

Transferability of water calibration to gas applications in Promass flowmeters

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Executive summary

This whitepaper describes the validity of the initial water calibration of Coriolis flowmeters intended for use in gas applications. The transferability of calibration using alternative fluids has already been described in important normative documents such as AGA Report No. 11 API MPMS 14.9. Today, with the increase in flow measurement applications involved in the global energy transition strategy, this alternative approach is becoming more relevant. The discussion of the technical aspects supporting this approach, as well as the results obtained in third party gas calibrations of Coriolis flowmeters initially calibrated with water, will help our customers to understand our transferability approach.



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1 Introduction

The global energy-transition strategy, intended to change our energy production/consumption structures from fossil-based to renewable and less environmentally harmful sources, demands a particularly reliable measurement infrastructure. Fluid flow is a relevant quantity involved in this measurement infrastructure. Flowmeters based on the Coriolis principle have expanded their presence to a wide variety of applications other than liquids. International measurement organizations, such as AGA and API MPMS¹, have supported the use of Coriolis mass flowmeters in natural gas custody transfer applications, giving a clear signal of trust from the international measurement technology continues to be a valid option in the implementation of energy-transition strategies for fluids such as H₂, CO₂, natural gas, and others. Endress+Hauser provides a variety of Coriolis mass flowmeters with proven performance in gas applications. These flowmeters, initially calibrated using water as calibration fluid, have demonstrated good performance in gas applications without any further adjustment of the calibration parameters. This transferability from water calibration to gas applications is analyzed in this technical white paper. In addition, the results from third-party calibrations facilities using gas as calibration fluid are discussed.

2 Coriolis flowmeter principle of operation

The Coriolis flow measurement principle is based on the linear relationship between the mass flowing through the measuring tubes of the device (q_m) and the phase shift $(\Delta \phi)$ or delay (Δt) detected between two points equipped with electrodynamic sensors (A and B in Figure 1). Each read measuring tube oscillates at its resonance frequency, imposed by the excitation driver.

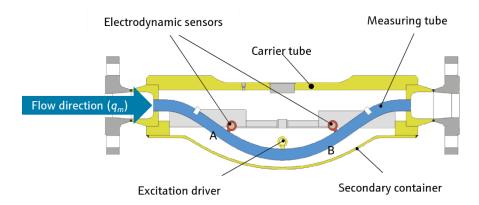


Figure 1: Coriolis sensor (simplified diagram).

¹ AGA: American Gas Association

API MPMS: American Petroleum Institute Manual of Petroleum Measurement Standards



The phase shift $(\Delta \varphi)$ is caused by the so-called Coriolis force, which is proportional to the mass flow rate (q_m) . The system balance is ensured by the antiphase oscillation of the two measuring tubes (Endress+Hauser Flow, 2022). In addition to the mass flow measurement, Coriolis mass flowmeters also measure other two variable, such as the density and temperature of the fluid.

A change in the total mass of the measuring tube, produced by a variation in a fluid density, will also produce a change in the measuring tube's resonance frequency, which is proportional to the fluid density. This variable is available as an output signal of the flowmeter.

A significant difference of temperature between the process temperature and a defined reference temperature (i.e., calibration fluid temperature) produces an offset effect in the density and mass flow rate measurements. This effect is compensated, using as input the signals supplied by temperature sensors installed in the measuring tube and in the instrument carrier. The process temperature measurement is also available as an output signal of the instrument.

The fluid pressure can also influence the flow and density measurements as a result of the deformation of the measuring tubes due to the internal pressure. By using the fluid pressure, either as a fixed value or the measured pressure supplied by a signal input of the instrument, this effect is also compensated in the instrument. A more detailed description of the effect of the pressure on Endress+Hauser Coriolis mass flowmeters and its compensation can be found in (Rojas Sossa, 2022).

3 Endress+Hauser Coriolis mass flowmeters in gas applications

Endress+Hauser Coriolis mass flowmeters have a significant presence in gas flow measurement applications worldwide. These flowmeters have demonstrated good performance under challenging gas measurement conditions, particularly where accurate and repeatable measurements are required and where direct mass reading is preferred. These flowmeters have been used in CNG (Compressed Natural Gas) dispensers for refueling natural gas vehicles, as well as various H₂ and CO₂ applications, mainly in custody transfer. The flowmeters have been certified for such applications by Notified Bodies and certification organizations such as the German Physikalisch-Technische Bundesanstalt (PTB), as a clear acknowledgement of compliance with the OIML-R137 (OIML-R137, 2012) recommendations established for these applications.

Gas applications are challenging for Coriolis mass flowmeters, mainly due to the low density of the fluid and consequently its operation at the lower end of the flowmeter's mass flow range. In this range, zeropoint stability plays an important role. Endress+Hauser Coriolis mass flowmeters are designed with specific features to reduce this effect. Two examples of these features are the high homogeneity of the materials used to build these instruments and the strict symmetry tolerances allowed in their construction. These features help to balance the mechanical behavior of the measuring tube dynamics, thus reducing the effect on zero-point stability.



However, gas flow measurement with Coriolis mass flowmeters also deals with the compressible behavior and the low speed of sound (SoS) of the gas, responsible for introducing changes in the resonance frequency with respect to the driving frequency imposed on the measuring tubes. This gas-related frequency effect is mostly influenced by three elements: the SoS in the gas, the fluid velocity, and the measuring tube geometry. These three elements are taken into consideration when implementing corrections to mitigate their effect (Rieder & Aguilera-Mena, 2018).

4 Water to gas transferability

According to AGA Report No. 11 API MPMS Chapter 14.9, section 7 (API MPMS, 2013): "Calibration with an alternative calibration fluid (e.g., water) is valid with Coriolis sensor designs where the transferability of the alternative calibration fluid, with an added uncertainty relative to gas measurement, has been demonstrated by the meter manufacturer through tests conducted by an independent flow calibration laboratory." This statement recognizes the calibration results obtained in gas measurement with Coriolis mass flowmeters originally calibrated with water, whenever the new measurement error and measurement uncertainties values are clearly demonstrated. This alternative becomes a feasible option in avoiding expensive initial gas calibration/verification, which is also difficult to implement due to the lack of proper gas flow calibration facilities.

4.1 Water calibration as initial metrological confirmation for flowmeters to be used in gas applications

Endress+Hauser Coriolis mass flowmeters are initially calibrated in water calibration facilities, accredited in conformity to ISO/IEC 17025 (ISO/IEC-17025, 2017) by accreditation bodies such as Swiss Accreditation Service (SAS), American Association for Laboratory Accreditation (A2LA), China National Accreditation Service for Conformity Assessment (CNAS), or the Brazilian Instituto Nacional de Metrologia, Qualidade e Tecnologia (INMETRO). These calibration follows the standard ISO 4185 (ISO-4185, 1980), where the calibration factor (CALF) is determined by using the gravimetric approach as described in that standard.

