Honeywell

Injection of hydrogen to the natural gas network – Suitability of Honeywell Gas Product lines

White paper

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Summary

The results for the individual product groups are summarized here (as of March 2023).

Details on the procedure, the selected categories and the tests performed can be found in the following sections.

Product line turbine and rotary gas meters (TRZ2, SM-RI-X, Q, Q75, QA/QAe, RABO/RABO-Compact, IRM3-DUO)[1]

Category	Subcategory	≤ 10 %	≤ 30 % [2)]	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection	yes	yes	yes [1)]
Function/ performance	measurement accuracy/ measurement range	yes	increased measurement error at Qmin expected	increased measurement error at Qmin expected
	long-term behaviour	yes	yes	currently no knowledge
	metrological approval	yes	currently no test basis	currently no test basis
Production/ testing	leakage test production	yes	testing with air; on request with helium	testing with air; on request with helium
	leakage test commissioning	yes	test with ‘suitable test gas’	test with ‘suitable test gas’

[1)] Encoder S1 (SCR) is not approved for ATEX IIC explosion group (> 75% hydrogen).

[2)] Rabo and IRM-DUO in preparation

[1] The data apply to products manufactured as of 2000.

Product line ultrasonic gas meter (Q.Sonic)

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection	yes	yes	yes
Function/ performance	measurement accuracy/ measurement range	yes	yes	no
	long-term behaviour	yes	yes	N/A
	metrological approval	yes	currently no test basis	N/A
Production/ testing	leakage test production	yes	testing with air; on request with helium	testing with air; on request with helium
	leakage test commissioning	yes	test with ‘suitable test gas’	test with ‘suitable test gas’

Product line Flow Computer (gas-net, enCore)

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	explosion protection[1)]	yes	yes	yes
Function/ performance	measurement accuracy/ measurement range	yes	yes[2)]	yes[2)]
	long-term behaviour pressure transmitter	yes	yes	yes[3)]
	metrological approval	yes	yes[4)]	yes[4)]

[1)] ExMFE5

[2)] enCore series: SGERG-mod-H2 and AGA8-92DC can be used up to 100 % according to MID approval.

[3)] Pressure transmitter with gold-coated measuring diaphragm.

[4)] enCore series: MID approval for SGERG-mod-H2 and AGA8-92DC available for enCore ZM1 and BM1; for enCore FC1 planned in Q2/2023.

Product line Electronic Volume Converters (Elster EK2xx)

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	material compatibility	yes[1)]	yes[1)]	yes[1)]
	explosion protection	yes	yes	yes[2)]
Function/ performance	measurement accuracy/ measurement range	yes	yes[3)]	yes[3)]
	long-term behaviour pressure transmitter	yes	yes	yes
	metrological approval	yes	yes[3)]	yes[3)]

[1)] Valid for Ex zone 2 and safe area. Currently no knowledge for use in Ex zone 1.
[2)] EK280 has no approval for the ATEX IIC explosion group and may therefore be used in Ex zone 1 up to max. 75 % hydrogen.
[3)] EK280: SGERG-mod-H2 can be used up to 100 % according to MID approval (Implementation and MID approval planned for Q2/2023).

Product line Electronic Volume Converters (Mercury EC350)

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	material	yes[1)]	yes[1)]	yes[1)]
	explosion protection	yes	yes	no[2)]
Function/ performance	measurement accuracy/ measurement range	yes	yes[3)]	yes[3)]
	long-term behaviour pressure transmitter	yes	yes	in evaluation
	metrological approval	yes	yes[3)]	yes[3)]

[1)] Valid for Ex zone 2 and safe area. Currently no knowledge for use in Ex zone 0/1.
[2)] EC350 has Ex ia IIB T4 G approval and can therefore be used for gases with up to 75 % hydrogen.
[3)] AGA8 is applicable with a measurement uncertainty of 0.1 % up to 10 %. Can also be used for higher amounts, but with higher measurement uncertainties.

