N/Réf : 2005/682/AT/CBOL/MTOU

ROTT test on Novus Sealing "Uniflon 50" gasket

N° : 790730/6J1/a

Date : December 15th 2005 **Test Report**

Destinataire (s) : Mr SMITH Gavin
NOVUS SEALING LIMITED
HUNSWORTH LANE
CLECKHEATON
BD 19 3UJ WEST YORKSHIRE (UK)

Réf. de la demande :

Purchase order n° 0000000535

Éléments remis par le demandeur :

- 6 samples of Novus Sealing Limited Uniflon 50 gasket

1. AIM OF TEST

The aim of ROTT (ROom Temperature Tightness) test is to determine the value of PVRC gasket factors (Gb, a, Gs) at room temperature. ROTT test enables to calculate constants "Gb", "a", "Gs" from leak measurements at various tightening and pressure levels, that ASME will soon use in place of "m" and "y". ROTT test made at CETIM's corresponds to a North-America technology developed by TTRL (Tightness Testing and Research Laboratory) on behalf of the PVRC (Pressure Vessel Research Council).

As an extension to ROTT test a CRUSH test is performed to determine the maximum allowable stress on the gasket before tightness is damaged.

2. ROTT + CRUSH TEST PROCEDURE

2.1 ROTT ASTM DRAFT 9 test procedure

2.1.1 Test sequence

ROTT test procedure includes a series of three (3) loadings and unloadings of the gasket applied in turn stepwise at increasingly high stresses during which the leak is measured at each stress level. A long enough holding time is observed at each measurement for the leak to stabilise. It varies from one (1) minute to five (5) hours. The gas used is helium pressurised at 27.5 and 55 bar. The Figure 2: ROTT Draft 9 test sequence vs time presents the various steps of ROTT test.

The ROTT test (according to Draft No. 9) can be made following three different procedures depending on the type of gasket to be tested, namely SOFT, STANDARD and HARD. These procedures correspond to the stress levels reached during testing. The SOFT procedure is used with PTFE-based gaskets and also with gaskets specially designed to withstand low stresses (spiral gaskets). In the case of fully metallic gaskets, the test must be made according to the HARD procedure. **Table 1: Gasket stress level during a ROTT ASTM Draft9 test** shows the stress levels for all these procedures. For this test **(ROTT test on Novus Sealing "Uniflon 50" gasket), SOFT** procedure has been used. For repeatability purposes, the test is performed at least 2 times. A third test is performed in case of incident during one of the two first tests or in case of incoherence between results of two first tests.

Stress level	Stress applied on the gasket					
	Soft		Standard		Hard	
	Mpa	Psi	Mpa	Psi	Mpa	Psi
S1	7.1	1025	7.1	1125	10.6	1540
S2	20.9	3040	31.4	4560	47.1	6840
S2.5	29.1	4220	41.6	6325	65.4	9490
S3	37.2	5390	55.8	8090	83.7	12140
S3.5	45.3	6575	68.0	9860	102.0	14790
S4	53.5	7750	80.2	11630	120.3	17450
S4.5	61.6	8930	92.4	13395	138.5	20095
S5	69.7	10110	104.2	15160	156.8	22740

