FFKM SIMRIZ® – HIGH-PERFORMANCE FFKM MATERIAL PORTFOLIO FOR EXTREME CONDITIONS

INNOVATING TOGETHER

FREUDENBERG
SEALING TECHNOLOGIES

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Your benefits from a single source

- In-depth material expertise in premium FFKM materials
- Many years of applications experience and use in a wide range of industries
- In-house R&D and production of high-performance materials with relevant approvals, such as FDA, USP Class VI and AMS7257

- In-house laboratory employing a wide range of analysis methods for optimum adaptation to specific operating conditions
- Development and calculation of virtual prototypes based on the finite element method (FEM)
- Customized designs

- Own production facilities worldwide
- Needs-based selection of production methods
- High, uniform quality standards (e.g. IATF 16949 certification, AS 9100D)
- Highest product quality and durability

- Many years of experience as part of the Freudenberg Group
- Applications advice based on countless tests and our own analyses (e.g. immersion tests, thermal analyses)

SIMRIZ®
MATERIAL PORTFOLIO

PERFLUOROELASTOMER (FFKM) SEALS

Simriz® perfluoroelastomer materials developed by Freudenberg Sealing Technologies are designed for thermal stability and almost universal protection against chemical substances and deliver superb sealing performance.

Material properties	134	481	484	485	491	495	498	501	502
Color	Black	Black	Black	Black	Black	Black	Black	Black	Black
Hardness (Shore A)	90	70	75	75	70	75	80	75	90
Temperature (static)	-15 – +230 °C	-30 – +230 °C	-10 – +230 °C	-15 – +230 °C	-20 – +230 °C	-15 – +230 °C	-5 – +320 °C	-5 – +320 °C	-5 – +320 °C
Tensile Strength (MPa)*	21,5	17,1	22,1	18,5	14,3	16,8	18,8	13,6	29,6

*Test values were generated using 2 mm test panels

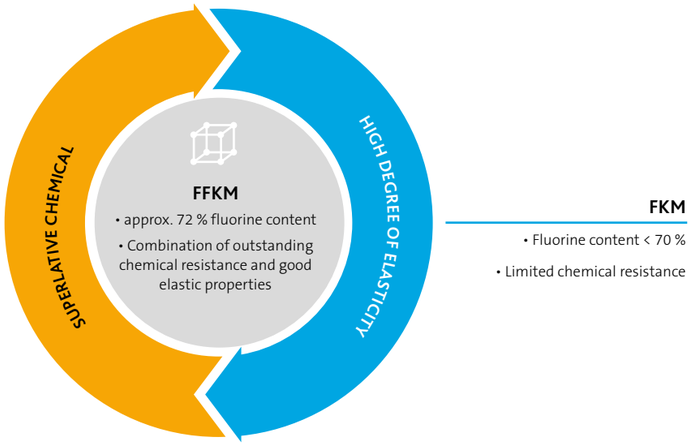


FIG. 1:
Comparison between FFKM, FKM and PTFE

90 Simriz® 134

Simriz® 134 offers excellent protection against aggressive chemicals. Its outstanding resistance to rapid gas decompression (RGD) makes Simriz® 134 the perfect choice for high pressure gas applications.
- Highest pressure resistance
- Applications:
  - oil and gas industry

70 Simriz® 481

Simriz® 481 performs well in a wide range of aggressive chemicals. Its outstanding performance at low temperatures makes Simriz® 481 the perfect match for almost any application in the chemical process industry.
- Resistance to low temperatures
- Broad chemical resistance
- Applications:
  - chemical industry
  - oil and gas industry

75 Simriz® 484

Simriz® 484 offers extensive resistance to aggressive chemicals and high temperatures. On the strength of its certifications, Simriz® 484 is ideal for use in the pharmaceutical and food industries.
- FDA-compliant
- Meets 3-A® Sanitary Standards
- USP Class VI Chapter 87 and 88
- Applications:
  - food industry
  - pharmaceutical industry

70 Simriz® 491

Simriz® 491 delivers excellent performance in aggressive chemicals and at low temperatures. These properties make it ideal for a wide range of applications in the chemical process industry.
- Good performance at low temperatures
- Low compression set for a long service life
- Applications:
  - chemical industry
  - oil and gas industry

