Leakage comparison across different test mediums – EN 13555 testing

As hydrogen technologies continue to expand, interest is growing in how different test media influence gasket leakage performance. This study compares helium, hydrogen, methane and forming gas testing under EN 13555 conditions across a range of industrial gasket types.

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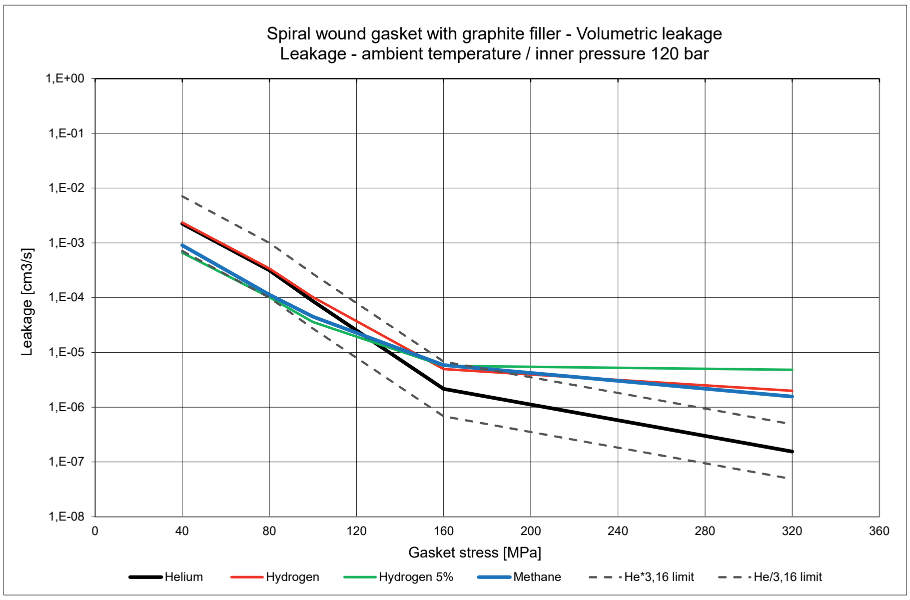
ATEX testing chamber

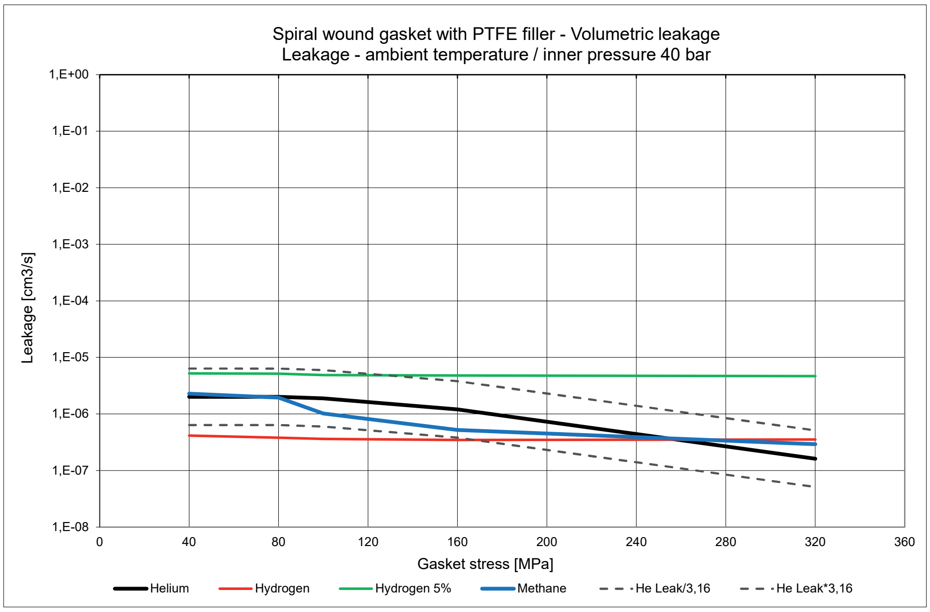
In modern flange joint engineering standards, both experimental characterisation and analytical design approaches emphasize tightness as a vital performance metric. A measured leakage rate is not only the key result of testing procedures performed in accordance with EN 13555 but also serves as a crucial input parameter for flange joint calculations as outlined in EN 1591-1. Within the context of European standardisation, helium is identified as the reference test medium. Helium, a monoatomic noble gas, is chemically stable, non-combustible, and has one of the smallest atomic diameters among all elements. Its remarkably high diffusivity and low viscosity facilitate swift permeation through micro-defects and leakage pathways, thus shortening test duration and improving measurement consistency. Additionally, helium is ideally suited for use with mass spectrometry-based leak detection systems, which offer extremely high sensitivity, with detection limits typically around 10^{-9} mbar·L/s or lower. In standards based on the imperial system, such as those established by ASTM, ASME, and API, helium is also acknowledged as an acceptable test medium. However, in API standards tailored for the petrochemical and refining industries, methane is often utilised. This choice arises from the need to replicate real operating conditions, methane is found in natural gas and is frequently encountered in hydrocarbon processing settings. Although methane has a larger molecular size than helium or hydrogen, it is still small enough to navigate leakage paths and can be effectively detected using flame ionisation detectors (FID) or similar sensing technologies.

