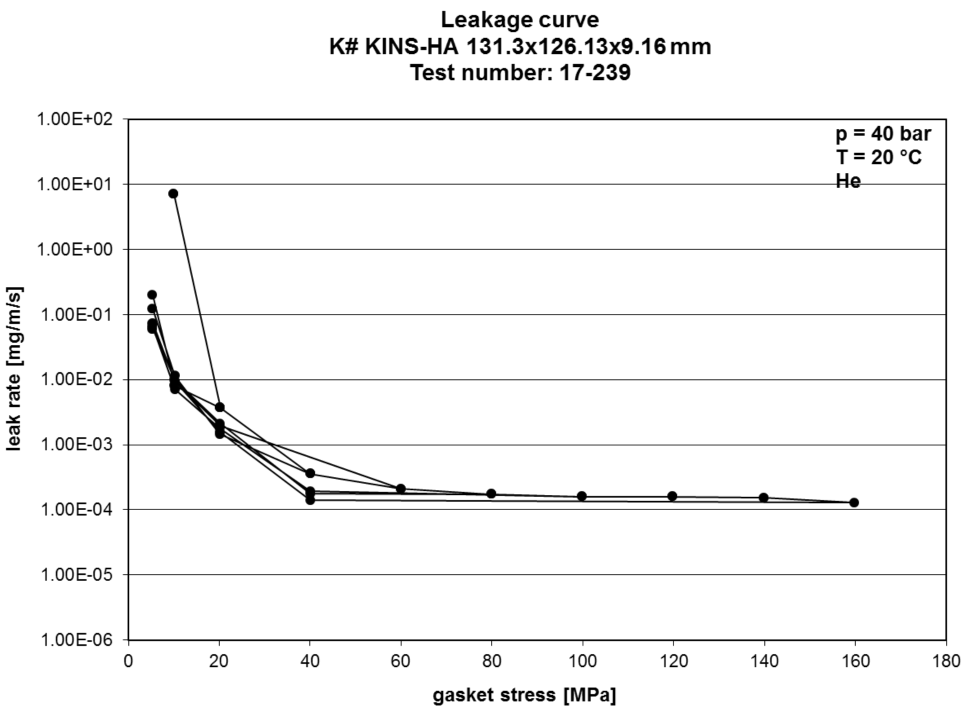
Test results

Remaining gasket stress Q_r:	160.1	MPa
Relaxation factor P_{QR} (T_P):	1.00	
Deflection Δe_{Gc}:	1	µm

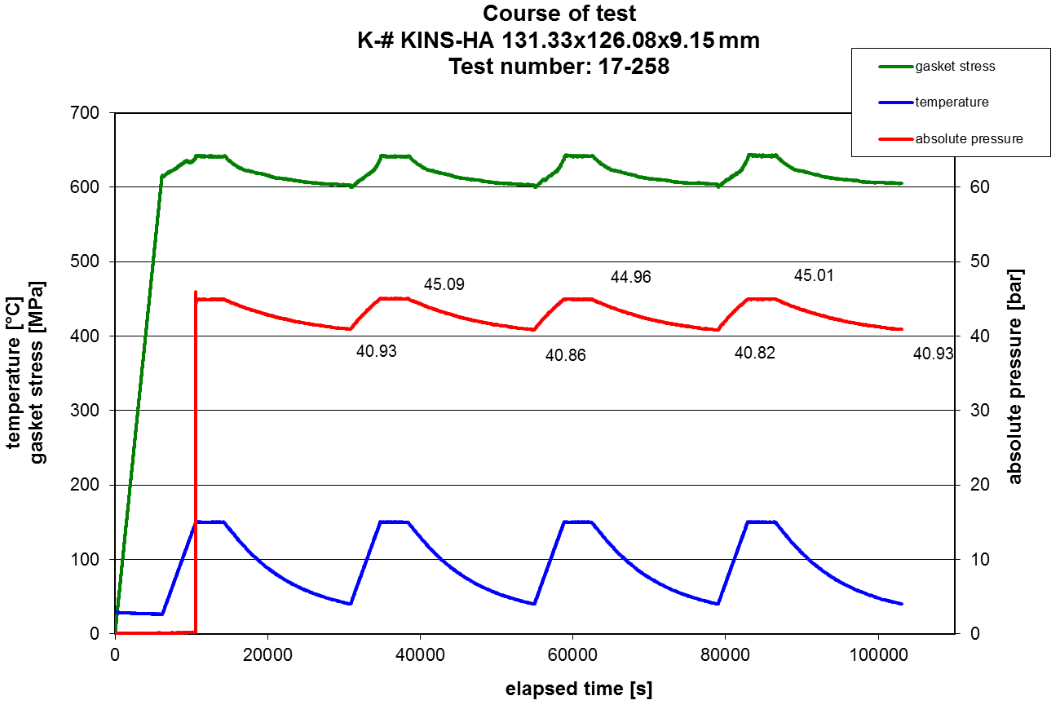
Compression creep curve
K/# KINS-HA 131.27x126.15x9.271 mm
Test number: 17-266







