Advanced Approach to Development & Production of Ultrasonic Gas Meters for Replacement of Turbine and Rotary Meters

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Highlights of the presentation

1. About Energoflow AG
2. Evolution of ultrasonic gas meters - Overview of the three generations of Ultrasonic Gas Meters
3. Current means for calibration of Ultrasonic Gas Meters
4. Advanced approach to calibration - making calibration simple and reliable
5. Additive technologies in the development of the third generation of Ultrasonic Gas Meters
6. Application of new methods in the manufacturing of Ultrasonic Meters
7. Conclusions

About company Energoflow AG

We are a Swiss company devoted to design, engineering and manufacture of flow metering solutions and related products based on the ultrasonic technology.

Our mission

Experience, Expertise & Efficiency!

Our compact team of EXPERIENCED professionals with a vast global exposure is dedicated to provide the best answer to client's requirements based on our EXPERTISE, and our business practices and management concepts are aimed to provide the highest degree of EFFICIENCY.

Energoflow AG can provide the optimal solution to all your flow metering requirements – the wide range of our products covers all the feasible fluid flow situations. And if you have an unusual, out of the way case – just contact us with the details! We love challenges and our team of Engineers will be just too happy to provide the exact flow meter corresponding to your requirements.

Gas flow meters

We Design and Manufacture
the Full Range of Solutions for Gas Measurement

- Residential Gas Meters (G1,6…G6)
- Gas Meters for Housing & Public Utility (G10… G650)
- Multichannel Ultrasonic Gas Flow Meters (G100…G 25 000)
- Reference Rotary & Turbine Meters (G2,5…G16, G100…G10 000)
- Calibration & Proving Rigs (Air/Natural Gas, G100-G2 500)
- Measuring Skids

Liquid flow meters

We Design and Manufacture
the Full Range of Solutions for measuring Liquids

- Stationary Liquid Flow Meters (transit time)
- Portable Liquid Flow Meters (transit time)
- Flow Meters based on Doppler effect
- Liquid Flow Meter LF-131H for High Pressure Applications

Calibration & verification units

We Design and Manufacture calibration rigs for all types of meters

TECHNICAL FEATURES		
Parameter	Proving rigs for liquids	Proving rigs for Gases
Capacity (m³/h)	45, 70, 120, 180, 280, 450, 600	650,1600, 2500, 6500, 10000
DN of calibrated flow meters	(15, 20, 25, 32, 40, 50, 65, 80, 100, 125, 150, 200)	(40, 50, 80, 100, 150, 200, 250, 300, 400)
Type of calibrated flow meters	Ultrasonic,Electromagnetic, Turbine, Rotary, Vane,	Ultrasonic,Turbine, Rotary, Vortex
Relative Accuracy	0,25% (comparison method); ±0,05, (0,04)% volumetric (tenzometric method)	±0,3%
Measurement method	Comparison with standard flow meter, weighting method	Comparison with reference flow meter
Medium used for calibration	water/liquid hydrocarbons	air and natural gas
Quantity of reference flow meters	3,4	3,4,5
Accuracy of temperature measurement	± 0,15 %	± 0,06 %
Accuracy of pressure measurement	± 0,5 %	± 0,075 %

Evolution of ultrasonic gas meters – Overview of the three generations of Ultrasonic Gas Meters

Upon analyzing various ultrasonic gas flow meters manufactured sinces the 90's till present time, we can group them in 3 generations:

Generation 1 :
Industrial flow meters for large flow rates and linesizes operating at high pressure , eg. Instromet, Daniel, RMG

Generation 2:
Industrial flow meters for medium to large flow rates and linesizes for wide range of pressure , eg. Sick, Instromet, Emerson (Daniel), RMG, RMA, Krohne, Energoflow

Generation 3:
Industrial flow meters for wide range of flow rates (linesizes) from G10 up to G16000 and above; autonomously powered; with built-in flow correction; not susceptible to effects of local resistances

Evolution of ultrasonic gas meters – Overview of the three generations of Ultrasonic Gas Meters

Presently, the main issues preventing replacement of rotary and turbine meters with ultrasonic meters are:

1. • High cost of reconstruction of gas pipelines since ultrasonic meters need long straight runs.
2. • The cost of ultrasonic meters is much more as compared to corresponding rotary or turbine meter.

But supposing the cost of ultrasonic meter is comparable to cost of mechanical meters?

Let's return to this question later .....

Evolution of ultrasonic gas meters – Overview of the three generations of Ultrasonic Gas Meters

Generation 1:

Industrial flow meters for large flow rates and linesizes operating at high pressure , eg. Instromet, Daniel, RMG

Basic characteristics:

- Accuracy in the range of 1 to 3%
- Operating pressure 10 bar and above
- Not less than 2 channels

Major drawbacks:

- Highly susceptible to effects arising from flow profile; Inefficient ultrasonic sensors
- Heavy power consumption
- Large dimensions
- Non ergonomic design; lack of built-in diagnostics; require calibration on natural gas at operating conditions

Evolution of ultrasonic gas meters – Overview of the three generations of Ultrasonic Gas Meters

Generation 2:

Industrial flow meters for medium to large flow rates and linesizes for wide diapazone of pressure, eg. Sick, Emerson (Daniel), RMG, RMA, Krohne, Energoflow GFE, Caldon

Basic characteristics

- Accuracy in the range of 0.5 to 1%
- Capable of operating at atmospheric pressure and above
- Not less than two ultrasonic beams

Advantages:

- Built-in algorythms for compensation of flow profile deviations;
- Sensitive ultrasonic sensors;
- Low power consumption;
- Dimensions comparable to turbine meters;
- Ergonomic design;
- Advance diagnostic features.

