North America, Inc.

Four Tower Bridge
200 Barr Harbor Drive
West Conshohocken, PA 19428
E-mail: info@amtec-services.com
Internet: www.amtec-services.com

quality certified
ISO 9001
KTA1401

DAkkS
Deutsche Akkreditierungsstelle
D-PL-12008-01-00

# Test Report

| | |
|---|---|
| Customer: | TEADIT International<br>Rosenheimer Straße 10<br>A-6330 Kufstein/Tirol |
| Project number (amtec): | A300 110 |
| Report number: | A300 110 1/- |
| Test procedure: | Room Temperature Tightness Test (ROTT) |
| Material: | GR 1700 |
| Date: | 26.04.2014 |
| Pages: | 4 |
| Appendices: | 16 |

Dipl.-Ing. F. Herkert

# 1. Subject of Investigation

The subject of investigation was a graphite gasket from TEADIT International which is named

- GR 1700.

The gasket consists of 5 stainless steel foils of 316 with a thickness of 0.05 mm and of several graphite layers which enclose the stainless steel foils.

# 2. Goal of Investigation

The goal of investigation was the characterization of the tightness behaviour of gasket materials for seating and operating conditions in accordance to ASTM WK 10193 – Draft 10.2: Standard Practice for Gasket Constants for Bolted Joint Design (dated October 2006). This standard practice is so-called ROTT test (Room temperature tightness test procedure). The ROTT test will determine the new PVRC gasket constants Gb, a and Gs related to a tightness parameter Tp, representing the mass leak rate and internal pressure.

Two "High Pressure" (HP) tests at 876 psi (60 bar) and two "Low pressure" (LP) tests at 290 psi (20 bar) will be performed.

# 3. Test Specimen

The tested dimensions of the specimen were:
5.875 ″ x 4.875 ″ x 0.125 ″ (149.2 x 123.8 x 3 mm)

# 4. Testing Equipment

The gasket tests were carried out on the following test rig:

| Test rig: | Serial number |
|---|---|
| TEMES$_{fl.ai1}$ | 010 362 |

A photo and a schematic view of the testing equipment are shown in **appendix 1**.

# 5. Test Procedure

The ROTT test is performed in a universal testing equipment of amtec with helium gas as the pressurized medium. Each test includes two parts, a loading (Part A) and several unloading (Part B) sequences.

Part A represents initial joint tightening and gasket seating. Each new level of gasket compression stress is higher than any previously applied stress. At each stress level, the leakage is measured at 876 psi (HP test) or at 290 psi (LP test). Part A test data are used to determine the required seating load.

Part B simulates the operating conditions by performing unload-reload cycles at different gasket stress levels, but only during the HP test procedure at 876 psi. Part B cycles represent gasket unloading, relaxation and retightening of a gasket during operation. Part B test data are used to determine the required operating gasket load.

The complete HP test procedure (Draft 10.2) is shown in **appendix 2** and the LP test procedure (Draft 10.2) is shown in **appendix 3**.

# 6. Results

In **appendices 4 to 7** the results of the HP tests of the material GR1700 are shown, the results of the LP tests are listed in **appendices 8 to 10**.

Two HP tests and two LP tests shall be performed for determining PVRC parameters. After these four tests a verification procedure must be done to check whether the tested gaskets show a good repeatability within the HP and LP test pairs or not. In **appendices 11 and 12** two tables are presented with the validity checks of the measured leak rates of Lrm for the double tests.

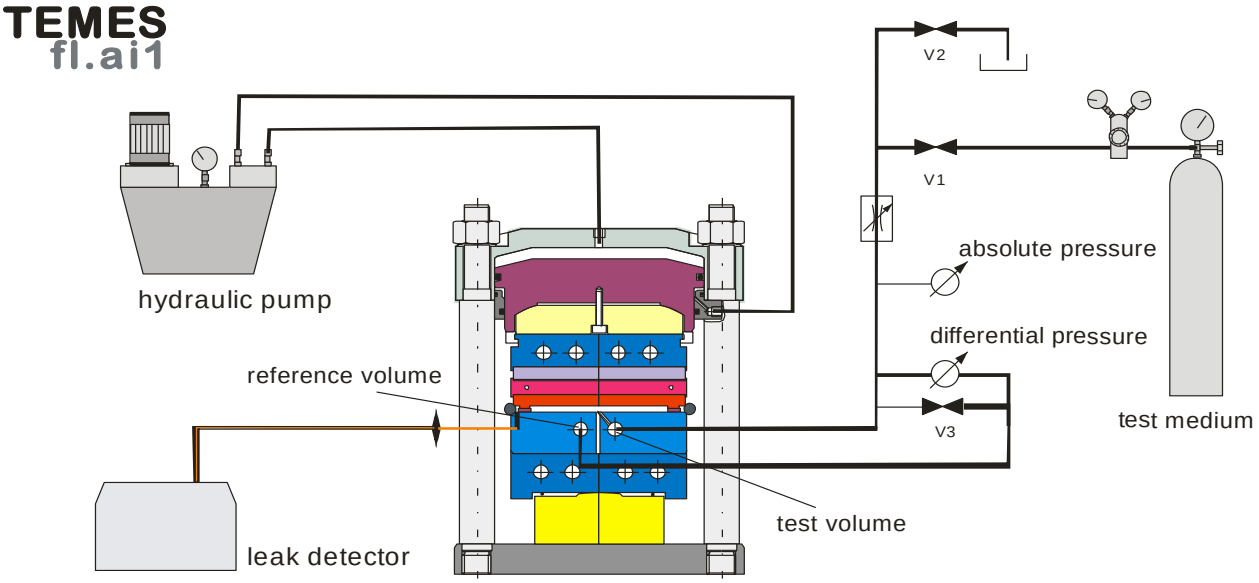
All the values of $R_{LM}$ are within the required band. So both HP-tests and LP-tests are used to calculate the PVRC parameters.