80 Simriz® 498

Simriz® 498 features an impressively unique, patented material structure that ensures outstanding long-term performance in nearly every environment. Be it at extreme temperatures of up to +320 °C, in aggressive chemicals or even overheated steam and hot water, Simriz® 498 is the optimum choice.
- Patented cross-linking system ensures superior performance compared to competitor products
- Outstanding long-term resistance at extreme temperatures
- Applications:
  - chemical industry
  - oil and gas industry

75 Simriz® 501

Simriz® 501 is composed in such a way that it far exceeds the requirements of AMS7257. It impresses with its high resistance to temperatures of up to +320 °C and to a wide range of aggressive chemical environments.
- Patented cross-linking system ensures superior performance compared to competitor products
- Outstanding long-term resistance at extreme temperatures
- Applications:
  - aerospace
  - chemical industry

75 Simriz® 485

Simriz® 485 performs well in a wide range of aggressive chemicals as well as in overheated steam and hot water conditions. Thanks to its exceptional performance and cost-effective price structure, Simriz® 485 is the ideal solution for many chemical applications in the process industry.
- Broad chemical resistance
- Cost effectiveness through reduced maintenance
- Applications:
  - chemical industry
  - oil and gas industry

75 Simriz® 495

Simriz® 495 offers universal chemical resistance, including to amines, acids, and oxidizing agents, and is therefore ideal for applications in the chemical industry. The material covers a temperature range from -15 °C to +230 °C (briefly also up to +260 °C), is available in many O-ring sizes and represents a cost-effective solution for customers.
- Outstanding performance in steam and hot water
- Very good chemical resistance
- Applications:
  - chemical industry
  - oil and gas industry

90 Simriz® 502

Simriz® 502 features an impressive patented material structure and has been specially developed for the requirements of oil and gas applications and the CPI market. Extreme temperatures of up to +320 °C, aggressive chemicals, hot water, and steam pose no problems.
- Patented cross-linking system ensures superior performance compared to competitor products
- Outstanding resistance to explosive decompression (RGD = Rapid Gas Decompression)
- Applications:
  - chemical industry
  - oil and gas industry

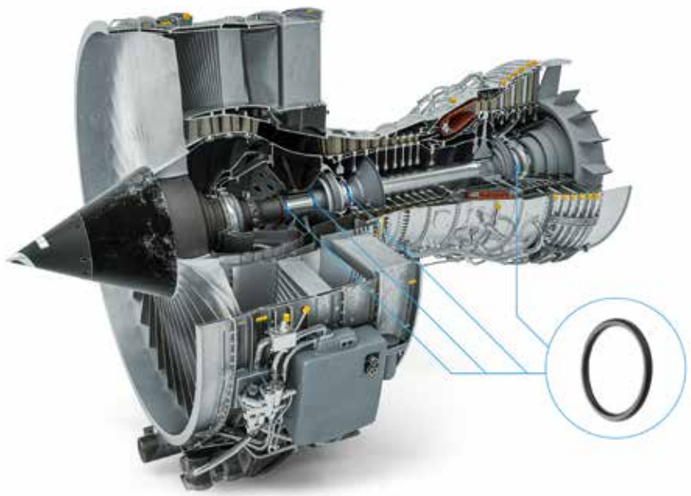
AEROSPACE

CHALLENGES IN THE AEROSPACE INDUSTRY

While aircraft fly at increasingly higher altitudes and therefore through colder layers of air, their engines are operated under extremely hot conditions. Engines are safety-critical components that must function properly even in long, challenging operating cycles and are also subject to strict regulations. This requires seals that can withstand not only very low, but also very high temperatures, while at the same time complying with statutory regulations, such as SAE AMS7257 for O-rings. Sustainability requirements for transporting people and freight by air also continue to increase, alternative fuels are becoming more important and the intention is to decrease the so-called footprint of flying.

FREUDENBERGS SIMRIZ® MATERIAL PORTFOLIO FOR THE AEROSPACE INDUSTRY

Freudenberg Sealing Technologies has developed special materials that are tailored to the requirements of the aerospace industry. Of particular note here is 75 Simriz® 501 (page 9).



