Precision Parts & Solutions

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Kalrez® Perfluoroelastomer Parts

Kalrez® The original.

Perfluoroelastomer behaviour in rapid gas decompression

Kalrez® Perfluoroelastomer Parts

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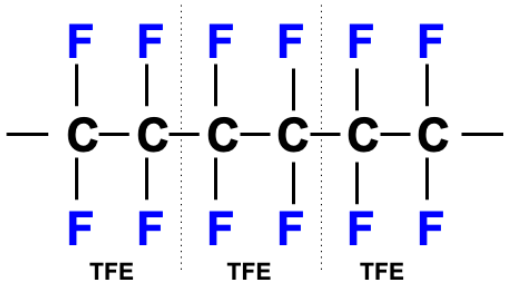
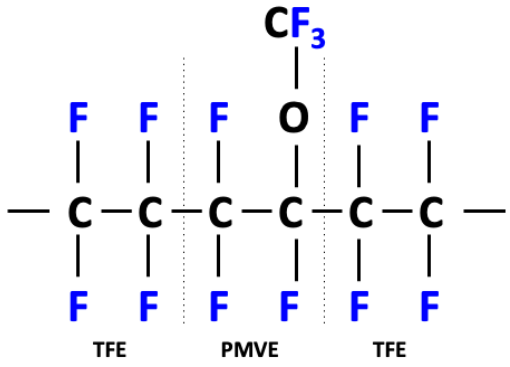
PTFE



Type	Fluorine [%]	Hydrogen [%]
TFE/P	54	4.2
FKM Type A	66	1.9
FKM Type B	68	1.4
FKM Type F	70	1.1
FFKM	73	0
PTFE	76	0

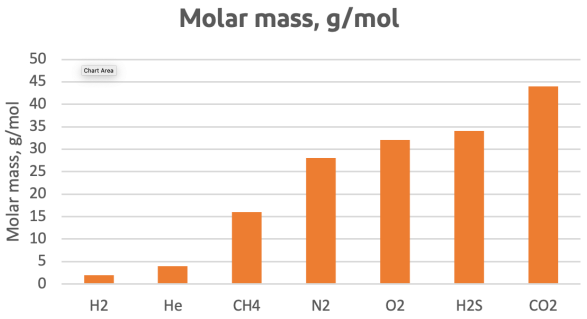
FFKM Kalrez®

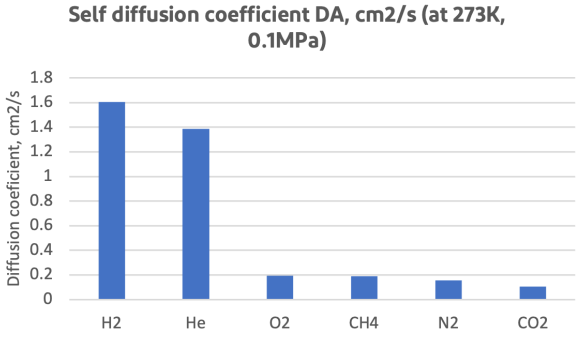


Bond type	Energy [kcal/mol]	Elastomer
C-F	105	Fluoro- and perfluoroelastomers
C-H	80	Ethylene-propylene elastomers
C-Cl	79	Polychloroprene

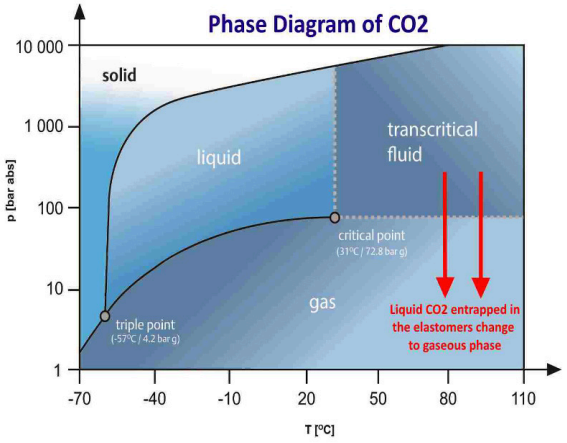
What is Rapid Gas Decompression - RGD?