In the graphs in **appendix 13** the gasket stress Sg is plotted vs. the tightness parameter Tp for all HP and LP tests. From these results the PVRC parameters have been evaluated, they are also shown in this graph.

The PVRC parameters Gb, a and Gs are summarized in the table in **appendix 14**. Also the values for Tpmin, Tpmax, $S_{100}$, $S_{1000}$, $S_{3000}$ and $S_{10000}$ are listed in this table.

# 7. Photo Documentation

In the **appendices 15 to 16** photos of the tested gasket specimens GR1700 are presented.


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

| Test Step | Test Part | Stress Level | Gasket Stress | | Fluid Pressure | |
|---|---|---|---|---|---|---|
| | | S | Sg [MPa] | Sg [psi] | P [MPa] | P [psi] |
| 1 | A | S1 | 8.0 | 1160 | 6.0 | 870 |
| 2 | A | S2 | 20.0 | 2900 | 6.0 | 870 |
| 3 | A | S3 | 30.0 | 4350 | 6.0 | 870 |
| 4 | A | S4 | 40.0 | 5800 | 6.0 | 870 |
| 5 | B1 | S1 | 8.0 | 1160 | 6.0 | 870 |
| 6 | A | S5 | 50.0 | 7250 | 6.0 | 870 |
| 7 | A | S6 | 60.0 | 8700 | 6.0 | 870 |
| 9 | B2 | S1 | 8.0 | 1160 | 6.0 | 870 |
| 10 | A | S7 | 70.0 | 10150 | 6.0 | 870 |
| 11 | A | S8 | 80.0 | 11600 | 6.0 | 870 |
| 13 | B3 | S1 | 8.0 | 1160 | 6.0 | 870 |
| 14 | A | S9 | 90.0 | 13050 | 6.0 | 870 |
| 15 | A | S10 | 105.0 | 15225 | 6.0 | 870 |
| 17 | B4 | S1 | 8.0 | 1160 | 6.0 | 870 |
| 18 | A | S11 | 120.0 | 17400 | 6.0 | 870 |
| 19 | A | S12 | 140.0 | 20300 | 6.0 | 870 |
| 20 | A | S13 | 160.0 | 23200 | 6.0 | 870 |
| 22 | B5 | S1 | 8.0 | 1160 | 6.0 | 870 |

## HP Test Sequence

| Test Step | Test Part | Stress Level | Gasket Stress | | Fluid Pressure | |
|---|---|---|---|---|---|---|
| | | S | Sg [MPa] | Sg [psi] | P [MPa] | P [psi] |
| 1 | A | S1 | 8.0 | 1160 | 2.0 | 290 |
| 1A | A | S2 | 20.0 | 2900 | 2.0 | 290 |
| 2 | A | S3 | 30.0 | 4350 | 2.0 | 290 |
| 3 | A | S5 | 50.0 | 7250 | 2.0 | 290 |
| 4 | A | S7 | 70.0 | 10150 | 2.0 | 290 |
| 5 | A | S10 | 105.0 | 15225 | 2.0 | 290 |
| 6 | A | S12 | 140.0 | 20300 | 2.0 | 290 |

## LP Test Sequence

# ROTT HP Test Sequence

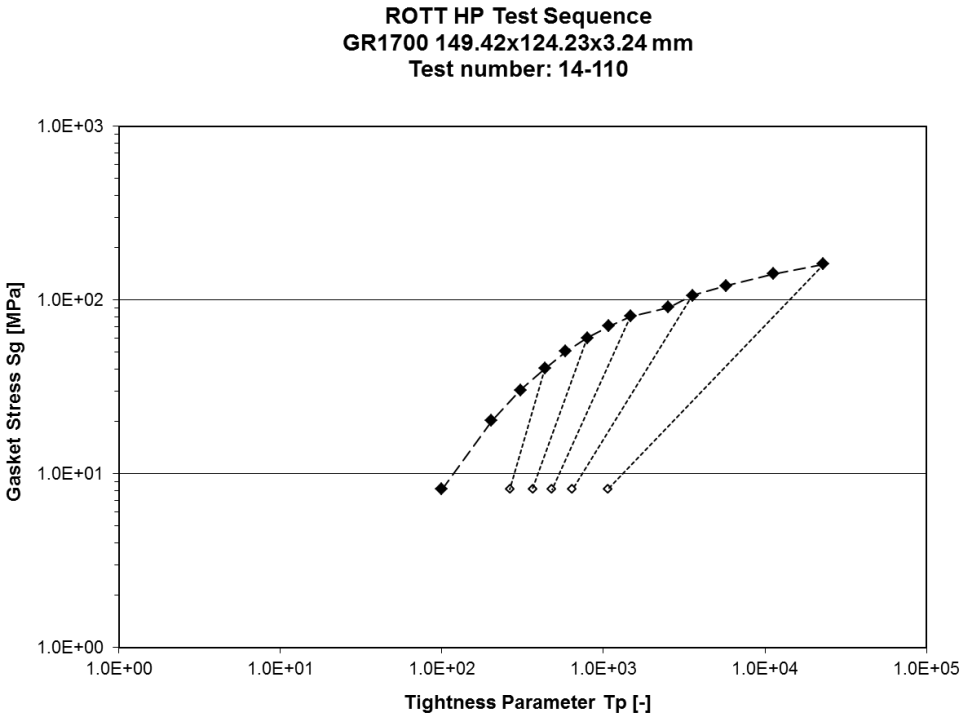
**GR1700**
**149.42x124.23x3.24 mm**
**Test number: 14-110**