Drawbacks:

- Need longer straight runs than turbine and rotary meters;
- Need special flow conditioners for achieving accuracy class 0.5;
- Require external power;
- Require calibration on natural gas.

Evolution of ultrasonic gas meters – Overview of the three generations of Ultrasonic Gas Meters

Generation 3:

Flow meters for small, medium and large flow rates (line sizes) and for a wide range of pressure, eg. Flowsick500, Energoflow GFA, Energoflow UHORN

Main application:

Replacement of turbine and rotary meters

Basic characteristics

- Accuracy 0,5 to 1%
- Operating pressure starting from atmospheric
- Not less than 2 ultrasonic beams

Advantages:

- Flow profile deviations do not affect operation;
- Need straight runs of length **similar** to turbine and rotary meters;
- Advanced ultrasonic sensors;
- Autonomously powered from installed batteries;
- Nominal dimensions similar to rotary and turbine meters;
- Built-in flow corrector, pressure & temperature sensors;
- Ergonomic design;
- Advanced diagnostic features;
- Do not need calibration on natural gas.

Diagnostic features of ultrasonic gas flow meters

- Diagnostics based on speed of sound
  The difference in speed of sound measured in different channels should not deviate more than 0.3%;

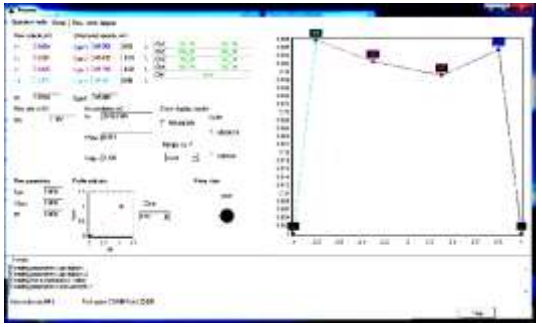
- Diagnostics based on profile of flow;

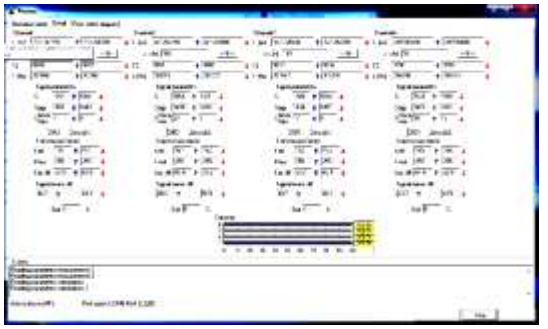
- Diagnostics based on ratio of signal to noise;

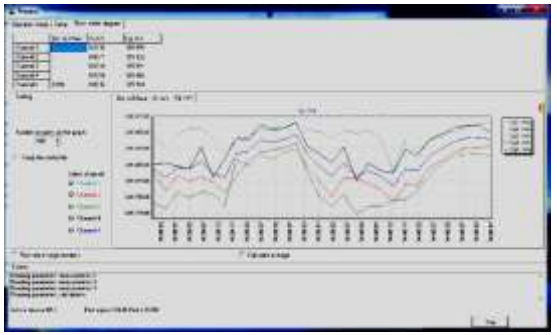
- Prediction of possible breakdowns, eg. due to contamination of sensor;

- Possibility of diagnostic sessions for recording all parameters of the device;

- Availability of archives of non standard situations and breakdowns.







Evolution of ultrasonic gas meters – Overview of the three generations of Ultrasonic Gas

The list of regulatory documents for ultrasonic gas meters:

AGA 9 Measurement of Gas by Multipath Ultrasonic Meters:
- **First edition (June 1998)**
- **Second edition (April 2007)**
- **Third edition (July 2017)**