Table 1: Gasket stress level during a ROTT ASTM Draft9 test

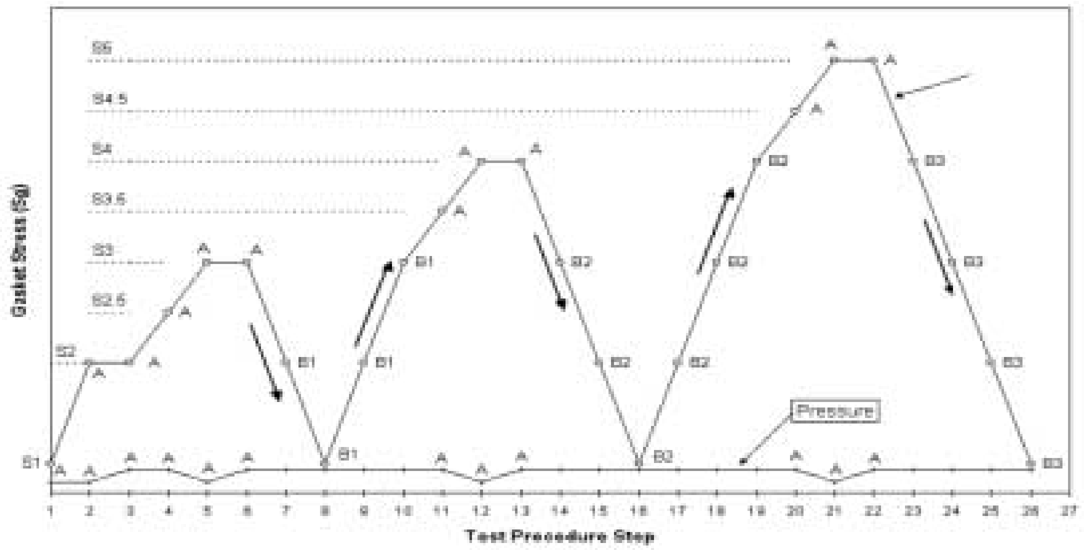


Figure 1: ROTT ASTM Draft9 Gasket stress sequence

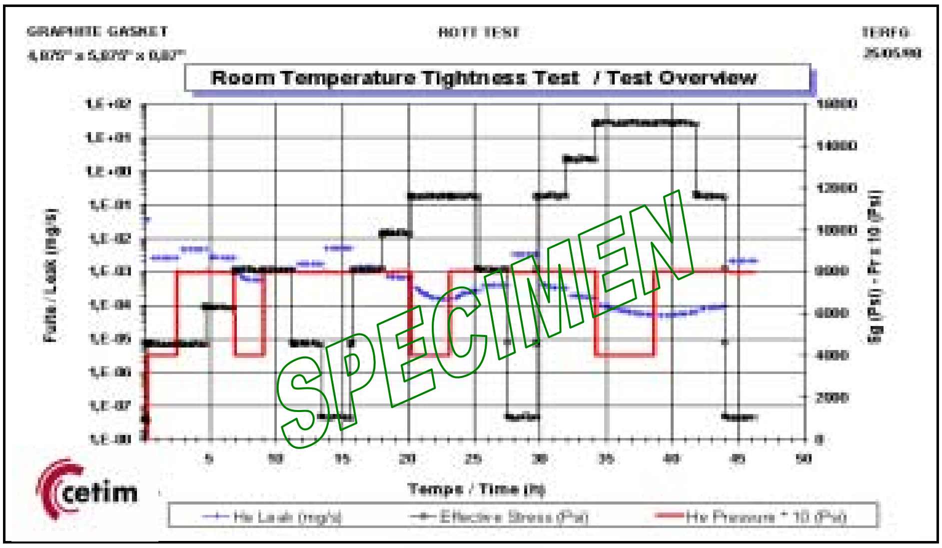


Figure 2: ROTT Draft 9 test sequence vs time

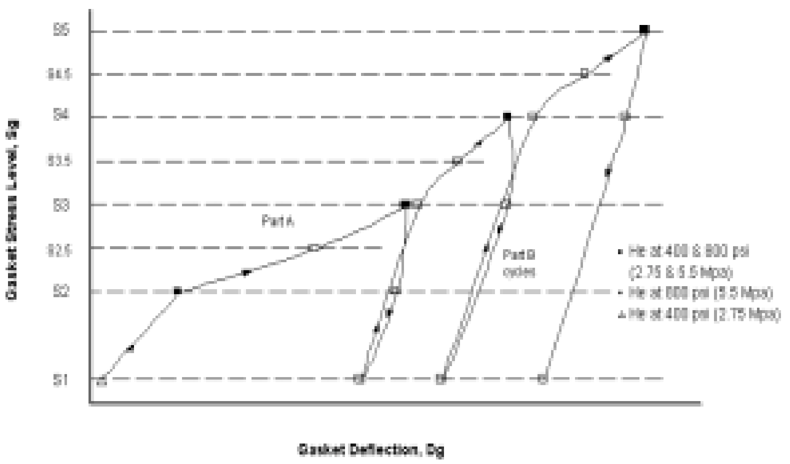


Figure 3: ROTT ASTM Draft 9 test sequence Sg vs Dg

2.1.2 *Leak rate measurement*

The test consists in measuring the leak on the gasket at various stresses and pressure levels. Three types of stresses are obtained by applying two different pressures in turn (28bar and 55bar). One of the measuring methods below is used depending on the leak level:
- flow meter (for a leak > 0.8mg/s)
- pressure drop (for a leak ranging from 0.8 to 0.018 mg/s)
- helium mass spectrometer (for a leak < 0.018 mg/s)

2.1.3 *Result analysis*

A dimensionless tightness parameter Tp (Tightness parameter) is calculated on basis of the measurement results. The effective stress on the gasket vs. tightness parameter Tp curve is plotted and used to determine tightness constants "Gb", "a", "Gs". The test must be repeated on the same type of gasket to calculate the constants.

The tightness of a gasket proves its capability to control the leak of a pressured joint. Many tightness tests have proven that the measured leak rate and the fluid pressure were closely related under a given compression load. The correlation appears as a linear relation with a slope "s" in log co-ordinates. This has allowed a dimensionless tightness parameter Tp to be defined.

$$Tp = \frac{P}{P^*}\left(\frac{Lrm^*}{Lrm}\right)^s$$

where:

- P = absolute fluid pressure (MPa).
- P* = reference pressure (0.1013 MPa).
- Lrm = leak (mg/s) for a gasket with OD 150 mm.
- Lrm* = unit leak (1 mg/s) for a gasket with OD 150 mm
- s = slope of graph Lrm-P in log co-ordinates. Values raised to 0.5 for simplification purposes.
- Tp = 1 corresponds to a leak 1mg/s under atmospheric pressure for a gasket with OD 150 mm. The greater the Tp, the greater the gasket tightness.

If we plot the stress applied on the gasket vs. the Tp obtained during both ROTT tests on a log-log scale graph, we can represent the ideal behaviour of the gasket by means of straight lines (Figure 5: Idealized Sg-Tp graph)

where:

"Gb" = stress at Tp = 1 associated to the linear regression of the data in part A (loading).

"a" = the slope obtained by the linear regression of the data in part A (loading). The combination of constants "Gb" and "a" characterises the seating stress and gives an indication of the capacity of the gasket to ensure the tightness.

"Gs" = stress at Tp = 1 associated to the linear regression of the data in part B (unloading). It represents the capacity of the gasket to maintain the tightness after the pressure has been applied and in service, and its sensitivity to unloading.

The definition of two other major parameters should also be noted:

Tpmax(A) = Maximum value of the tightness obtained in part A (tightening) of ROTT test (out of the CRUSH part of the test)

The greater the Tpmax, the greater the tightness on tightening.

Tpmin(B) = Minimum tightness value obtained in part B (loosening) of ROTT test (out of the CRUSH part of the test).