Water calibration is a preferred approach that allows the consistent evaluation of flowmeter performance using a well-known fluid under reference conditions. Under these conditions, deviations can be identified, isolated and effectively corrected. Water calibration is therefore the ideal starting point to explore the flowmeter performance and to determine its flowmeter CALF, a parameter that characterizes the device's dynamic behavior. Consequently, flowmeters intended for gas applications can also be initially calibrated using water as a calibration fluid.

4.2 Proving Promass in gas applications

A sample of Endress+Hauser Coriolis mass flowmeters intended for gas applications has been systematically calibrated in third-party laboratories, such as the Gas Research Institute - Colorado



Engineering Experiment Station Inc. (GRI-CEESI), Southwest Research Institute (SwRI), Pigsar (Germany's national standard for high-pressure natural gas metering, together with PTB), Det Norske Veritas (DNV) and others, using gas in all cases. Figure 2 shows the results of the calibration of a Promass 83F in CEESI facilities, using water, air, and dry and wet natural gas as calibration fluids. The complete report of this calibration round can be found in (GRI-04/0172, 2004).

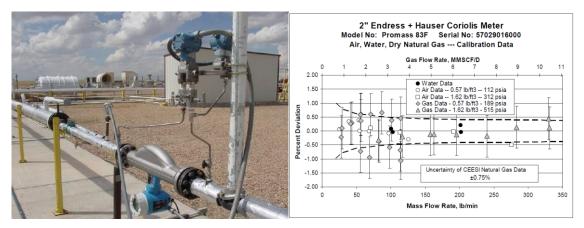


Figure 2: Promass 83F calibrated in CEESI wet test facility (left), result of the calibrations (right) (GRI-04/0172, 2004).

These third-party calibrations, which are part of our quality assurance policies, are intended to prove the performance of the meter in gas flow measurement under real process conditions, without any adjustments (as found) to the CALF obtained in water calibrations. Under new calibration facility conditions, a zero-point verification is a must, and a zero-point adjustment is performed if necessary (DE-19-MI002-PTB001, 2019). The basic setup used in these calibrations follow the manufacturer's installation requirements and the calibration procedure of the facility.

Ultimately, the goal is to prove that the flowmeters fulfill the maximum permissible error or tolerance limit according to the standard document under which the calibration is performed, as well as the maximum measured error specified by the manufacturer for the fluid and for the measured flow rate range.

Recent calibration results obtained in Pigsar facilities (see Figure 3) using natural gas as calibration fluid, are shown in Annexes 1 - 3. All the calibrations were performed using the same initial water CALF. The effect of the pressure on the flow reading was compensated in the instrument by considering the gas pressure as described in (Rojas Sossa, 2022).

The error values over the entire calibration range were always within the range of the maximum measurement error specified for gas flow measurement in the technical information of the instrument (Endress+Hauser Flow, 2022). This value corresponds to $\pm 0.25\%$ o.r. for the linear range of the instrument. Consequently, the errors are also within the OIML-R137 maximum permissible error (MPE) accuracy class 0.5.

The flow weighted mean error (FWME) and the expanded measurement uncertainty, U(k=2) per each flow rate value, can also be seen in each calibration certificate (Annexes 1 – 3).





Figure 3: Proline Promass Q DN200 being calibrated in Pigsar facilities using natural gas as calibration fluid.

The error curve of one the flowmeters calibrated in Pigsar combining natural gas and water calibration is shown in Figure 4 (see Annex 3). Promass Q DN 200 was initially calibrated with water in Endress+Hauser Flow facilities in Reinach. This calibration was made only at two points, 57 698 kg/h and 229 184 kg/h with $\pm 0.1\%$ o.r. of maximum permissible error, and an expanded measurement uncertainty, U(k=2), equal to 0.054%.

The combination of high zero-point stability with high repeatability and linearity at an extended turndown ratio (up to 33:1, see

Table **1**) exhibited by the instruments, allows to achieve this consistency between the calibration results in water and in natural gas throughout the calibrated range. This favorable behavior reinforces, with experimental data, the transferability approach from water to gas addressed in this whitepaper.

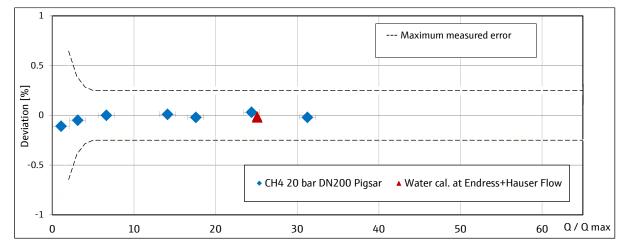


Figure 4: Error curve of a Promass Q DN 200 calibrated using water and natural gas: good measurement performance with natural gas, using the CALF value determined in water calibration.

The certificates for all the calibrations performed in Pigsar are shown in Annexes 1 - 3, according to the Table 1.

| Annex | Sensor model | DN | Calibration flow range [kg/h] | Turndown ratio | Pressure [bar] | Fluid | FWME [%] | Calibration facility |
|-------|-----------------|-----|-------------------------------------|-------------------|-------------------|----------------|-------------|----------------------|
| 1 | Promass F | 25 | 84 - 2 800 | 33:1 | 20 | CH_4 | -0.1 | Pigsar |
| 2 | Promass Q | 25 | 84 - 2 800 | 33:1 | 20 | CH_4 | -0.08 | Pigsar |
| 3 | Promass Q | 200 | 2 400 - 70 000 | 29:1 | 20 | CH_4 | 0.0 | Pigsar |
| | | | 455 - 746 | 1.6:1 | 30 | H ₂ | 0.18 | DNV |
| , | D | ~~ | 493 - 1 091 | 2.2:1 | 2.3 | N_2 | 0.08 | DNV |
| 4 | Promass Q | 80 | 466 - 1 337 | 2.9:1 | 40 | H ₂ | 0.33 | DNV |
| | | | 7 184 - 36 021 | 5:1 | 2.1 | H_2O | - | Endress+Hauser Flow |

Table 1: List of Annexes with the calibration results for each Endress+Hauser flowmeter in third-party facilities.

Another group of calibrations was carried out on Promass Q DN 80 in DNV facilities, this time using hydrogen at 30 bar and 40 bar, and nitrogen at 2.3 bar, see Annex 4. This flowmeter was also initially calibrated with water at Endress+Hauser Flow, Reinach, at five points, from 7 184 kg/h to 36 021 kg/h, with ±0.05% o.r. of the maximum permissible error and U(k=2) equal to 0.025%.

