SICK AG WHITE PAPER

FLOWSIC600 / FLOWSIC600-XT
POWER-TO-GAS – Admixture of hydrogen from renewable energies into the natural gas grid and the associated suitability of SICK ultrasonic gas meters

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SUMMARY

Gas meters of the FLOWSIC600 and FLOWSIC600-XT families are already suitable today for measuring natural gases containing proportions of hydrogen within the scope transport according to the laws of calibration. The reliability and quality of the measurement results are not affected by changes in density, flow velocity or speed of sound.

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1. Introduction

In addition to the requirements for a secure, reliable and affordable power supply, the idea of sustainability within the context of the energy revolution is coming into focus. Renewable energy sources such as wind, water or solar have an important role to play in this energy mix.

Since the electricity generated from these upcoming but highly fluctuating energy sources cannot be transported or consumed in a way that allows for grid compensation, it must be stored. One possibility is to store the energy as gas in the existing natural gas network. For years, there have been developments towards converting electrical energy into storable gases such as hydrogen (H_2) or synthetic natural gas. The process of converting electricity into gas by electrolysis is known as power-to-gas (also PtG or P2G). The hydrogen produced can be fed into the existing natural gas network, stored there, transported and consumed as required.

In numerous countries of the European Union, research projects have been running since about 2010 looking at the question of how much hydrogen the existing natural gas network is able to absorb without the gas consumption points being negatively affected.

In industry, very different limit values for the admixture of H_2 with natural gas are currently mentioned. Values typically range from 5 to 25 percent by volume. However, what seems clear is that the proportion will increase steadily over the coming years. How quickly this happens will certainly depend on the speed of investment and the progress made with developing power-to-gas technologies.

The question of what effects the admixture of hydrogen into natural gas has on the infrastructure installed today is of increasing concern to the industry.

2. Technical Guideline G19 (TR G 19)

In December 2014, the Physikalisch Technische Bundesanstalt (PTB) issued the Technical Guideline TR G 19[1], which regulates “Feeding hydrogen into the natural gas network” for “measuring instruments for gas”.

The Guideline declares the use of gas measurement devices “of any technologies” shall be safe provided that the hydrogen content of the natural gas is less than 5% by volume. The use of meters is permitted for a proportion between 5 and 10% by volume of hydrogen, provided the manufacturer explicitly permits this. For the use of meters with natural gas containing > 10% hydrogen by volume, a manufacturer’s declaration as well as a PTB declaration of clearance must be submitted in addition to the manufacturer’s declaration.

The FLOWSIC600 and FLOWSIC600-XT gas meters installed today can be used in applications with up to 10% hydrogen by volume in natural gas; this is possible within the calibration error limits and without the need for a new metrological test. SICK has published a corresponding manufacturer’s declaration in accordance with TR G 19.[2]

Since applications with more than 10% hydrogen by volume in natural gas require an evaluation of the respective application, SICK will, after further investigations, prepare a corresponding manufacturer’s declaration and arrange for the PTB safety certificates in accordance with TR G 19.

[1] PTB: TR G 19, Braunschweig, 12/2014
[2] SICK: FLOWSIC600 and FLOWSIC600-XT, manufacturer’s declaration according to TR G 19 “Input of hydrogen into the natural gas grid”, Ottendorf-Okrilla, 11/2019

3. Effect of the admixture of hydrogen on measuring capability

The addition of hydrogen has an effect on the characteristic curve behavior and thus on the measuring uncertainty of the devices. A measuring capability does not amount to the same thing as an unchanged measurement accuracy.

The latest test results of an ultrasonic gas meter calibrated with natural gas show the relative error (measurement deviation) on the measurement result (Fig. 1 and Fig. 2) caused by a hydrogen admixture of 10% and 25% by volume, respectively.

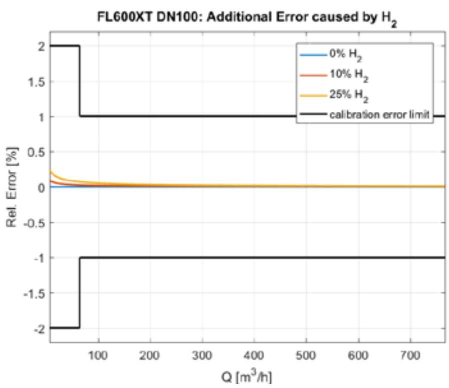

Fig. 1: Influence of the H_2 content on the measurement error of a DN100 FLOWSIC600-XT after application of the linearization correction, on the basis of pure natural gas data.

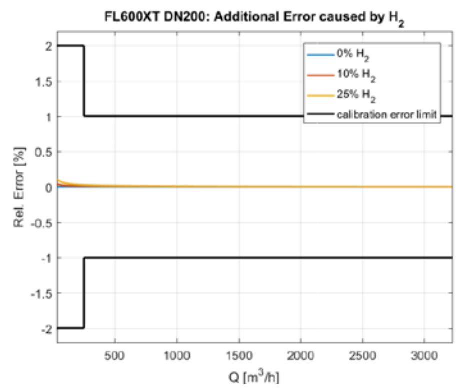

Fig. 2: Influence of the H_2 content on the measurement error of a DN200 FLOWSIC600-XT after application of the linearization correction, on the basis of pure natural gas data.

The relative error is about 0.1% with a proportion of 10% hydrogen by volume in the natural gas in the lower flow rate range (Q_{min}). This error lies far within the transport error limits for natural gas measurements subject to calibration.