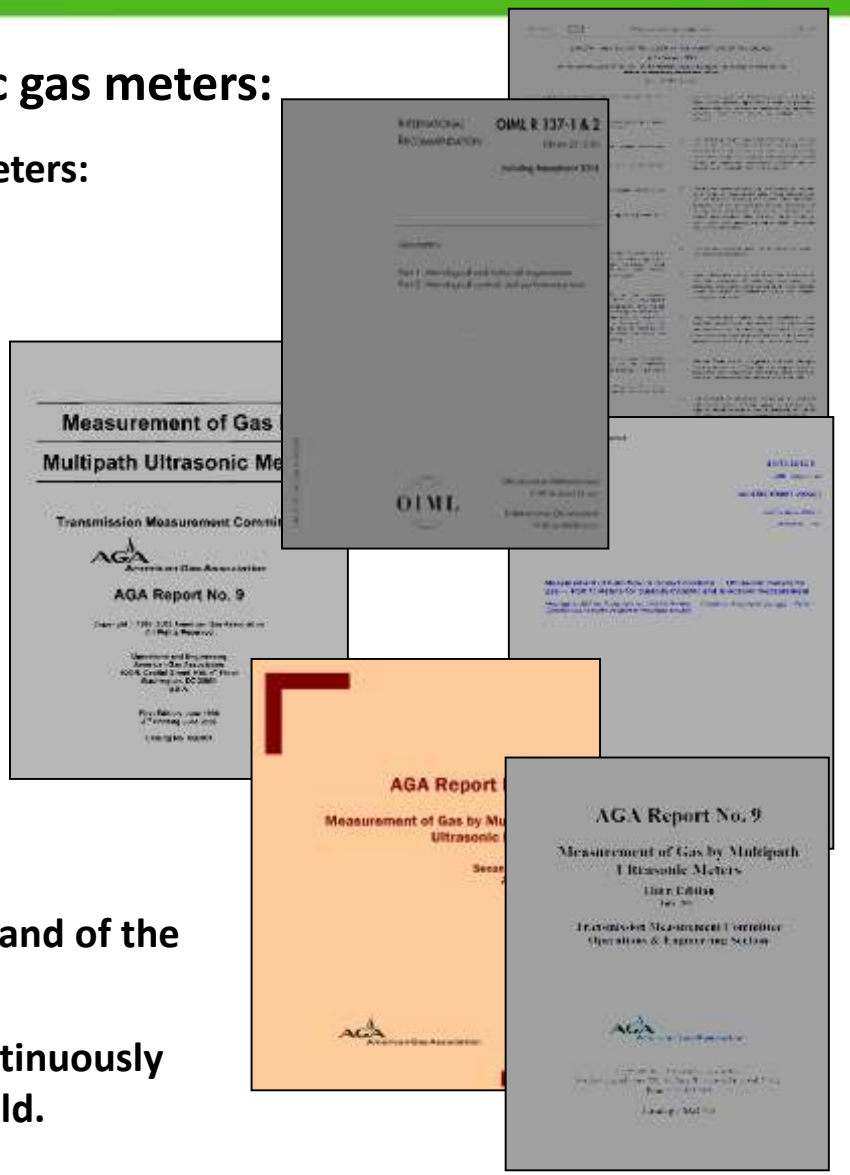
Recommendation OIML R 137-1&2-2014 "International Recommendation. Gas meters».

ISO 17089-1:2010. "Measurement of fluid flow in closed conduits - Ultrasonic meters for gas. Part 1: Meters for custody transfer and allocation measurement».

ISO 17089-2:2012 Measurement of fluid flow in closed conduits - Ultrasonic meters for gas -- Part 2: Meters for industrial applications

MID 2014/32 / EU. Directive of the European Parliament and of the Council on measuring instruments.

It should be noted that the regulatory documents are continuously renewed to keep pace with latest developments in the field.



Calibration of Ultrasonic Gas Flow meters – available means and proven results

As per para 13.1.3 " test conditions " of OIML R137 calibration of flow meters must be carried out in conditions maximally close to operating conditions

(«The accuracy requirements of 5.3 and 5.4 shall be verified while the gas conditions are kept as close as possible to the intended operating conditions (pressure, temperature, gas type) of the meter after being put into use.»)

Calibration facilities on natural gas

Manufacturer country	Number of installations	Pmin – Pmax, bar	Qmin – Qmax, m^3/h	Uncertainty %
USA	2	1 - 87	2 - 35000	0,2 – 0,25
Canada	1	0 - 70	up to 55000	0,15 – 0,3
Germany	6	1 - 50	up to 6500	0,2 – 0,25
Netherlands	3	1 - 66	5 - 30000	0,15
Denmark	1	0 - 50	8 - 16000	0,2
England	1	0 - 50	0,2 - 65000	0,21 – 0,33
France	1	6 - 55	9 – 10000	0,15
Poland	1	up to 55	0 - 6500	0,3
Russia	1	55 - 75	up to 10000	0,3
China	3	1 - 50	up to 10000	0,3

Over past 10 years the number of calibration facilities on natural gas has doubled

Advanced approach to calibration – making calibration simple and reliable

One of the salient features of Energoflow ultrasonic gas meters is that they are calibrated on air at factory and then can function successfully in gas medium. Our gas meters can be configured to work with any type of gaseous medium simply by inputting the composition of the gas using special software.

Gas flowmeter GFE40

Air calibration rig

Customer installation object

How it works

Algorithm of Comparative Tests of Ultrasonic Gas Meters Energoflow under Different Operating Conditions

Meter calibration at atmospheric pressure on air

↓

Entering medium parameters corresponding to the conditions of verification and/or operation manually or automatically