The greater the Tpmin, the greater the tightness on loosening

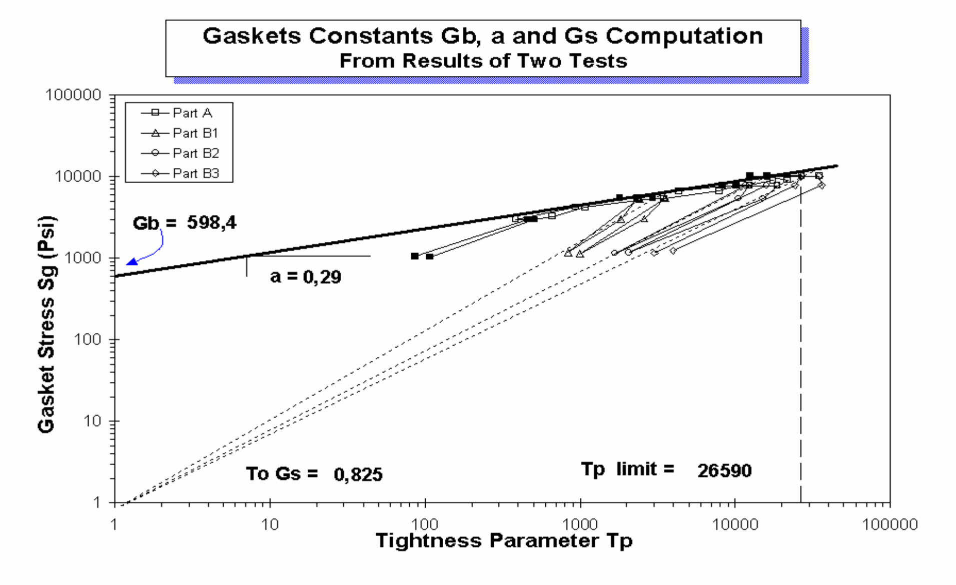


Figure 4: Typical ROTT Sg-Tp graph

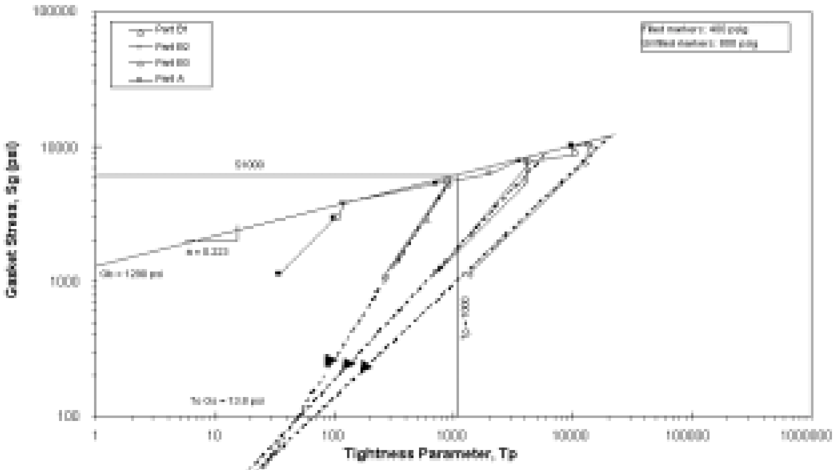


Figure 5: Idealized Sg-Tp graph

2.2 CRUSH test procedure

The CRUSH test is made as a continuation of the ROTT test. After having restored stress level S1, the CRUSH test consists in the cyclical application of gradually increasing compression loads on the gasket up to the maximum force for the rig. The leak is measured at each stress level under a 27.5 bar helium pressure as the test progresses. As the test is not aimed to quantify the leak but to check the gasket tightness throughout the stress cycles, the holding time for measuring the leak does not exceed 15 minutes. The test procedure is presented on Figure 6: CRUSH Test sequence

The CRUSH test allows to determine the maximum allowable stress on the gasket before tightness is damaged. It consists in checking that the tightness is still present at stress level S1 (7 MPa) during successive loading and unloading cycles. The maximum allowable stress is reached when the leak seen at the stress level is greater than the leak measured at the initial stress level S1.

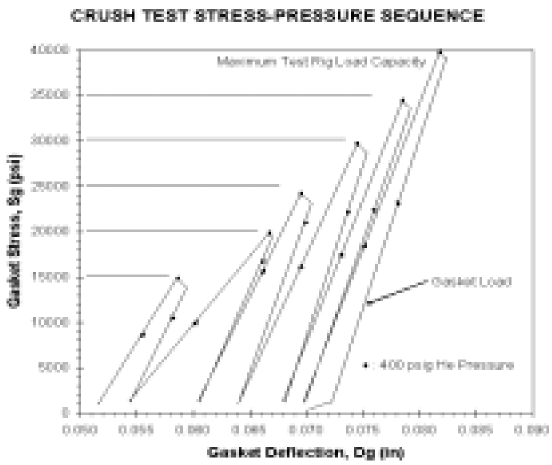


Figure 6: CRUSH Test sequence

3. TESTED SPECIMENS

The test has been performed on the following specimen

Gasket type	Gasket Dimension	Testing temperature
Novus Sealing Uniflon 50 gasket	OD : 5.875” ID : 4.875” Thickness: 1/16”	Room

Photo 1: Sample before test

4. TESTING EQUIPMENT AND MEASUREMENT INSTRUMENTS

4.1 Test rig

Tests are performed at CETIM using a compression machine or the ROTT test rig realized by TTRL.(Tightness Testing and Research Laboratory)

Photo 2: Test rig

4.2 Gasket metrology
The gasket is measured using a DIGIMATIC calliper (manufacturer: MITUTOYO), step value: 0.01 mm, capacity 300 mm ± 0.03 mm.

4.3 Leak measurement
Leaks < 0.018 mg/s are measured using an ASM 180T type helium mass spectrometer (CETIM reference: SPE005).

The helium mass spectrometer is calibrated each week.

4.4 Compression plates
Gasket is compressed between two dimensionally stable plates:

Testing plates	
Dimension	43x88 and 114x157 mm (sealing face, raised faces)
Surface condition	Ra = 250 AARH (6.3µm)

4.5 Gasket crushing measurement
Crushing is measured from 2 sensors set 180° apart on the outside of the compression plates.

5. RESULTS

5.1 ROTT Test results - gasket constants

Gasket Constant Determination : Gb, a and Gs Date : 01-déc-05

Gasket : Uniflon 50
Designation : 124.8 x 150.6 x 1.4 mm
Test info : 790730_a2&3

SUMMARY: PreliminProcedure : soft
SUMMARY

Gb	a	Gs	Ts	Ss	Tpmin	Tpmax	S_{100}	S_{1000}	S_{3000}	S_{10000}
458	0,3	5,37E+0	13 314	7 913	813	13 314	1 823	3 638	5 059	7 261

Computation of **ROTT test on Novus Sealing "Uniflon 50" gasket** leads to following gasket constants.

5.2 CRUSH Test results

On both tested gaskets the CRUSH test shows that there is no big drop in gasket tightness. The tests have been performed until the maximum gasket stress for the rig has been reached (275 MPa). So, the maximum allowable gasket stress for tested gaskets is greater than 275 MPa.

6. APPENDICES LIST

- APPENDIX 1: Gaskets pictures after ROTT + CRUSH test
- APPENDIX 2: ROTT + CRUSH Test Sequence
- APPENDIX 3: ROTT test Sg-Tp graphs
- APPENDIX 4: ROTT test Sg-Dg graphs
- APPENDIX 5: Gasket constant result
- APPENDIX 6: CRUSH test Sg-Tp graphs
- APPENDIX 7: CRUSH test Sg-Dg graphs

