Frenzelit

creating hightech solutions

GASKET SOLUTIONS

for hydrogen applications

Use in
fuel cells,
electrolyzers and
all power-to-X processes

DICHTUNGEN
GASKETS

ISOLATIONEN
INSULATION

KOMPENSATOREN
EXPANSION JOINTS

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SECURE SEALING OF HYDROGEN

Gasket solutions for hydrogen applications

Green hydrogen is a key component of the energy transition because it offers many ways to replace conventional energy sources – as a fuel in engines, in fuel cell heating systems or in power-to-X processes (conversion into alternative storage forms, fuels or chemicals). At the same time, however, hydrogen is also a very challenging medium due to its low mass and small molecular size, which requires efficient sealing solutions. Pipe systems, tanks and fittings must be securely sealed to transport and furtherprocess hydrogen. Safety engineering considerations play an important role here since hydrogen is an extremely flammable and potentially explosive gas due to its chemical reactivity.

Tight seal for hydrogen

Testing for suitability in hydrogen applications at Frenzelit focuses on two aspects: tightness and material strength. Hydrogen molecules are extremely small, which is why tightness is a key criterion when it comes to suitability for hydrogen. Conventional leak tests with helium or nitrogen provide only limited information about tightness in applications with hydrogen due to the different molecular structure. For this reason, Frenzelit has developed a method to test the gaskets for leakage using the same medium that they must withstand in actual operation – hydrogen.

Gaskets must maintain their functionality for as long as possible – and this is why chemical resistance testing using hydrogen is so crucial. Frenzelit simulates the service life by keeping the gasket material in hydrogen under a defined level of pressure for a specific period of time. In order for a gasket to receive the "H_2-approved" logo, the material must not show any cracks or porous areas after this test period. This verifies the suitability of the material and customers can rest assured that the gaskets will work properly in hydrogen applications. Many Frenzelit materials have already demonstrated this suitability.

And not just with the "H_2-approved by Frenzelit" branding: Frenzelit already wants to set benchmarks in the industrial use of hydrogen with its own proprietary test method and the resulting measurement protocols.

Chemical resistance testing

Resistance testing is based on the carrier test procedure for refrigerants. The test specimens are loosely stored in an autoclave under a hydrogen atmosphere with the following parameters:

- Test pressure: 3 bar
- Test period: 6 weeks
- Test temperature: Room temperature

The dimensions and weight of the specimens are determined and compared before and after storage. The gasket materials passed this test with extremely minimal (well below the specified limit values) geometric and gravimetric changes. The materials' leakage performance did not change as a result of storage in hydrogen.

New Frenzelit inner eyelet technology for even greater adaptability

To further improve its gaskets, Frenzelit also incorporates advanced inner eyelet technology in conjunction with the aforementioned gasket materials. This new eyelet material has a flexible coating for improved adaptability to the flange. In combination with the high-performance gasket materials, this keeps leakage to a minimum – even in hydrogen applications.