Product line EnCal 3000/EnCal 3000 Quad[2]

Category	Subcategory	≤ 10 %	≤ 20 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection	yes	yes	yes
Function/ performance	measurement accuracy/ measurement range	yes	yes[1)]	no
	long-term behaviour	yes	yes	yes
	metrological approval[2)]	yes	yes[1)]	no

[1)] Only for EnCal 3000 Quad

[2)] available certifications with hydrogen: PTB only

Product line EnCal 3000 proChain

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection	yes	yes	yes
Function/ performance	measurement accuracy/ measurement range	yes	in final testing stage	No
	long-term behaviour	yes	yes	pending
	metrological approval[1)]	yes	pending	No

[1)] Pending certifications with hydrogen: NMi according OIMLR140

[2] Legacy EnCal 2000 PGC is not suitable for Hydrogen application

Product line GasLab Q2[3]

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection	yes	yes	yes
Function/ performance	measurement accuracy/ measurement range	yes	in final testing stage	pending
	long-term behaviour	yes	yes	yes
	metrological approval[1)]	yes	pending	No

[1)] Pending certifications with hydrogen: NMi according OIMLR140

Product line gas pressure regulators, safety devices

Category	Subcategory	≤ 10 %	≤ 20 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection[1)]	yes[1)]	yes[1)]	yes [1)]
Function/ performance	accuracy/ flow capacity	yes, with restrictions[2)]	yes, with restrictions[2)]	yes, with restrictions[2)]
	long-term behaviour	yes	yes	yes
Production/ testing	leakage test production	yes	testing with air; on request with helium	testing with helium
	leakage test commissioning	yes	test with ‘suitable test gas’	test with ‘suitable test gas’

[a.]

[1)] For purely mechanical versions. Attached electronic devices need to be approved for ATEX IIC explosion group (> 75%).

[2)] With an increasing proportion of hydrogen in the natural gas, the device performance, based on the KG value for natural gas, increases. This must be considered when selecting devices and designing a station

[3] Legacy GasLab Q1 is not suitable for Hydrogen applications

Introduction

The decarbonization of the energy system to achieve the defined climate protection targets is a topic of global debate. The prerequisite for this is a massive expansion of renewable power generation and the use of this electricity in industry, transport, as well as households, trade, and services.
To transport the electricity to where it is needed, a major expansion of electricity transmission capacities is necessary. Similarly, the expansion of storage technologies must be pushed forward to ensure security of supply even in times of low wind and sunshine. To date, however, electricity cannot be stored on a large scale and over an extended period. With the concepts tested to date, such as pumped storage power plants, underground compressed air storage or the development of huge lithium-ion batteries, only a small part of the storage capacities required in the future can be realized.
One contribution to solving this problem is the coupling between the electricity and gas sectors via power-to-gas technology: The transport and storage of electrical energy takes place in the form of hydrogen or synthetic methane (synthetic natural gas; SNG) in the natural gas network .

With this background, the injection of hydrogen into the existing natural gas network has become a predominant topic in the gas industry. However, there are currently no clear and uniform specifications regarding the proportion of hydrogen that can be fed into the existing gas networks. However, it is becoming apparent in the discussion that the limits of 10 % [4] or even up to 30 % hydrogen in the existing gas grid may be technically feasible. Besides this there will be gas networks that will transport 100 % hydrogen.

Honeywell has therefore evaluated all major product lines to verify readiness for 10 %, 30% and 100 % hydrogen content. So far, these assessments have been carried out at Honeywell's GAS Center-of-Excellence in Mainz and Kassel and as partly off a joint industry project at DNV in the Netherlands. Official MID or PED certifications cannot be conducted at present, as neither relevant criteria or product standards nor certification laboratories are available.
As soon as appropriate product standards as well as test laboratories of certification bodies such as PTB or NMi are available for hydrogen tests, Honeywell will validate the results with the help of these external partners

[4] The percentages in this document refer to the molar fraction of hydrogen.

Evaluation of the product lines

For the evaluation, it is important to note that hydrogen differs substantially in some physical properties from those of natural gas that the industry knows for many decades:

- Volume-related calorific value: approx. 1/3 natural gas
- Density: approx. 1/7 methane, approx. 1/10 air
- Dynamic viscosity: approx. 50 % air
- Thermal conductivity: high, similar to helium
- Higher ignitability than natural gas
- Diffuses very quickly through porous materials or the smallest leaks.
- Mixtures of hydrogen with air or pure oxygen are highly explosive (oxyhydrogen).

The percentage content of hydrogen is relevant when evaluating product properties. Generally, it is assumed that percentages of up to 10 % have no significant effect. This means that the specific properties of hydrogen have no influence on the properties of the device. On the other hand, with 20 % and 100 % hydrogen content, the effects on the material, gas tightness, explosion protection etc. must be considered in detail.