↓

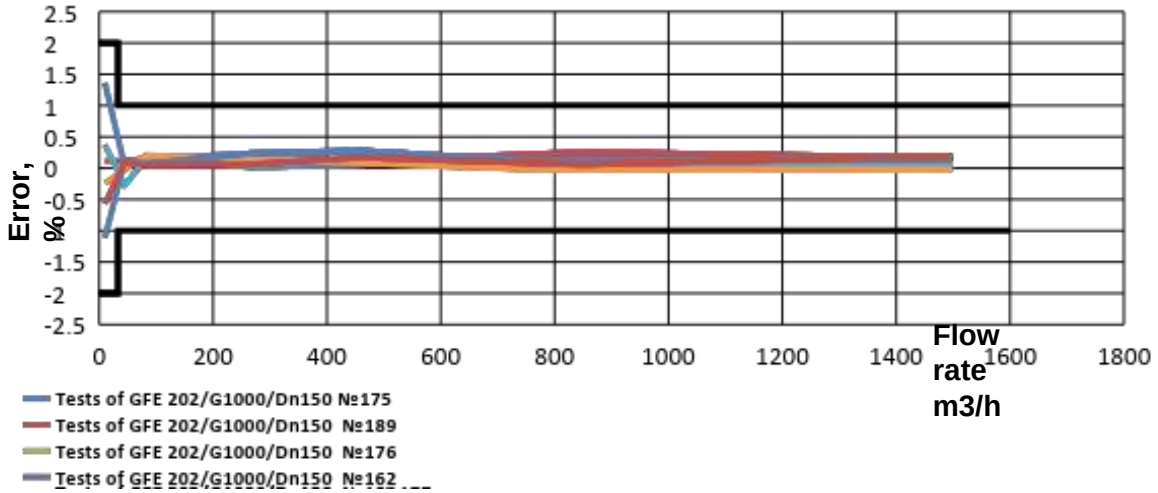
Meter verification at working pressure on natural gas

Advanced approach to calibration – making calibration simple and reliable

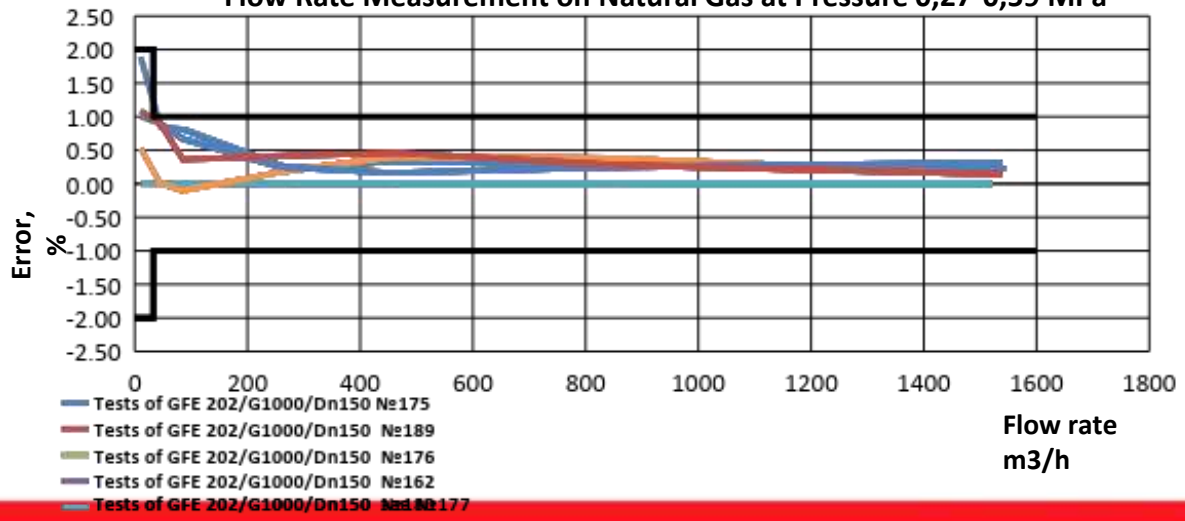
Test Results of GFE 202 during Flow Rate Measurement under Different Operating Conditions 2014 - 2015

GFE 202/G1000/DN150
Serial No.:162,175,176,177,180,189

Test Results of Gas Meters GFE 202/G1000/Dn150 during Flow Rate Measurement on Air at Atmospheric Pressure



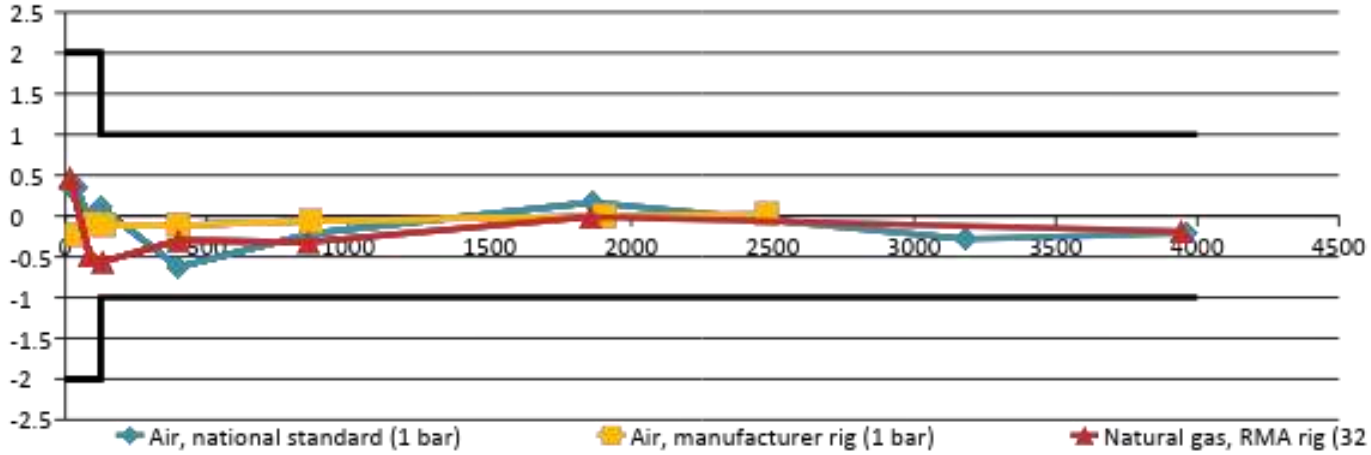
Test Results of Gas Meters GFE 202/G1000/Dn150 during Flow Rate Measurement on Natural Gas at Pressure 0,27-0,59 MPa



