Certification programme ZP "Zertifizierungsprogramm" 5101 of DVGW CERT GmbH, Bonn

Supplementary tests on elastomer materials for seals and diaphragms in gas appliances and equipment with respect to a hydrogen content of up to 100 vol. %

0 Preliminary remark

This is the English version of document 55101.100-04-DE from 05.12.2025.

This certification and test specification (Zertifizierungsprogramm ZP) describes the requirements, motivation, and tests to characterize elastomer materials for seals and diaphragms in gas equipment and systems with respect to permeation of hydrogen and behaviour towards Rapid Gas Decompression (RGD). Existing (DIN) DVGW certifications for elastomer materials according to DIN EN 549 or DIN EN 682 can be extended to include the addition '**H_2 tested**' if the permeation tests have been carried out in accordance with this ZP. In addition, the classification of elastomer materials can be extended to include behaviour towards RGD if the corresponding tests have been carried out in accordance with this ZP. The supplementary tests for permeation and RGD can be carried out separately.

Generally, the material compatibility of elastomer materials with hydrogen is given based on the information given in the material table in DIN EN ISO 11114-2. The DVGW research project G 201615 [2] also referred to this standard, along with other sources, to classify compatibility. DIN EN ISO 11114-2 incorporates findings on the service life, durability and long-term behaviour of various groups of plastics and elastomers. The compatibility data contained therein refer to single gases but can also be used to a certain extent for gas mixtures. This therefore also applies to elastomers tested and certified according to DIN EN 549 or DIN EN 682 with regard to the gases of the 2nd and 5th gas families defined in DVGW G 260.

Permeation is only handled qualitatively in DIN EN ISO 11114-2. This standard can therefore only support the evaluation of the compatibility of gas/material combinations as only the effect of the gas on changes in the material properties (e.g. due to a chemical reaction or changes in the physical state) is considered. The basic material properties required for design purposes, such as mechanical properties, are usually provided by the material supplier and are not considered in DIN EN ISO 11114-2.

Rapid Gas Decompression (RGD) refers to the rapid drop in pressure in a system under high gas pressure, as defined by DIN EN ISO 23936-2. This disrupts the balance between the external gas pressure and the concentration of gas dissolved in the polymer. As a result of this imbalance, the excess gas attempts to escape at various points in the material, leading to expansion. If the pressure drop occurs quickly enough – faster than the gas can diffuse out of the polymer naturally – this can lead to blistering or tearing of the polymer.
ISO 19880-7 and NORSOK M-710 also describe RGD. The occurrence of RGD damage within gas infrastructure was investigated in research project G 202208 [6] and the test method developed in this project has been included into this ZP.

This certification and testing programme is based on DVGW research projects (e.g. G 201205 [1], G 201615 [2], G 201824 [3], G 202138 [4], G 202021 [5], G 202208), industrial research and the various literature on hydrogen use in chemistry and industry (e.g. Marchi et al. [7], NASA publication series [8]).

Change history

Version 0 – 55101-00-N-DE dated 19 November 2021
- Original version with permeation test

Version 1 – 55101-01-N-DE dated 7 December 2021
- Editorial addition of the DIN-DVGW mark

Version 2 – 55101-02-N-DE dated 12 March 2024
- Editorial revision of the entire document
- Update of references and bibliography

Version 3 – 55101-03-N-DE dated 6 September 2024
- Update of cited research projects

Version 4 – 55101-04-N-DE dated 05.12.2025
- Inclusion of RGD tests
- and resulting restructuring of the entire document.

Bibliography

[1] Dörr, H., Kröger, P., Nitschke-Kowsky, P., Senner, J., Tali, E., Feldpausch-Jägers, S., „Untersuchungen zur Einspeisung von Wasserstoff in ein Erdgasnetz - Auswirkungen auf den Betrieb von Anwendungen im Be-stand, auf Gas-Plus-Technologien und auf Verbrennungsregelungsstrategien“, DVGW G 201205, DVGW Deutscher Verein des Gas- und Wasserfaches e. V. Technisch-wissenschaftlicher Verein, Bonn, 2016.