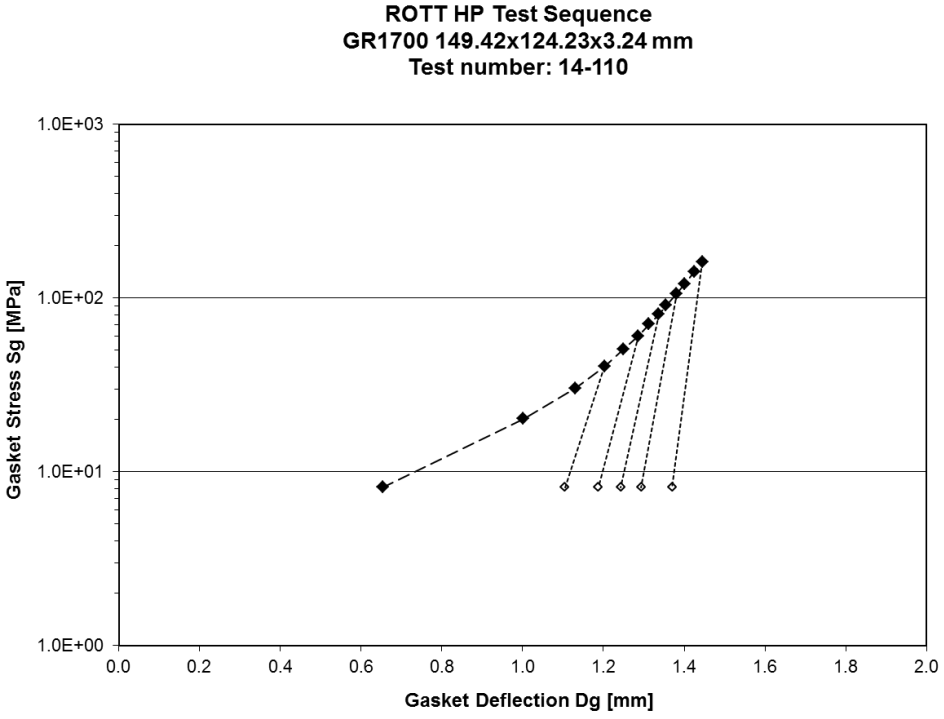
| Test Step | Gasket Deflection Dg [mm] | Gasket Stress Sg [MPa] | Fluid Pressure P [MPa] | He Mass Leak Rate Lrm [mg/s] | Test Part | Stress Level S | Tightness TpA | Tightness TpB |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.654 | 8.1 | 5.9 | 3.43E-01 | A | S1 | 9.97E+01 | |
| 2 | 1.002 | 20.2 | 5.9 | 8.26E-02 | A | S2 | 2.03E+02 | |
| 3 | 1.131 | 30.3 | 5.9 | 3.66E-02 | A | S3 | 3.07E+02 | |
| 4 | 1.203 | 40.4 | 5.9 | 1.81E-02 | A | S4 | 4.36E+02 | 4.36E+02 |
| 5 | 1.105 | 8.2 | 5.9 | 4.82E-02 | B1 | S1 | | 2.64E+02 |
| 6 | 1.249 | 50.5 | 5.9 | 1.00E-02 | A | S5 | 5.85E+02 | |
| 7 | 1.286 | 60.5 | 5.9 | 5.41E-03 | A | S6 | 7.96E+02 | 7.96E+02 |
| 9 | 1.188 | 8.2 | 5.9 | 2.55E-02 | B2 | S1 | | 3.66E+02 |
| 10 | 1.313 | 70.6 | 6.0 | 3.00E-03 | A | S7 | 1.08E+03 | |
| 11 | 1.337 | 80.7 | 6.0 | 1.61E-03 | A | S8 | 1.48E+03 | 1.48E+03 |
| 13 | 1.243 | 8.2 | 5.9 | 1.48E-02 | B3 | S1 | | 4.81E+02 |
| 14 | 1.355 | 90.8 | 6.0 | 5.58E-04 | A | S9 | 2.52E+03 | |
| 15 | 1.381 | 105.9 | 6.0 | 2.74E-04 | A | S10 | 3.56E+03 | 3.56E+03 |
| 17 | 1.293 | 8.2 | 5.9 | 8.30E-03 | B4 | S1 | | 6.42E+02 |
| 18 | 1.402 | 121.0 | 6.0 | 1.04E-04 | A | S11 | 5.76E+03 | |
| 19 | 1.425 | 141.1 | 6.0 | 2.76E-05 | A | S12 | 1.12E+04 | |
| 20 | 1.445 | 161.0 | 6.0 | 6.63E-06 | A | S13 | 2.30E+04 | 2.30E+04 |
| 22 | 1.37 | 8.2 | 6.0 | 3.06E-03 | B5 | S1 | | 1.06E+03 |