Testing

Recent industrial trends, especially those related to the advancement of hydrogen energy systems, have sparked a growing interest in using hydrogen as a medium for leakage testing. Hydrogen possesses a unique set of

Selected representative results for two gasket types are presented below:





characteristics: it is highly combustible (akin to methane), and its molecular size is smaller than that of helium, making it the smallest diatomic molecule. Due to its high diffusivity and low molecular weight, hydrogen is particularly effective in detecting micro-leakage paths that might not be identified with other gases. It is important to highlight that, under standard conditions, hydrogen exists as a diatomic molecule (H_2), in contrast to monoatomic helium. Considering these developments, our research laboratory initiated a comparative research programme aimed at assessing leakage behaviour with various test media. The study encompassed the following types of gaskets:

- Expanded PTFE gasket
- Reinforced graphite sheet gasket with internal metallic eyelet
- Aramid fibre gasket
- Spiral wound gasket with graphite filler
- Spiral wound gasket with PTFE filler
- Cam profile gasket with graphite layers
- Cam profile gasket with PTFE layers
- Weld ring gasket

The comparative tests were performed under the standard test conditions of EN 13555, ensuring that the mechanical loading and boundary conditions remained the same for each type of gasket. The sole variable parameter was the medium used for testing. Leakage measurements were taken using gas-specific detection methods for the following media:

- Helium
- Hydrogen
- Methane
- Forming gas: 95% nitrogen, 5% hydrogen

Given the significant flammability and explosion hazards linked to hydrogen and methane, all testing protocols were performed inside an ATEX-compliant test chamber, thereby ensuring compliance with relevant safety standards for explosive environments.

Conclusions

- The results of the tests are not clear-cut. Depending on the type and material of the gasket, various outcomes can be observed; thus, based on the studies conducted, it is impossible to pinpoint a single universal testing medium.
- It is important to highlight that the variations in leakage rates (tightness classes) for the media utilised were quite similar in scale and remained within or near the ± tolerance band established from the conversion. The conversion for helium volumetric leakage was defined as: He Leak / 3.16 and He Leak × 3.16 — a tolerance range accepted by ESA during cross-testing for the approval of gasket inclusion in the ESAdata database.
- This suggests that employing helium in leak-tightness testing permits a relatively precise estimation of leakage for other media such as 100% hydrogen and methane. In contrast, using 5% hydrogen (forming gas) introduces considerable uncertainty when assessing high tightness classes (very low leakage values), due to the limitations of the measurement equipment.
- Regardless of the testing medium used, all gaskets generally demonstrated high tightness at elevated contact stresses. According to PN–EN 13555:2021(E), three tightness classes are specified: L1.0, L0.1, and L0.01. The gaskets tested attained tightness classes at least one order of magnitude better. ■

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Maria and Mateusz work as laboratory engineers at SPETECH Sp. z o.o.. They specialise in joint-flange calculations and the testing of industrial valves. Both are engaged participants in the ESA Young Engineers Initiative.