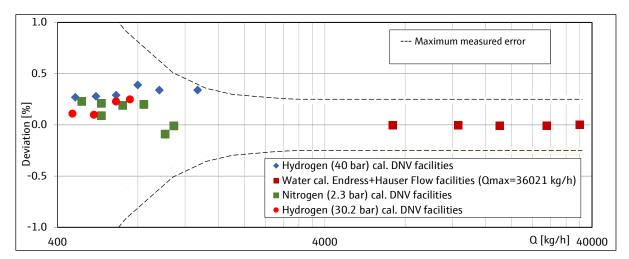
The "as found" gas calibrations were performed at mass flow rates, between approximately 1.3% and 4%, relative to the maximum calibrated flowrate in water. For these calibrations the gas density was ranging from 2.3 kg/m³ to 3.3 kg/m³, which is a common scenario for H_2 applications.

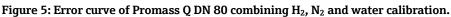
The error (deviation) during the calibration, the standard deviation (Std. Dev (95%)) of the error, as a measure of the repeatability, and the expanded measurement uncertainty (U_{-tot} (95%)) are shown in Annex 4. The flow weighted mean error values (FWME), as defined in AGA Report No. 11 API MPMS Chapter 14.9) can also be seen in this annex.

As shown in Figure 5, even in this region of the flowmeter range, where the stability at zero-point is relevant, the error values obtained during the calibration were within the band of the maximum measured error for gas fluids at these flow rates (trumpet or non-linear region). It is also remarkable, that most of the error values were also within the maximum measured error value specified in the instrument's technical information for gas flow measurement in the linear region (±0.25% o.r.).

This performance is possible due to the high zero-point stability and the instrument's high repeatability and linearity, also shown under gas measurement conditions.

Endress + Hauser





5 Conclusion

Endress+Hauser Coriolis mass flowmeters have consistently shown a very good performance in diverse gas applications using the same CALF obtained during their initial water calibration. Beyond the theoretical considerations, there are trustable results obtained in third-party gas calibration facilities using different sensors and nominal diameters, different fluids, pressures, densities, etc., all of them initially calibrated using water and with no further adjustments in CALF. Some of these recent calibrations are shown in this document.

These results are possible thanks to the advanced design of Endress+Hauser Coriolis mass flowmeters, which combines high zero-point stability with high repeatability and linearity at an extended turndown ratio. On the other hand, influencing factors such as the gas speed of sound (SoS) and the pressure effect in the oscillating tubes are also taken into account for their proper correction.

The validation of these results is one of the factors considered by the Notified Bodies when granting custody transfer certificates according to OIML-R137 for Endress+Hauser Coriolis mass flowmeters. To maintain such certifications, periodic testing of the instruments in third-party calibration facilities is also required. The results of these tests also allow us to extend and reinforce the Endress+Hauser transferability approach applied to our family of Coriolis mass flowmeters when used in gas applications. This eliminates the need for new, expensive and time-consuming special calibrations in gas. At the same time, the instruments maintain their performance requirements as stated in the technical information and required by national and international standards.



6 References

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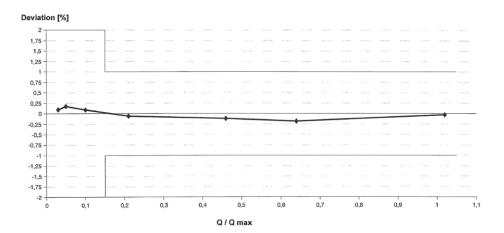


Appendix

Annex 1: Promass F DN 25; 84 kg/h - 2800 kg/h CH₄ @20 bar

| Operator of German Natio | nal Standards | | | gsa | | | | | | | |
|------------------------------|--|--|-------------------------|----------------------------|--|--|-----------------------------|--|------------|--|----------------|
| for volume of high-pressu | ire natural gas | page 1 of 4 | | | | | | | | р | age 3 of |
| | Calibration Number | Certificate 19225/2021 | | | | ertificate Nu late: | mber: | | | 19225/2021 2021-05-06 | |
| | Date | 2021-05-06 | Applicant | | Endress & Hause | r Flowtec AG | | | | | |
| | | | Meter unde | r Test | Туре | | Coriolis me | eter Proma | ss F | | |
| pplicant leter under test | Name: Order no. | Endress & Hauser Flowtec AG 275001178 | | | Manufacturer Serial number Nominal Size | | Endress+H S31AE202 1" | lauser | | | |
| leter under test | Description: Manufacturer: | Coriolis meter Endress+Hauser | | | Year of manufact | ure | 2021 | | | | |
| | Type: Serial number: Nominal size: Range of flowrate: Year of manufacture: | Promass F S314E202000 1" 842800 kg/h 2021 | Test Cond | tions | Test medium Pressure, absolute Gas Temperature Gas density (p, T) Dyn. viscosity (p, 1 | 1 17,0 | 2 bar 7 °C) kg/m³ | CO ₂ H ₂ Calorific Density,n Norma | ormal | 1,57 0,0 10,35 0,8306 (73,15 K; 101,325) | kWh/m kg/m³ |
| | Nominal diameter of meter: | 25 mm | Results | Qi / Qmax | Qi (kg/h) Re | ynoldsnumber | Deviation | (%) n | Umeter (%) | Utot (%) | |
| | Nominal diameter of flange: Nominal flange pressure: | 25 mm ANSI 600 RF | (as left) | 0,03 | 82,77 | 0,10*106 | 0,09 | 5 | 0,05 | 0,28 | |
| te of test | 2021-05-06 | | | 0,05 | 128,17 282.89 | 0,16 *10 ⁶ 0.35 *10 ⁶ | 0,17 | 5 5 | 0,04 | 0,25 | |
| | | | | 0,21 | 600,77 | 0,74 *106 | -0,06 | | 0,03 | 0,23 | |
| sults | The results of the calibration | are presented on page 3. | | 0,46 0.64 | 1296,39 1794.62 | 1,61 *10 ⁶ 2.22 *10 ⁶ | -0,12 -0,18 | | 0,12 | 0,26 | |
| est procedure | | sgeräte für Gas, Hochdruckprüfung von Gaszählern esanstalt, Braunschweig und Berlin, 2003 | | 1,02 | 2843,55 | 3,48 *106 | -0,03 | | 0,12 | 0,26 | |
| st facility | | Standard of the Federal Republic of Germany | Weighted n | iean error, with | continuous and linear dec | rease of weighing fac | tor between 0,7 | Qmax and Q | max: | -0,1 %. | |
| | pigsar disseminates the harmo | pressure natural gas under supervision of PTB. nised values for the unit of volume for high pressure Federal Republic of Germany, France and The | The deviati | on is defined as | | Deviation=(In | | | | | |
| | | a management system according to EN ISO 17025. | | | eference volume re ation are the arithme | | | | | | s |
| aceability | German reference values for th | libration are based on the unified Dutch-French- e unit of volume for high-pressure gas flow | The reporte | d total uncerta | inty is defined as: | U _{to} | $=\sqrt{U_{harmo}^2}$ | $+U_n^2$ | neter | | |
| | measurements. On June-02-19 | 999, PTB (Physikalisch-Technische Bundesanstalt) and erlands Measurement Institute - Van Swinden | | where U _{barm} | is the expande | d uncertainty of | the harmon | zed refere | nce value, | | |
| | Laboratorium) and later on May | y-04-2004 LNE (The Laboratoire national de métrologie | | | e standard uncertai expanded standard | | | | | | |
| | et d'essais) have joined the ha these reference values, see pa | rmonization (unification) procedure and the use of ge 2. | | An Edge | t each flow-rate, mu | | | | | | |
| | Dorsten, 2021-05-06 | and and and for the second | The meter | had been cal | Security marks are t the meter had n librated at 20 bar a e presented in cer | ot been adjus and at 40 bar. | | | | | |
| | | Statu Aproved Facility Management System according to Management System A SCORE (1725 - 5 -5 -5 -5 -5 -5 -5 -5 -5 -5 - | | parameters ha mode: Gas | ave been used du Stor | ring the calibra ed zero(pipo): | | ive an infl | uence to t | he test result | s: |
| | | son entrand | Gas type: Meter fact | | Sen | offset before offset after ca | orr. (bar): 2 calibration | g/3 min): | | | |
| ninearTM - Viar Gas Ser | vices Gmbbi & Co. KG - Halteroor Straße 125 - J | 16264 DORSTEN - GERMANY - www.pigsar.de - e-mail: info@pigsar.de | Tested in | Dorsten at pig | isar on | 2021-05 | -06 | Göbbele | er | | |