Leakage Test according EN 13555



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

Hot Blow-Out Test HOBT

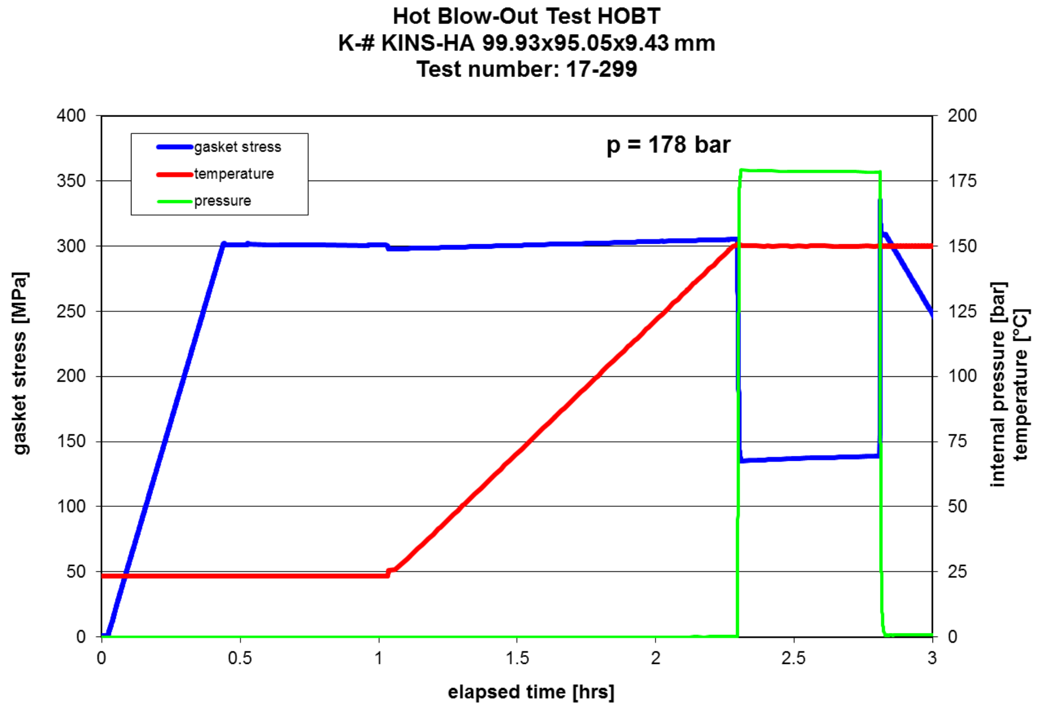
K-# KINS-HA
99.93x95.05x9.43 mm
Test number: 17-299

Test parameters

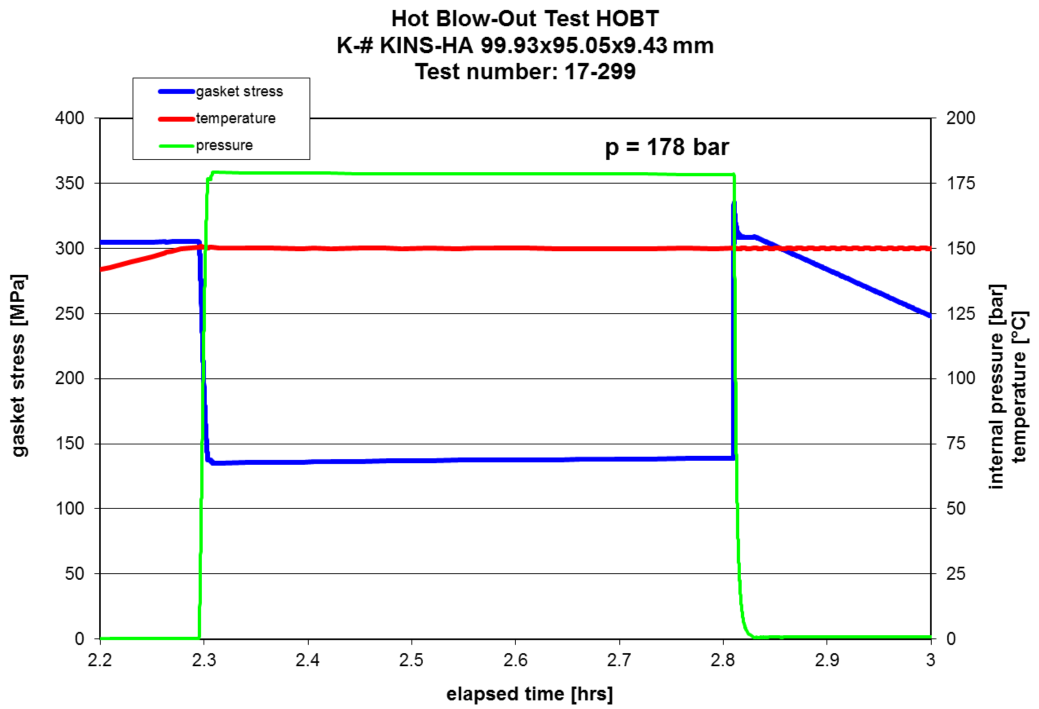
Nominal initial gasket stress:	43920	psi	302.8	MPa
Nominal pressure:	2611	psi	180	bar