[2] Scholten, F., Dörr, H., Werschy, M., „Mögliche Beeinflussung von Bauteilen der Gasinstallation durch Wasserstoffanteile im Erdgas unter Berücksichtigung der TRGI“, DVGW 201615, DVGW Deutscher Verein des Gas- und Wasserfaches e. V. Technisch-wissenschaftlicher Verein, Bonn, 2018.

[3] Köppel, W., Mörs, F., Hüttenrauch, J., Burmeister, F., „Entwicklung einer Roadmap zur Umsetzung des DVGW-Energie-Impulses bis zum Jahr 2050“, DVGW G 201824, DVGW Deutscher Verein des Gas- und Wasserfaches e. V. Technisch-wissenschaftlicher Verein, Bonn, 2023.

[4] Anghilante, R., Bhagwan, R., Dörr, H., Burmeister, F., Joormann, N., Oberschelp, L., Tali, E., „Experimentelle Charakterisierung der Leckraten von Prüflecks mit Wasserstoff und/oder Methan-Gasmischungen gegenüber Luft“, DVGW G 202138, DVGW Deutscher Verein des Gas- und Wasserfaches e. V. Technisch-wissenschaftlicher Verein, Bonn, 2023

[5] Erler, F., Knorr, C., Wiersig, M., Strauß, A., Anghilante, R., Dörr, H., Elhami, O., Janßen, N., Burmeister, F., Kinnen, W., „F&E als Grundlage für den Einsatz von Wasserstoff in der Gasversorgung und der Umsetzung in Prüfgrundlagen – F&E für H_2“, DVGW G 202021, DVGW Deutscher Verein des Gas- und Wasserfaches e. V. Technisch-wissenschaftlicher Verein, Bonn, 2024.

[6] Strauß, A., Lutz, S., Domnick, C., Stoermer, M., „Ermittlung von wissenschaftlichen Grundlagen für Wasserstoffanwendungen von Elastomeren, Kunststoffen, Schmier- und Dichtmitteln in der Gasinfrastruktur“, DVGW G 202208, DVGW Deutscher Verein des Gas- und Wasserfaches e. V. Technisch-wissenschaftlicher Verein, Bonn, 2025.

[7] C. S. Marchi, B. P. Somerday, Technical Reference for Hydrogen Compatibility of Materials, Sandia Report SAND2012-7321 (unlimited release), (2012)

[8] NASA, SAFETY STANDARD FOR HYDROGEN AND HYDROGEN SYSTEMS, Guidelines for Hydrogen System Design, Materials Selection, Operations, Storage, and Transportation, Report NSS 1740.16 (1997)

1 Certification procedure

Gas products, conformity mark national (European non-harmonised area).

The possibility of using elastomer materials with natural gas-H_2 mixtures or pure hydrogen is indicated and listed in a directory of H_2 certification programs maintained by DVGW CERT GmbH.

2 Accreditations

An accreditation No. D-ZE-16028-01 exists for the procedure at German accreditation body (die Deutsche Akkreditierungsstelle GmbH) (DAkkS), Berlin.

3 Marks

3.1 Certification mark

DVGW resp. DIN-DVGW certification mark Products

Registration number scheme:
DG-5101DP0001 resp. NG-5101DP0001

DG = DVGW certification mark for gas,
NG = DIN-DVGW certification mark for gas,
5101 = product code, DP = 2024, 0001 = consecutive no.

3.2 Note on use

Note: The H_2-Ready mark of DVGW CERT GmbH has no direct reference to the tests described in this ZP. The H_2-Ready mark is an indication that the material can be used with natural gas-H_2 mixtures or pure hydrogen.

4 Type of certificate and test procedure

The subject of the certification are material tests on elastomer materials with (DIN-)DVGW certification according to DIN EN 549 or DIN EN 682.

The duration of validity of the confirmation of conformity according to this certification scheme is linked to the existing (DIN-)DVGW certificate according to DIN EN 549 or DIN EN 682.