We considered three categories:

1. Safety:
   - Gas compatibility of materials e.g., housings, seals, springs, membranes etc.
   - PED approvals
   - Approvals for hazardous areas: e.g., explosion gas group and class
   - For (attached) electronic devices: approvals for hazardous areas: e.g., explosion gas group and class
2. Function/performance:
   - Functional accuracy (measurement technology, energy calculation, etc.)
   - Long-term behaviour
   - Influence on the measuring range (Qmin and Qmax)
   - Metrological approvals, e.g., MID
   - Type plate
   - Calibration
3. Production/testing:
   - Test benches with hydrogen, e.g., for leakage test

Product lines turbine and rotary gas meters (TRZ2/SM-RI-X/RABO/IRM-3-Duo)[5]

Safety

The steel types used in our gas meters are up to 100 % hydrogen compatible.
The material compatibility of plastics, elastomers and lubricants is evaluated based on long-term experience in plants operated by producers of technical gases using up to 100 % hydrogen.

All electrical components, except the encoder S1 (SCR), are approved according to ATEX IIC explosion group and can therefore be used up to 100 % hydrogen. The use of encoder S1 is limited to a maximum of 75 % hydrogen.

Function/performance

Turbine and rotary gas meters are considered suitable even for high hydrogen concentrations.
However, due to the low density, strong effects on the measurement behaviour are to be expected – especially at low flow rates:

- Qmin will increase due to the lower drive torque at turbine gas meters or the lower force on the piston at rotary gas meters with the same flow.
- Qmax is determined by the limit speed and does not change.

Currently, only qualitative statements can be made here, as there are only very few reliable studies available on the metrological behaviour of 100 % hydrogen on large gas measuring devices.

Further investigations are necessary regarding measuring accuracy with fluctuating gas properties as well as long-term stability, permeation and dynamic behaviour at higher pressures.

For turbine wheel gas meters TRZ2 and SM-RI-X, PTB has issued a clearance certificate for the admixture of hydrogen up to 30%.

Production/testing

Leak tests in production are carried out with air as a standard. On request, this can be done with helium [6]. Leak tests on site during commissioning or periodic inspections must be conducted with a "suitable test gas", depending on the hydrogen content.

[5] The data apply to products manufactured as of 2000.
[6] Due to declining helium resources, alternative test gases are currently being investigated.

Summary of the results for turbine and rotary gas meters

Category	Subcategory	≤ 10 %	≤ 30 % [2)]	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection	yes	yes	yes[1)]
Function/ performance	measurement accuracy/ measurement range	yes	increased measurement error at Qmin	increased measurement error at Qmin
	long-term behaviour [3)]	yes	yes	currently no knowledge
	metrological approval	yes	currently no test basis	currently no test basis
Production/ testing	leakage test production	yes	testing with air; on request with helium	testing with air; on request with helium
	leakage test commissioning	yes	test with ‘suitable test gas’	test with ‘suitable test gas’

[1)] encoder S1 (SCR) is not approved for ATEX IIC explosion group (> 75% hydrogen)

[2)] Rabo and IRM DUO in preparation

Product line ultrasonic gas meters (Q.Sonic-plus, Q.Sonic-max, Q.Sonic-max6+)[7]

Safety

The steel types used in our ultrasonic gas meters are up to 100% hydrogen compatible. When evaluating materials such as plastics, elastomers and lubricants, there are empirical values from applications at manufacturers of technical gases that are operated with up to 100 % hydrogen.
In addition, Titanium grade 2 transducers are used for the Q.Sonic product series to support 100 % hydrogen.

The ultrasonic transducers of the Q.Sonic product series are designed in such a way that their maximum capacitive energy content is far below the ATEX limit. Therefore, no explosion protection approval is required.

Function/performance

Ultrasonic gas meters are generally suitable for the measurement of 10 % hydrogen within the calibration error limit.

For the ultrasonic gas meters Q.Sonic-max, PTB has issued a certificate of safety for the addition of hydrogen up to 30%.

Production/testing

Leak tests in production are conducted with air as a standard. On request, this can be done with helium[8]. Leak tests on site during commissioning or periodic inspections must be conducted with a "suitable test gas", depending on the hydrogen content.

[7] The data apply to products manufactured as of 2000.
[8] Due to declining helium resources, alternative test gases are currently being investigated.