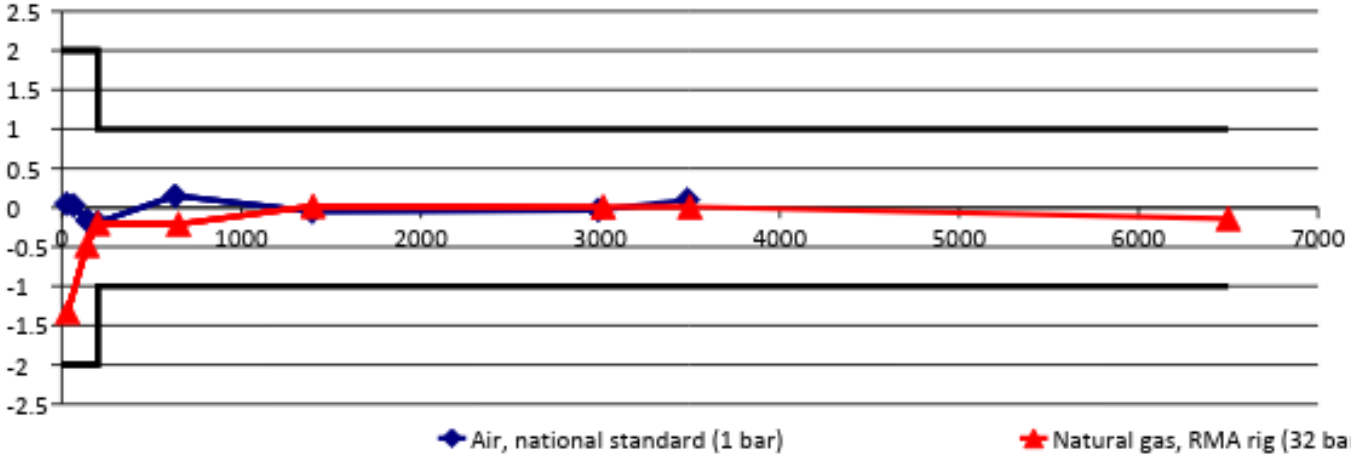
Advanced approach to calibration – making calibration simple and reliable

Test Results of Gas Meters GFE 404/G2500/Dn200 and G4000/DN250 during Flow Rate Measurement in Various Environments (Germany, 2016)