Similar data was published in a technical report by gwf-Gas in May 2013. A FLOWSIC600 DN80 was used for the investigations. The report concludes, "Up to 10% H_2 content by volume, no influence on the ultrasonic gas meter can be detected if the hydrogen is well mixed with the natural gas"[3].
SICK ultrasonic gas meters are able to measure natural gas containing hydrogen. A recalibration is not necessary if up to 10% by volume of hydrogen is fed in.

In addition, an admixture of 25% by volume of hydrogen has already been evaluated and, with the technology currently installed in the field (sensors and electronics), especially in the lower flow range, this has a slightly higher influence on the measurement accuracy which is about 0.2%.

By correcting for the gas composition in the gas meter, the indicated influence on natural gas calibrated devices can be reduced. SICK is working on appropriate measures so that the owner/operator itself can easily carry out the correction.

4. Effect of the admixture of hydrogen on material compatibility

The Federal Institute for Materials Research and Testing (BAM), in its report entitled "Resilience assessments of metallic container materials and polymeric sealing/coating and lining materials"[4] of January 2015, examined the material resilience of certain materials for use with natural gas containing hydrogen. This shows that the gas flow meters made of the usual material alloys (steels) and all other parts in contact with the medium, such as ultrasonic probes and sealing rings, are resistant to natural gas containing hydrogen.

[3] Steiner, K., Wolf, D., Mozgovoy, A. and Vieth, D.: Influence of hydrogen on the high-pressure error curve of natural gas meters, gwf-Gas | Erdgas, pages 344-347, 03/201
[4] BAM: Resilience assessments of metallic container materials and polymeric sealing/coating and lining materials, Berlin, 01/2015

5. Effect of the admixture of hydrogen on explosion protection

Hydrogen has a different specific ignition capability from that of natural gas. Taking account of purely hydrogen flow rate measurements, the applicable explosion group under explosion protection regulations is IIC. This defines higher requirements for the equipment with regard to ignition gap dimensions and energy inputs than for natural gas. Explosion group IIA is sufficient for a natural gas measurement.

In September 2016, the Federal Institute for Materials Research and Testing (BAM) published its report entitled "Safety properties of natural gas/hydrogen mixtures", looking into the effects of admixing hydrogen with natural gas on explosion behavior and requirements for the explosion group.[5]

This report shows that the explosion pressure changes only slightly up to an H_2 proportion of 25% by volume. Likewise, a 10% by volume admixture of hydrogen has no significant influence on the standard gap width for the gas group IIA (Fig. 3). The results lead to the conclusion that a 25% admixture of hydrogen by volume, in all likelihood, does not inadmissibly reduce the standard gap width for the gas group IIA.

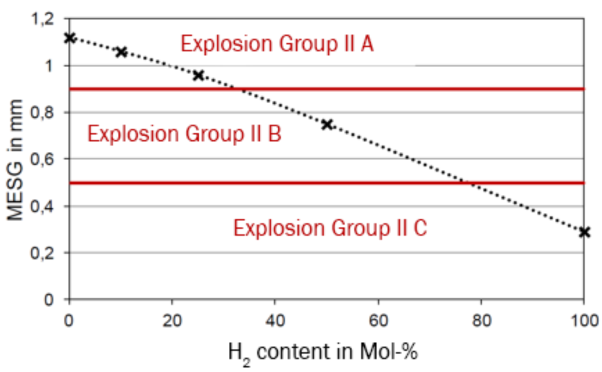

Figure 3: Measured standard gap widths of mixtures of model natural gas 2 and hydrogen (measured values connected with trend line) [6]

According to the German Gas and Water Association (DVGW), work is underway on further developing the rules for admixing hydrogen into the natural gas network.[7]

Already today, a 10% admixture of H_2 by volume is possible with the current rules under consideration of specific applications or restrictions. The new regulation is intended to increase the admixture to 20% by volume. According to the current state of knowledge, this proportion is estimated to be technically feasible.

Based on current publications, the conclusion can be drawn for installed SICK ultrasonic gas meters FLOWSIC600 and FLOWSIC600-XT that for a natural gas mix with 10% proportion of hydrogen by volume, there will be no need to adapt the electronics or ultrasonic sensors from the perspective of explosion protection.

[5] BAM: Safety properties of natural gas/hydrogen mixtures, 06/2015
[6] BAM: Safety properties of natural gas/hydrogen mixtures, 06/2015
[7] https://www.chemietechnik.de/dvgw-will-das-erdgasnetz-fuer-wasserstoff-einspeisung-fit-machen, 04/2019

6. Conclusion

The Scientific Service of the German Bundestag, in its June 2019 report “Limit values for hydrogen (H2) in the natural gas infrastructure”, has already reached the conclusion that "from the chemical and technical point of view of some operators [...] infeed into the natural gas infrastructure has not yet been conclusively clarified in all individual aspects, and there is still a need for development activities and regulatory adjustments. Opinions also depend on the hydrogen process chain, e.g. electrolysis processes or methanization, on end users and on the economic environment."[8]

Gas flow meters of the SICK FLOWSIC600 and FLOWSIC600-XT families, due to their ultrasonic technology, are already suitable today for measuring natural gases containing proportions of hydrogen up to 10% by volume within the scope transport according to the laws of calibration. The reliability and quality of the measurement results are not affected by changes in density, flow velocity or speed of sound.

SICK will continue to investigate the measuring capability of ultrasonic gas meters for hydrogen-containing natural gas, especially with proportions of 25% by volume (and above), and if necessary will adapt the measuring devices to meet the market requirements for precise gas flow rate measurement which are capable of calibration requirements.

[8] German Bundestag. Scientific Service. Limit values for hydrogen (H_2) in the natural gas infrastructure, 06/2019

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