| - | | | Erro | or C | urve | | | | | | page 4/4 19225/2021 |
|----------------|----------------|---------------|--------------------------------|-------|-------|---------|------|-------------|----|---------|------------------------|
| Type of meter: | Coriolis meter | Customer: | Endress & Hauser Flowtec AG | DN: | 25 mm | p(abs): | 21 | bar | HF | 1000,00 | pulses / kg |
| Meter no: | S31AE202000 | Manufacturer: | Endress+Hauser | Size: | 1" | Q max: | 2800 | kg/h | - | | pulses / kg |
| Date: | 2021-05-06 | Gear 1: | - | | | Q min: | 84 | kg/h | - | | pulses / kg |
| Inspector: | Göbbeler | Gear 2: | - |] | | - | F | oulses / kg | - | | pulses / kg |



page 3 of 4

Annex 2: Promass Q DN 25; 84 kg/h - 2800 kg/h CH₄ @20 bar

| Operator of German National Science Sc | | page 1 of 4 |
|--|---|---|
| | Calibration | Certificate |
| | Number Date | 19189/2021 2021-04-23 |
| Applicant | Name: Order no. | Endress & Hauser Flowtec AG 275001178 |
| Meter under test | Description: Manufacturer: Type: Serial number: Nominal size: Year of flowrate: Year of manufacture: Nominal diameter of flange: Nominal flange pressure: | Coriolis meter Endress+Hauser Promass Q RB0F7202000 1" 42800 kg/h 2020 25 mm 25 mm ANSI 600 RF |
| Date of test | 2021-04-23 | |
| Results | The results of the calibration | are presented on page 3. |
| Test procedure | | geräte für Gas, Hochdruckprüfung von Gaszählern esanstalt, Braunschweig und Berlin, 2003 |
| Test facility | for the unit of volume for high p pigsar disseminates the harmon gas flow measurements of the | Standard of the Federal Republic of Germany ressure natural gas under supervision of PTB. nised values for the unit of volume for high pressure Federal Republic of Germany, France and The a management system according to EN ISO 17025. |
| Fraceability | German reference values for th measurements. On June-02-19 VSL (formerly NMi-VSL, Nethe Laboratorium) and later on May | libration are based on the unified Dutch-French- e unit of volume for high-pressure gas flow 99, PTB (Physikalisch-Technische Bundesanstalt) and rands Measurement Institute - Van Swinden -04-2004 LNE (The Laboratoire national de métrologie monization (unification) procedure and the use of ge 2. |
| | Dorsten, 2021-04-23 | Standards for low and the standards for low |

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SED ICT

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This calibration certificate may not be reproduced other than in full except with the permission of the issuing laboratory. Calibration certificates without signature and seal on the first page are not valid.