Technician in charge of tests
Cédric BOULBEN

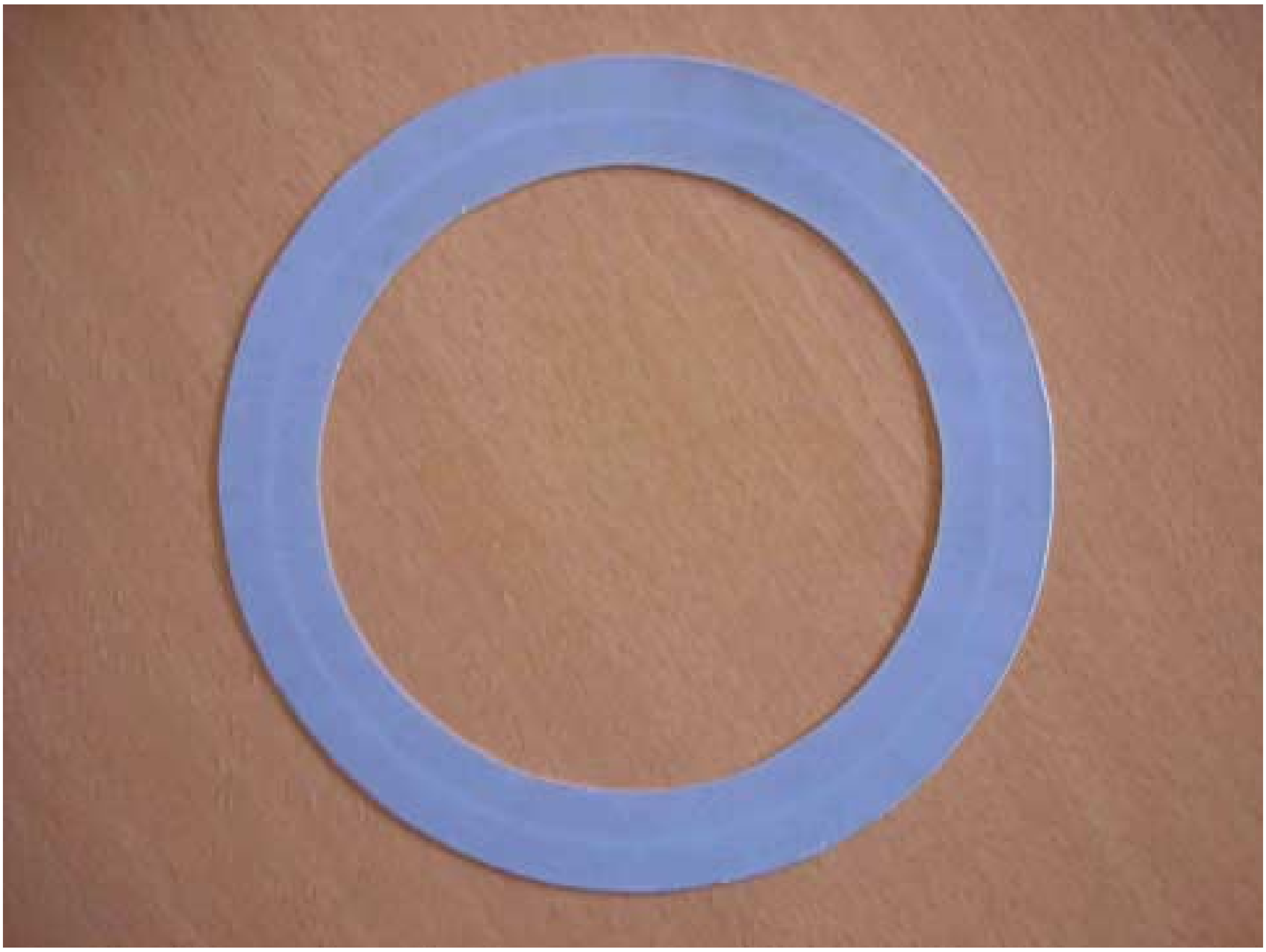
Business Engineer
Hubert LEJEUNE

APPENDIX 1

Gaskets pictures after test

TEST1

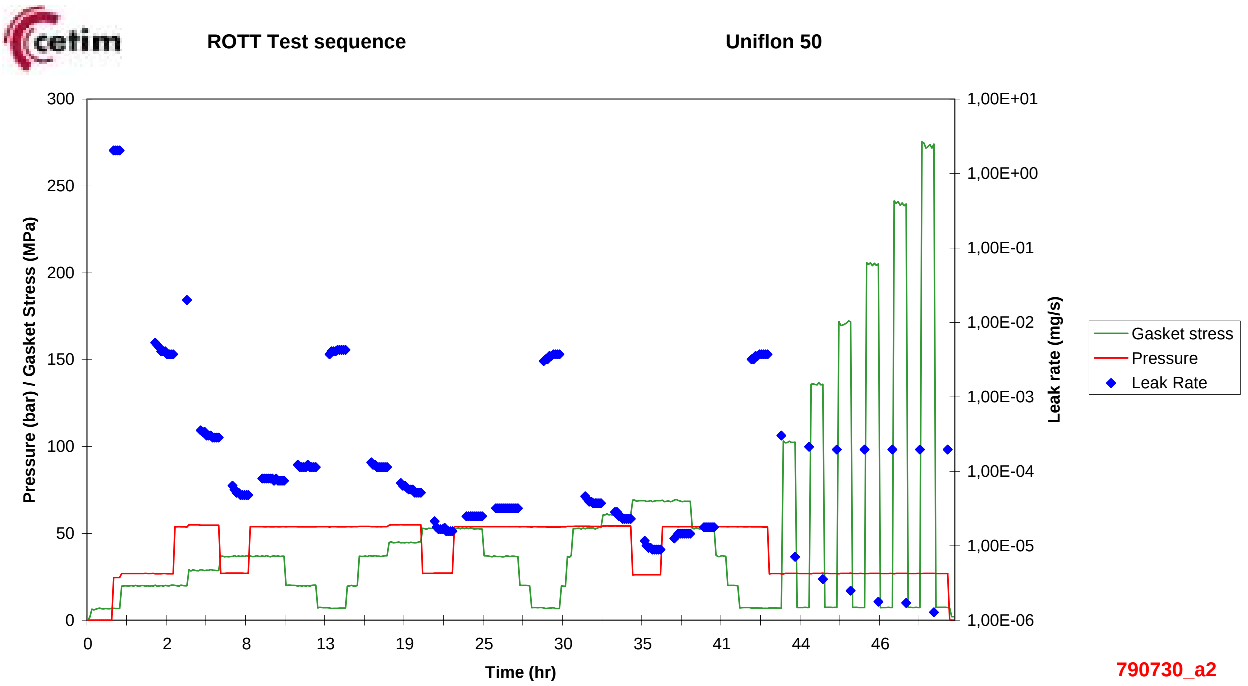
TEST2



APPENDIX 2

ROTT + CRUSH Test Sequence