Rapid Gas Decompression (RGD) can cause structural failure in the form of blistering, internal cracking and splitting. This is caused when the gas pressure applied on the seal is reduced quickly enough so that the gas entrapped in the elastomer cannot migrate out.





The most damaging gas for non-metallic materials and more particularly elastomers is carbon dioxide mostly because it acts as a solvent and induces high swell in elastomers.



Presentation of the study

The aim of this study is to evaluate the parameters influencing the rapid gas decompression performance of a perfluoroelastomer using Kalrez® OG193 as a test candidate.

The main parameters studied are:

- Decompression rate
- Type of gas
- CO_2 content
- Hydrogen
- O-ring cross section
- Temperature
- Cycles

Those parameters and gases are very important with the current alternative energy trends with a market focused on hydrogen and carbon capture, utilization and storage technologies.

Kalrez® OG193 Perfluoroelastomer Parts

DuPont™ Kalrez® OG193 is a 95 durometer, FFKM compound that combines Rapid Gas Decompression (RGD) performance and chemical resistance with good low temperature and thermal stability.

TABLE 1: Typical Physical Properties[1]	Kalrez® OG193 parts
Color	Black
Hardness, Shore A[2]	95
50% Modulus[3], MPa (psi)	11.5 (1670)
Tensile Strength at Break[3], MPa (psi)	20.0 (2900)
Elongation at Break[3], %	100
Compression Set[4], %, 70 hrs. at 204 °C (400 °F)	21
Upper Service Temperature[5], °C (°F)	250 (482)
Rapid Gas Decompression[6]	Pass
ISO 23936-2	0000-0000-0000

1 Not to be used for specification purposes
2 ASTM D2240 (slab test specimens)
3 ASTM D1414 (AS568 K214 O-ring test specimens)
4 ASTM D395B (AS568 K214 O-ring test specimens)
5 DuPont proprietary test method (anaerobic conditions)
6 Externally tested in certified lab, under ISO 23936-2 guidelines

Test procedure

A specific short **20 hours** internal test procedure is used to determine the perfluoroelastomer seal behaviour according to the various influencing parameters.

Specific short test procedure used:

Test duration: 20 hours

Temperature: 90 °C / 194 °F to 200 °C / 392 °F

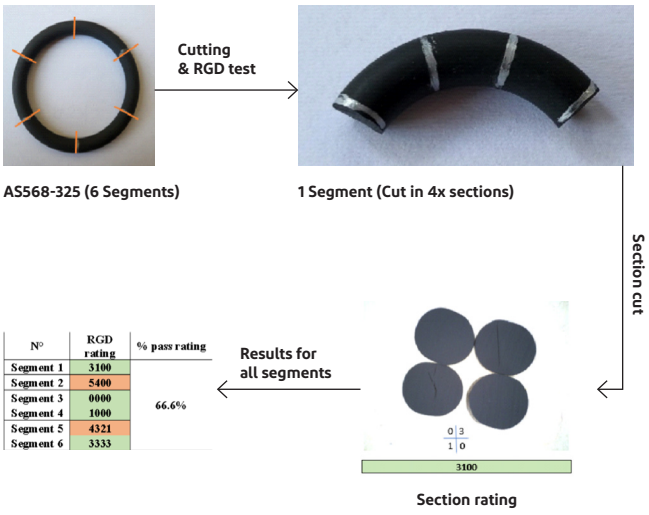
Pressure: up to 300bar / 4350psi

Gas: He, N_2, CO_2, H_2

Open groove with only axial compression

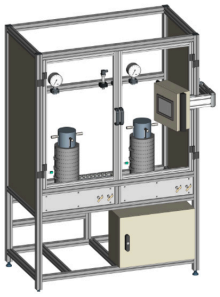
RGD ISO 23936-2 rating calculated into % pass rating