LEAKAGE TESTING

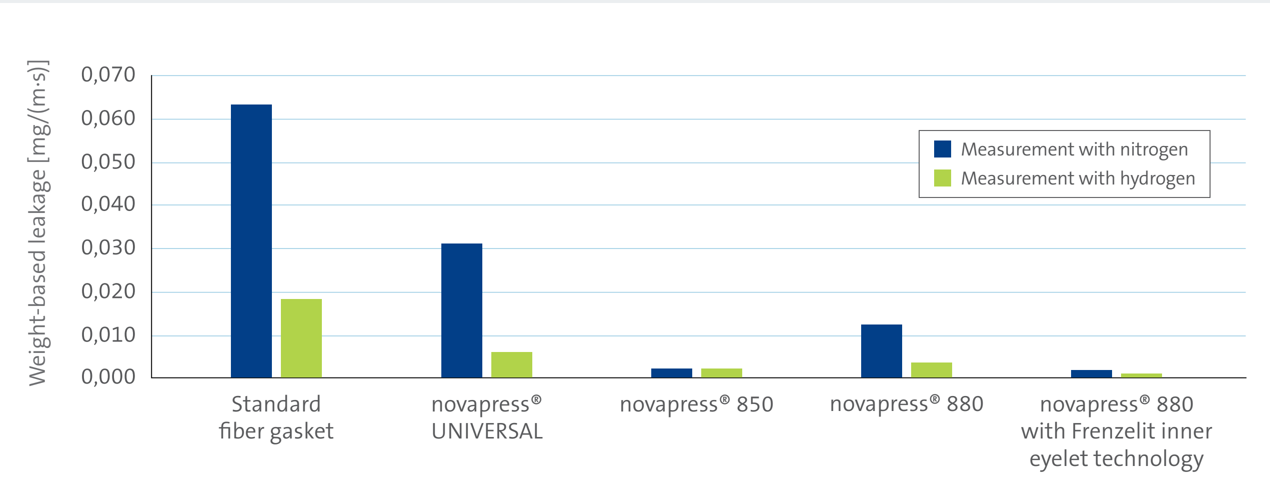
Proprietary hydrogen test method

- The leak tests are performed based on DIN 28090-2 (09-1995).
- Nominal flange width and pressure level: DN 40 / PN 40
- Media pressure: 40 bar
- Assembly surface pressure: 32 MPa / Operating surface pressure: 30 MPa
- Measurement period: 1 h
- Gaskets tested
  - novaphit® SSTC
  - novaphit® SSTC^{TA-L} (also with new Frenzelit inner eyelet technology)
  - novaphit® MST (also with new Frenzelit inner eyelet technology)
  - novapress® 850
  - novapress® 880 (also with new Frenzelit inner eyelet technology)
  - novamica® THERMEX

Based on the results of the leakage tests and case studies from real-world applications, these materials were found to be particularly suitable. The use of Frenzelit's inner eyelet technology significantly reduces the already very low leakage levels.

Leakage measurement

at 40 bar, based on DIN 28090-2 (09-1995)

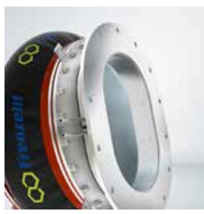


Although sealing hydrogen is considered more critical than other gases because of its small molecular size and density and high diffusivity, the diagram shows lower leakage values for hydrogen. This is due to the leakage unit of mg/(m·s) used. If the outflowing gas volume is measured in ml/min, the volume loss for hydrogen is greater than nitrogen. However, due to the extremely low density and the low weight of hydrogen gas, the opposite is true when the values are converted into the weight-based leakage unit mg/(m·s). The outflowing gas quantity for hydrogen has a lower weight than the outflowing nitrogen, despite its higher volume.

Regardless in which unit the leakage is represented, it is clear that the materials specially developed by Frenzelit to achieve the best possible tightness also offer very good leakage values even with hydrogen. For example, novapress® 850, novaphit® SSTC^{TA-L}, novaphit® MST or gaskets featuring Frenzelit's new inner eyelet technology are particularly well suited for hydrogen applications.

But in addition to gaskets for hydrogen applications, Frenzelit also offers expansion joints. Strip galvanizing and continuous annealing lines in cold rolling mills, for instance, require a very high level of tightness in order to reliably seal off the inert gas atmosphere of hydrogen and nitrogen that is present in certain sections of the annealing furnace. Different versions of in-house developed fabric expansion joints are used here.

For more information visit:
frenzelit.com/en/products/expansion-joints



FUEL CELLS:

Applications for high-performance Frenzelit gasket materials

The tighter the seal, the more efficient the operation

Basic functionality of fuel cells: Chemical energy is converted into electrical energy. In a fuel cell, hydrogen (H_2) and oxygen (O_2) are combined to produce water and electricity. Waste heat is also generated in the process.

How a fuel cell works

A single fuel cell consists of two electrodes, the anode and cathode, and what are known as bipolar plates for conducting the current generated during the reaction and distributing the reaction gases. There is also a specific electrolyte and, finally, the fuels hydrogen and oxygen. However, since a single fuel cell generates only a small amount of electricity, practical applications usually connect a large number of these individual cells in a series – also known as a stack. The number of stacks and thus the size of the fuel cell varies depending on how much electricity must be generated. The stacks are limited by the bipolar plates, which ultimately conduct electrical current from cell to cell. Ultra-high-performance gasket materials in various areas are essential in order for fuel cells to operate. They are sandwiched between the stacks and the individual cells to prevent the escape of fuel gases and the electrolyte. They are also used to shield the bipolar plates from one another and thus to prevent short circuits. The supply lines that transport hydrogen and oxygen gases must likewise be sealed. The same gasket materials are not necessarily used on stacks and supply lines, as the requirements may vary and require specific gasket properties.

This figure shows the various potential areas where gasket materials can be used in fuel cells. These include sealing the hydrogen and oxygen supply lines (positions 1 and 4) and sealing the individual stacks at the bipolar plates (positions 2 and 3).

High demands on gasket materials

One of the most important functions of the gaskets is to insulate the bipolar plates from one another. Depending on the design requirements, the opposite may also be required – that the gaskets should be conductive, but not in the stack structure; the insulating function is critical here. In supply lines, for example, conductive gaskets may also be required in order to allow current to flow away and to prevent the component from becoming electrically charged. In this case the gasket must not act as an insulator. The mostly liquid electrolyte inside the stacks must also be sealed. It is often a challenging medium, such as strong alkalis in alkaline fuel cells, that can attack the gaskets. In addition, hydrogen and oxygen, which act as fuels, must be sealed. This means the gasket must also be resistant to such media.

