GOETZE TECH-TALK

SAFETY IN HYDROGEN APPLICATIONS

The four most important facts briefly explained:

Materials - Seals - Production - Approvals

TOPIC OVERVIEW

Situation and challenge

THE HYDROGEN CHALLENGE

The four most important facts briefly explained

MATERIALS
What materials are suitable for hydrogen?
Not all stainless steel is the same
Hydrogen embrittlement: What does it mean?

SEALS
Which seals are suitable for hydrogen?

MANUFACTURING
What has to be considered when manufacturing valves for H_2 applications?
Cleaning requirements for valves in hydrogen applications

APPROVALS
Which approvals for safety valves are necessary in the field of H_2 applications?

Conclusion

SAFETY IN HYDROGEN APPLICATIONS
These points have to be observed

PRESENT SITUATION AND CHALLENGE

"Water is the coal of the future. Tomorrow's energy is water that has been decomposed by electric current. The elements of water thus decomposed, hydrogen and oxygen, will secure the earth's energy supply for the foreseeable future."

Jules Verne

THE PRESENT SITUATION

The energy transition and the use of sustainable resources for power generation pose major challenges for the energy industry.

By using innovative splitting processes and electricity from renewable energy sources, hydrogen can be produced without the consumption of fossil fuels and also without emitting CO_2. This process and its further use make green hydrogen a promising resource for energy production and storage, as well as for the industrial sector. One thing is indisputable: The future will be based on green energy.

HYDROGEN RESEARCH CENTRE

HYDROGEN FILLING STATION

PRODUCTION OF TECHNICAL GASES

THE HYDROGEN CHALLENGE

On the one hand, it is a colourless, odourless and completely non-toxic gas, which on the other hand is very volatile, highly flammable and has a high flame speed. With hydrogen as a medium, the challenge is to produce, transport, store and use the gas safely, depending on the application and environment.

As the last mechanical component in the chain of safety, safety valves play an important and indispensable role. This especially applies to the materials and seals used, as well as the manufacturing process of the valves and specific approvals.

HIGH-PRESSURE COMPRESSION PLANT

THE FOUR MOST IMPORTANT FACTS BRIEFLY EXPLAINED

Materials

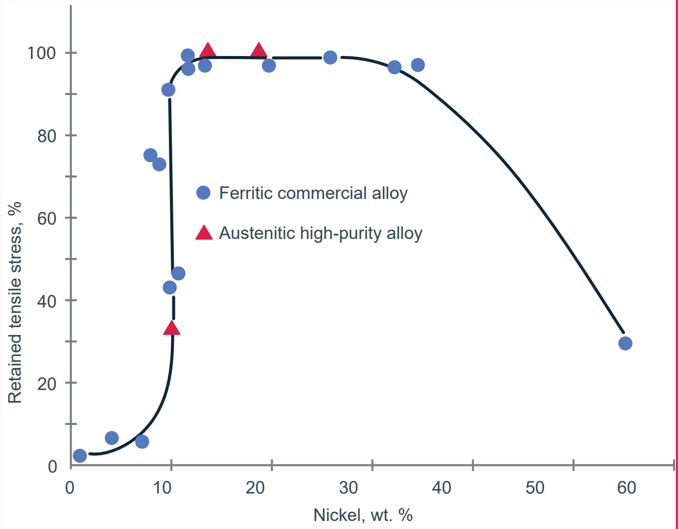
WHAT MATERIALS ARE SUITABLE FOR H_2?
The selection of a suitable material depends on the expected stresses (e.g. pressure, tension, temperature, alternating load). So far, austenitic steels with a nickel content > 10% have proven to be effective.

NOT ALL STAINLESS STEEL IS THE SAME
The differences can be found in the composition of the stainless steel or the alloys. Relevant for the hydrogen compatibility are chromium and nickel, which reduce the risk of hydrogen embrittlement.

An inferior quality or an inferior alloy could increase the risk of hydrogen embrittlement (depending on pressure and temperature).

However, a higher grade of stainless steel is also reflected in the price.

Illustration:
Influence of nickel in a hydrogen environment



Source: G.R. Caskey, Hydrogen Compatibility Handbook for Stainless Steels (1983)

The graph illustrates that ferritic alloys become very brittle in a hydrogen environment with a very low nickel content, whereas austenitic alloys with a nickel content of 10% have resistant characteristics

!

GOETZE uses high-quality stainless steels.