Test results

Initial gasket thickness:	0.3713	in	9.43	mm
Final gasket thickness:	0.2745	in	6.97	mm
Initial gasket stress:	43810	psi	302.1	MPa
Actual test pressure:	2585	psi	178	bar
Gasket stress S_g:	43878	psi	302.5	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-HA 17-227

geometries

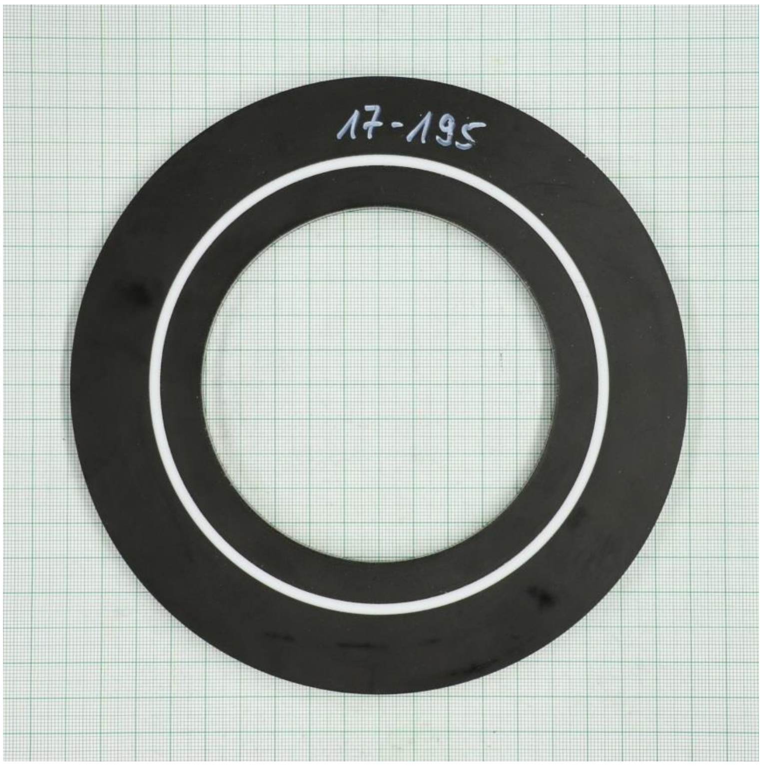
bolts	8	-
OD gasket	130.4	mm
ID gasket	126.1	mm
mean gasket circumference contact area	402.9	mm
gasket area	866.3	mm²
gasket contact area	866.3	mm²
OD raised faces flange (4" Class 300)	155	mm

calculation of gasket stress

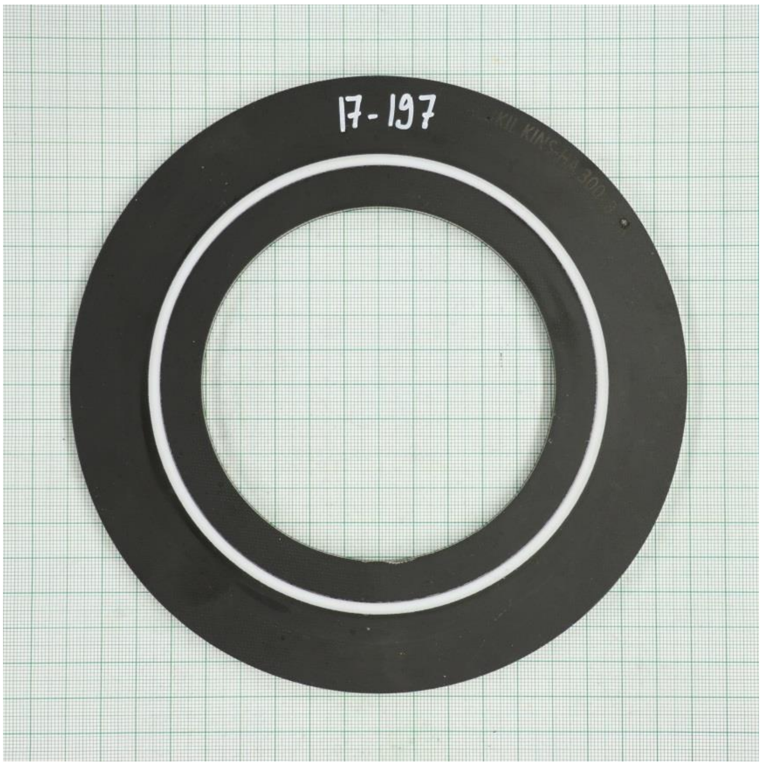
hydraulic spanners - No.	GS 3/1	-
pressure	430	bar
force per bolt	67.1	kN
force total	536.6	kN
gasket stress	619.5	MPa