75 SIMRIZ® 501 PREMIUM MATERIAL FOR THE AEROSPACE INDUSTRY

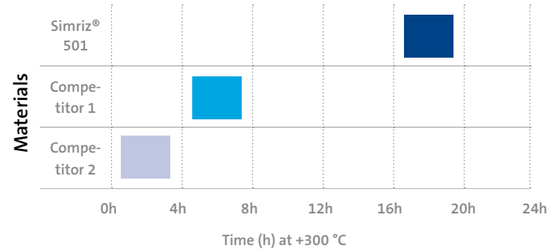
75 Simriz® 501 far exceeds the requirements of AMS7257. The material is resistant to high temperatures – in the air up to +320 °C – as well as in fuels, turbine and hydraulic oils. Its superlative temperature properties are particularly evident in the compression set, which is far below the required limit both in air and in tested media. This results in a very long service life for seals made from Simriz® 501.

TYPICAL APPLICATIONS

Suitable applications for effective use of 75 Simriz® 501 include:

- Bleed air management systems
- Gas turbine lubrication
- High-temperature propulsion units
- Control devices featuring strong oxidizing

O-ring service life: flying hours at continuous + 300 °C



Simriz® performs better than tested competitor materials in aerospace applications at +300 °C. With more than twice the maintenance interval, the material is a cost-effective solution.

Flying hours (x 1000) at + 300 °C before failure

BENEFITS AT A GLANCE

- Outstanding O-ring compressive stress relaxation
- Diverse flight tests at high temperatures and in exacting flight conditions
- Manufactured in the first NADCAP-certified production facility
- Patented cross-linking system delivers superlative performance that goes beyond what any competitor FFKM material can offer
- Cost-effective solution thanks to longer service life

PHARMACEUTICAL AND FOOD INDUSTRY

CHALLENGES IN THE PHARMACEUTICAL AND FOOD INDUSTRY

In the **pharmaceutical industry**, purity requirements for products and processes are particularly stringent. This requires sealing solutions that reliably prevent contamination and can come into contact with the product without any concerns. The pharmaceutical industry incorporates many different applications and processes, all of which have specific requirements. The production of finished medicinal products, for example, requires sealing materials with excellent chemical resistance to various reactants and solvents. Very low temperatures can occur during the production of vaccines or the separation of blood, which requires very cold-resistant seals. Sealing products must not only withstand CIP/SIP cleaning agents, but also comply with hygienic design standards and the relevant statutory regulations, such as USP Class VI and FDA.

One of the biggest challenges in the **food industry** is the wide range of different end products and applications, such as filling machines, heat exchangers, valves, and many more. These place different demands on the sealing solutions used. They not only have to withstand high temperatures and pressures, grease, acids, abrasive media, and CIP/SIP cleaning agents, but also comply with hygienic design standards and the relevant statutory regulations, such as FDA and 3-A® Sanitary Standards. The prevention of aroma transfer also plays an important role.

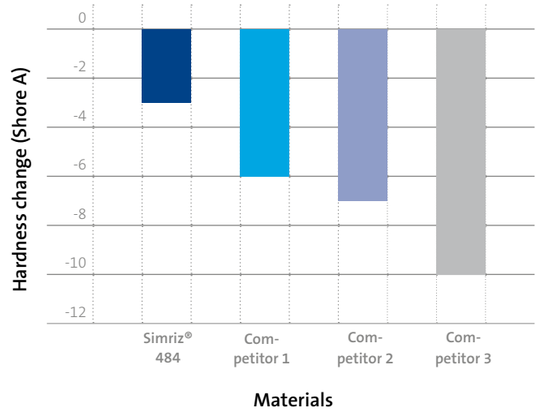
FREUDENBERGS SIMRIZ® MATERIAL FOR THE PHARMACEUTICAL AND FOOD INDUSTRY

Freudenberg Sealing Technologies has developed the special material 75 Simriz® 484 to meet the requirements of the pharmaceutical and food industries.

75 SIMRIZ® 484 IDEAL FOR THE PHARMACEUTICAL AND FOOD INDUSTRY

75 Simriz® 484 is well suited to use in aggressive chemicals and high temperatures. The material is FDA-compliant and meets the requirements of USP Class VI Chapters 87 and 88. These properties make 75 Simriz® 484 the ideal material for the pharmaceutical and food industries.

Change in hardness after storage in steam at +200 °C for 72 h



The diagram shows the change in hardness of various materials after storage in steam. 75 Simriz® 484 has the lowest loss of hardness and withstands steam sterilization correspondingly better or longer than the other comparable materials.