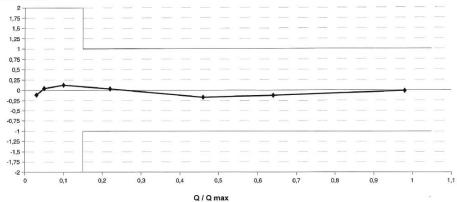
| | | | Certifi Date: | icate Nur | nber: | | | 19189/2021 2021-04-23 | |
|--|---|--|--|---|--|---|---|--|-------------------|
| | | | | | | | | | |
| Applicant | | Endress & Ha | auser Flow | tec AG | | | | | |
| Meter unde | r Test | Туре | | | Coriolis me | eter Pror | nass Q | | |
| | | Manufacturer | | | Endress+H | lauser | | | |
| | | Serial numbe | r | | RB0F7202 | 000 | | | |
| | | Nominal Size | | | 1" | | | | |
| | | Year of manu | facture | | 2020 | | | | |
| Test Condit | tions | Test medium | | Natural ga | s | CO, | | 1,53 | mole 9 |
| | | Pressure, abs | olute | 21,2 | bar | H ₂ | | 0,0 | mole 9 |
| | | Gas Tempera | ature | 17 | °C | Calorif | c value,s | 10,36 | kWh/n |
| | | Gas density (| p, T) | 17,0 | kg/m ³ | Densit | ,normal | 0,8312 | kg/m ³ |
| | | Dyn. viscosity | (p, T) | 1,15E-5 | Pas | No | mal conditions (| 273,15 K; 101,325 k | Pa) |
| Results | Qi / Qmax | Qi (kg/h) | Reynolds | number | Deviation | (%) n | Urneter (%) |) Utot (%) | |
| (as left) | 0,03 | 85,09 | | *105 | -0,11 | 6 | | 0,30 | |
| | 0,05 | 132,83 | 0,16 | *10* | 0,04 | 5 | 0,05 | 0,25 | |
| | 0,10 | 281,18 | 0,35 | *10* | 0,13 | 5 | 0,03 | 0,24 | |
| | 0,22 | 602,46 | 0,74 | *105 | 0,03 | 5 | 0,03 | 0,23 | |
| | 0,46 | 1278,39 | 1,58 | *10 ^s | -0,17 | 5 | 0,10 | 0,25 | |
| | 0,64 | 1804,60 | 2,22 | *10* | -0,13 | 5 | 0,19 | 0,30 | |
| | | | | | | 6 | 0,14 | 0,27 | |
| Veighted me | 0,98 ean error, with co | 2735,50 | | weighing factor | | Qmax and | Qmax: | -0,08 %. | |
| | | ontinuous and linea | r decrease of | weighing factor | r between 0,7 | Qmax and | | -0,08 %. | |
| | ean error, with o n is defined as: where the rel | ontinuous and linea | r decrease of <i>Devia</i> e refers to t | weighing facto a <i>tion</i> = <u>(India</u> the conditio | r between 0,7 cated Value (References ns at the m | Qmax and =-Refer ence Val neter und | Qmax: ence Value) ue) ler test. The | -0,08 %. 100 % reported values | |
| | ean error, with o n is defined as: where the rel | ontinuous and linea | r decrease of <i>Devia</i> e refers to t | weighing facto a <i>tion</i> = <u>(India</u> the conditio | r between 0,7 cated Value (References ns at the m | Qmax and =-Refer ence Val neter und | Qmax: ence Value) ue) ler test. The | -0,08 %. 100 % reported values | |
| The <i>deviation</i> | ean error, with o n is defined as: where the rel | ontinuous and linea ference volume ion are the arit | r decrease of <i>Devia</i> e refers to t hmetical m | weighing factor ation = <u>(India</u> the conditio leans of <i>n</i> s | r between 0,7 cated Value (References ns at the m | Qmax and <u> - Refer</u> ence Val neter und at measu | Qmax: ence Value) ue) ler test. The rements at e | -0,08 %. 100 % reported values | |
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| The deviation The reported Remarks At custome The meter h | ean error, with co is defined as: where the rel of this deviat total uncertain where U _{namer} stated as the U _{meter} is the e in repeats at e See or's request t rad been calib | ference volume ion are the ariti- ty is defined as very standard unce xpanded stance apach flow-rate, acurity marks the meter had reated at 20 bi | r decrease of Devia e refers to t hmetical m s: anded unce ertainty of m dard uncert multiplied are applied a not bee ar and at 4 | weighing factor $tilion = \frac{(Inditi}{tot})$ the condition the condition the condition $U_{tot} =$ trainity of the neasurement ainty of the by Student- ded n adjusted 40 bar. | r between 0,7 cated Value (Refer ns at the m ingle repeating $=\sqrt{U_{harmonic}^2}$ | Qmax and e-Refer ence Val heter und at measu hized + L ced refer d by the er test, o | Qmax: ence Value) ue) ler test. The rements at e meter ence value, coverage fai letermined o | -0,08 %. 100 % reported values ach flow-rate. ctor k=2, and n the base of | |
| The deviation The reported Remarks At custome The meter h | can error, with α is defined as: where the reliant of this deviation of this deviation to take the take of the take where U_{harmer} is the eight of the take in repeats at the take of the take of take of the take of the take of t | ference volume ion are the ariti- ty is defined as very standard unce xpanded stance apach flow-rate, acurity marks the meter had reated at 20 bi | r decrease of Devia e refers to t hmetical m s: anded unce ertainty of m dard uncert multiplied are applied a not bee ar and at 4 | weighing factor $tilion = \frac{(Inditi}{tot})$ the condition the condition the condition $U_{tot} =$ trainity of the neasurement ainty of the by Student- ded n adjusted 40 bar. | r between 0,7 cated Value (Refer ns at the m ingle repeating $=\sqrt{U_{harmonic}^2}$ | Qmax and e-Refer ence Val heter und at measu hized + L ced refer d by the er test, o | Qmax: ence Value) ue) ler test. The rements at e meter ence value, coverage fai letermined o | -0,08 %. 100 % reported values ach flow-rate. ctor k=2, and n the base of | |
| The deviation The reported Remarks At custome The meter h The results : Following pa | an error, who are not seen error, who are not seen and the seen are not seen and the seen are not seen are not seen are seen are seen are not seen a | Antinuous and linea ference volume ion are the ariti- ity is defined ar standard unce xpanded stand ach flow-rate, accurity marks the meter han rated at 20 b presented in u- | r decrease of Devia e refers to t hmetical m s: inded uncert multiplied are applied are applied are and at 4 certificate during the | weighing factor $tion = \frac{(Indic)}{(Indic)}$ the conditione eans of <i>n</i> is $U_{tot} =$ rtainty of the by Student- dup function n adjusted 40 bar. no. 19222 e calibratio | r between 0.7 cated Value (Refer ns at the m ingle repeating $e \sqrt{U_{narmov}^2}$ e harmoniz nt multiplie meter und t-factor (n) d. V/2021. on and hav | Qmax and a - Refer ance Val heter und at measu- hized + L ced refer d by the ier test, of / nº. ⁵ , wi | Omax: ence Value) ue) ter test. The remeter ence value, coverage fa letermined o th a probabil | -0,08 %. 100 % reported values ach flow-rate. ctor k=2, and n the base of | |
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| The deviation The reported The reported The meter h The meter h The results : Following pe Measuring n Measuring n | an error, with or n is defined as: where the rel of this deviat total uncertain where U _{name} is the stated as the U _{mme} is the or n repeats at or Se or 5 request tad been calib at 40 bar are arameters hav node: Gas | Antinuous and linea ference volume ion are the arit ity is defined ar viver is the expa standard unce standard unc | r decrease of Devia a refers to the hemetical m s: inded unce ertainty of n Jard uncert multiplied are applied are applied are applied d not bee ar and at 4 certificate during the tored zero | weighing factor tion = (Indication) the condition the condition the condition $U_{tot} =$ relative of the by Student- by Student- the distribution n adjuster 40 bar. no. 19222 e calibration (pipo): -43 source of the second | r between 0.7 cated Value (Refer ns at the m ingle repect $e \sqrt{U_{harmon}^2}$ e harmonia nt multiplie meter und t-factor (n) d. V2021. on and have 3,1 (bar): 20 | Qmax and <u>e - Refer</u> <u>ence Val</u> neter und t measu <u>nized</u> + <u>U</u> ed refer d by the ler test, c / nº. ⁵ , wi re an int | Qmax: ence Value) ue) let rest. The rements at e remets value, coverage fa letermined o th a probabil fluence to th | -0,08 %. 100 % reported values ach flow-rate. tor k=2, and the base of ity of 95%. | |
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| | | | Er | ror C | Curve | | | | | | page 4/4 19189/2021 |
|----------------|----------------|---------------|--------------------------------|-------|-------|---------|------|-------------|----|---------|------------------------|
| Type of meter: | Coriolis meter | Customer: | Endress & Hauser Flowtec AG | DN: | 25 mm | p(abs): | 21 | bar | HF | 2000,00 | pulses / kg |
| Meter no: | RB0F7202000 | Manufacturer: | Endress+Hauser | Size: | 1" | Q max: | 2800 | kg/h | - | | pulses / kg |
| Date: | 2021-04-23 | Gear 1: | - | | | Q min: | 84 | kg/h | - | | pulses / kg |
| Inspector: | Görgülü | Gear 2: | - | | | - | | pulses / kg | - | | pulses / kg |