TEST1



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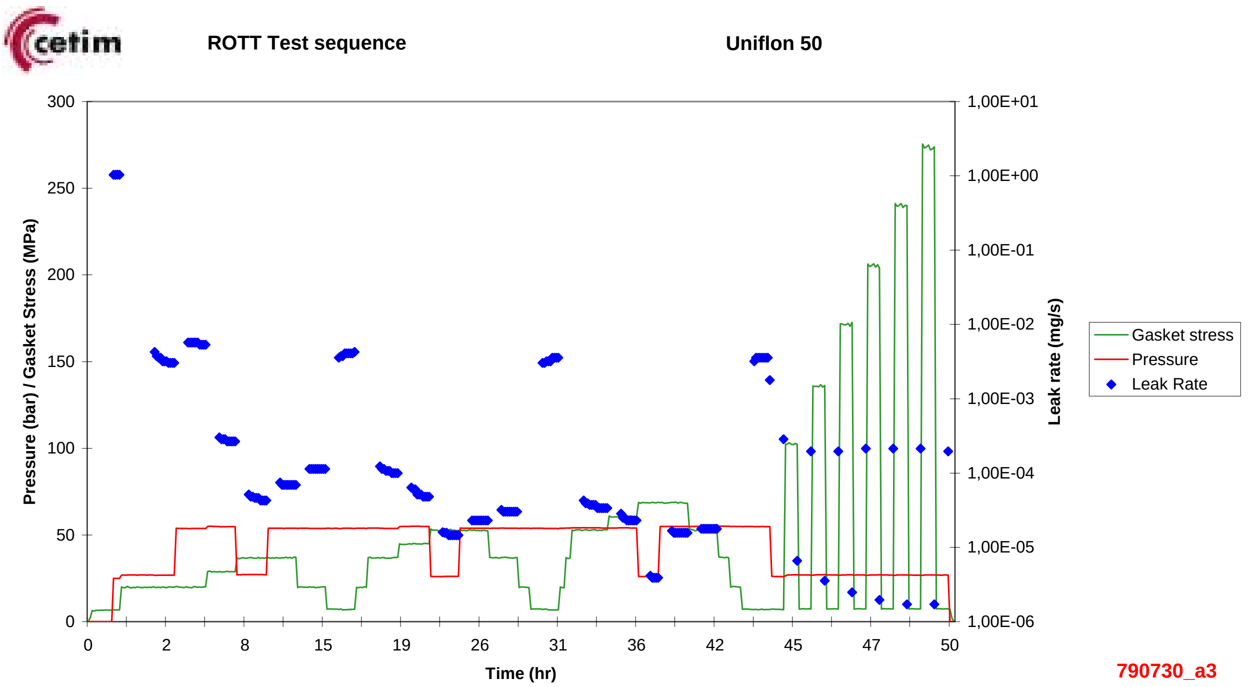
TEST2



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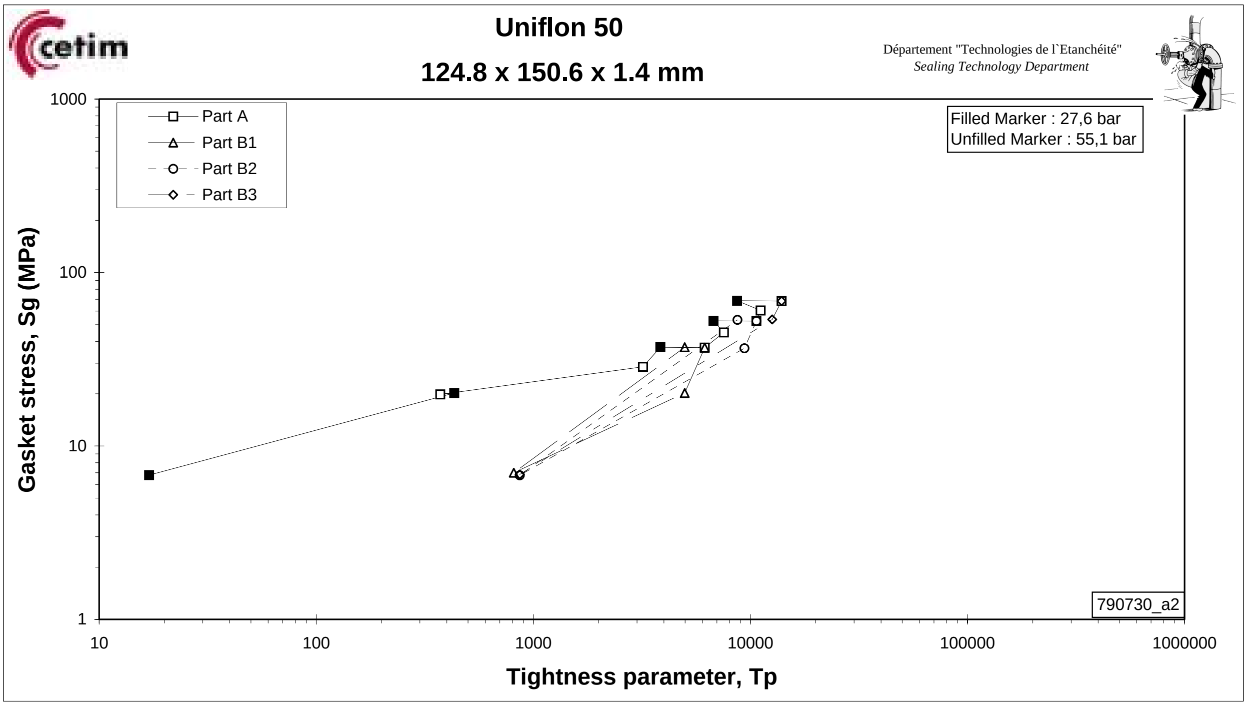
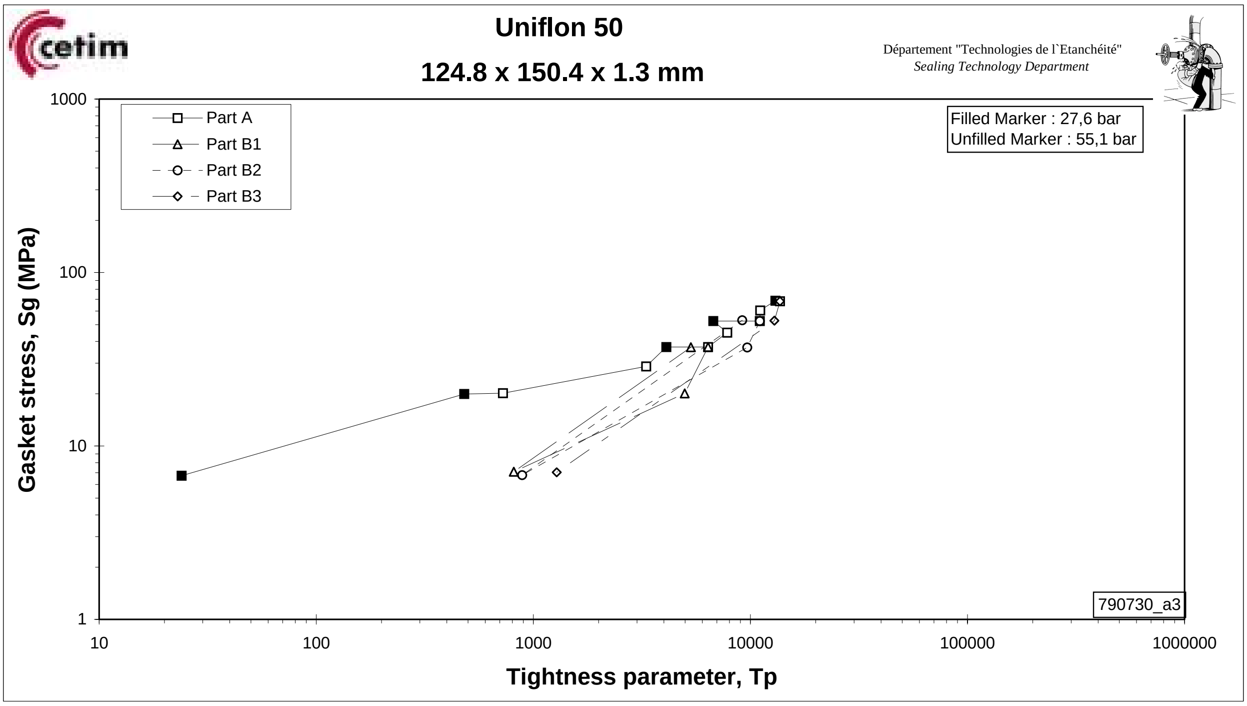
APPENDIX 3