TYPICAL APPLICATIONS

75 Simriz® 484 is already being used successfully in a wide range of applications. Suitable applications include:

- CIP/SIP equipment (Cleaning in Place/ Sterilization in Place)
- Pumps
- Valves
- Mechanical seals
- Dispenser systems
- Mixers

BENEFITS AT A GLANCE

- Broad chemical resistance in a wide range of aggressive chemical environments (e.g. CIP/SIP media)
- Low compression set results in a longer service life of the seal
- Relevant regulatory approvals have been obtained (ADI free, FDA, 3-A® Sanitary Standards)
- Solution for particularly exacting applications in the pharmaceutical and food industries

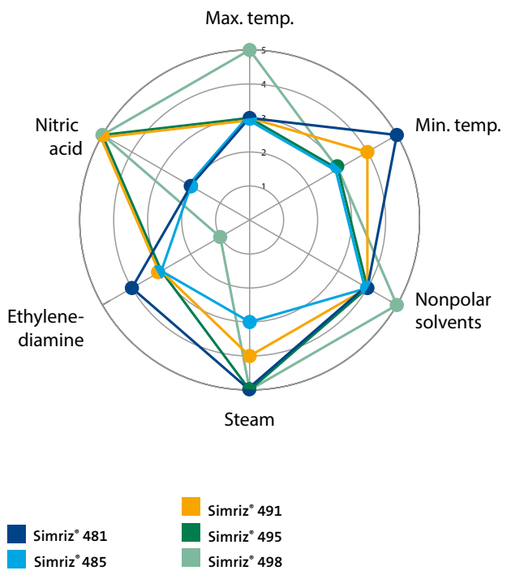
CHEMICAL INDUSTRY

CHALLENGES IN THE CHEMICAL INDUSTRY

The chemical industry is divided into various sectors: base chemistry, fine chemistry, specialty chemistry, inorganic chemistry, and organic chemistry. Each of these sectors places different demands on the seals used, due to the special features of their systems. Given the often sensitive or sometimes even dangerous processes in the chemical industry, very stringent safety requirements apply. Among other things, the traceability and documentation of processes through safety labeling plays an important role. Seals also ensure that nothing harmful enters the process or that toxic raw materials escape. This is particularly important as chemical processes often involve the use of high-priced media, such as boron compounds, the loss of which must be avoided at all costs. Seals and the materials from which they are made must also withstand extreme pressures, very low and very high temperatures as well as aggressive and sometimes toxic media. Depending on the process, extreme temperatures of up to +300 °C as well as extremely low temperatures must be covered. Another important aspect is rapid, global availability, to prevent costly downtimes as far as possible.

FREUDENBERGS SIMRIZ® MATERIAL PORTFOLIO FOR THE CHEMICAL INDUSTRY

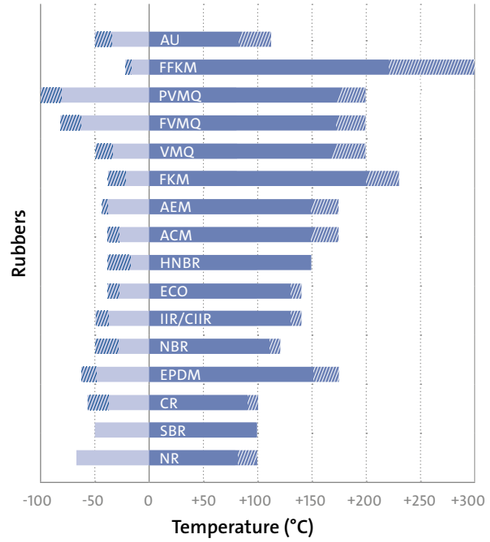
Freudenberg Sealing Technologies has developed special materials that are tailored to the requirements of the chemical industry. These include, in particular, the low-temperature material 70 Simriz® 481 (page 13), the all-rounder material 75 Simriz® 485 (page 14), the highly resistant material 75 Simriz® 495 (page 16), and 70 Simriz® 491 (page 15). The materials 80 Simriz® 498, 75 Simriz® 501, and 90 Simriz® 134 can also be used. The following illustration shows a comparison of the relevant Simriz® materials for the chemical industry.



The spider diagram shows the properties of the materials compared to each other. The further out the material is positioned, the more pronounced the property; the maximum operating temperature is – despite the gradation – very good for all Simriz® grades; no other elastomer has comparable thermal resistance. The resistance of Simriz® 491, 495 and 498 is best in acids and these materials are preferable to the other FFKM materials. In amines, on the other hand, Simriz® 481 is the test winner, closely followed by Simriz® 485, 491 and 495. The high-temperature material 80 Simriz® 498, on the other hand, is not suitable in amines.