Top flange gasket adhesion

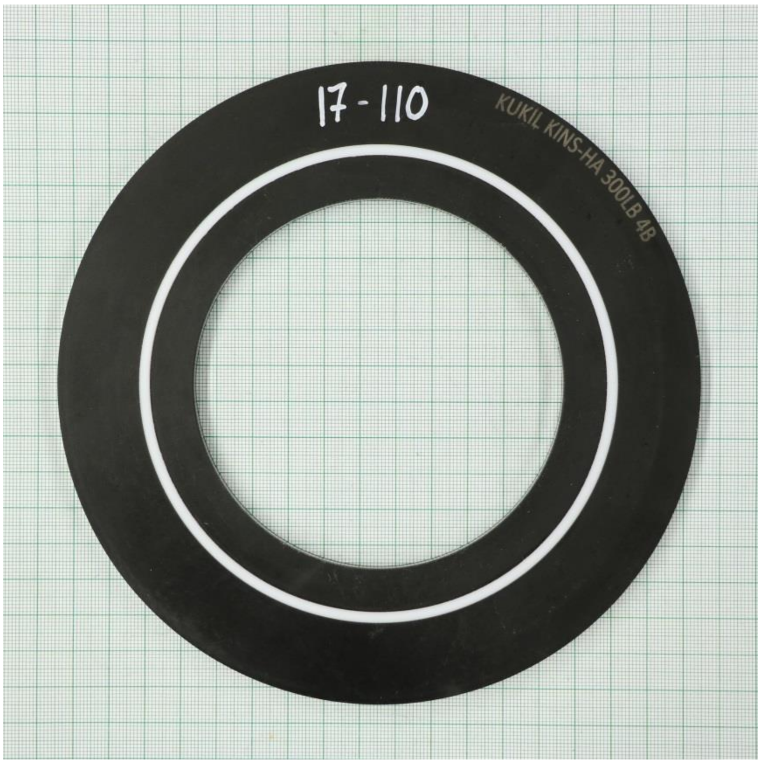
Bottom flange gasket adhesion



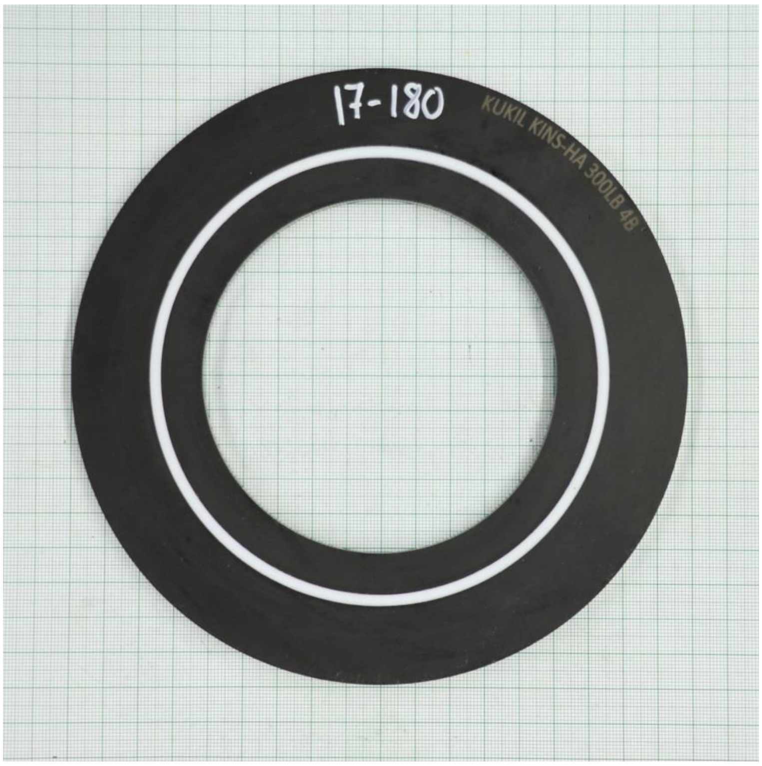
Shell leakage test (RT) according MESC SPE 85/300 - 3.3.2