5 Scope

Product group	Product code	Product type
Elastomer materials for seals and diaphragms	5101	Elastomer material for seals in gas appliances and equipment with life assessment
	5102	Elastomer material for diaphragm and seals in gas appliances and equipment with life assessment
	5104	Elastomer material for seals in gas supply mains and pipelines with life assessment
	5105	Materials for diaphragm in gas appliances and equipment, not reinforced, with life assessment
	5106	Materials for diaphragm in gas appliances and equipment, reinforced, with life assessment
	5111	Elastomer material for seals in gas installations
	5112	Elastomer material for seals in gas appliances
	5113	Elastomer material for seals in gas supply mains and pipelines
	5131	Materials for membranes for gas appliances and equipment, not reinforced
	5132	Materials for membranes for gas appliances and equipment, reinforced
	5133	Materials for membranes for gas equipment
	5134	Materials for membranes for gas meters and their equipment
	5139	Elastomer material for diaphragm and seals for gas appliances and equipment

6 Testing laboratories

Testing laboratories accredited in accordance with EN ISO/IEC 17025 for the relevant test bases and contractually bound to DVGW CERT GmbH.

7 Requirements and tests

7.1 General requirements

The elastomer materials shall be certified by DVGW CERT GmbH in accordance with DVGW regulations for use with natural gas.

The materials tested and certified according to ZP 5101 are listed in a directory issued by DVGW CERT GmbH.

7.2 Permeability

The requirements and testing are described in Appendix A.

7.3 Rapid Gas Decompression (RGD)

The requirements and testing are described in Appendix B.

8 Applicable documents

In the case of undated references, the current edition of the following documents applies:

- DVGW CERT GmbH <40014> Geschäftsordnung der DVGW CERT GmbH zur Zertifizierung von Produkten im nicht harmonisierten Bereich
- DVGW Arbeitsblatt G 260:2021-09
  Gasbeschaffenheit
- DIN EN 549:2024-07
  Elastomer-Werkstoffe für Dichtungen und Membranen in Gasgeräten und Gasanlagen
- DIN EN 682:2006-10
  Elastomer-Dichtungen - Werkstoff-Anforderungen für Dichtungen in Versorgungsleitungen und Bauteilen für Gas und flüssige Kohlenwasserstoffe
- DIN EN ISO 11114-2:2022-02
  Gasflaschen - Verträglichkeit von Flaschen- und Ventilwerkstoffen mit den in Berührung kommenden Gasen - Teil 2: Nichtmetallische Werkstoffe
- DIN EN ISO 23936-2:2012-03
  Erdöl-, petrochemische und Erdgasindustrie – Nichtmetallische Werkstoffe mit Medienkontakt bei der Öl- und Gasproduktion – Teil 2: Elastomere
- EN ISO/IEC 17025
  Allgemeine Anforderungen an die Kompetenz von Prüf- und Kalibrierlaboratorien
- ISO 14687:2025-02
  Wasserstoffbeschaffenheit - Produktspezifikation
- ISO 15105-1:2007-10
  Kunststoffe - Folien und Flächengebilde - Bestimmung der Gasdurchlässigkeit - Teil 1: Differentialdruck-Verfahren
- ISO 19880-7:2025-08
  Gasförmiger Wasserstoff - Befüllungsanlagen - Teil 7: O-Ringe

- DIN ISO 23529:2020-10
  Elastomere – Allgemeine Bedingungen für die Vorbereitung und Konditionierung von Prüfkörpern für physikalische Prüfverfahren
- NORSOK M-710:2014
  Qualification of non-metallic materials and manufacturers — Polymers

The currently valid issue status applies.

9 Period of validity

This certification programme is valid from 05.12.2025.

<u>In case of doubt, the German document is the legally binding document.</u>

10 Appendix A: Permeability

10.1 Requirements for use with up to 100 vol.% hydrogen

The method described provides an additional technical parameter in the form of H_2 permeability as a material property, which allows different materials to be compared with regard to hydrogen permeation. This material characteristic is determined without specifying a limit value and serves as an aid for the user in selecting elastomer materials with regard to their specific behaviour for hydrogen applications and the dimensioning of the moulded parts to be manufactured from them.

No statement is therefore made regarding the permeation or tightness of moulded parts, as design aspects play a significant role here. This ZP therefore states that the elastomer material is **"H_2 tested"**.
Since elastomer materials are used as seals and diaphragms in products and systems, leak testing in the system remains crucial and is not replaced by the permeability specification.