Rating method:



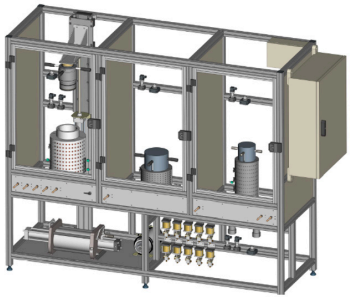
Test equipment

RGD scouting bench



✓ 2 Cells
✓ Up to 35MPa with gas
✓ RT to +250 °C
✓ CO_2 up to 100%

Automatic RGD bench



✓ 2 Cells
✓ Up to 70MPa with gas
✓ RT to +250 °C
✓ Automated pressure cycling

Overall test capabilities:

Full ISO 23936-2 (Norsok M710) cycles with CO_2/N_2 and other industry specification

Test mainly with N_2 and CO_2

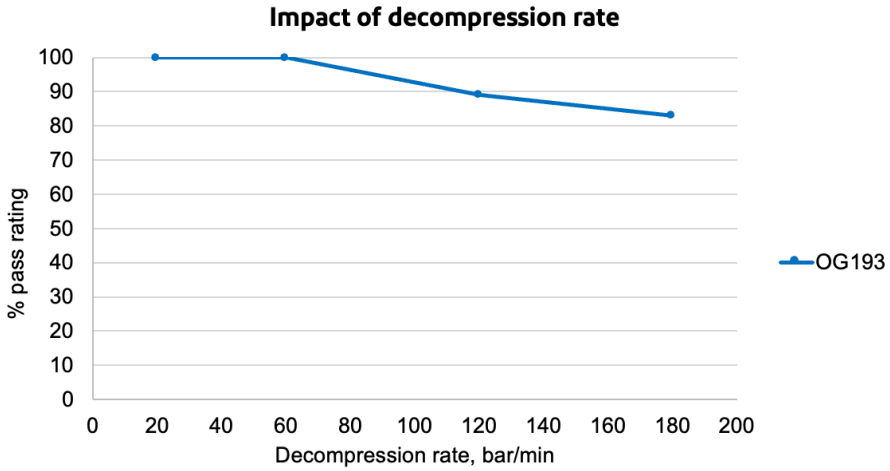
From room temperature (RT) to 250 °C / 482 °F

Up to 700bar / 10'000psi

Pressure vessel & piston type groove

Test O-rings AS568: 214, 315, 325, 349, 425

Impact of decompression



Test conditions:

FFKM: Kalrez® OG193

Pressure: 200bar / 2900psi

Temperature: 200 °C / 392 °F

Gas: CO_2/N_2 – 10/90%

Test duration: 20hrs

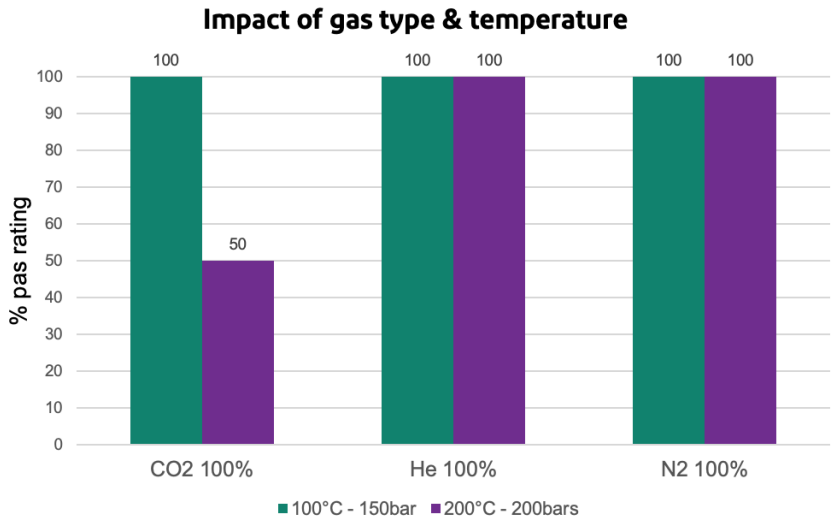
Specimen: 5.33mm O-ring

Decompression rates:

- 20bar/min
- 60bar/min
- 120bar/min
- 180bar/min

✓ The decompression rate has shown an impact over the rapid gas decompression performance and rating
✓ In this test no impact was measured up to 60bar per minute for Kalrez® OG193

Impact of gas type and temperature



Test conditions:

FFKM: Kalrez® OG193

Test duration: 20hrs

Decompression rate: 120bar/min

Specimen: 5.33mm O-ring

Conditions:

- 200 °C & 200bar (392 °F & 2900psi)
- 100 °C & 150bar (212 °F & 2175psi)

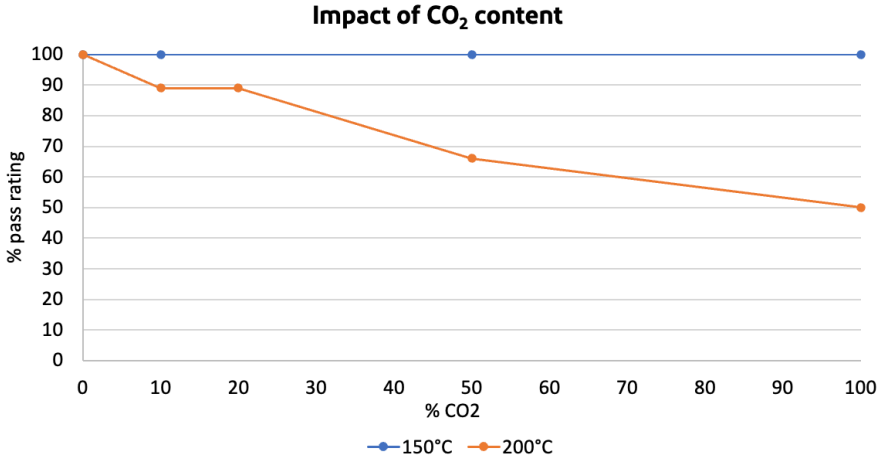
Gases:

- 100% CO_2
- 100% He
- 100% N_2

✓ The most aggressive gas is carbon dioxide which is more hostile when tested at higher temperature and pressure than the standard ISO 23936-2 conditions.

✓ Helium and Nitrogen did not show any crack or blistering on the tested specimens.

Impact of CO_2 content



Test conditions:

FFKM: Kalrez® OG193

Test duration: 20hrs

Decompression rate: 120bar/min

Pressure: 200bar / 2900psi

Temperature:

150 °C / 302 °F

200 °C / 392 °F

Specimen: 5.33mm O-ring

CO_2 gas content mixed with N_2:

- 10%
- 20%
- 50%
- 100%

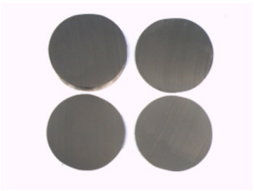
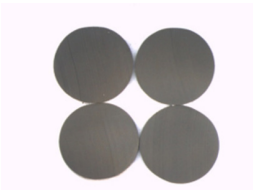
✓ It is possible to pass an RGD cycle with no cracks even using 100% CO_2

✓ The impact of CO_2 is clearly visible at 200°C and contents above 20% is showing more aggressive behaviour on the specimen tested.

Impact of hydrogen

Rapid gas decompression test on Kalrez® OG193 using pure H_2 gas at elevated temperature and pressure.