Deviation [%]



page 3 of 4

Annex 3: Promass Q DN200; 2400 kg/h - 70000 kg/h CH₄ @20 bar

| for volume of high-press | Calibration Certificate | page 1 of 4 |
|--------------------------|---|--|
| | Number 19756/2021 Date 2021-12-15 | |
| Applicant | Name: Endress+Hauser Flowtec AG Order no. 1005273117 | |
| Meter under test | Description: Coriolis meter Manufacturer: Endress+Hauser Type: Promass Q Serial number: TEST0002145 Nominal size: 8" Range of flowrate: 240070000 kg/h Year of manufacture: 2021 Nominal diameter of meter: 200 mm Nominal diameter of flange: 200 mm Nominal diameter of Range: 200 mm | |
| Date of test | 2021-12-15 | |
| Results | The results of the calibration are presented on page 3. | |
| Test procedure | PTB-Prüfregeln Band 30, Messgeräte für Gas, Hochdruckprüfung von Ga Physikalisch-Technische Bundesanstalt, Braunschweig und Berlin, 2003 | szählern |
| Test facility | pigsar represents the National Standard of the Federal Republic of Germ for the unit of volume for high pressure natural gas under supervision of F pigsar disseminates the harmonised values for the unit of volume for high gas flow measurements of the Federal Republic of Germany, France and Netherlands. pigsar maintains a management system according to EN IS | PTB. pressure The |
| Traceability | The presented results of the calibration are based on the unified Dutch-Fr German reference values for the unit of volume for high-pressure gas flow measurements. On June-02-1999, PTB (Physikalisch-Technische Bunde VSL (formerly NMi-VSL, Netherlands Measurement Institute - Van Swind Laboratorium) and later on May-04-2004 LNE (The Laboratoire national d et d'essais) have joined the harmonization (unification) procedure and the these reference values, see page 2. | v sanstalt) and en e métrologie |
| | Dorsten, 2021-12-15 | |

pigsarTM - Vier Gas Services GmbH & Co. KG - Halterner Straße 125 - 46284 DORSTEN - GERMANY - www.pigsar.de - e-mail: info@pigsar.de

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| | | | Certificate N Date: | lumber: | | | 19756/2021 2021-12-15 | |
|--------------|--------------------------------------|--------------------|--|------------------------|------------|------------------|--------------------------|-------------------|
| Applicant | | Endress+Hau | ser Flowtec AG | | | | | |
| Meter unde | er Test | Type | | Coriolis m | eter Pror | mass Q | | |
| | | Manufacturer | | Endress+H | | | | |
| | | Serial number | | TEST0002 | | | | |
| | | Nominal Size | | 8" | | | | |
| | | Year of manuf | acture | 2021 | | | | |
| Test Condi | tions | Test medium | Natural | | CO. | | 1.41 | mole % |
| rest condi | uons | Pressure, abso | |).6 bar | Η, | | 0,0 | mole % |
| | | Gas Temperat | | 20 °C | | ic value,s | 10,36 | kWh/m |
| | | Gas density (p. | | .3 kg/m ³ | Densit | | 0.8299 | kg/m ³ |
| | | Dyn. viscosity | | | | | 73,15 K; 101,325 k | |
| Results | Qi / Qmax | Qi (ka/h) | Reynoldsnumber | Deviation | (0/) | 11 (%/) | Utot (%) | |
| (as left) | 0.03 | 2426.27 | 0.37 *10 ⁶ | -0.11 | (%) n 7 | | 0.23 | |
| (as iere) | 0,10 | 7089.82 | 1,09*10* | -0,05 | | | 0,23 | |
| | 0,22 | 15157,84 | 2,33 *10 | 0,00 | 6 | | 0,23 | |
| | 0,46 | 32303,27 | 4,96 *10 | 0,00 | 6 | | 0,24 | |
| | 0,40 | 40249.26 | 6.18*10 | -0.02 | | | 0.25 | |
| | 0,80 | 55909,73 | 8.59 *10* | 0,02 | 7 | | 0,23 | |
| | 1,02 | 71591,80 | 11,06 *10* | -0,02 | 8 | | 0,27 | |
| | ean error, with c m is defined as | | decrease of weighing for Deviation=(<u>1</u> | | | | 0 %. 100 % | |
| | | | | | | | | |
| | | | refers to the cond metical means of | | | | | |
| The reported | | nty is defined as | | $=\sqrt{U_{harmon}^2}$ | | | | |
| | where Uhamoo | nized is the expan | ided uncertainty o | f the harmonia | zed refer | ence value, | | |
| | | | tainty of measure ard uncertainty of | | | | | |
| | n repeats at | each flow-rate, r | nultiplied by Stude | ent-t-factor (n) | / nº.5, wi | ith a probabilit | y of 95%. | |
| Remarks | Se | ecurity marks a | are applied | | | | | |
| | | | bar and at 40 ba certificate no. | | | | | |
| | | | | | | | | |

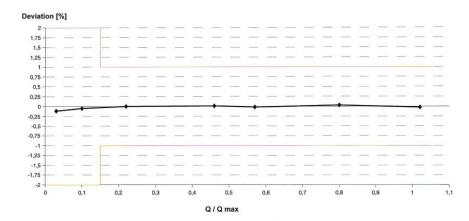
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2021-12-15

Görgülü

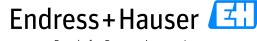
| | | | | | Curve | | | | | | page 4/4 19756/2021 |
|----------------|----------------|---------------|------------------------------|-------|--------|---------|-------|-------------|----|---------|------------------------|
| Type of meter: | Coriolis meter | Customer: | Endress+Hauser Flowtec AG | DN: | 200 mm | p(abs): | 21 | bar | HF | 62,5000 | pulses / kg |
| Meter no: | TEST0002145 | Manufacturer: | Endress+Hauser | Size: | 8" | Q max: | 70000 | kg/h | - | | pulses / kg |
| Date: | 2021-12-15 | Gear 1: | | | | Q min: | 2400 | kg/h | - | | pulses / kg |
| Inspector: | Görgülü | Gear 2: | | | | - | | pulses / kg | - | | pulses / kg |