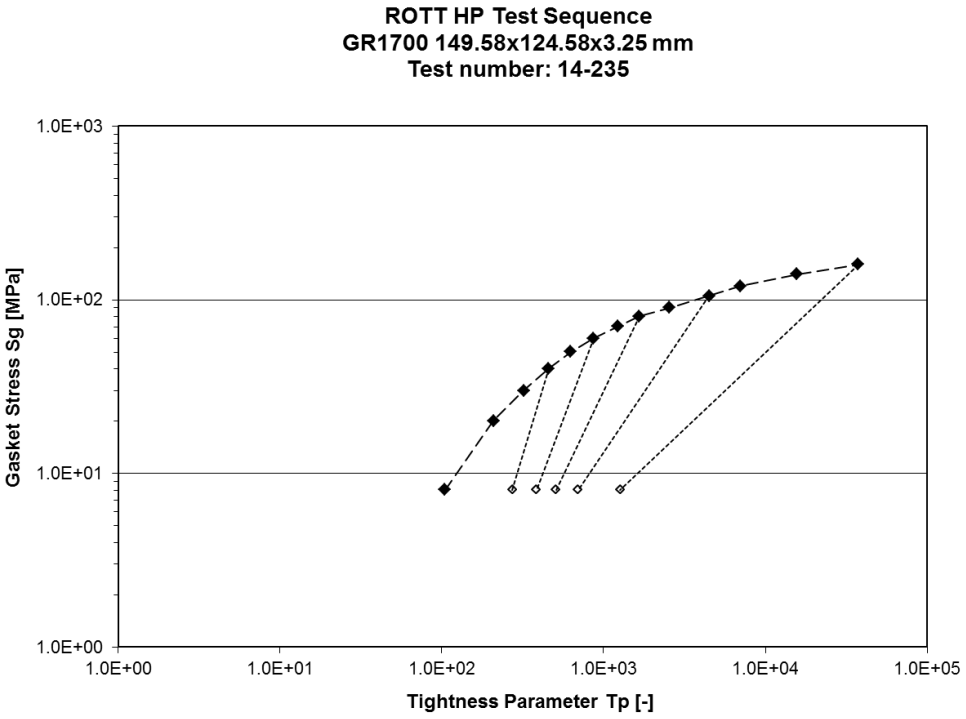
# ROTT HP Test Sequence

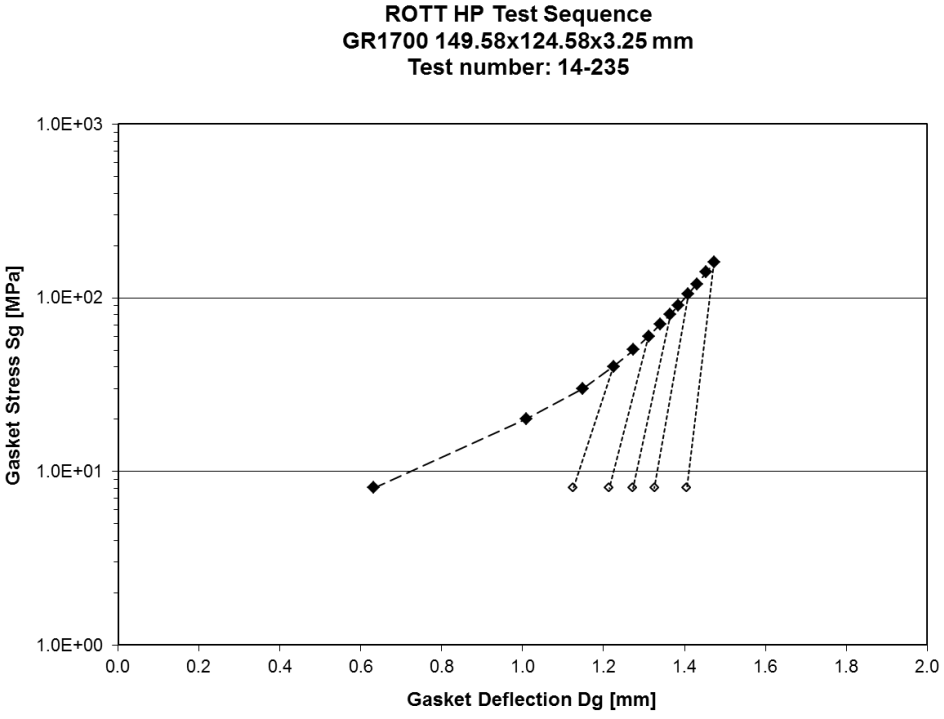
**GR1700**
**149.58x124.58x3.25 mm**
**Test number: 14-235**

| Test Step | Gasket Deflection Dg [mm] | Gasket Stress Sg [MPa] | Fluid Pressure P [MPa] | He Mass Leak Rate Lrm [mg/s] | Test Part | Stress Level S | Tightness TpA | Tightness TpB |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.632 | 8.1 | 5.9 | 3.09E-01 | A | S1 | 1.05E+02 | |
| 2 | 1.01 | 20.1 | 5.9 | 7.86E-02 | A | S2 | 2.09E+02 | |
| 3 | 1.149 | 30.1 | 5.9 | 3.33E-02 | A | S3 | 3.20E+02 | |
| 4 | 1.225 | 40.1 | 5.9 | 1.63E-02 | A | S4 | 4.58E+02 | 4.58E+02 |
| 5 | 1.125 | 8.1 | 5.9 | 4.52E-02 | B1 | S1 | | 2.73E+02 |
| 6 | 1.274 | 50.1 | 6.0 | 8.85E-03 | A | S5 | 6.26E+02 | |
| 7 | 1.312 | 60.2 | 6.0 | 4.58E-03 | A | S6 | 8.69E+02 | 8.69E+02 |
| 9 | 1.214 | 8.1 | 5.9 | 2.33E-02 | B2 | S1 | | 3.84E+02 |
| 10 | 1.34 | 70.2 | 5.9 | 2.31E-03 | A | S7 | 1.22E+03 | |
| 11 | 1.365 | 80.2 | 6.0 | 1.25E-03 | A | S8 | 1.66E+03 | 1.66E+03 |
| 13 | 1.272 | 8.1 | 5.9 | 1.33E-02 | B3 | S1 | | 5.08E+02 |
| 14 | 1.384 | 90.2 | 6.0 | 5.30E-04 | A | S9 | 2.56E+03 | |
| 15 | 1.41 | 105.3 | 6.0 | 1.74E-04 | A | S10 | 4.49E+03 | 4.49E+03 |
| 17 | 1.326 | 8.1 | 5.9 | 7.00E-03 | B4 | S1 | | 6.98E+02 |
| 18 | 1.431 | 120.3 | 6.1 | 7.25E-05 | A | S11 | 7.03E+03 | |
| 19 | 1.454 | 140.3 | 6.0 | 1.46E-05 | A | S12 | 1.56E+04 | |
| 20 | 1.473 | 160.1 | 6.0 | 2.51E-06 | A | S13 | 3.75E+04 | 3.75E+04 |
| 22 | 1.406 | 8.1 | 5.9 | 2.12E-03 | B5 | S1 | | 1.27E+03 |


ROTT HP Test Sequence
GR1700 149.42x124.23x3.24 mm
Test number: 14-110
Gasket Stress Sg [MPa]
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
1.0E+05
Tightness Parameter Tp [-]


ROTT HP Test Sequence
GR1700 149.42x124.23x3.24 mm
Test number: 14-110
Gasket Stress Sg [MPa]
1.0E+03
1.0E+02
1.0E+01
1.0E+00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Gasket Deflection Dg [mm]