Forged material:
1.4404 / 316 L for inlet body and internal parts

Stainless steel investment casting:
1.4408 / CF8M for body and partly for spring housings

Materials

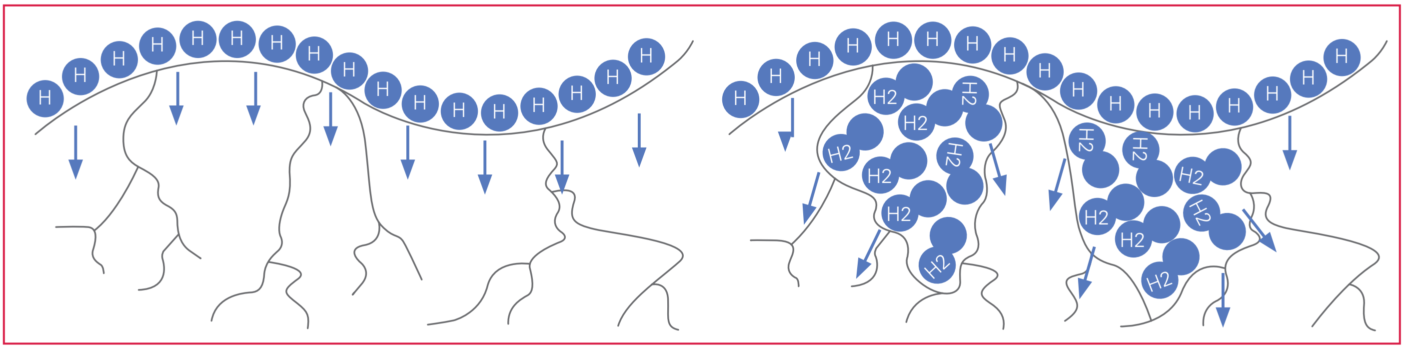
HYDROGEN EMBRITTLEMENT: WHAT DOES IT MEAN?

Hydrogen embrittlement occurs when atomic hydrogen is generated and diffuses into the material faster than it assembles into densely diffusible H_2 molecules at the material surface.

This happens especially on active metal surfaces, i.e. on non-passivated surfaces, or when the surfaces are enlarged by plastic deformation. A part of the hydrogen is deposited at defects or grain boundaries in the metal grid. The result is an embrittlement of the metal.

Further preferred locations are crack tips or other locations of high stress, such as welding undercuts. Here, the hydrogen weakens the cohesion of the grid, inducing cracks in the presence of static or time-varying mechanical tensile stresses, or causing existing incipient cracks to propagate (faster crack growth).

In practice, this means that dissociation of hydrogen on steel surfaces is only possible with alternating stresses resulting in plastic deformation at notches or crack tips. The probability of possible damage is influenced, for example, by the level and type of pulsating stress, frequency, surface roughness (growth-capable germs), high pressure of the hydrogen, high and low temperatures, and the tensile strength of the steel.



Seals

WHICH SEALS ARE SUITABLE FOR H_2?

The suitability of a seal depends on many factors, similar to the metallic materials. Apart from pressure and temperature, the permeation and diffusion of hydrogen also play a crucial role.

In elastomer seals, another important aspect becomes visible only at higher pressures (> 30 bar) and a rapidly occurring pressure relief. Due to the very small molecular size, the H_2 gas deposits in tiny cavities of the seal. In case of a sudden pressure release in the system to be protected, the H_2 gas also expands in the cavities inside the seal, and the gas cannot escape as quickly. This causes the seal to burst or even be destroyed. The purpose of the seal is then lost.

This process is known from the oil and gas industry and is referred to as „explosive decompression" among experts.