The Meters Were Calibrated on Air within Flow Range Qmin-Qmax/2



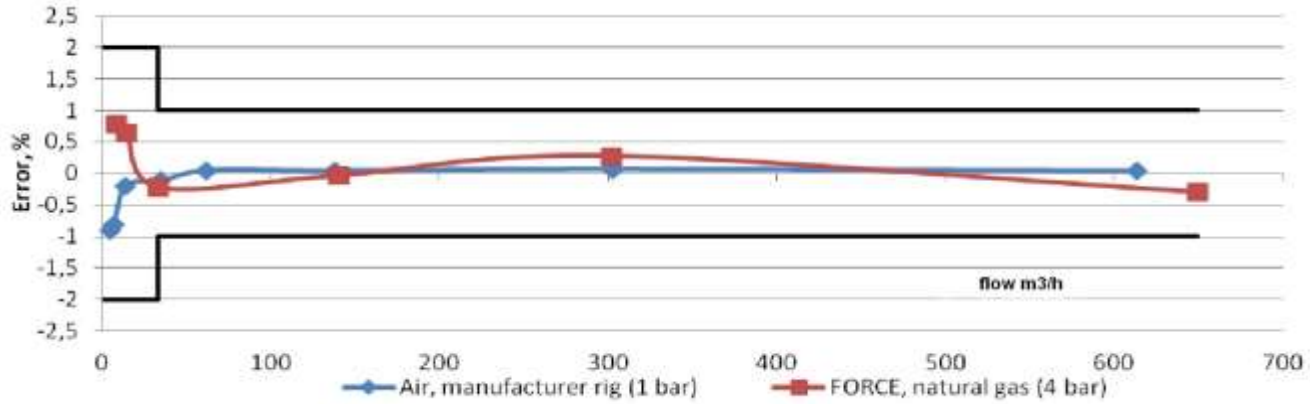
GFE 404
G2500/Dn200
№2384



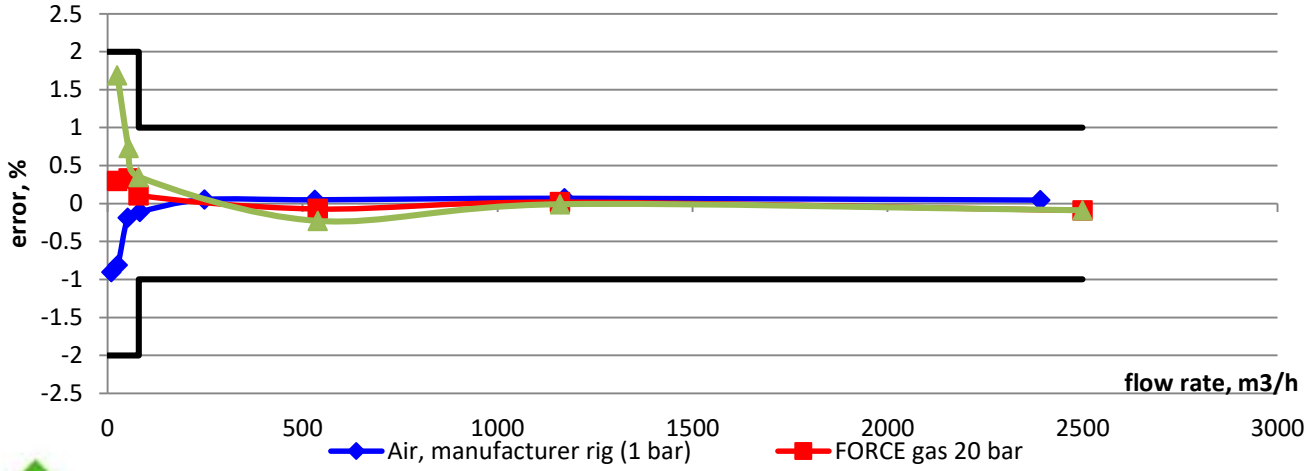
GFE 404
G4000/Dn250
№2385

Advanced approach to calibration – making calibration simple and reliable

Tests Results of GFE 202,404 during Flow Rate Measurement under Different Operating Conditions after Calibration on Air at Atmospheric Pressure (Denmark, 2015)



GFE 202
G400/Dn100
№2206



GFE 404
G1600/Dn150
№1001

Conclusions

Energoflow correction algorithm was specially designed for Energoflow ultrasonic gas meters.

This algorithm has been incorporated in ultrasonic gas meters Energoflow GFE 202 and Energoflow GFE 404, which have been certified by PTB to be compliant to MID class 1 (GFE202; 404) and OIML requirements for accuracy class 0.5 (GFE404)


PTB

KBS

EU-Baumusterprüfbescheinigung


PTB

Bericht

Additive technologies in the development of the third generation of Ultrasonic Gas Meters

For developing third generation ultrasonic gas meters it is absolutely necessary to apply mathematical modeling

For example:

1. **AGA-9 specifies at least 5 tests**
2. **ISO 17089 specifies at least 9 tests**
3. **OIML 137 specifies at least 9 tests**

These can be first tried out using mathematical models

The most commonly used software:

SolidWorks

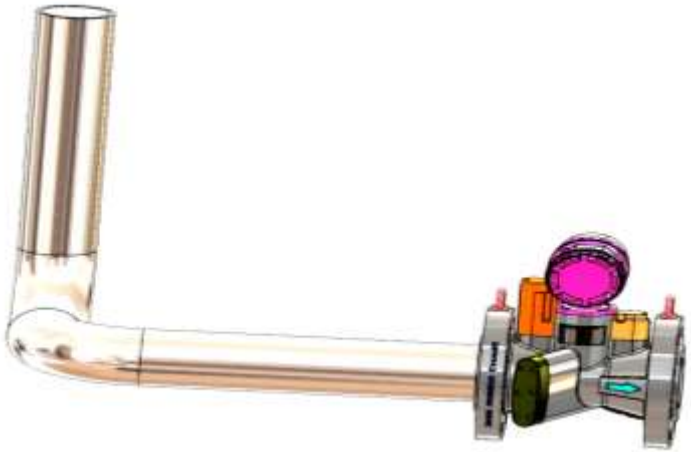
ANSYS

Using mathematical modeling allows:

- **Optimal design of meter body**
- **Optimization of number of beams and sensor installation**
- **Calculation of the effect of local resistances**

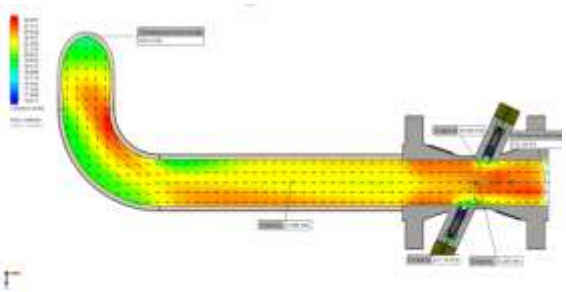
Additive technologies in the development of the third generation of Ultrasonic Gas Meters

Simulation of operation of 4 channel flow meter with local resistances

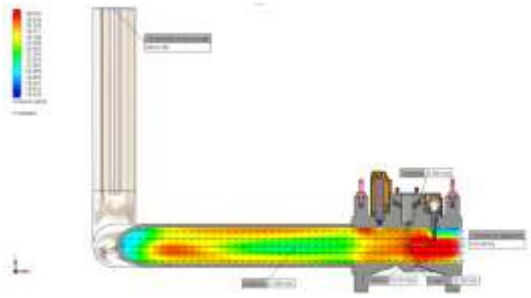


GFE 404 DN100 with two bends

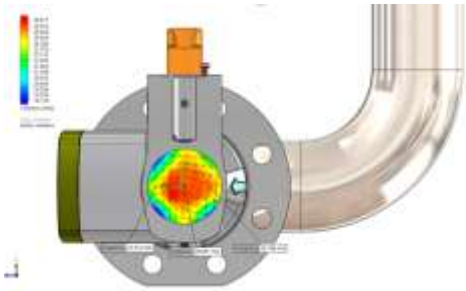
Calculated Profile of flow at Q=650 m3/h