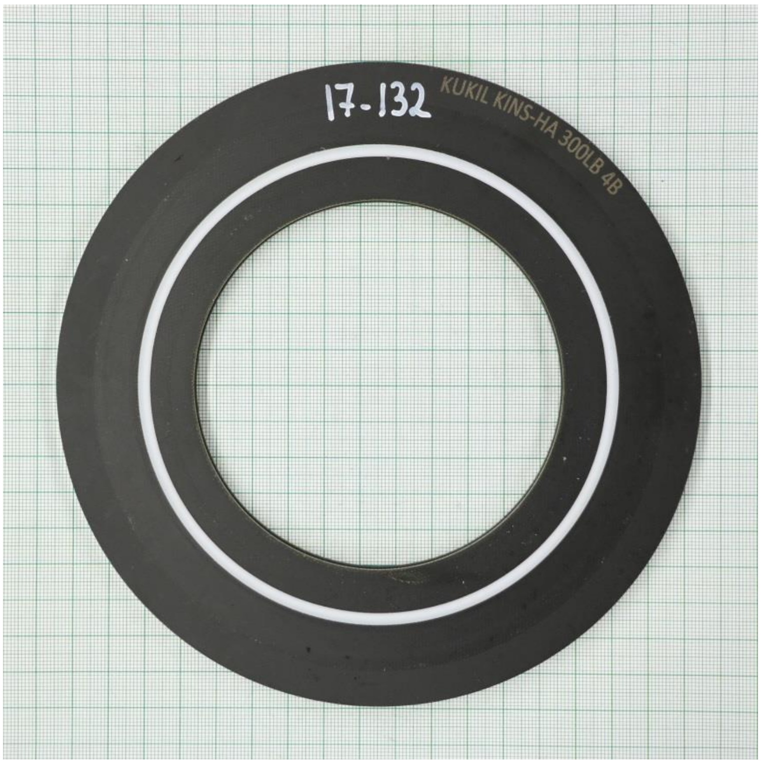
Shell leakage test (T) according MESC SPE 85/300 - 3.3.2



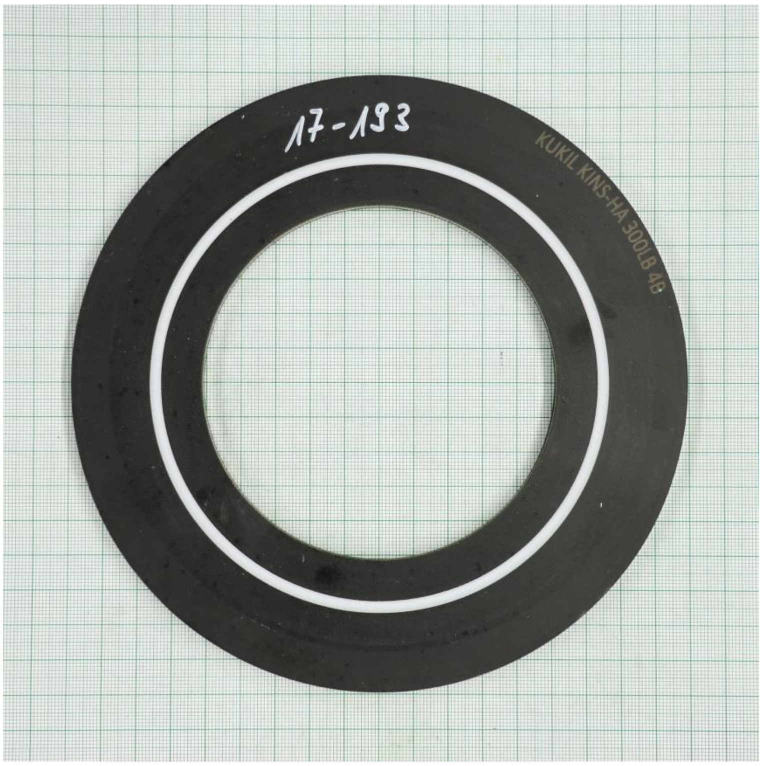
Compression Test at RT (EN 13555)