ROTT test Sg-Tp graphs

TEST 1 - Sg-Tp graph



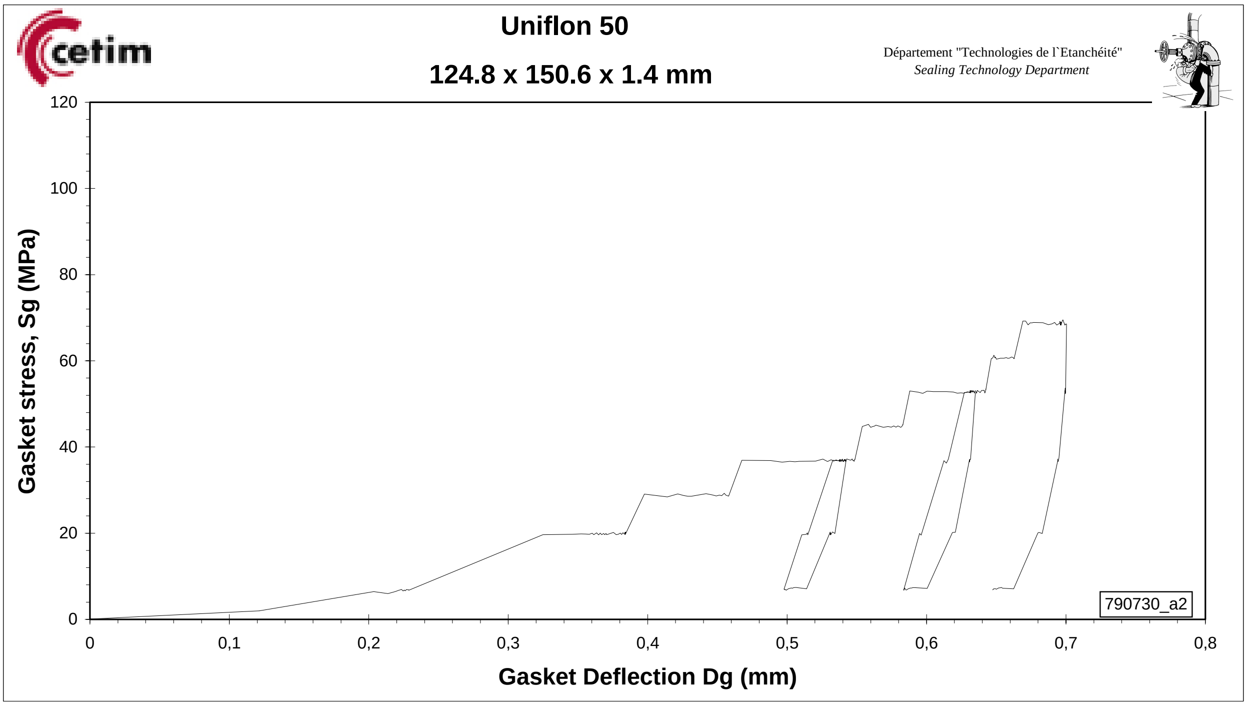
TEST 2 – Sg-Tp graph



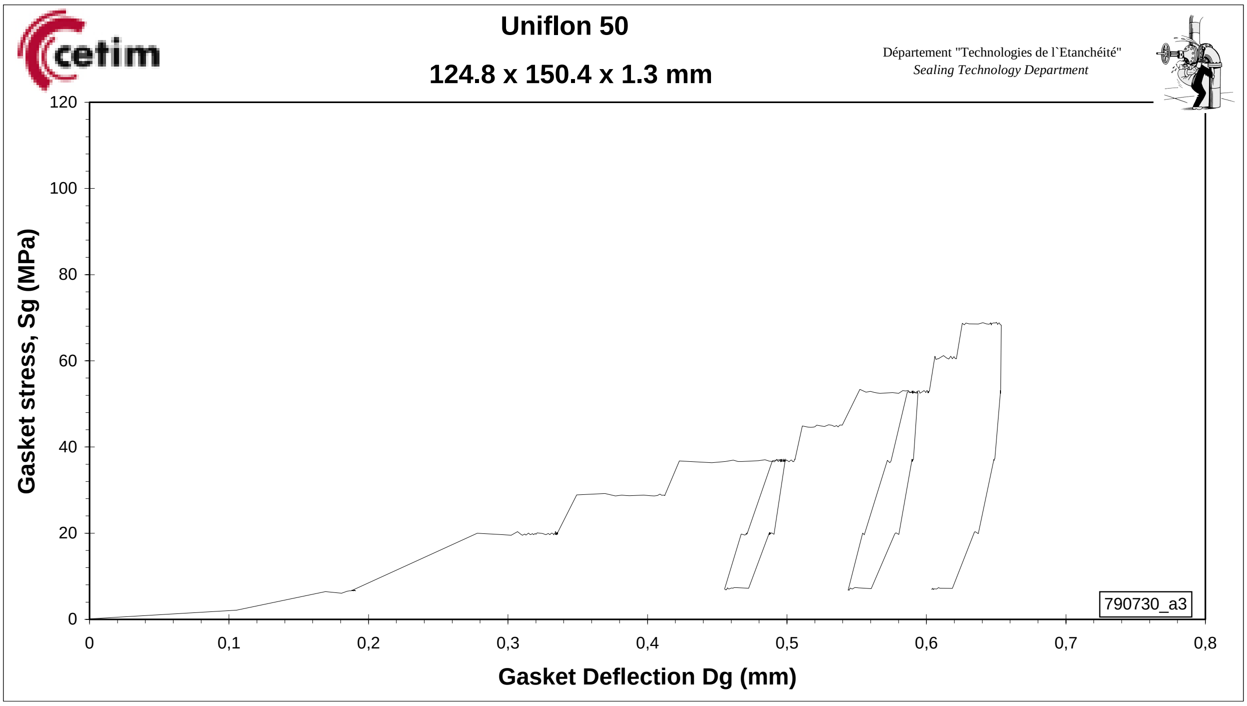
APPENDIX 4

ROTT test Sg-Dg graphs

TEST 1 - Sg-Dg graph



TEST 2 - Sg-Dg graph



APPENDIX 5

Gasket constants

Gasket Constant Determination : Gb, a and Gs