Axis X



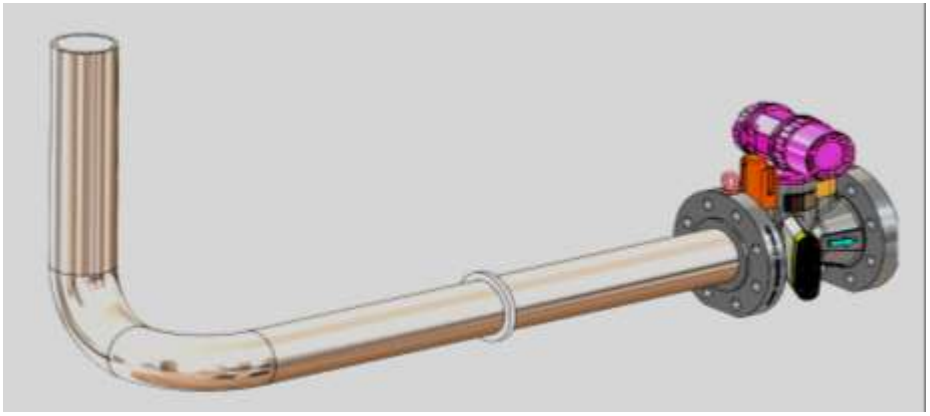
Axis Y



Axis Z

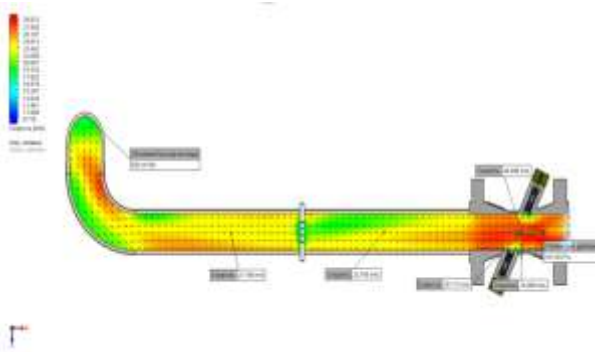
Additive technologies in the development of the third generation of Ultrasonic Gas Meters

Simulation of operation of 4 channel flow meter with local resistances



GFE404 DN100 with two bends and flow conditioner "ZANKER"

Calculated Profile of flow at Q=650 m3/h



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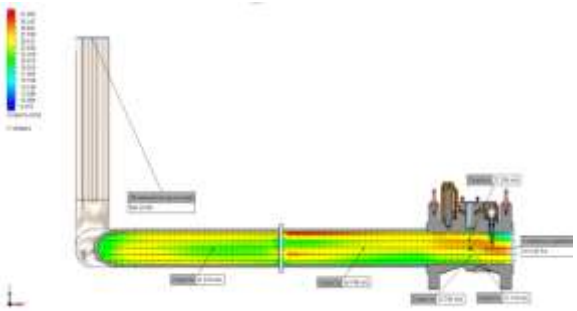

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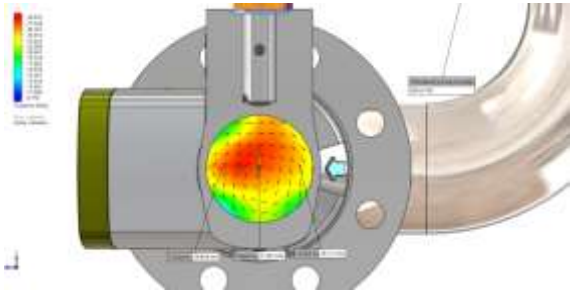
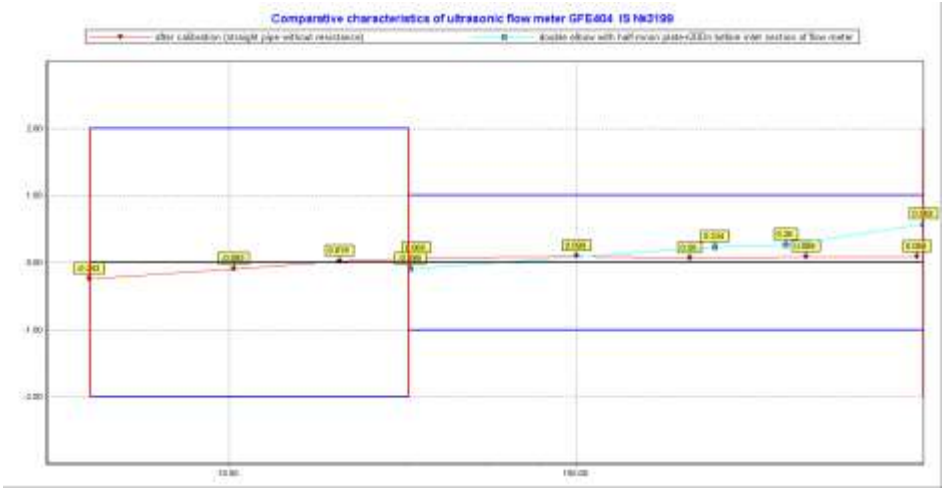
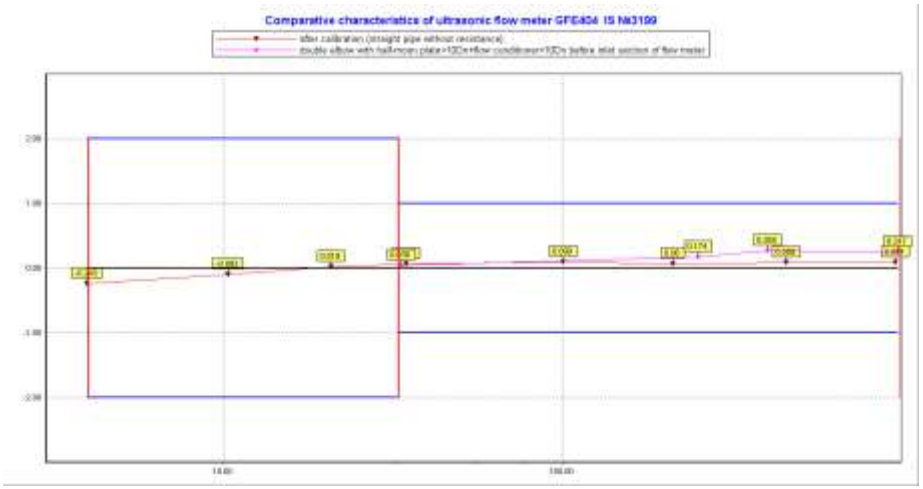