70 SIMRIZ® 481
PREMIUM LOW-TEMPERATURE MATERIAL

70 Simriz® 481 is suitable for use in a wide range of aggressive chemicals. Its superlative performance at low temperatures makes the material the perfect choice for many applications in the chemical process industry, especially where low temperatures are expected.



The graph shows the temperature range of use for common rubbers. Only a few can be used at +200 °C and above. Perfluoroelastomers therefore extend the range upwards significantly.
Most FFKMs are only slightly elastic at temperatures below zero degrees. This is where 70 Simriz® 481 stands out, because it can fulfill its sealing function even at -30 °C.

TYPICAL APPLICATIONS

70 Simriz® 481 is already being used successfully in a wide range of applications. Suitable applications include:

- Pumps
- Valves
- Mechanical seals
- Dispenser
- Vacuum components
- Mixers

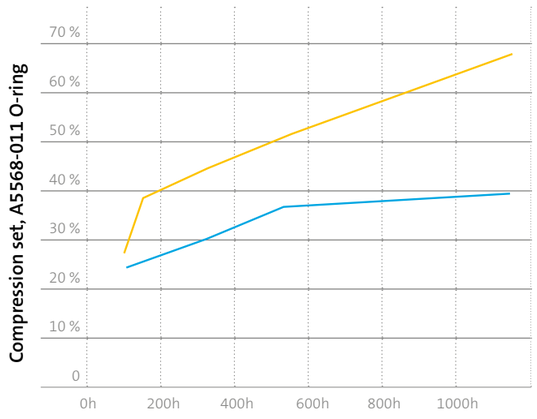
BENEFITS AT A GLANCE

- Broad chemical resistance in a wide range of aggressive chemical environments (e.g. strong acids or base chemicals)
- Outstanding performance at low temperatures (down to -30 °C)
- Low compression set and therefore a longer product service life

75 SIMRIZ® 485 ALL-ROUNDER MATERIAL

Simriz® 485 performs well in a wide range of aggressive chemicals, as well as in overheated steam and hot water conditions. The combination of exceptional performance and its cost-effective price structure makes Simriz® 485 the ideal solution for many applications in the chemical process industry.

Chronological sequence of compression set at +200 °C*



*Data is for reference only. The actual values depend on the relevant conditions.

** High-temperature FFKM material

TYPICAL APPLICATIONS

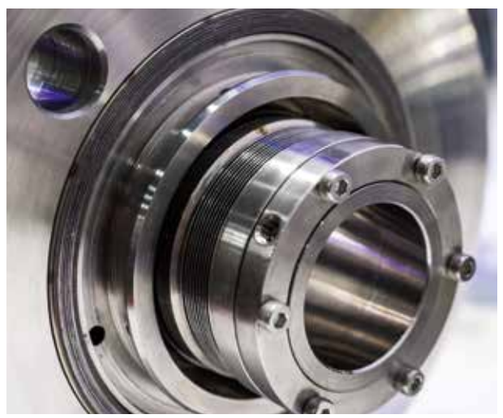
Suitable applications for 75 Simriz® 485 include:

- Pumps
- Valves
- Paint spraying equipment
- Mechanical seals
- Dispenser
- Vacuum components

The lower the compression set, the greater the elastic recovery of the material. The graph clearly shows that even after 100 hours in a +200 °C environment, the resilience of 75 Simriz® 485 is better than the market standard. This difference in performance increases over time: after 1,000 hours, 75 Simriz® 485 is still elastic, while the comparative material has hardly any sealing power.

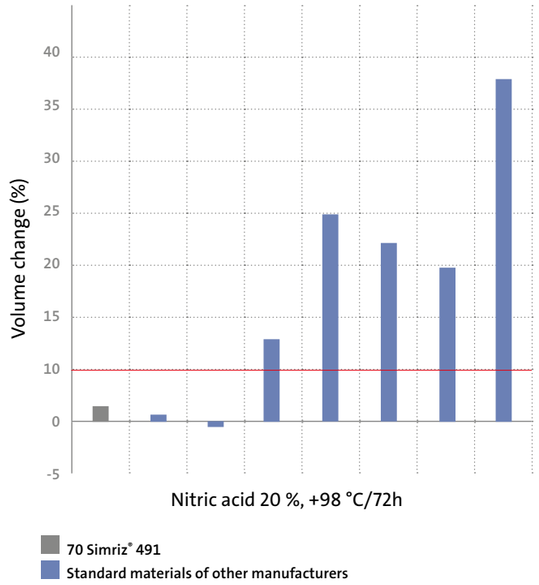
BENEFITS AT A GLANCE

- Broad chemical resistance in a wide range of aggressive chemical environments (e. g. strong acids or base chemicals)
- Outstanding performance in many solvents
- Low compression set and therefore a longer seal service life