Date : 01-déc-05

Gasket : Uniflon 50
Designation : 124.8 x 150.6 x 1.4 mm
Test info : 790730_a2&3

SUMMARY: PreliminProcedure : soft
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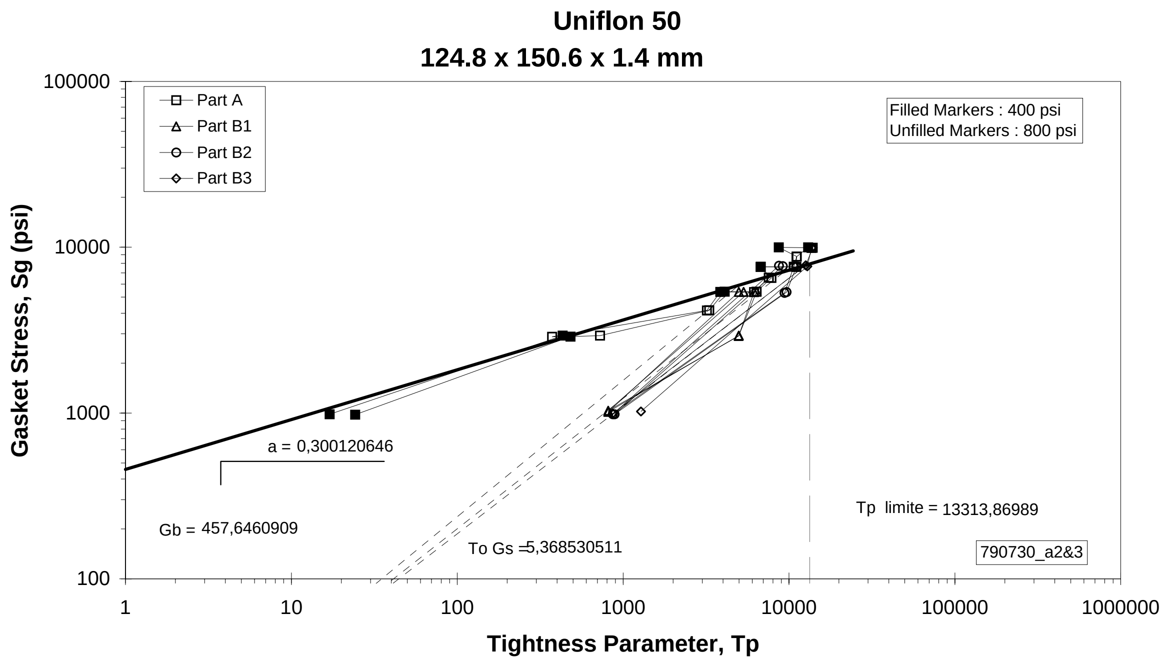
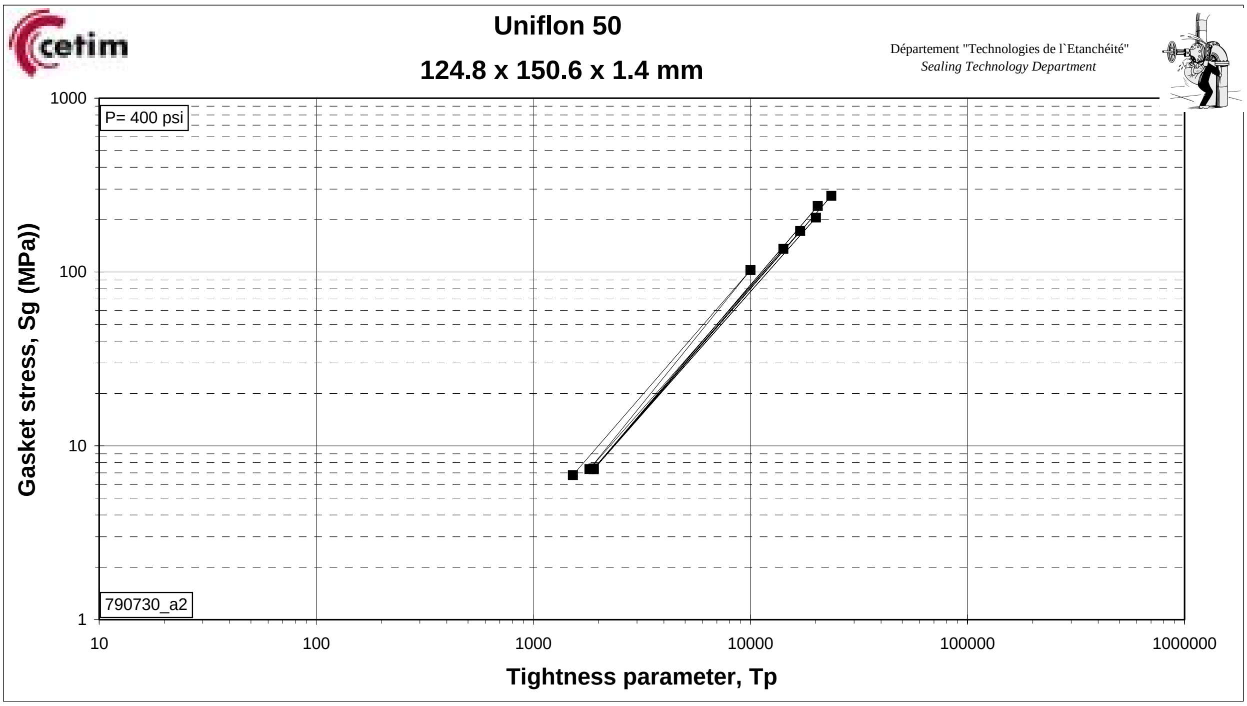