10.2 Tests

Test conditions	Based on ISO 15105-1, *"Plastics - Film and sheeting - Determination of gas-transmission rate - Part 1: Differential-pressure methods*". Method with a pressure measurement according to Annex A of ISO 15105-1 (manometric method) Partial pressure difference (1 ± 0.1) bar (1 atmosphere = 1.01325 bar) Sample thickness d (2 ± 0.2) mm => Determination of the actual thickness according to DIN ISO 23529 Medium H_2 (purity at least 99.9% by volume) Test temperature (23 ± 2) °C The gas transmission rate (GTR) is determined according to ISO 15105-1. For reasons of practicability, the GTR is to be given in the unit [cm³ / (m² (24 h) bar)]. Accordingly, the gas permeability as the relevant material parameter P = GTR x d is to be given in the unit of [(cm³ mm) / (m² 24 h bar)].
Evaluation	To determine the gas permeability, the gas transmission rate must be related to the actual thickness.

11 Appendix B: Rapid Gas Decompression

RGD tests on elastomers are already considered in several international standards. Examples include EN ISO 23936-2 for the petroleum, petrochemical and natural gas industries, ISO 19880-7 for filling stations with gaseous hydrogen, and NORSOK M-710 for the Norwegian oil and gas industry in the field of production. The testing and certification basis developed as part of the HydEKuS research project and presented in this certification programme is initially based on the regulations mentioned here. Furthermore, the testing and certification basis was adapted within the research project based on the results and findings for the relevant area of application. For comparability, the information from the standards is also referenced.

As with the permeability test, no limit value for the degree of damage is specified for RGD. The materials are classified according to the degree of damage that occurs. The classification should not be understood to mean that the material will reach the degree of damage shown under all circumstances. Rather, the classification, based on a uniform standardised test, provides the user with guidance on the basic resistance of the material to RGD damage and thus enables a comparison of different materials.

11.1 Test conditions

Test gas

This certification programme focuses on testing with hydrogen and natural gas. Hydrogen shall have a minimum purity of 99.9 % by volume (in accordance with ISO 14687, Grade B). For methane, the standard test gas G20 with 100 % CH_4 by volume shall be used.

The tests can optionally be carried out with other pure gases, and this can be indicated on the certificate in accordance with the classification. This does not extend the scope of the certification to these other gases. Regardless of the tests specified in Appendix B, the scope of the certificate remains for natural gas with the additional marking **H_2 tested** if the hydrogen permeability tests specified in Appendix A have been carried out.

> Note: ISO 19880-7 uses hydrogen as the test gas. In addition to methane, NORSOK M-710 also uses mixtures of methane containing carbon dioxide and hydrogen sulphide, as these can occur during natural gas production and are not processed. EN ISO 23936-2 specifies a mixture of carbon dioxide and methane or nitrogen but also allows the use of other gases.

Test temperature

The tests must be carried out at a temperature of 23 ± 2 °C.

> Note: ISO 19880-7, NORSOK M-710 and EN ISO 23936-2 specify higher test temperatures in the range between 30 °C and up to 240 °C. However, other test temperatures are also permitted in some cases. A lower temperature has been chosen for this certification programme because materials are being compared with each other and no limit value is defined to exclude materials that do not exhibit a certain resistance to RGD damage. The lower test temperature enables a more practical test that is relevant to the area of application in question.

Test pressure
The maximum operating pressures correlate with the application, 10 MPa (long-distance pipelines) and 3 MPa (gas plants), are considered. With a safety factor of ≈ 1.3, this results in test pressures of 13 MPa and 4 MPa.

The manufacturer shall choose the test pressure at which the material is to be tested. Depending on the area of application, one pressure level may be more appropriate than the other. The degree of damage shall be classified according to the pressure level tested. The degree of damage achieved at one pressure level shall also apply to lower pressure levels without further testing. However, both pressure levels may also be tested and two different degrees of damage reported.

> Note: ISO 19880-7, NORSOK M-710 and EN ISO 23936-2 specify higher test pressures in the range between 10 MPa and 90 MPa or more. This is due to the corresponding areas of application. The safety factor is derived from ISO 19880-7. This applies to passenger car pressure tanks, which are typically operated at 70 MPa. With a prescribed test pressure of 90 MPa, this results in a safety factor of 1.28.

Exposure and cycles
The exposure must be carried out for 24 ± 1 h at test pressure. After depressurisation, the tank must be held at ambient pressure for 1 h and then exposed again for 24 ± 1 h at test pressure.