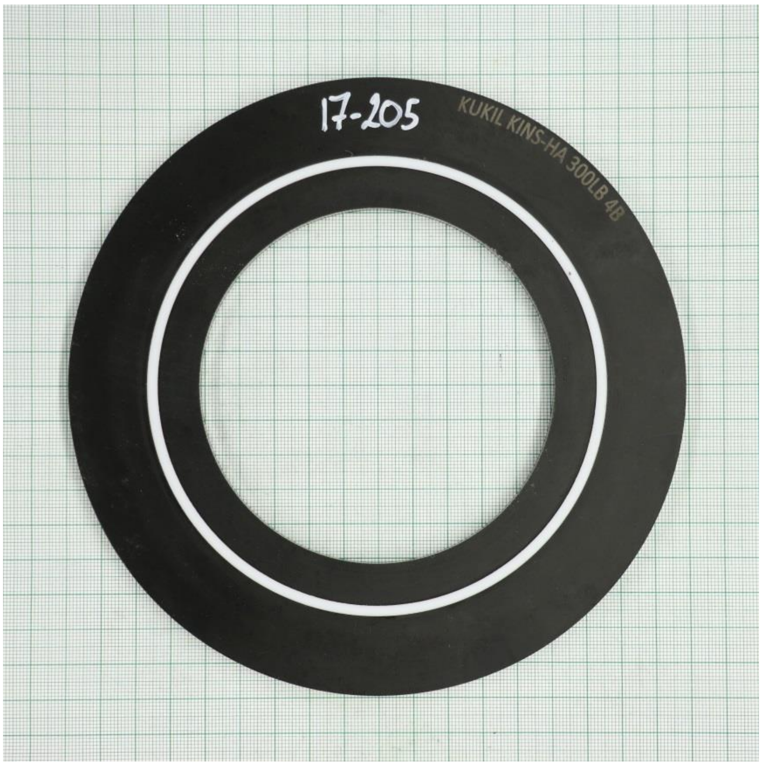
Compression Test at RT (EN 13555)



Compression Test at 150 °C (EN 13555)

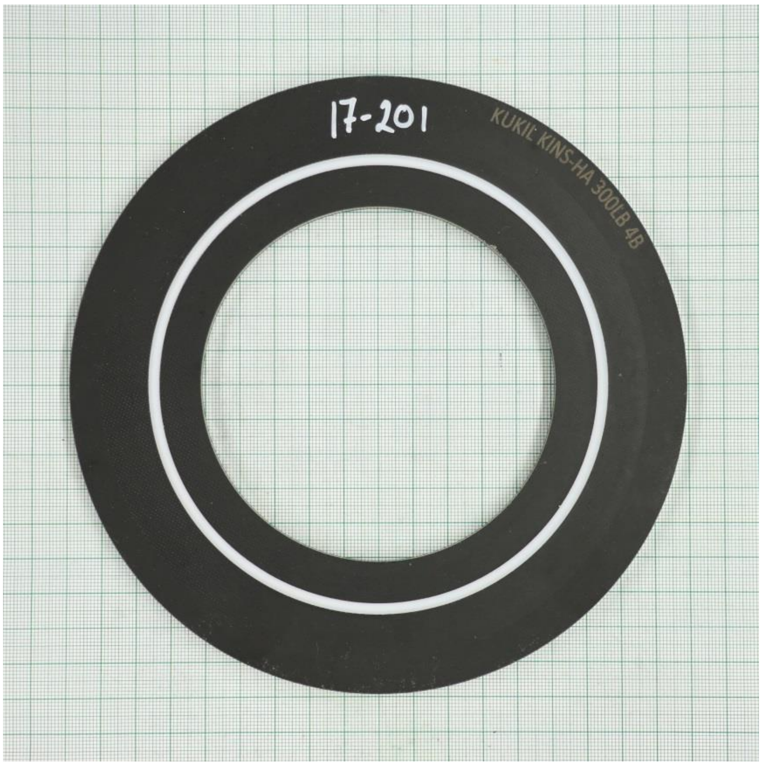


Compression Test at 150 °C (EN 13555)