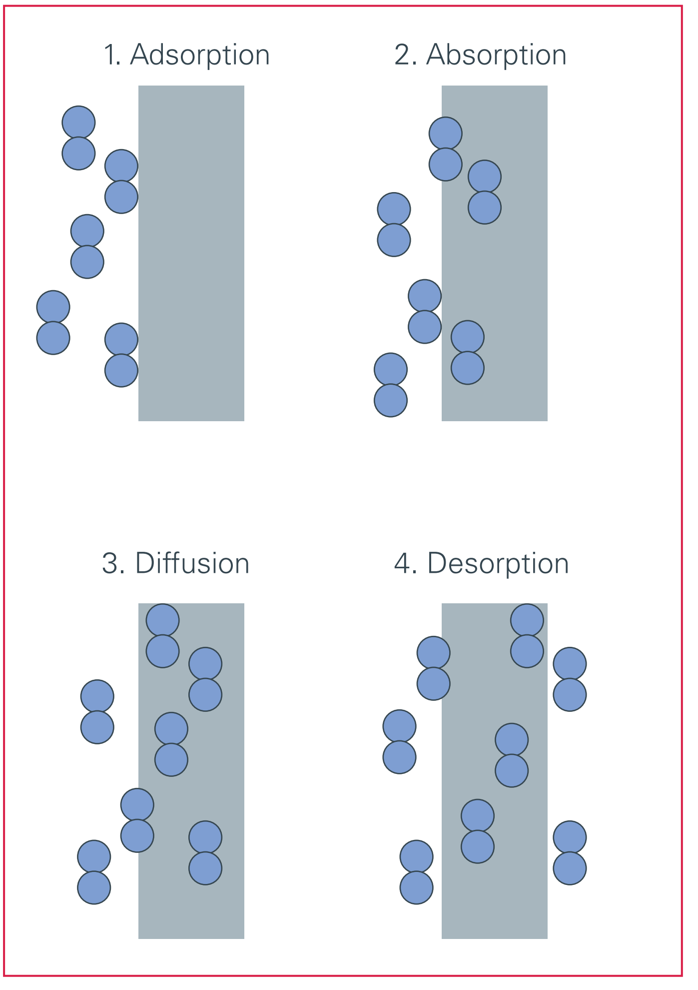
In many cases, the sudden release of pressure is unavoidable. Therefore, the seals must be specially tested for this process. These elastomer sealing materials can be identified if they are tested according to the NORSOK M-710 standard. Also to be found with the designation AED = Anti-Explosive Decompression, or RGD = Rapid Gas Decompression.

Leakage rates of Goetze valves:

Depending on the seal used, leakage rates of 1x10-4 mbar*l/s are achieved as standard with soft seals.

With metal seals as standard, it is 1x10-3 mbar*l/s.

Plastic permeation



Depending on the aforementioned factors, the following materials are generally suitable:

Elastomers
EPDM
FKM/FFKM
NBR
IIR
CR

Thermoplastic materials:
PTFE / PCTFE
PVDF
PA
PE
PEEK
PAI

Manufacturing Process

WHAT HAS TO BE CONSIDERED WHEN MANUFACTURING VALVES FOR H_2 APPLICATIONS?

In general, it is important that H_2 valves are manufactured according to the following standards:

- Specially defined manufacturing process for gas valves
- Observation of cleaning requirements depending on the hydrogen purity (see next point)
- Execution of bubble tests according to API Standard 527.

CLEANING REQUIREMENTS FOR VALVES IN HYDROGEN APPLICATIONS

There is no generally applicable requirement. Depending on the requirements, the following production methods are recommended:

- With a hydrogen purity of < 5.0 (< 99.999%), oil and grease-free production is recommended
- With a hydrogen purity of > 5.0 (> 99.999 %), oil- and grease-free production in the clean room is explicitly recommended. This ensures the required purity of the hydrogen for use e.g. in fuel cell systems.

Approvals

WHICH APPROVALS FOR SAFETY VALVES ARE NECESSARY IN THE FIELD OF HYDROGEN APPLICATIONS?

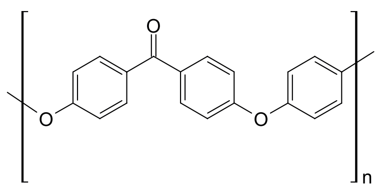
Specific approvals for use in the field of H_2 are generally not required or do currently not exist.

Here is a checklist of what should generally be considered when selecting a valve:

- Correct design/dimensioning of the capacity and size of the valve, as well as the connections of the supply and discharge lines.
- Is there counterpressure on the outlet side, or is it to be expected in the event of relieving?
- The level of the required operating pressure. A margin of at least 10% to the response pressure of the safety valve must strictly be maintained.
- Are the materials used for the body, spring housing and internal parts suitable for the application?
- Check the suitability of the sealing material (keyword: explosive decompression). For gas mixtures, other, usually stricter requirements may apply (e.g. for toxic sulphur-hydrogen (H_2S) compounds).
- Only type-tested approved safety valves with approval according to PED/TÜV, ASME, ML, EAC and/or specific approvals may be used.

Threaded connections

Flange connections



EUROPÄISCHE DGR

TÜV component approval

NATIONAL TYPE TEST (TÜV)

EU type examination

EU TYPE EXAMINATION

TYPE TEST (USA)

TR ZU 032/2013 (RU)

CONCLUSION

Safety in hydrogen applications

As the last mechanical component in the chain of safety, safety valves are an important and indispensable part of hydrogen applications. It is therefore even more important that every component of a safety valve, as well as the manufacturing process, have specific properties.