70 SIMRIZ® 491 CHEMICAL RESISTANCE AT LOW TEMPERATURES

70 Simriz® 491 delivers excellent performance in aggressive chemicals. The material also delivers very good performance at low temperatures. Thanks to these properties, it is suitable for many applications in the chemical process industry and offers a good compromise between low-temperature properties and media resistance.



TYPICAL APPLICATIONS

Suitable applications for 70 Simriz® 491 include:

- Pumps
- Valves
- Mechanical seals
- Dispenser
- Vacuum components
- Mixers

The graph shows the swelling of various FFKM after storage in 20 % nitric acid. Up to 10 %, the resistance is said to be very good, which only 3 of the tested materials achieve – 70 Simriz® 491 is one of them.

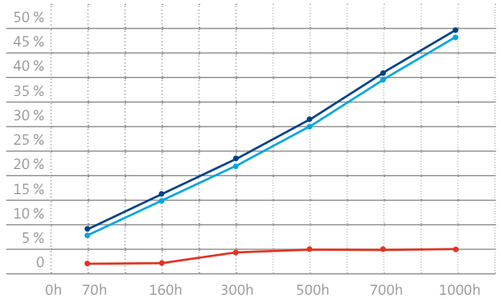
BENEFITS AT A GLANCE

- Broad chemical resistance in a wide range of aggressive chemical environments (e.g. strong acids or base chemicals, solvents, and steam)
- Good performance at low temperatures (down to -20 °C)

75 SIMRIZ® 495
IDEAL FOR THE CHEMICAL INDUSTRY

75 Simriz® 495 performs well in a wide range of aggressive chemicals, as well as in overheated steam and hot water conditions. The material covers a temperature range from -15 °C to +230 °C (also up to +260 °C for short periods) and is available in a range of O-ring sizes.

Volumetric swelling after storage in 69% nitric acid at +80 °C



75 Simriz® 495
Competitor material 1
Competitor material 2

TYPICAL APPLICATIONS

Suitable applications for 75 Simriz® 495 include:

- Pumps
- Valves
- Paint spraying equipment
- Mechanical seals
- Dispenser
- Vacuum components

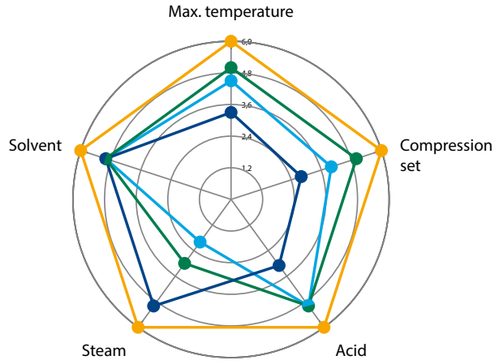
The graph shows volumetric swelling over the storage time in hot nitric acid. The superiority of 75 Simriz® 495 is already evident after 70 hours. After 500 hours, the swelling of the other materials is so high that this can lead to leakage. 75 Simriz® 495 does not swell by more than 5 % and is very resistant even after 1,000 hours.

BENEFITS AT A GLANCE

- Universal media resistance compared to other FFKM materials
- Outstanding performance in steam and hot water
- High resistance to strong acids and oxidizing agents

80 SIMRIZ® 498
EXCELLENT TEMPERATURE AND MEDIA RESISTANCE

80 Simriz® 498 is an FFKM material for maximum requirements in terms of temperature and media resistance. Its unique, patented material structure guarantees outstanding long-term performance in almost any environment. Be it at extreme temperatures of up to +320 °C, in aggressive chemicals or even in overheated steam and hot water conditions, 80 Simriz® 498 is the optimum choice.