Reliable sealing is an important safety aspect as well, considering that these are very demanding, flammable and potentially explosive gases. Moreover, the seal is decisive for the efficiency of a fuel cell, which needs to be as high as possible to enable effective use. The more gases that escape, the lower the level of efficiency. In this respect, high-performance gasket materials play a large role in the efficiency of fuel cells.

Test setup of a fuel cell on a small laboratory scale, as commonly used for research purposes.

In addition, in some fuel cell variants the gasket material must withstand temperatures exceeding 500 °C. A purely elastomer-based material cannot be used here; the gasket material must be designed for high temperatures in such applications. The service life of the materials must also be long to ensure the fuel cell requires little maintenance and remains operational.

Frenzelit already uses these effective gasket materials in a wide range of fuel cell applications. The company is also involved in research projects and is continuously advancing gasket materials based on customer requirements, e.g. with specific coatings or custom designs. New high-performance gasket materials are also developed in-house as needed.

Materials for use in fuel cells

- **novapress®** products can achieve a leakage level up to 10,000 times better than comparable standard gaskets.
- **novamica®** products are used in high-temperature fuel cells due to their temperature resistance.
- **novaphit®** products transport electricity away due to their conductivity, thereby preventing the fuel cell from becoming electrically charged.

Application example: In private households, the electricity generated can be used to charge electric cars, for instance. At the same time, waste heat from the fuel cell flows into the heating circuit.

ELECTROLYSIS:

Gasket solutions for use in electrolyzers

Water is split into hydrogen and oxygen using electricity.

Through the input of electrical energy, electrolyzers trigger a chemical reaction which subsequently leads to a conversion of substances. We look at electrolysis in connection with the production of hydrogen. Here, a redox reaction is triggered by means of electrical energy that converts water into hydrogen (H_2) and oxygen (O_2).

A single electrolysis cell consists of two electrodes (cathode and anode) and an electrolyte, where the electrolyte used determines the type of electrolyzer.

- **Alkaline electrolysis:** Strong alkali as electrolyte
- **PEM electrolysis:** thin solid polymer membrane (Proton Exchange Membrane)
- **High-temperature electrolysis:** Solid oxide electrolyte (e.g. ceramic zirconium dioxide)

Analogous to the fuel cell, a "stack structure" is forced at the electrolyzer by connecting several individual electrolysis cells in a series.