MATERIALS

Ensure the use of high quality stainless steels
Austenitic steels with a nickel content > 10% have proven to be effective

SEALS

Pressure, temperature, permeation (diffusion) play an important role here. For elastomer sealing materials, comply with the NORSOK M-710 standard.

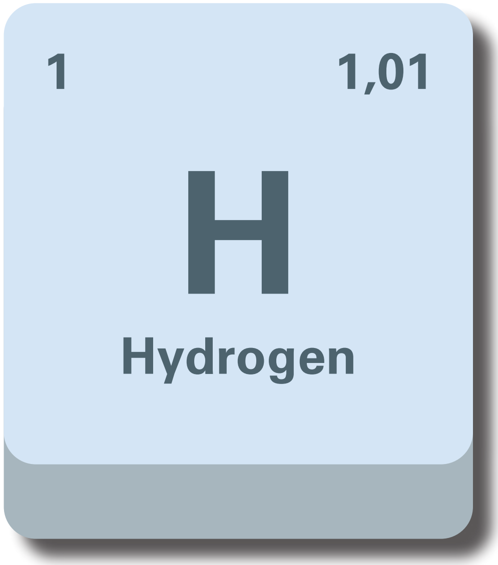
MANUFACTURING PROCESS

Set high standards for the cleaning requirements.
Apart from the necessary oil- and grease-free production, production in the clean room is explicitly recommended for a hydrogen purity of > 5.0 (> 99.999 %).

APPROVALS

Even if there are currently no specific H_2 approvals (yet) ...
Only use type-test approved safety valves to protect your systems.

Sound technical advice from the valve manufacturer is in any case indispensable. This is the only way to take your specific conditions into account and to design the valve correctly according to the conditions prevailing on site.



The technical experts at GOETZE will be pleased to assist you

>>>

Perfect **product solutions** for your industry.

SERIES 492

Stainless steel, with threaded connections, other variants on request

DN6

d0 = 3 mm

Pressures
from 100 to 1500 bar

Threaded connections
¼" to 1"
cone & thread connection possible

Valve versions
gastight version, without lifting device

Seals
MD/PEEK

DN8

d0 = 4,5 mm

Pressures
from 150 to 1000 bar

Threaded connections
¼" to 1"
cone & thread connection possible

Valve versions
gastight version, without lifting device

Seals
MD/PEEK

DN10

d0 = 6 mm

Pressures
from 50 to 630 bar

Threaded connections
¼" to 1"
cone & thread connection possible

Valve versions
gastight version, without lifting device
atmospheric discharge, without lifting device
atmospheric discharge, with twist-type lifting mechanism

Seals
MD/PAI, MD/PEEK

DN15

d0 = 9 mm

Pressures
from 50 to 250 bar

Threaded connections
⅜" to 1"
cone & thread connection possible

Valve versions
gastight version, without lifting device
atmospheric discharge, without lifting device
atmospheric discharge, with twist-type lifting mechanism

Seals
MD/PAI, MD/PEEK

YOUR CONTACT TO US

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For more information on the 492 series, please refer to the data sheet.

Perfect **product solutions** for your industry.

SERIES 492

NEW!

Safety valve

stainless steel,
positionable angled body

Pressures
from 50 bar to 1500 bar

Temperatures
from -60 °C to +200 °C

Threaded conections
from ¼" to 1"

SERIES 420

Safety valve

stainless steel,
angled body

Pressures
from 0,5 bar to 50 bar

Temperatures
from -40 °C to +260 °C

Threaded conections
from ¼" to ⅜"

SERIES 455

Flanged safety valve

stainless steel,
angled body

Pressures
from 0,2 bar to 40 bar

Temperatures
from -255 °C to +400 °C

Flange connection
from DN 15 to DN 100

SERIES 451

Safety valve

stainless steel,
angled body

Pressures
from 0,5 bar to 70 bar

Temperatures
from -60 °C to +400 °C

Threaded conections
from ½" to 2"

SERIES 2400

Safety valve

stainless steel,
angled body

Pressures
from 0,2 bar to 70 bar

Temperatures
from -200 °C to +200 °C

Threaded conections
from ¼" to 1½"

SERIES 484

Pressure reducer

stainless steel

Pressures Inlet: from 60 bar
Outlet: 0,5 to 50 bar

Temperatures
from -40 °C to +120 °C

Threaded conections
from ¼" to 2"

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