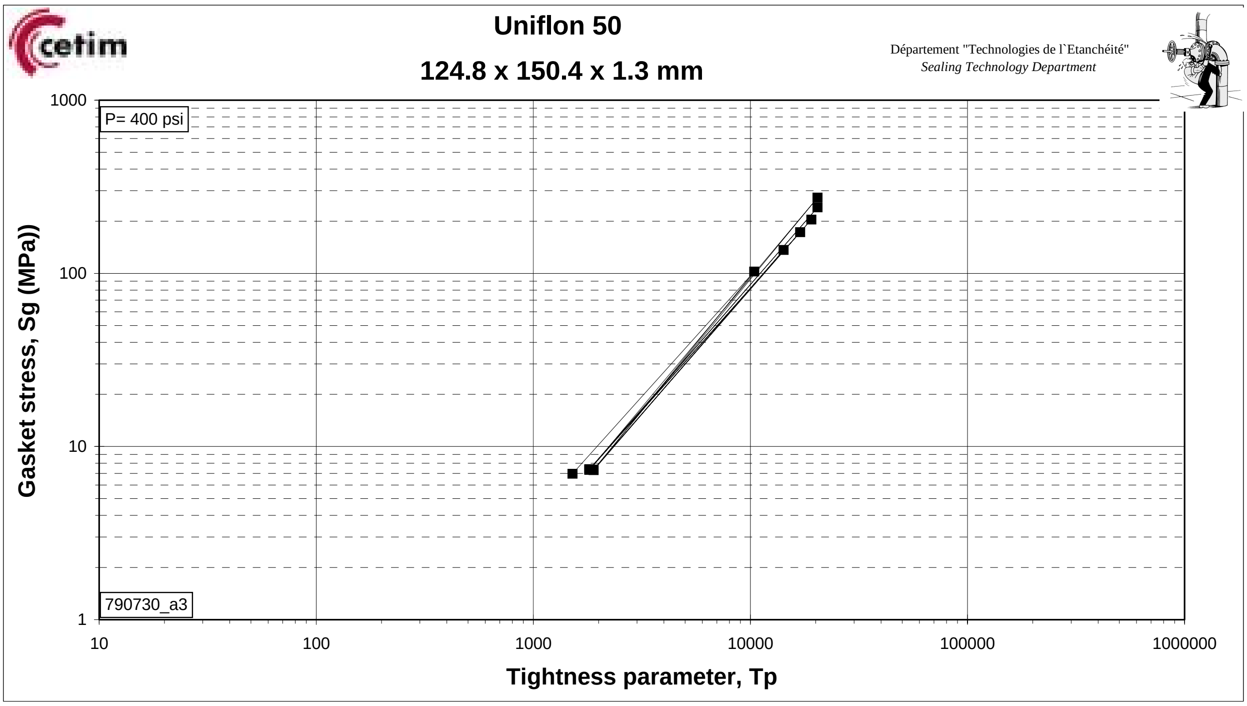
APPENDIX 6

CRUSH test Sg-Tp graphs

<u>TEST 1 – CRUSH - Sg-Tp graph</u>



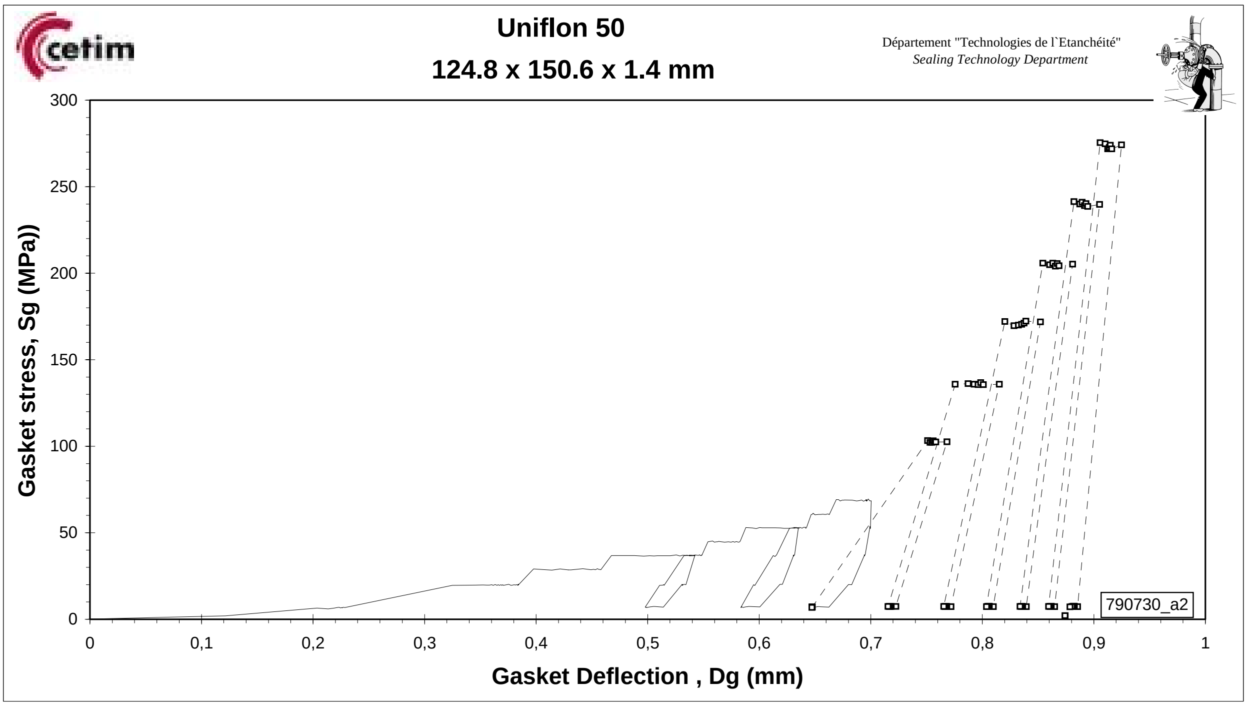
TEST 2 – CRUSH - Sg-Tp graph



APPENDIX 7

CRUSH test Sg-Dg graphs

TEST 1 – CRUSH - Sg-Dg graph



TEST 2 – CRUSH - Sg-Dg graph