Requirements of gasket materials

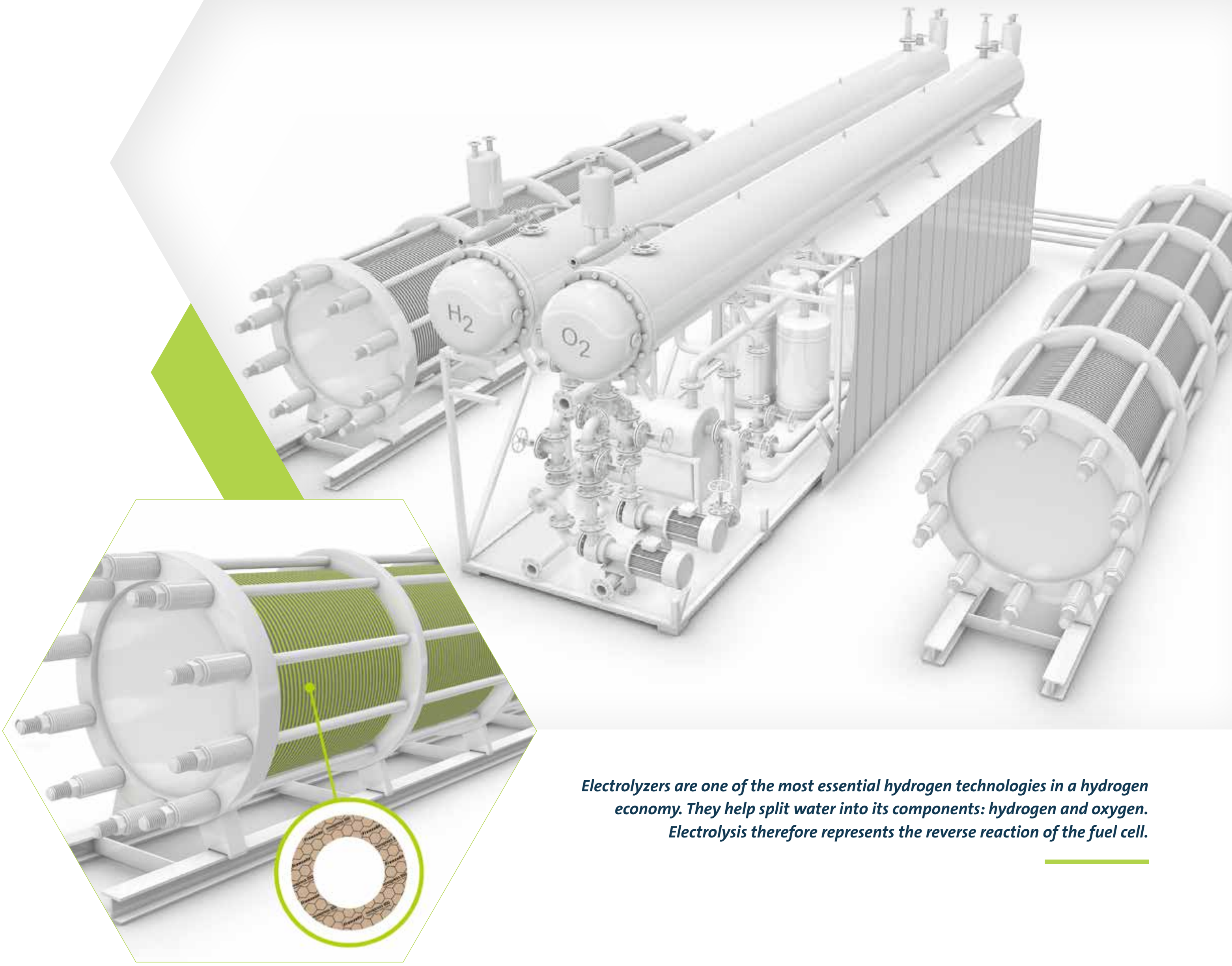
- Very good leakage performance of the gasket material for high electrolyzer efficiency
- Media resistance (e.g. strong alkalis in alkaline electrolysis)
- High temperature resistance (high-temperature electrolysis up to 1,000 °C)
- Electrical insulation when used within the stack
- Very good mechanical properties: low creep, defined setting behavior → Electrolyzers must not deform during operation.
- Long service life of the materials to ensure the electrolyzers require little maintenance and remain operational
- Other application areas outside the electrolyzer: Pipelines for supply and discharge lines

Sealing is the decisive factor in ensuring electrolyzer efficiency. The following applies here as well: The tighter the seal, the more efficient the operation!
Various gasket materials are suitable depending on the type of electrolysis.

Application temperature limits for Frenzelit gaskets in hydrogen applications

200 °C	novapress®
280 °C	gaskets with Frenzelit inner eyelet technology (novapress® product family: max. 200 °C)
550 °C	novaphit®
1,000 °C	novamica®

Frenzelit gaskets can also be used in electrolyzer supply and discharge lines.



Electrolyzers are one of the most essential hydrogen technologies in a hydrogen economy. They help split water into its components: hydrogen and oxygen. Electrolysis therefore represents the reverse reaction of the fuel cell.

POWER-TO-X:

The right gasket material for each technology

In addition to the direct use of hydrogen as an energy source, there are also many other possibilities for storing or further processing hydrogen. These technologies are categorized under the term "power-to-X". This includes the conversion of hydrogen into fuel gas (power-to-gas), into synthetic fuels (power-to-fuel) or into various basic products for the chemical industry (power-to-chemicals).

Gasket solutions are required in all processes related to power-to-X, for example in tanks, pipeline systems or reactors. The "H_2-approved"– product portfolio offers the right solutions for all hydrogen applications and their downstream processes.

OUR RESPONSIBILITY
to people and the environment.

As a company with a rich tradition, we care about long-term success and the satisfaction of our customers. Quality is always a top priority for us – as is our commitment to the environment, society and our employees.

We also pride ourselves on always considering our customers' present and future needs, something that is apparent in our application consulting, training seminars and installation services. A development partnership with us is an excellent opportunity for you to optimize products that are already a success – and a great way to get your new developments to the market even faster. We help you modify products or support you in implementing innovative material concepts – and create real added value for you.

TÜV SÜD ISO 9001 · TÜV SÜD ISO 14001 · TÜV SÜD ISO 50001 · TÜV SÜD ISO 45001

GASKET MATERIALS

- **novapress®**
  approx. –100 to 200 °C
- **novatec®**
  approx. –100 to 250 °C
- **novaflon®**
  approx. –270 to 260 °C
- **novaphit®**
  approx. –270 to 550 °C
- **novamica®**
  approx. –200 to 1000 °C

INSULATION MATERIALS

- **isoplan®**
  approx. –100 to 1100 °C

The temperature data refer to use with non-critical media.

novadisc.de
ONLINE Design Software

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