ROTT HP Test Sequence
GR1700 149.58x124.58x3.25 mm
Test number: 14-235
Gasket Stress Sg [MPa]
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
1.0E+05
Tightness Parameter Tp [-]


ROTT HP Test Sequence
GR1700 149.58x124.58x3.25 mm
Test number: 14-235
Gasket Stress Sg [MPa]
1.0E+03
1.0E+02
1.0E+01
1.0E+00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Gasket Deflection Dg [mm]

## ROTT LP Test Sequence

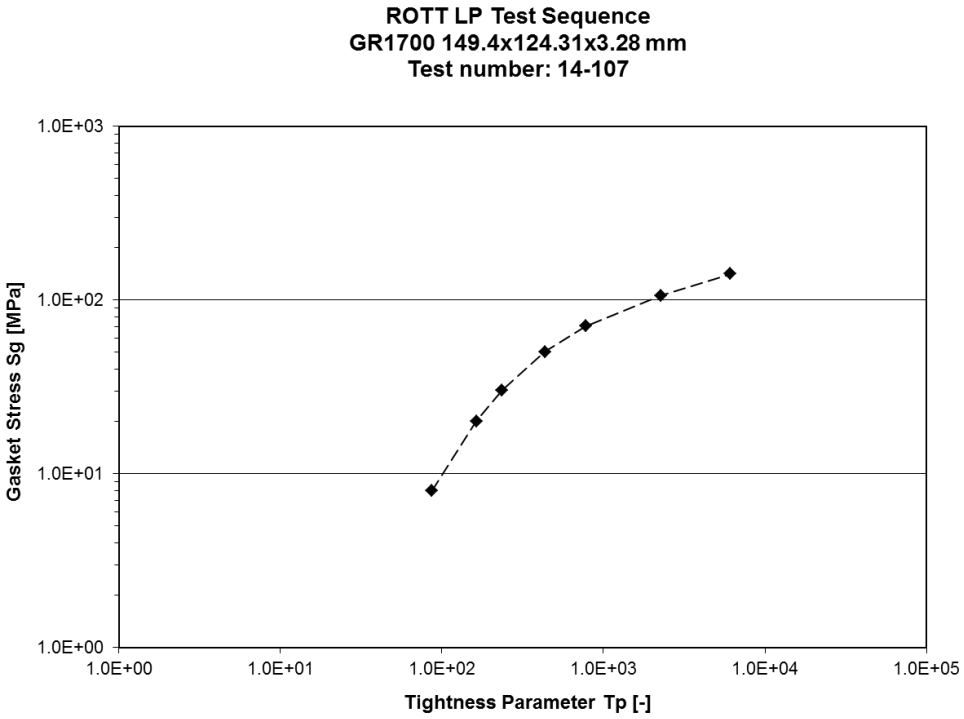
**GR1700**
**149.4x124.31x3.28 mm**
**Test number: 14-107**

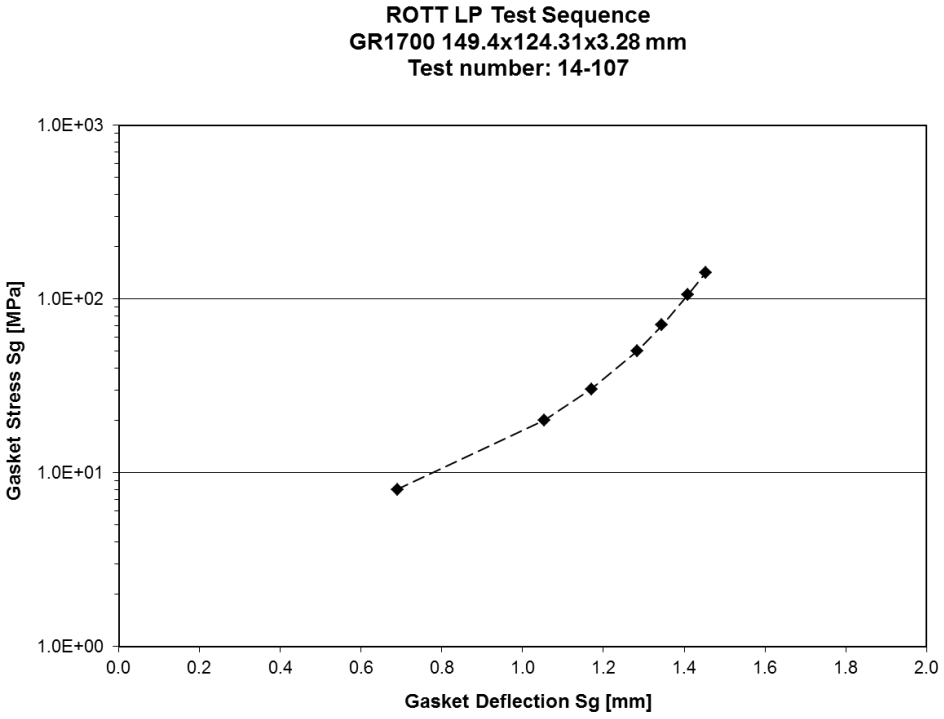
| Test Step | Gasket Deflection Dg [mm] | Gasket Stress Sg [MPa] | Fluid Pressure P [MPa] | He Mass Leak Rate Lrm [mg/s] | Test Part | Stress Level S | Tightness TpA | Tightness TpB |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.69 | 8.0 | 2.0 | 4.97E-02 | A | S1 | 8.67E+01 | |
| 1A | 1.054 | 20.1 | 2.0 | 1.42E-02 | A | S2 | 1.64E+02 | |
| 2 | 1.17 | 30.2 | 2.0 | 6.69E-03 | A | S3 | 2.36E+02 | |
| 3 | 1.284 | 50.4 | 2.0 | 2.00E-03 | A | S5 | 4.35E+02 | |
| 4 | 1.345 | 70.5 | 2.0 | 6.44E-04 | A | S7 | 7.76E+02 | |
| 5 | 1.41 | 105.8 | 2.0 | 7.67E-05 | A | S10 | 2.27E+03 | |
| 6 | 1.453 | 141.1 | 2.0 | 1.05E-05 | A | S12 | 6.11E+03 | |