H_2 - Kalrez® OG193

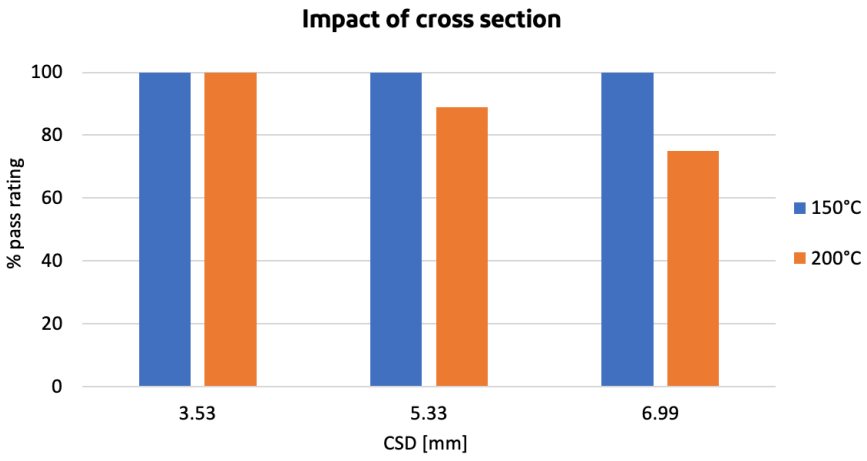
B1	B2
	
Rating: 0000	**Rating: 0000**

Test conditions:

FFKM: Kalrez® OG193
Hold time: 72hrs
Number of cycle: 1
Compression level: 13%
Specimen: AS568-315 O-rings
Decompression rate: 120bar/min
Pressure: 200bar / 2900psi
Temperature: 150 °C / 302 °F
Gas: dihydrogen: H_2

✓ The tested perfluoroelastomer was able to pass one cycle at high pressure and elevated temperature in hydrogen H_2 gas. No significant hardness or weight change was measured after the test.
✓ Like with Helium gas the hydrogen did not generate any cracks based on those conditions.

Impact of cross section

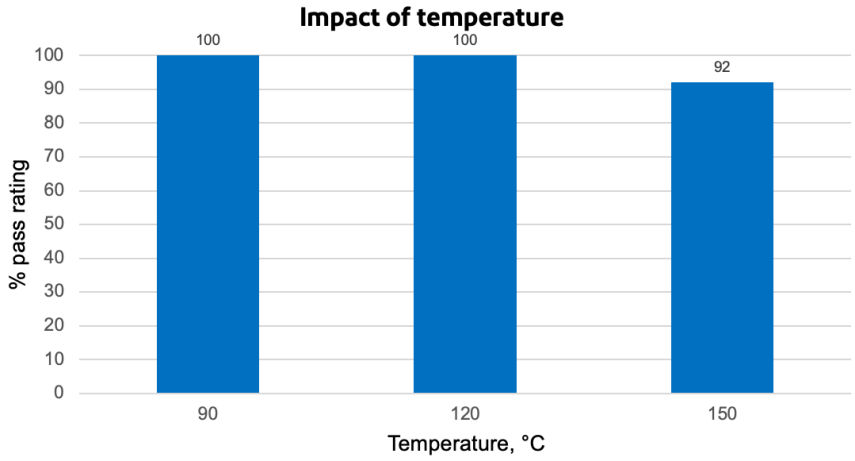


Test conditions:

FFKM: Kalrez® OG193
Test duration: 20hrs
Decompression rate: 120bar/min
Gas: CO_2/N_2 – 10/90%
Pressure: 200bar / 2900psi
Temperature:
• 150 °C / 302 °F
• 200 °C / 392 °F
O-ring cross sections:
• 6.99mm
• 5.33mm
• 3.53mm

✓ The impact of cross section dimensions over the rapid gas decompression performances is noticeable at 200 °C
✓ Test is failing more frequently for larger cross section at 200bar and 200°C.