Summary of the results for ultrasonic gas meters

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection	yes	yes	yes
Function/ performance	measurement accuracy/ measurement range	yes	yes	no
	long-term behaviour	yes	yes	N/A
	metrological approval	yes	currently no test basis	N/A
Production/ testing	leakage test production	yes	testing with air; on request with helium	testing with air; on request with helium
	leakage test commissioning	yes	test with ‘suitable test gas’	test with ‘suitable test gas’

Product lines Flow Computer and Electronic Volume convertors (gas-net, enCore, Elster EK2xx, Mercury EC350)

Safety

The pressure transmitter is the only component of a volume corrector that has direct contact with the measured gas. According to the manufacturers, the pressure transmitters used by Honeywell are suitable for up to 100 % hydrogen, but the question of the long-term durability, especially of the measuring membrane, must be asked here.

Another important aspect is the Ex-approval of the transmitter and the Ex-power supply unit. These must be checked individually for the pressure transmitters of the Flow Computer. In case of compact volume correctors, it is part of the device approval.

For the compact volume correctors, which are usually installed directly on or at the gas meter, the corresponding ATEX approval of the device must also be considered:

- ATEX zone 1: If the hydrogen concentration in natural gas is > 75 %[9], the Ex-approval of the compact volume corrector must meet the requirements for explosion group IIC for hydrogen.
- ATEX zone 2: In this case, adding hydrogen does not represent an increased risk.

Function/performance

The application range of a volume converter is limited by the used compressibility factor algorithm. The following applies to the algorithms commonly used:

- SGERG-88: The SGERG-88 has an upper limit of 10 % hydrogen in natural gas according to the specification. However, there is no practical experience in this respect.
- SGERG-mod-H2: The SGERG-mod-H2 is derived from SGERG-88 and, according to the MID approval[10], allows the calculation of gas mixtures with hydrogen contents up to 100%.
- AGA8-92DC: The ISO12213-2 standard specifies that the AGA8-92DC method is only used up to a maximum hydrogen content of 10%. However, in accordance with the MID approval[11], the procedure can be used for any hydrogen content up to 100%.

[9] according to CEN-TC234-WG5 (N0116), section 4.3
[10] available for enCore ZM1 and BM1; for enCore FC1 and EK280 planned in Q2/2023
[11] available for enCore ZM1 and BM1; for enCore FC1 planned in Q2/2023

Summary of results for Flow Computers (gas-net, enCore)

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	explosion protection[1)]	yes	yes	yes
Function/ performance	measurement accuracy/ measurement range	yes	yes[2)]	yes[2)]
	long-term behaviour pressure transmitter	yes	yes	yes[3)]
	metrological approval	yes	yes[4)]	yes[4)]

[1)] ExMFE5

[2)] enCore series: SGERG-mod-H2 and AGA8-92DC can be used up to 100 % according to MID approval.

[3)] Pressure transmitter with gold-coated measuring diaphragm.

[4)] enCore series: MID approval for SGERG-mod-H2 and AGA8-92DC available for enCore ZM1 and BM1; for enCore FC1 planned in Q2/2023.

Summary of results for Electronic Volume converters (Elster EK2xx)

Category	Subcategory	≤ 10 %	≤ 20 %	100 %
Safety	material compatibility	yes[1)]	yes[1)]	yes[1)]
	explosion protection	yes	yes	yes[2)]
Function/ performance	measurement accuracy/ measurement range	yes	yes[3)]	yes[3)]
	long-term behaviour pressure transmitter	yes	yes	yes
	metrological approval	yes	yes[3)]	yes[3)]

[1)] Valid for Ex zone 2 and safe area. Currently no knowledge for use in Ex zone 1.

[2)] EK280 has no approval for the ATEX IIC explosion group and may therefore be used in Ex zone 1 up to max. 75 % hydrogen.

[3)] EK280: SGERG-mod-H2 can be used up to 100 % according to MID approval (Implementation and MID approval planned for Q2/2023).

Summary of results for Mercury Electronic Volume converters (EC350)

Category	Subcategory	≤ 10 %	≤ 20 %	100 %
Safety	material compatibility	yes[1)]	yes[1)]	yes[1)]
	explosion protection	yes	yes	no[2)]
Function/ performance	measurement accuracy/ measurement range	yes	yes[3)]	yes[3)]
	long-term behaviour pressure transmitter	yes	yes	In evaluation
	metrological approval	yes	yes[3)]	yes[3)]

[1)] Valid for Ex zone 2 and safe area. Currently no knowledge for use in Ex zone 0/1.
[2)] EC350 has Ex ia IIB T4 G approval and can therefore be used for gases with up to 75 % hydrogen.
[3)] AGA8 is applicable with a measurement uncertainty of 0.1 % up to 10 %. Can also be used for higher amounts, but with higher measurement uncertainties.