80 Simriz® 498
Competitor 1 (high chemical resistance)
Competitor 2 (general purposes)
Competitor 3 (high temperatures)

TYPICAL APPLICATIONS

Suitable applications for 80 Simriz® 498 include:

- Pumps
- Valves
- Mechanical seals
- Dispenser systems
- Power generation plants
- Spray gun equipment
- Oil and gas in boreholes

In terms of both chemical and temperature resistance (upper temperature limit and compression set), 80 Simriz® 498 has the best properties compared to the competition.

BENEFITS AT A GLANCE

- Outstanding long-term performance at extreme temperatures
- Broad chemical resistance in a wide range of aggressive chemical environments
- Outstanding performance in steam and hot water
- Patented cross-linking system delivers superlative performance that goes beyond what any competitor FFKM material can offer

OIL AND GAS INDUSTRY

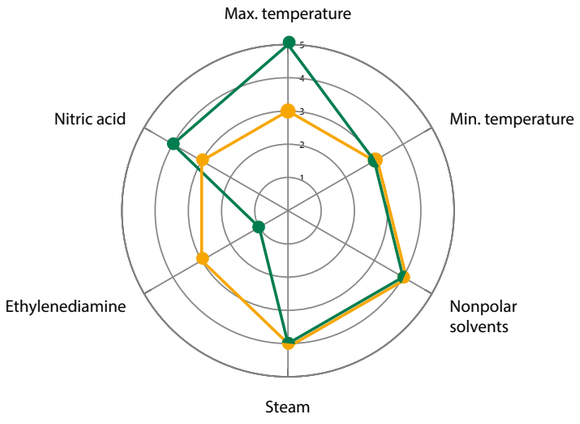
CHALLENGES IN THE OIL AND GAS INDUSTRY

In oil and gas systems, such as pipeline probes, blowout preventers or inflators, extreme pressures often prevail and explosive decompression sometimes occurs. This requires seals with task-aligned mechanical properties, such as increased hardness and strength. Both very low and very high temperatures can also occur.

However, the oil and gas industry is constantly changing. Operating conditions are becoming more challenging as temperatures become more extreme, chemicals more aggressive and pressures are increasing. This is all the result of rising energy consumption worldwide and increasing demand for clean energy with fewer emissions.

FREUDENBERGS SIMRIZ® MATERIAL PORTFOLIO FOR THE OIL AND GAS INDUSTRY

Freudenberg Sealing Technologies has developed special materials that are tailored to the requirements of the oil and gas industry. Due to their high Shore hardness and good resistance to high pressures and explosive decompression, the optimum materials here are 90 Simriz® 134 (page 19) and 90 Simriz® 502 (page 20). The chemical materials 70 Simriz® 481 and 75 Simriz® 495 can also be used for less exacting applications in the oil and gas industry.

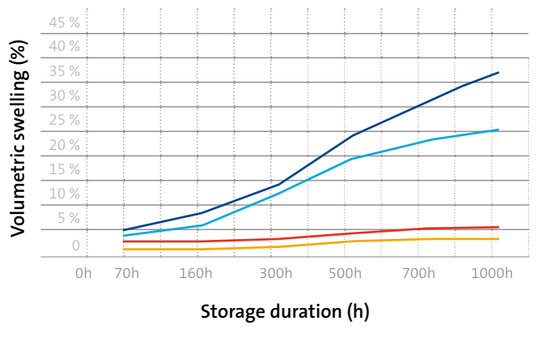


The illustration graphically compares the two Simriz® grades for the oil and gas industry using exemplary properties. It shows that Simriz® 502 has a higher temperature resistance and better performance in acids, while Simriz® 134 is the material of choice in applications involving amines.

90 SIMRIZ® 134 HIGHEST PRESSURE RESISTANCE IN AGGRESSIVE MEDIA

90 Simriz® 134 delivers superb performance in aggressive chemicals. Its outstanding resistance to rapid gas decompression (RGD) makes the material the ideal candidate for high-pressure gas applications in the oil and gas industry.

Volumetric swelling after storage in steam at +160 °C



The graph shows the volumetric swelling of 4 FFKM materials over time. A difference in volume increase is already visible in the first measurement after 70 hours. Simriz® 498 has only swollen by approx. 2 %, whereas a competitor material has already reached 5 %. The longer the storage time, the greater this difference becomes. At 1,000 hours, Simriz® 498 and 134 are still very stable with swelling values of 5 % and less. The two materials from other manufacturers are at 25 % and over 35 % respectively. Here we can at best speak of satisfactory resistance.