Axis Z

Additive technologies in the development of the third generation of Ultrasonic Gas Meters

Results of lab flow test of DN100 with local resistances





Additive technologies in the development of the third generation of Ultrasonic Gas Meters

3D printing of prototypes of ultrasonic gas meters

This technology enables one to develop the prototype in short time

And carry out testing of its metrological parameters

Additive technologies in the development of the third generation of Ultrasonic Gas Meters

3D printer is also used for making models for casting flow meter bodies which is a faster and cheaper way than making moulds

Conclusions:

application of mathematical modeling together with prototyping on a 3D printer reduces the time and cost of product development and reduces the risks of inconsistency of the meter being developed to the initial requirements

Application of new methods in the manufacturing of Ultrasonic Meters

In the manufacture of flow meters of the third generation ultrasonic gas flow meters:

1. **Cast bodies made of Steel and Aluminium are often used.**

2. **Special integrated circuits with low power consumption are employed**

ACAM TEXAS INSTRUMENTS maxim integrated

3. **Custom made ultrasonic sensors are used.**

By using these advanced technologies, the cost of meters of the third generation may be greatly reduced.

Application of new methods in the manufacturing of Ultrasonic Meters

In the nearest future, cost of ultrasonic meters of the third generation will be comparable to the cost of rotary and turbine meters, at the same time providing a number of advantages:

- ✓ **Wider range of measurement**
- ✓ **Better accuracy and reliability, no tear and wear since there are no moving parts**
- ✓ **Safe in operation - not subject to blocking like rotary meters**
- ✓ **Detailed diagnostic features**
- ✓ **Simple in calibration**
- ✓ **Stable results of measurement for wide range of operating conditions**

Second generation Energoflow Ultrasonic Gas Meters

Gas Flow Meter GFE-404

Type	Flow range	Qmax, m³/h	DN, mm
G650	1:250	1000	100
G1600	1:250	2500	150
G2500	1:250	4000	200
G4000	1:250	6500	250
G6500	1:250	10000	300
G10000	1:250	16000	400

Second generation Energoflow Ultrasonic Gas Meters

Gas Flow Meter GFE-202

Type	Flow range	Qmax, m³/h	DN, mm
G100	1:160	160	50
G160	1:160	250	80
G400	1:160	650	100
G1000	1:160	1600	150
G1600	1:160	2500	200
G2500	1:160	4000	250
G4000	1:160	6500	300
G6500	1:160	10000	400

Third generation Energoflow Ultrasonic Gas Meters

Gas Flow Meter GFA-202

Type	Flow range	Qmax, m^3/h	DN, mm
G160	1:250	250	50
G250	1:250	400	80
G650	1:250	1000	100
G1600	1:250	2500	150
G2500	1:250	4000	200
G4000	1:250	6500	250
G6500	1:250	10000	300
G10000	1:250	16000	400

Third generation Energoflow Ultrasonic Gas Meters

Gas Flow Meter UHORN

Type	Flow range	Qmax, m³/h	DN, mm
G10	1:250	16	25
G16	1:250	25	25
G25	1:250	40	32
G40	1:250	65	40
G65	1:250	100	40
G100	1:250	160	50
G160	1:250	250	80
G250	1:250	400	80
G400	1:250	650	100
G650	1:250	1000	150

Summarizing what has been said

Based on the above,
I have a feeling that,
in the nearest future,

third generation Ultrasonic Meter will cost not more than 2-5 thousand USDollars

if the quantities manufactured are similar to those for rotary and turbine meters.

We invite gas companies, distributors, investors, who are interested in cooperating with us for implementation of these technologies for development, production and sales of flow meters of the third generation in the US.

Thank you for your kind attention!

Dr. Andrii Stetsenko.
General Manager, Energoflow AG

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