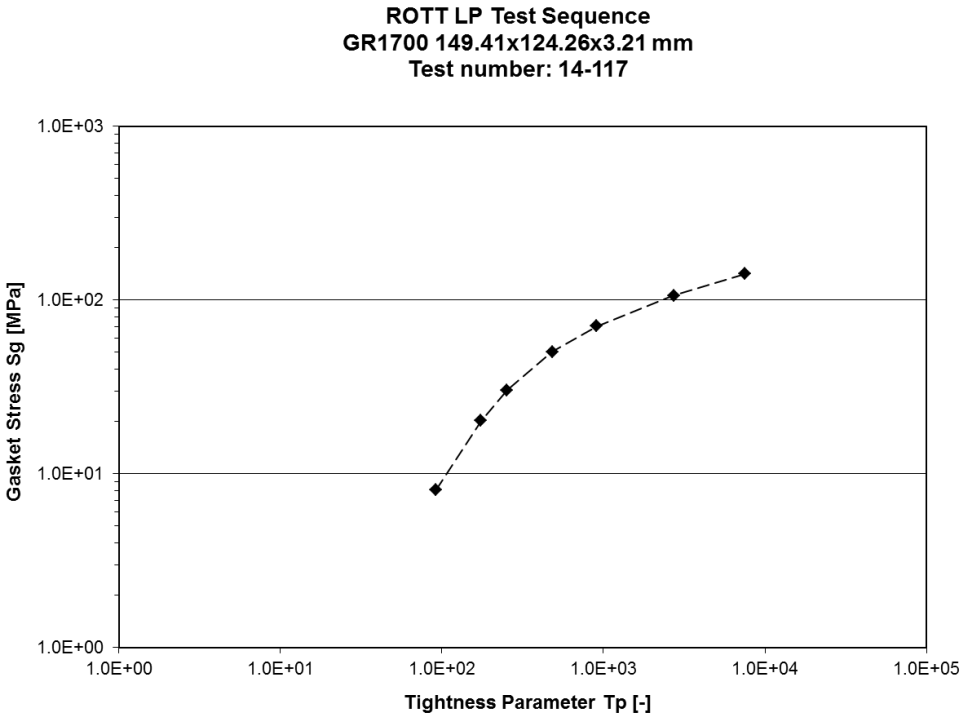
## ROTT LP Test Sequence

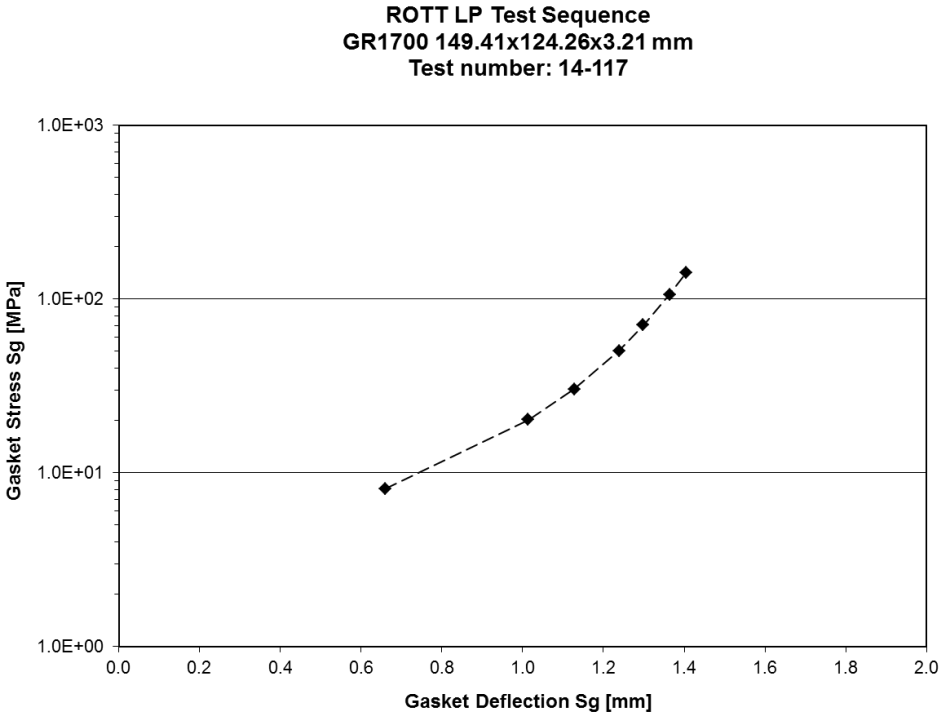
**GR1700**
**149.41x124.26x3.21 mm**
**Test number: 14-117**

| Test Step | Gasket Deflection Dg [mm] | Gasket Stress Sg [MPa] | Fluid Pressure P [MPa] | He Mass Leak Rate Lrm [mg/s] | Test Part | Stress Level S | Tightness TpA | Tightness TpB |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.661 | 8.1 | 2.0 | 4.38E-02 | A | S1 | 9.23E+01 | |
| 1A | 1.014 | 20.2 | 2.0 | 1.25E-02 | A | S2 | 1.74E+02 | |
| 2 | 1.128 | 30.2 | 2.0 | 5.81E-03 | A | S3 | 2.54E+02 | |
| 3 | 1.239 | 50.4 | 2.0 | 1.64E-03 | A | S5 | 4.82E+02 | |
| 4 | 1.299 | 70.6 | 2.0 | 4.73E-04 | A | S7 | 9.07E+02 | |
| 5 | 1.364 | 105.8 | 2.0 | 5.33E-05 | A | S10 | 2.72E+03 | |
| 6 | 1.405 | 141.1 | 2.0 | 6.89E-06 | A | S12 | 7.51E+03 | |