> Note: ISO 19880-7 specifies one cycle with a storage time of 24^{0}_{-2} h. EN ISO 23936-2 specifies eight cycles, with the first cycle having a duration of at least 68 h and all subsequent cycles alternating between 6 h and 12 h of storage time with an intermediate holding time of 1 h at ambient pressure. NORSOK M-710 specifies a variable number of cycles from 1 to 10, with the first cycle lasting 72 ± 4 h and all subsequent cycles lasting 23 ± 1 h, with an intermediate holding time of 1 h at ambient pressure.

Relief time
The pressure must be reduced from the test pressure to ambient pressure within a maximum of 5 s. With a test pressure of 13 MPa, this corresponds to an average pressure reduction gradient of more than 2.6 MPa/s, and with a test pressure of 4 MPa, to an average pressure reduction gradient of more than 0.8 MPa/s. The pressure reduction gradient is not linear.

> Note: ISO 19880-7 specifies a pressure reduction of at least half the test pressure, i.e. at least 45 MPa, in the first 10 s. This results in an average pressure reduction gradient of over 4.5 MPa/s. In contrast, the average pressure reduction gradients specified in EN ISO 23936-2 with a primary value of 2 ± 0.2 MPa/min and NORSOK M-710 with 7 ± 0.7 MPa/min are significantly lower.

Test specimens

The test shall be carried out on three cylindrical test discs with a diameter of (13 ± 0.5) mm and a thickness of (6.3 ± 0.3) mm, which shall be cut from sheets of material. The cylindrical test discs shall be free from visible surface damage.

> Note: EN ISO 23936-2 and NORSOK M-710 specify testing on O-rings. As the two standards EN 549 and EN 682, to which this ZP refers, are material standards, no moulded part testing is carried out here. ISO 19880-7 also specifies tests on circular samples with a thickness of 2 ± 0.2 mm and the same diameter.

11.2 Test equipment

Suitable testing equipment that meets the following requirements must be used to carry out the tests:

- Pressure-resistant container (e.g. autoclave) suitable for the selected pressure range with a suitable valve for rapid depressurisation.
- Test device that allows the test specimens to expand in all directions.
- Sensors for temperature and pressure measurement
- Device for constant temperature control (e.g. water bath)
- Digital camera, microscope and suitable measuring equipment for documentation

11.3 Test procedure

1) Inspection of the test specimens with regard to dimensions and possible damage
2) Placement of the test specimens in the test device.
3) Placement of the test device in a suitable pressure vessel.
4) Triple flushing of the pressure vessel with inert gas at 1 MPa to remove air. Leak test of the pressure vessel with a suitable leak detection spray. Avoid holding at 10 MPa with inert gas to prevent saturation of the test specimens with the inert gas.
5) Applying test gas and test pressure to the pressure vessel.
6) Maintaining the test pressure for the duration of the storage period, recording the temperature and pressure at regular intervals.
7) Release to ambient pressure within the maximum relaxation time and maintain the ambient pressure for 1 hour.
8) Reapply the test pressure to the pressure vessel and maintain the test pressure for the duration of exposure, recording the temperature and pressure, followed by release to ambient pressure within the maximum release time.
9) Triple flush the pressure vessel with inert gas at 1 MPa to remove hydrogen.
10) Open the pressure vessel and remove the test specimens.
11) Visual inspection and documentation of any damage that has occurred.
12) Evaluation of the degree of damage according to section 11.4.

11.4 Evaluation of the degree of damage

The damage caused by RGD is evaluated in accordance with DIN EN ISO 23936-2, as NORSOK M-710 refers to DIN EN ISO 23936-2 and, in contrast, ISO 19880-7 only considers cracks and blisters occurring on the surface. However, the investigations carried out in the research project show that cutting is necessary, which is why ISO 19880-7 is not considered for the evaluation.

11.4.1 Preparation of the test specimens

For the evaluation of the cylindrical test discs considered here, they must be prepared as described below. The research project has shown that practically only one cut according to Figure 11-1 is possible. For this purpose, the test specimen is cut open with a sharp blade, e.g. a scalpel. If bubbles or damages on the surface are visible, the specimens are to be sectioned in this area.