Product line gas quality devices (GasLab Q2, EnCal 3000/proChain)[12]

Our gas quality devices are all prepared or being prepared to handle any percentage of H2. We are working towards 100% capability of 100% H2

The information on hydrogen compatibility in the “Safety” section refers to the general suitability to the materials used, the required safety approvals, etc.

In contrast, the information on hydrogen compatibility in the section “Function/ performance” refers to the limit value up to which the metrological specification regarding measurement uncertainty and repeatability is met.

Safety

The materials used in the EnCal 3000, EnCal 3000 Quad, EnCal Prochain and the GasLab Q2 are compatible with 100 % hydrogen.

The devices are approved for ATEX IIC explosion protection class and can therefore also be used in the Ex-zone with 100 % hydrogen.

Function/performance

Different device variants with corresponding metrological approvals are implemented for the EnCal Series:

- EnCal 3000 e-gas:
  Operating range up to 20 % hydrogen, metrological approval of the PTB up to 5 % hydrogen
- EnCal 3000 Quad:
  Operating range up to 20 % hydrogen, metrological approval of the PTB up to 20 % hydrogen
- EnCal 3000 proChain: Currently not suitable for hydrogen gases

[12] EnCal 2000 PGC and GasLab Q1 are not hydrogen compatible

Summary of results for EnCal 3000/EnCal 3000 Quad

Category	Subcategory	≤ 10 %	≤ 20 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection	yes	yes	yes
Function/ performance	measurement accuracy/ measurement range	yes	yes[1)]	no
	long-term behaviour	yes	yes	yes
	metrological approval[2)]	yes[1)]	yes[1)]	no

[1)] Only for EnCal 3000 Quad

[2)] available certifications with hydrogen: PTB only

Summary of results for EnCal 3000 proChain

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection	yes	yes	yes
Function/ performance	measurement accuracy/ measurement range	yes	in final testing stage	No
	long-term behaviour	yes	yes	Pending
	metrological approval[1)]	yes	pending	No

[1)] Pending certifications with hydrogen: NMi according OIMLR140

Summary of results for GasLab Q2

Category	Subcategory	≤ 10 %	≤ 30 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	Yes
	explosion protection	yes	yes	Yes
Function/ performance	measurement accuracy/ measurement range	yes	in final testing stage	Pending
	long-term behaviour	yes	yes	Yes
	metrological approval[1)]	yes	pending	No

[1)] Pending certifications with hydrogen: NMi according OIMLR140

Product line regulators

Safety

The steel types used in our gas pressure regulator are up to 100 % hydrogen compatible.
The material compatibility of plastics, elastomers and lubricants was evaluated based on long-term experience in plants operated by producers of technical gases using up to 100 % hydrogen.

All attached electrical components, are approved according to ATEX IIC explosion group and can therefore be used up to 100 % hydrogen.

Function/performance

Gas pressure regulators are considered suitable even for high hydrogen concentrations.
However, due to the low density of hydrogen, we see effects on the flow capacity. With the reduction of the density with growing hydrogen content, we are experiencing an increase in capacity over the devise. Taking the 1/3 ratio of the energy content of hydrogen into account, we see a slight energy flow capacity reduction for the device, but with an increase of the flow velocity. These effects are still under investigation in which way this will have influence on the station sizing.

Production/testing

Leak tests in production are carried out with air as a standard. On request, this will be done with helium. Leak tests on site during commissioning or periodic inspections must be conducted with a "suitable test gas", depending on the hydrogen content.

Summary of results for gas pressure regulators, safety devices

Category	Subcategory	≤ 10 %	≤ 20 %	100 %
Safety	material compatibility (gas tightness)	yes	yes	yes
	explosion protection[1)]	yes[1)]	yes[1)]	yes [1)]
Function/ performance	accuracy/ flow capacity	yes, with restrictions[2)]	yes, with restrictions[2)]	yes, with restrictions[2)]
	long-term behaviour	yes	yes	yes
Production/ testing	leakage test production	yes	testing with air; on request with helium	testing with helium
	leakage test commissioning	yes	test with ‘suitable test gas’	test with ‘suitable test gas’

[1)] For purely mechanical versions. Attached electronic devices need to be approved for ATEX IIC explosion group (> 75%).
[2)] With an increasing proportion of hydrogen in the natural gas, the device performance, based on the KG value for natural gas, increases. This must be considered when selecting devices and designing a station

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