ROTT LP Test Sequence
GR1700 149.4x124.31x3.28 mm
Test number: 14-107
Gasket Stress Sg [MPa]
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
1.0E+05
Tightness Parameter Tp [-]


ROTT LP Test Sequence
GR1700 149.4x124.31x3.28 mm
Test number: 14-107
Gasket Stress Sg [MPa]
1.0E+03
1.0E+02
1.0E+01
1.0E+00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Gasket Deflection Sg [mm]


ROTT LP Test Sequence
GR1700 149.41x124.26x3.21 mm
Test number: 14-117
Gasket Stress Sg [MPa]
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
1.0E+05
Tightness Parameter Tp [-]


ROTT LP Test Sequence
GR1700 149.41x124.26x3.21 mm
Test number: 14-117
Gasket Stress Sg [MPa]
1.0E+03
1.0E+02
1.0E+01
1.0E+00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Gasket Deflection Sg [mm]

## Validity check rules

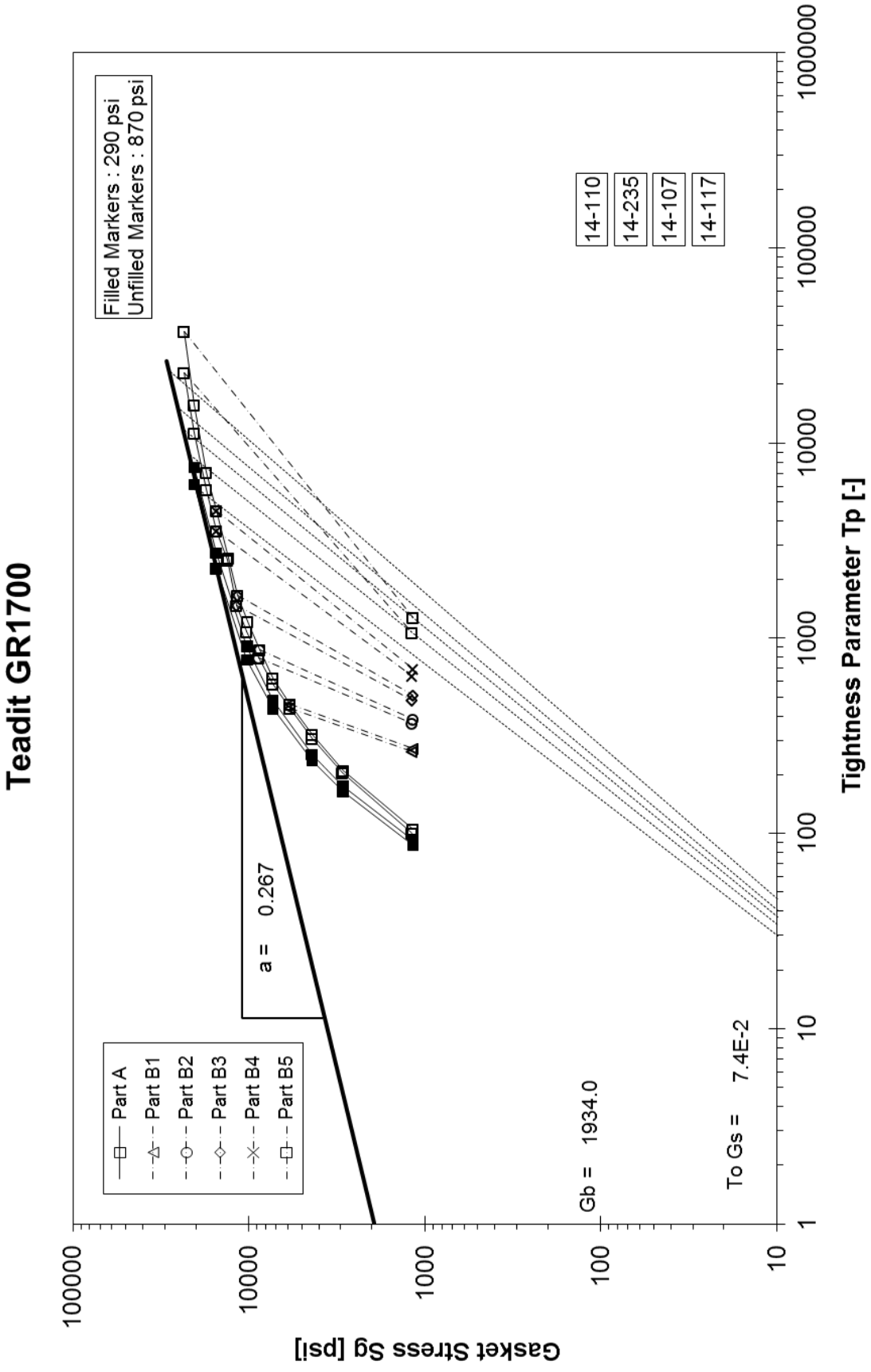
| Test Step | Test-No.: 14-110 | Test-No.: 14-235 | $R_{LM}$ = Lrm/Lrm | $R_{LM}$ = Lrm1/Lrm2 |
|---|---|---|---|---|
| | He Mass Leak Rate | He Mass Leak Rate | **required** | |
| | Lrm1 [mg/s] | Lrm2 [mg/s] | | |
| 1 | 3.43E-01 | 3.09E-01 | $0.2 < R_{LM} < 5$ | 1.11 |
| 2 | 8.26E-02 | 7.86E-02 | $0.33 < R_{LM} < 3$ | 1.05 |
| 3 | 3.66E-02 | 3.33E-02 | $0.33 < R_{LM} < 3$ | 1.10 |
| 4 | 1.81E-02 | 1.63E-02 | $0.33 < R_{LM} < 3$ | 1.11 |
| 5 | 4.82E-02 | 4.52E-02 | $0.33 < R_{LM} < 3$ | 1.07 |
| 6 | 1.00E-02 | 8.85E-03 | $0.33 < R_{LM} < 3$ | 1.13 |
| 7 | 5.41E-03 | 4.58E-03 | $0.25 < R_{LM} < 4$ | 1.18 |
| 9 | 2.55E-02 | 2.33E-02 | $0.33 < R_{LM} < 3$ | 1.09 |
| 10 | 3.00E-03 | 2.31E-03 | $0.25 < R_{LM} < 4$ | 1.30 |
| 11 | 1.61E-03 | 1.25E-03 | $0.25 < R_{LM} < 4$ | 1.29 |
| 13 | 1.48E-02 | 1.33E-02 | $0.33 < R_{LM} < 3$ | 1.11 |
| 14 | 5.58E-04 | 5.30E-04 | $0.25 < R_{LM} < 4$ | 1.05 |
| 15 | 2.74E-04 | 1.74E-04 | $0.25 < R_{LM} < 4$ | 1.58 |
| 17 | 8.30E-03 | 7.00E-03 | $0.33 < R_{LM} < 3$ | 1.19 |
| 18 | 1.04E-04 | 7.25E-05 | $0.25 < R_{LM} < 4$ | 1.43 |
| 19 | 2.76E-05 | 1.46E-05 | $0.25 < R_{LM} < 4$ | 1.89 |
| 20 | 6.63E-06 | 2.51E-06 | $0.25 < R_{LM} < 4$ | 2.64 |
| 22 | 3.06E-03 | 2.12E-03 | $0.33 < R_{LM} < 3$ | 1.44 |