Impact of temperature



Test conditions:

FFKM: Kalrez® OG193

Test duration: 20hrs

Decompression rate: 120bar/min

Gas: CO_2/N_2 – 10/90%

Pressure: 300bar / 4350psi

Specimen: 5.33mm O-ring

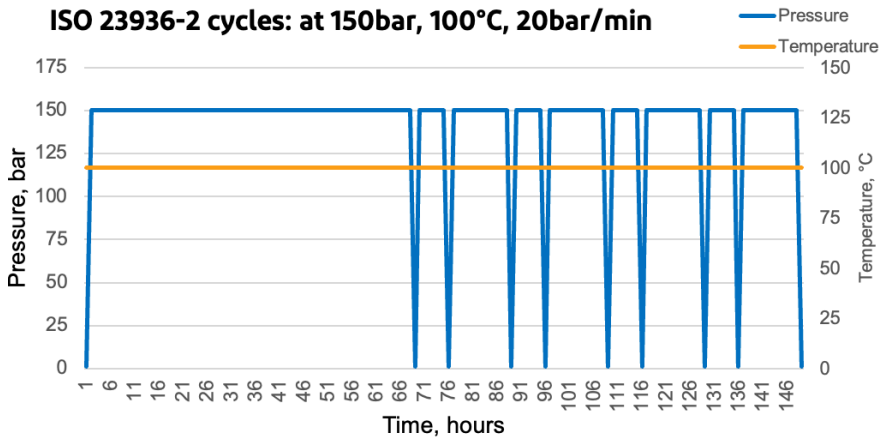
Temperature:

- 90 °C / 194 °F
- 120 °C / 248 °F
- 150 °C / 302 °F

✓ The rapid gas decompression performances decrease when the temperature is increased.

✓ Based on this study and other internal testing the most aggressive parameter in RGD testing seems to be the temperature.

Impact of cycles: ISO 23936-2



ISO 23936-2: using the ISO test fixture and AS568-315 O-rings

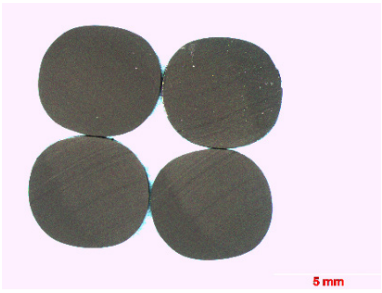
Gas: CO_2/N_2 – 10/90%

Pressure: 150bar / 2175psi

Temperature: 100 °C / 212 °F

Decompression rate: 20bar/min

Number of cycles: 1 + 8

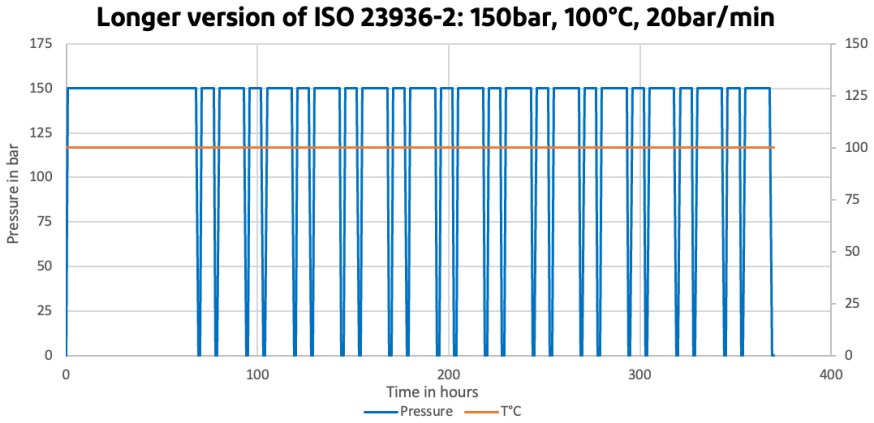


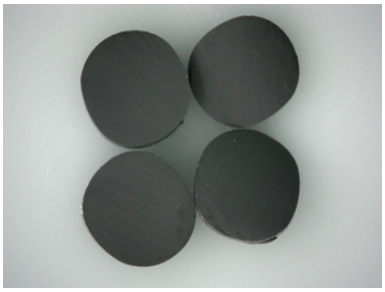
O-ring rating

O-ring 1	0000	PASS
O-ring 2	0000	PASS

✓ Both specimens have passed the acceptance criteria of the ISO 23936-2 RGD standard with a total of 8 cycles with 9 decompression events.