TYPICAL APPLICATIONS

Suitable applications for 90 Simriz® 134 include:

- Pumps
- Valves
- Oil field completion equipment
- Perforation equipment
- Drilling equipment
- Well intervention equipment
- Compressors

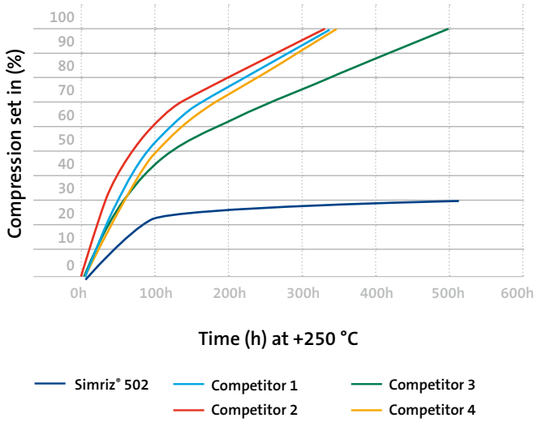
BENEFITS AT A GLANCE

- Good resistance to rapid gas decompression (RGD) and high pressures
- Broad chemical resistance and high thermal stability

90 SIMRIZ® 502
HIGHEST PRESSURE RESISTANCE AT EXTREME TEMPERATURES

90 Simriz® 502 is the ultimate FFKM material developed for the highly exacting requirements of oil and gas applications and the CPI market. Its unique, patented material structure delivers outstanding long-term performance in almost any environment. Be it extreme temperatures of up to +320 °C, aggressive chemicals or overheated steam and hot water, performance is not constrained.

Compression set at +250 °C, AS568-214 O-rings



The chart shows that the compression set curve over the storage time is significantly flatter for 90 Simriz® 502 than for the other materials. While the competitor materials tested show hardly any recovery after 300 hours, 90 Simriz® 502 seals reliably even after 500 hours.

TYPICAL APPLICATIONS

Suitable applications for 90 Simriz® 502 include:

- Drilling tools
- Wireline tools
- Perforation equipment
- Completion equipment
- Valves
- Pumps
- Mechanical seals
- Steam/hot water injection
- Enhanced Oil Recovery/SAGD

BENEFITS AT A GLANCE

- Outstanding resistance to rapid gas decompression (RGD)
- Long service life even at extreme temperatures
- Broad chemical resistance
- Excellent performance in overheated steam and hot water
- Patented cross-linking system delivers superb performance that goes beyond what any competitor FFKM material can offer

GUIDE TO MATERIAL SELECTION

MATERIAL SELECTION

Material	Industries	Color	Minimum operating temperature	Maximum operating temperature	Approvals	Available products	Special feature	Page
70 Simriz® 481	- Chemical industry - Oil and gas industry	Black	-30 °C	+230 °C		- O-rings - Special O-ring types	Excellent performance at low temperatures	13
70 Simriz® 491	- Chemical industry - Oil and gas industry	Black	-20 °C	+230 °C		- O-rings - Special O-ring types - Customized components	Very good chemical resistance at low temperatures	15
75 Simriz® 484	- Food industry - Pharmaceutical industry	Black	-10 °C	+230 °C	- USP Class VI - USP Chapter 87 (in vitro) - FDA - 3-A® Sanitary Standards	- O-rings - Special O-ring types	Developed for applications in the food industry	11
75 Simriz® 485	- Chemical industry - Oil and gas industry	Black	-15 °C	+230 °C		- O-rings - Special O-ring types	All-rounder material	14
75 Simriz® 495	- Chemical industry - Oil and gas industry	Black	-15 °C	+230 °C		- O-rings - Special O-ring types	Extremely broad media resistance	16
75 Simriz® 501	- Aerospace - Chemical industry	Black	-5 °C	+320 °C	AMS7257	- O-rings - Special O-ring types	Optimized for aerospace applications	9
80 Simriz® 498	- Chemical industry - Oil and gas industry	Black	-5 °C	+320 °C		- O-rings - Special O-ring types	Outstanding temperature and media resistance	17
90 Simriz® 134	- Oil and gas industry	Black	-15 °C	+230 °C		- O-rings - Special O-ring types	Superb pressure resistance in aggressive media	19
90 Simriz® 502	- Chemical industry - Oil and gas industry	Black	-5 °C	+320 °C		- O-rings - Special O-ring types	Superb pressure resistance at extreme temperatures	20

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