Tested in Dorsten at pigsar, on



Annex 4: Promass Q DN80; 455 kg/h – 746 kg/h H₂ @30 bar; 493 kg/h – 1091 kg/h N₂ @2.3 bar; 466 kg/h – 1337 kg/h H₂ @40 bar; 7184 kg/h – 36021 kg/h H₂O @2.1 bar

| Test | | | | | | | | | | | |
|--|--|---|--|---|--|---|--|---|---|---|--|
| pplicant: | Endress+Hauser Flowtec AG Christoph Merian-Ring 4 4153 Reinach Switzerland | Certificate No: Page: | H003 1 of 2 | Meter: | Serial No: Meter type ID Manufacturer Type: | e P | 6040202000 romass Q 3 indress+Hau coriolis | 0 00, DN80 user Flowtec A | G | Certificate No: Page: | H003 2 of 2 |
| leter: | Serial No: T6040202000 Meter type ID: Promass Q 300, DN80 Manufacturer : Endress+Hauser Flowtec AG Type: Coriolis Build Year: 2022 | G-size: Pressure rate: Diameter [mm]: Q-min [kg/h]: Q-max [kg/h]: | n.a. ANSI-300 100 0 5904 | | | | | | | Adjustment [%]: FWME As Lft [%] | no : 0,18 |
| ppendix: | | P-max [bar]: Density range [kg | - /m²]: - | Results: | Rev. flow | | | CMC (95%) | Std Dev (95%) | U-tot (95%) | Reyr |
| oject Descript | tion: Flowtest of E+H Coriolis on DNV hydrogen loop | Project No : | 10370462 | | [m ⁴ /h] 316 | [kg/h] 746 | [%] 0,25 | [%] 0,36 | [%] 0,23 | [%] 0,42 | 30 |
| st method: | The deviation of the meter under test is established | with the master meter m | ethod. | | 280 232 | 662 547 | 0,23 0,10 | 0,36 0,36 | 0,08 0,13 | 0,37 0,38 | 268 |
| scomposition | n [mol%]: H ₂ : 99,998, N ₂ >0,002% | | | | 193 | 455 | 0,11 | 0,36 | 0,12 | 0,38 | 185 |
| st Date: | 2022-07-20 | | | | 115 | / | | | | | |
| esult: | The 'As Left' results of the Test are presented on pa | age 2. | | | 12 | | | | | | - |
| ncertainty: | The reported expanded uncertainty is based on the resulting in a coverage probability corresponds to 95 has been estimated based on known Test and esime | 5% uncertainty. The stan | dard uncertainty | | | | | JV | | | |
| aceabillity: | The reference turbine meter used was calibrated at The behaviour of the turbine reference meter under PTB turbine model, described in DNV document ES | hydrogen has been pred NL 220127.FFA. | licted using the | | Location Groningen | Date 2022-07-20 | | Medium Hydrogen | P [bar](abs) 30,2 | T [°C] 33,0 | Rho [2, |
| | Precaution is that the reference is not compared with | h other references under | hydrogen flow. | Deviation: | n: Formula = ((| (IndicatedFlow / | Reference | Flow) - 1) * 10 | 00% | | |
| emark: | Reference meter: 4" Elster Instromet SM-RI-X, G250 | 0, built 2014, s.n. 105209 | 901 | CMC: | | | | | | lly available for Te | sts. |
| | | | | U-tot: | | tal (95%) meas | | | | | |
| gnatures: | For DNV Netherlands B.V. Groning | en 2022-12-09 | | Ambient c | conditions: | 33 ± 2 °C | | | | | |
| | Task responsible Peter Groeneveld | Principal analist: | Z | Disclaimer | | hat this report n e circumstances | | | | vice only at the tim | e of |
| | | v | Bertus Bergsma | | | | | | Deserter | on of the complete certif | icate is allow |
| DNV Netherlands E Energieweg 17, 97- The Netherlands | 43 AN, Groningen | Parts of the certificate may written approval of the calib | te certificate is allowed. only be produced with ration laboratory. | DNV Neth Energiewe The Nethe | therlands B.V. veg 17, 9743 AN, Gronin herlands | gen | | | Parts of the written app | e certificate may only be roval of the calibration la | produced wit boratory. |
| inergieweg 17, 67 he Netherlands thone 131 50 700 ggroningen@drv NV Netherlands B gjeweg 17, 9743. 1 50 700 97 00 | 49 AN, Goringen 97 00 000 BX The Netherlands, All rights reserved. All Groungers 97.0 Bes 2023, 3755 CA Grounges The Netherlands. Trade register 09006404 | Parts of the certificate may written approval of the calib | te canfindate is allowed. In the produced with ration laboratory. | © DNV Nethe Energieweg 1 | becadade B V. egg 17, 8743 AN, Gronin end and sol and 20 ar 20 gen@dw.com herfands B.V. The Nett 17, 9743 AN Groningen 0 9700 Trade registe | herlands. All righ P.O. Box 2029, 9 r 09006404 | | gen The Nether | Parts of the written app | , certificate may coly be | produced wit |
| ergieweg 17, 9743. 31 50 700 97 00 D N Cest | 49 AV, Gonngen 9750 aon EX. The Netherlands. All rights reserved. AN Groungen 7:0, 8:e. 2025, 9704 CA Groungen The Netherlands. Trade register 9905634 Certificate | | te certificate is allowed. | B DAV Neth Enropement T +3150 700 | rzem, gen@dru.com herfandt 8 V. The Net 17, 9748 AN Groninger 99700 Trade registe | herlands. All righ P.O. Box 2029, 9 r 09006404 | 704 CA Gronin | | Parts of the written app | certificate may only be roval of the calibration is | |
| Energieveg (7, 67, The Netherlands Priore 43 120 700 www.drv.com Regrongen@drv. DNV Netherlands B ergieveg (7, 9743 31 50 700 97 00 | 49 AV, Goningen 9760 aon BV. The Netherlands. All rights reserved. AV Groungen P.D. Bez 2025 9704 CA Groungen The Netherlands. Trade register 9000649 | Parts of the certificate may written approval of the calb | Hooz 1 of 2 | © DNV Nethe Energieweg 1 | herlands 8.V. The Nett 17, 9743 AN Groningen 0 97 00 Trade registe | nerlands, All high nerlands, All high 00000404 | 704 CA Gronin 1604020200 7romass Q 3 | 0 | Parts of the written app | Certificate No: Page: | H002 2 of 2 |
| Energieweg 17, 07 The Netherlands Phone +31 50 700 www.dhv.com figgroningen@dmv. DNV Netherlands B congleweg 17, 5743, +31 50 700 97 00 | 49 AV, Gonngen 970 ann EX. The Netherlands. All rights reserved. All Granegen P.O. Bas 2023 5700 CA Groningen The Netherlands. Trader register 9000604 Certificate Endrass Hauser Flowlee AG Christoph Meniar-Fäng 4 4153 Reinad. | Certificate No: Page: G-size: Pressure rate Dame (r filt) C-max (Pach): C-max (Pach): | H002 | B DAV Neth Enropement T +3150 700 | room, meriands B.V. The Nett 17,943 AM Commercia 97 00 Trade registe DINN Serial No: Meter type IC Manufacture! | nerlands, All high nerlands, All high 00000404 | 704 CA Gronin 1604020200 20mass Q 3 2ndress Ha | 0 00, DN80 | Parts of the written app | Certificate may city be | H002 2 of 2 no |
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People for Process Automation