Impact of cycles





Kalrez® O-ring's rating

O-ring 1	0000	PASS
O-ring 2	0000	PASS

Using the ISO test fixture and AS568-315 O-rings / Kalrez® OG193

Gas: CO_2/N_2 – 10/90%

Pressure: 150bar / 2175psi

Temperature: 100 °C / 212 °F

Decompression rate: 20bar/min

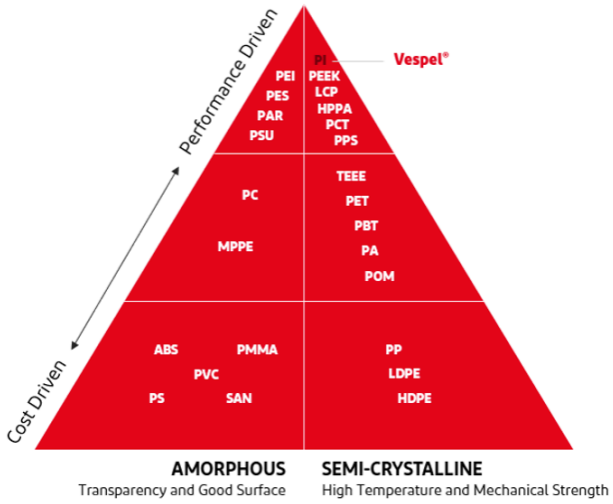
Number of cycles: 1 + 24

✓ The two first O-ring tested have passed the acceptance criteria of the ISO 23936-2 RGD standard with a total of 24 cycles with **25 decompression events.**

Polyimide ageing in sCO_2

Several DuPont™ Vespel® Polyimide parts were evaluated in sCO_2 to determine if they were affected by the ageing and the rapid gas decompression. Those products can be used for valve seats, bushings, seal rings and back up rings.

Test conditions	
Testing	Ageing and rapid gas decompression
Gas	100% CO_2
Temperature	150 °C / 302 °F
Pressure	200bar / 2900psi
Decompression rate	120bar/min – 1740psi/min
Duration	20hrs & 100hrs
Specimen	ISO527-1BA
Vespel® polyimide grades	Vespel® SP-1 (unfilled polymer) Vespel® SP-21 (graphite filled) Vespel® SCP-50094 (advanced filler technology)
Tested properties	E-Modulus, elongation at break, visual inspection



Polyimide ageing in sCO_2

✓ No visual defect or dimensional change was observed on the tensile specimens after 100 hours ageing coupled with a rapid gas decompression event.

✓ No significant impact over the E-modulus of the elongation at break was noticed after testing.

Conclusion

Based on this study and for the FFKM Kalrez® OG193 the most significant parameter for rapid gas decompression is the **temperature**. A temperature of 200 °C can be considered as high for rapid gas decompression test with the tested perfluoroelastomer grade.

The most damaging gas for non-metallic materials and more particularly elastomers is **carbon dioxide** mostly because it acts as a solvent and induce high level of swell. The third most aggressive parameter is the **decompression rate**.

The main recommendation for OEM and designers is to take care of specifying the correct temperature and to allow a process where the pressure changes and decompression can be controlled and recorded.

Finally, the Vespel® Polyimide Parts tested in this study did not exhibit any significant loss of mechanical properties after CO_2 exposure and could therefore be a candidate for super critical CO_2 services.