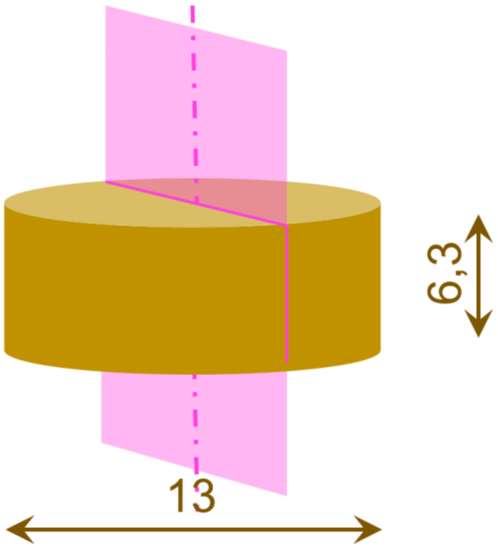

Figure 11-1: Cut plane of the cylindrical test discs [Source: OGE]

> *Note: The procedure specified in DIN EN ISO 23936-2 applies to the use of a moulded part in the form of an O-ring. It provides for axial cutting of the O-ring. The number of cuts varies depending on the size of the O-ring. This procedure cannot be directly adopted due to the changed geometry of the test specimen.*

11.4.2 Assessment of damage

The number and length of the cracks that have occurred shall be recorded. The number of cracks shall be counted across the entire cut surface. In addition, the length of each crack shall be determined. The sum of all crack lengths and the individual crack length shall be set in relation to the diameter of the test specimen. The crack length shall be determined directly from the starting point to the end point. In the case of curved cracks, the length can be determined along the path. The evaluation shall be carried out in accordance with Table 11-1. To obtain an evaluation level, the material shall meet all the criteria for the respective level.
The individual values of the three test specimens shall be reported in the test report. If there are two or more levels between the highest and lowest ratings, the test shall be repeated. In the case of minor deviations, the mean value shall be calculated and rounded up to the next higher level.

Table 11-1: Evaluation according to ISO 23936-2

<table>
<tr><th>Rating</th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>n_{max}</td><td>0</td><td>2</td><td>3</td><td>5</td><td rowspan="2">Any</td><td rowspan="3">Any</td></tr>
<tr><td>ΣL</td><td>0</td><td>≤ 0.6 * D</td><td>≤ 1.6 * D</td><td>Any</td></tr>
<tr><td>L_{max}</td><td>0</td><td>≤ 0.5 * D</td><td>≤ 0.5 * D</td><td>2 pcs: ≤ 0.8 * D
Rest: ≤ 0.5 * D</td><td>< D</td></tr>
</table>

n_{max} = maximum number of cracks
ΣL = sum of crack lengths
L_{max} = maximum crack length
D = diameter

Note: DIN EN ISO 23936-2 also determines the sum of all crack lengths and the individual crack length, which are set in relation to the diameter. This is used to derive a six-level rating system. Due to the different surface areas of O-rings and test coupons, this rating system cannot be directly transferred to this test basis. The criteria of the rating system presented here are derived from the rating system of DIN EN ISO 23936-2, considering the different surface areas. For the exact calculations, it is referred to the research report of the project.

11.5 classification

The materials shall be classified according to the degree of damage depending on the pressure level, as specified in Table 11-2.

Table 11-2: Classification – Degree of damage depending on the pressure level

Class	Pressure level (bar)	Degree of damage
RGD-xx-30-0	30	0
RGD-xx-30-1		1
RGD-xx-30-2		2
RGD-xx-30-3		3
RGD-xx-30-4		4
RGD-xx-30-5		5
RGD-xx-100-0	100	0
RGD-xx-100-1		1
RGD-xx-100-2		2
RGD-xx-100-3		3
RGD-xx-100-4		4
RGD-xx-100-5		5

Note: "xx" stands for the test gas used in chemical formula. The indices are not subscripted here.

EXAMPLE: The classification of an elastomer material that can be used in a temperature range from -20 °C to +80 °C with a specified nominal hardness of 70 IRHD-M and exhibits damage level 5 at a methane pressure of 100 bar and damage level 2 at 30 bar would be B2/H3/RGD-CH4-100-5/RGD-CH4-30-2.

Note: The classes for other gases at one or more pressure levels are optionally added according to the scheme shown.