| DNV |
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Test Certificate

| Applicant: | Endress+Haus Christoph Meri 4153 Reinach Switzerland | | Certificate No: Page: | H001 1 of 2 | | | |
|----------------------|--|---|---|--------------------------------------|--|--|--|
| Meter: | | T6040202000 Promass Q 300, DN80 Endress+Hauser Flowtec AG Coriolis 2022 | G-size: Pressure rate: Diameter [mm]: Q-min [kg/h]: Q-max [kg/h]: P-max [bar]: | n.a. ANSI-300 100 0 7836 | | | |
| Appendix: | | | Density range [kg/m | nº]: - | | | |
| Project Description: | Flowtest of E- | H Coriolis on DNV hydrogen loop | Project No : | 10370462 | | | |
| Test method: | The deviation of | of the meter under test is established w | vith the master meter met | thod. | | | |
| Gascomposition [m | ol%]: H2: 99,996 | N ₂ : 0,004 | | | | | |
| Test Date: | 2022-07-20 | | | | | | |
| Result | The 'As Left' results of the Test are presented on page 2. | | | | | | |
| Uncertainty: | resulting in a c | xpanded uncertainty is based on the st overage probability corresponds to 95% ated based on known Test and esimat | % uncertainty. The stand: | | | | |
| Traceabillity: | The reference turbine meter used was calibrated at 4 pressures in ISO 17025 accredited labs. The behaviour of the turbine reference meter under hydrogen has been predicted using the PTB turbine model, described in DNV document ESNL 220127.FFA. Precaution is that the reference is not compared with other references under hydrogen flow. | | | | | | |
| Remark: | Reference met | er: 4" Elster Instromet SM-RI-X, G250, | built 2014, s.n. 1052090 | н | | | |
| | | | | | | | |
| Signatures: | For DNV Nethe | rlands B.V. Groninger | n 2022-12-09 | | | | |
| Signatures: | For DNV Nethe Task responsit | | n 2022-12-09 Principal analist: | Ţ | | | |
| Signatures: | | | Principal analist: | Bertus Bergsma | | | |

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| Meter: | Serial No: Meter type ID: Manufacturer : Type: | | T6040202000 Promass Q 300, DN80 Endress+Hauser Flowtec AG Coriolis | | | Certificate No: Page: | H001 2 of 2 |
|---|--|--------------------|---|----------------------------------|------------------------|--|----------------|
| | | | | | | Adjustment [%]: | no |
| | | | | | | FWME As Lft [%]: | 0,33 |
| Results: | Rev. flow | MUT flow | Deviation | CMC (95%) | Std Dev (95%) | U-tot (95%) | Reynold |
| | [m³/h] | [kg/h] | [%] | [%] | [%] | [%] | E |
| | 426 | 1337 | 0,34 | 0,36 | 0,14 | 0,38 | 53858 |
| | 307 | 962 | 0,34 | 0,35 | 0,03 | 0,36 | 38786 |
| | 255 | 798 | 0,39 | 0,36 | 0,03 | 0,36 | 32146 |
| | 212 | 663 | 0,29 | 0,36 | 0,13 | 0,38 | 26765 |
| | 178 | 557 466 | 0,28 | 0,36 | 0,10 | 0,37 | 18867 |
| | 143 | 400 | 0,27 | 0,50 | 0,10 | 0,51 | 10007 |
| | 10 | 1 | | | | | |
| | | 14 | | | | | |
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| | | | | | | | |
| | and a second | | | | | | |
| | Location | Date 2022-07-20 | | Medium | P [bar](abs) 40.0 | T [°C] 33.0 | Rho [kg/i |
| | Groningen | 2022-07-20 | | Hydrogen | 40,0 | 33,0 | 3,13 |
| Deviation: | Formula = (| (IndicatedFlo | w / Reference | =Flow) - 1) * 10 | 00% | | |
| CMC: | Test and Me | asurement Ca | pability is the | e (95%) uncerta | inty that is normal | lly available for Test | ts. |
| U-tot: | U-tot is the to | otal (95%) me | asurement u | ncertainty. | | | |
| Ambient con | ditions: | 33 ± 2 °C | | | | | |
| Disclaimer: | | | | performance of during the Tes | | vice only at the time | e of |
| | | | | | | | |
| DNV Netheri Energieweg The Netheria Phone +31 5 www.dnv.cor figgroningen | 17, 9743 AN, Gronir nds 0 700 97 00 n | igen | | | Parts of the | on of the complete certific certificate may only be p roval of the calibration lab | roduced with |

Energieweg 17, 9743 AN Groningen | P.O. Box 20 T +31 50 700 97 00 | Trade register 09006404



DNV



Certificate

3015432979 Purchase order number N.V. Nederlandse Gasunie NL-3007032251-10 / Endress+Hauser Flowtec AG

Promass Q 300 3"

T6040202000 / T6040202000 Serial Nº – Tag N

New

 Flow
 Duration
 m sage

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 Nd

 7184.13
 75.1
 149.917

 12608.4
 43.0
 150.576

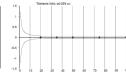
 18030.0
 50.1
 251.058

 20994.9
 33.5
 251.559

 36021.6
 35.2
 351.937
 m meas. Ref 149,911 150,571 251,041 251,541 351,946 ∆ e.r.* N -0.004 -0.003 -0.007 -0.007 0.003 Flow 1N 20.0 35.0 50.1 75.0 100.1 Outp.** maj 7.19 9.60 12.01 16.00 20.01

This certificate shall not be published or reproduced other than in full, except with the prior written approval of the issuing laboratory.

| FCP-7.1.5 / gravimetric | | | |
|-------------------------------------|---|---|-------|
| Reference: Calibration rig/Method | | | |
| 36000 kg/h | (| ≙ | 100%) |
| Calibrated full scale | | | |
| Service interface | | | |
| Calibrated output | | | |
| 0.52557 | | | |
| Calibration factor | | | |
| -17.2 | | | |
| Zero point | | | |
| 25.8 °C | | | |
| Water temperature | | | |
| 0.025 % | | | |
| Expanded uncertainty of measurement | | | |



For detailed data concerning out The order water value value of the second se

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15.06.2022 Date of calibration



Operator Endress+Hauser Flowtec AG Kägenstrasse 7 CH-4153 Reinach