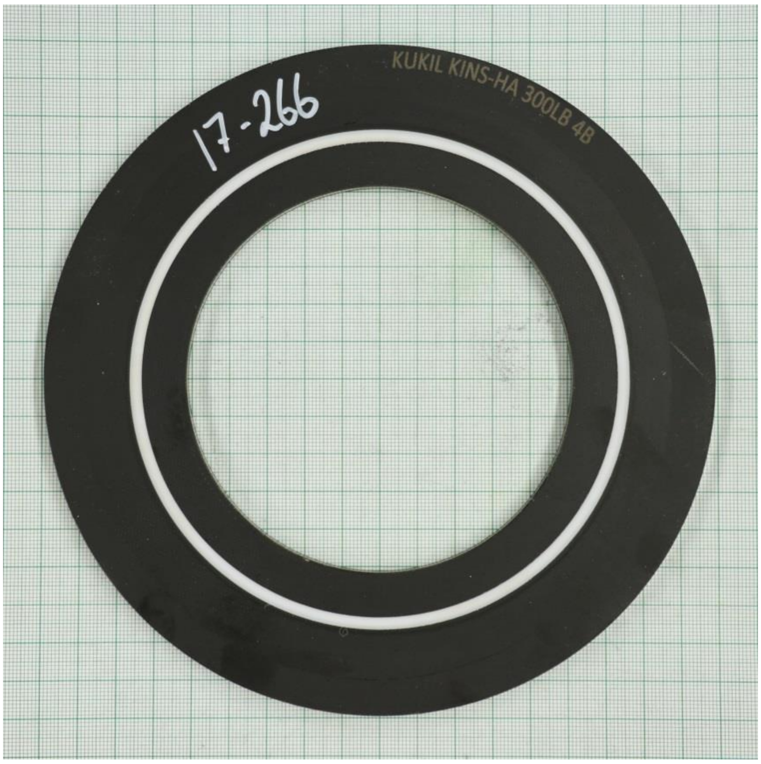


Creep Relaxation Test at 160 MPa - RT (EN 13555)

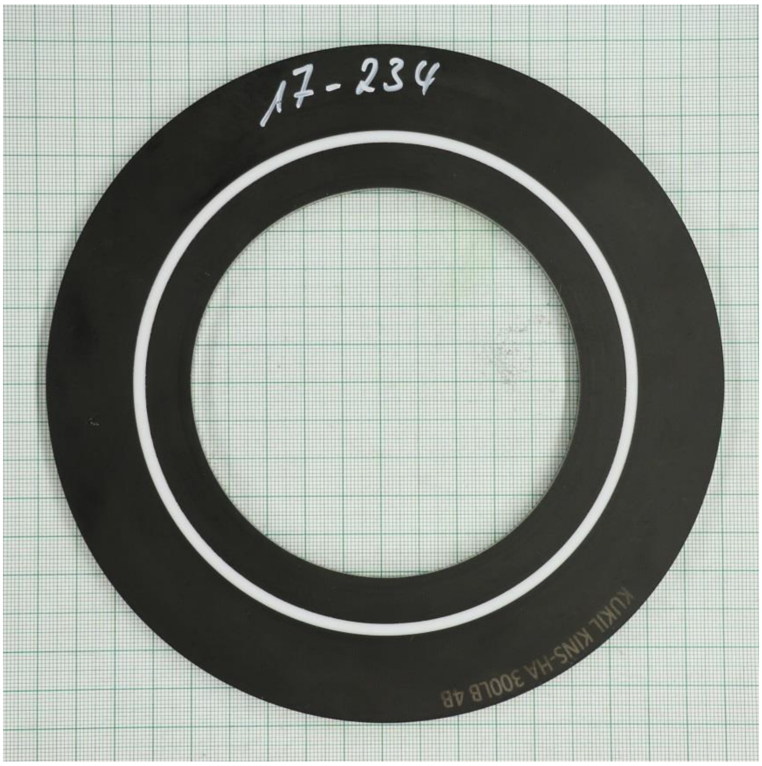
Creep Relaxation Test at 160 MPa - RT (EN 13555)



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

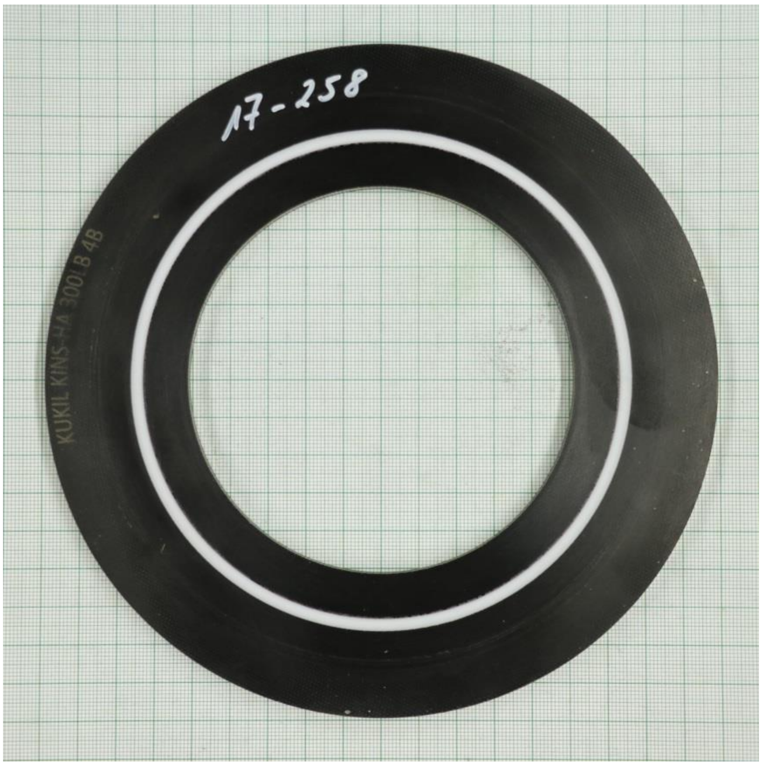


Creep Relaxation Test at 160 MPa – 150 °C (EN 13555)