## ROTT HP Test Sequence

## Validity check rules

| Test No. 14-107 | Test No. 14-117 | $R_{LM}$ = Lrm/Lrm | $R_{LM}$ = Lrm1/Lrm2 | Test Step |
|---|---|---|---|---|
| He Mass Leak Rate | He Mass Leak Rate | **required** | | |
| Lrm [mg/s] | Lrm [mg/s] | | | |
| 4.97E-02 | 4.38E-02 | $0.2 < R_{LM} < 5$ | 1.13 | 1 |
| 1.42E-02 | 1.25E-02 | $0.33 < R_{LM} < 3$ | 1.13 | 1A |
| 6.69E-03 | 5.81E-03 | $0.25 < R_{LM} < 4$ | 1.15 | 2 |
| 2.00E-03 | 1.64E-03 | $0.25 < R_{LM} < 4$ | 1.22 | 3 |
| 6.44E-04 | 4.73E-04 | $0.25 < R_{LM} < 4$ | 1.36 | 4 |
| 7.67E-05 | 5.33E-05 | $0.25 < R_{LM} < 4$ | 1.44 | 5 |
| 1.05E-05 | 6.89E-06 | $0.25 < R_{LM} < 4$ | 1.52 | 6 |

## ROTT LP Test Sequence

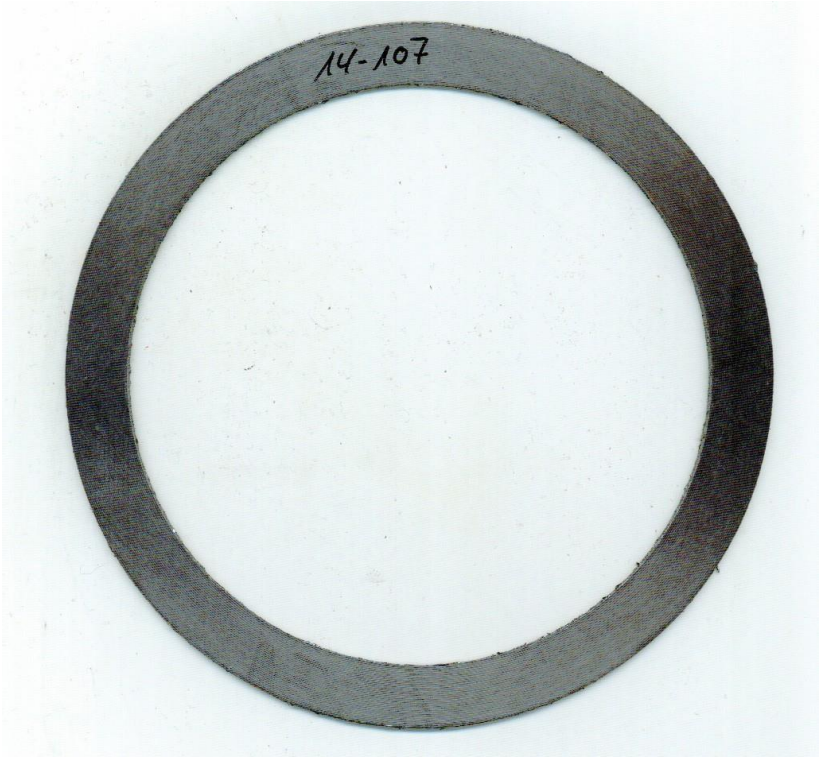

Teadit GR1700
Filled Markers : 290 psi
Unfilled Markers : 870 psi
14-110
14-235
14-107
14-117
Part A
Part B1
Part B2
Part B3
Part B4
Part B5
a = 0.267
Gb = 1934.0
To Gs = 7.4E-2
Gasket Stress Sg [psi]
Tightness Parameter Tp [-]
100000
10000
1000
100
10
1
10
100
1000
10000
100000
1000000

| Material | Teadit GR 1700 |
|---|---|
| Gb | 1934 |
| a | 0.267 |
| Gs | 0.1 |
| Tpmin | 264 |
| Tpmax | 13 253 |
| S100 | 6 620 |
| S1000 | 12 248 |
| S3000 | 16 427 |
| S10000 | > Su |

**GR 1700: PVRC Parameters Gb, a and Gs**


**GR 1700 – ROTT HP Test**


**GR 1700 – ROTT HP Test**




**GR 1700 – ROTT LP Test**


**GR 1700 – ROTT LP Test**