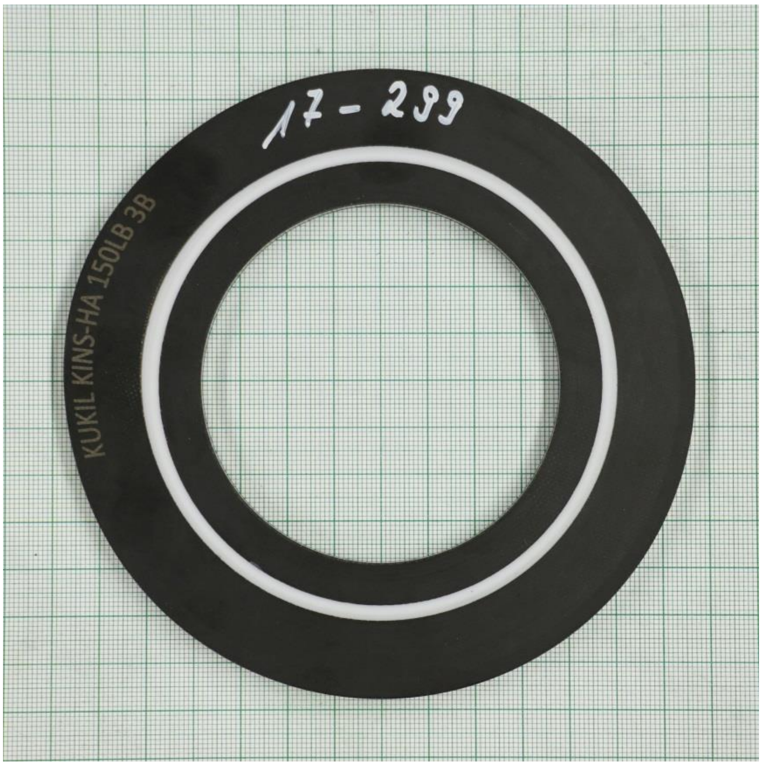


Leakage Test at RT (EN 13555)

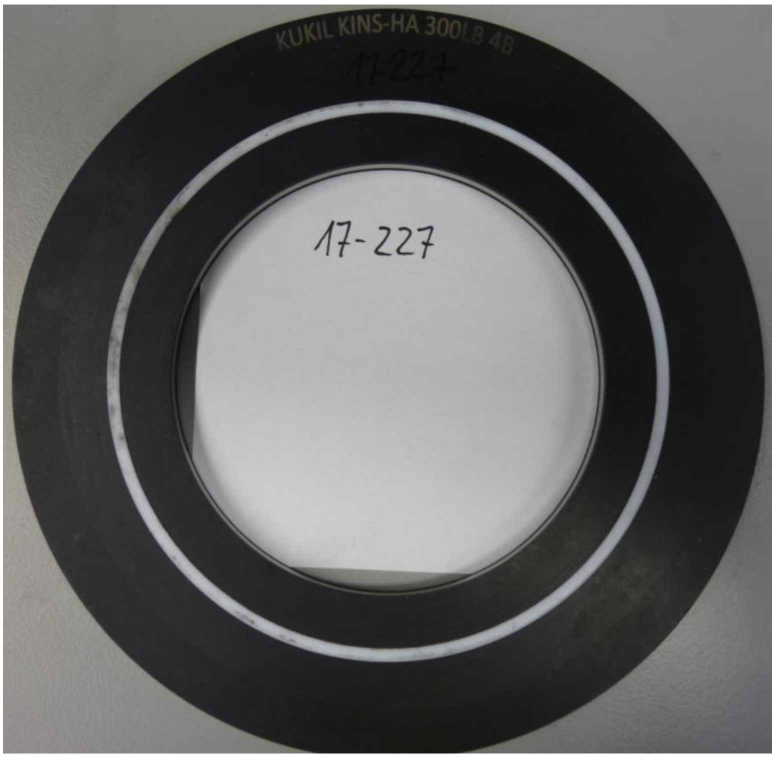
Leakage Test at RT (EN 13555)



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-HA (after test)

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