History

Revision	Date	Editor	ECN	Status	Description
Rev. 01 / B	31.01.2008	xx	20143	released	Take over from KOS SAP System
Rev. 00C	April 2008	NB	20207	released	New Logo
Rev. 00D	September 2008	IC	20384	released	Technical description of Force calibration Facility.
00E	February 2009	Thk	20512	Released	New first and last page
Rev. F	October 2009	FRL	20756	released	Test set up modified
Rev. G	October 2009	NB	20767	released	Average flow deviation delete

Important

All information and technical specifications in this documentation have been carefully checked and compiled by the author. However, we cannot completely exclude the possibility of errors. **Smith Meter GmbH** is always grateful to be informed of any errors.

TABLE OF CONTENT

1. INTRODUCTION

This document describes the flow test procedure of the MPU Series B ultrasonic gas flow meter.

The ability of the meter to measure the correct gas flow rate, is the functional characteristic to be tested.

There are limitations at the flow test facility regarding pressure and temperature variations. The conditions at the test facility may differ from the operational conditions, but the meter is zero-calibrated for both the test conditions and the operating conditions.

The flow test result will be presented in a flow calibration certificate for each meter, issued by the flow test facility. The deviation between the measured gas volume flow and the reference measurement shall be within the required limits. If not, further investigation is needed.

1.1. Equipment Required

- An MPU ultrasonic gas flow meter with zero-calibrated transducers.
- If applicable; required upstream and downstream spools and/or Adapter Spools.
- If applicable; flow conditioner
- Required gaskets, bolts and nuts.
- Cables and interface converters to be used between the meter and the safe area.
- PC or laptop for logging of trendlog data, checking of signal quality, and calculation of correction factors.
- Spare parts for the meters:
  - Ø Electronic boards
  - Ø Transducers
  - Ø Transducer cables
- Tools to open the electronic box and to change the transducers.

1.2. References

The following documents are referred to within this Test Procedure:

1	NPD-regulations	Regulations for fiscal measurement of oil and gas.
2	NPD-regulations	Regulations relating to measurement of petroleum for fiscal purposes and for calculation of CO2-tax (Måleforskriften / The measurement regulations). 1 November 2001.
3	NORSOK standard, I-104	Fiscal Measurement systems for hydrocarbon gas, Rev. 3, November 2005.
4	A.G.A. Report No. 9 Second Edition April 2007	Measurement of Gas by Multipath Ultrasonic Meters
5	PRD-0000022555	Function Test Procedure, MPU Series B
6	PRD-0000022541	Product Identification, MPU Series B
7	USM-0000020565	User Manual, MPU Series B

1.3. Warnings

Warning, gas under pressure!

Never attempt to disconnect or connect a pressurized connection.

Never apply power to the meter without permission from the test site operator.

1.4. Abbreviations

Abbreviation	*Description*
AGA	American Gas Association
FAT	Factory Acceptance Test
HES	Health, Environment and Safety
MPU	MultiPath Ultrasonic
NPD	Norwegian Petroleum Directorate

Abbreviation	Description
PC	Personal Computer
STDEV	Standard Deviation
VOS	Velocity Of Sound

1.5. Responsibility

The FMC representative is the test coordinator. The FMC representative will cooperate with the appointed test site operator and the Contractor in order to perform the flow test.

NOTE: FMC is not liable for availability of gas flow or problems at the test site on the day of the calibration.

If deviations from this procedure are required, this must be agreed upon first between the Contractor and FMC, second between the test site and FMC.

All work is performed in accordance with relevant Health, Environment and Safety (HES) regulations. Relevant parts of FMC Kongsberg Metering HES manual and pressure test manual will be followed. FMC is responsible for all equipment delivered by FMC Kongsberg Metering, regarding both high pressure and hazardous area related aspects.

The test site is responsible for their part of the test loop, regarding both high pressure and hazardous area related aspects. The test site is responsible for checking for gas leakage on all equipment, and to permit power to be switched on.

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2. TEST SET-UP

2.1. In-House Testing

In-house testing is performed prior to the flow test (FAT) according to PRD-0000022555 "Function Test Procedure, MPU Series B" [5].

- Zero calibration is performed to determine transducer delays and Δt-corrections.

- Inner diameter and path lengths are accurately measured.

- Zero flow and velocity of sound is verified either with pressurized Nitrogen or air after flow meter parameter configuration.

2.2. Installation Arrangement

A general installation arrangement is sketched below. The item numbers refer to table in chapter 7.5.

Figure 1 Installation Arrangement
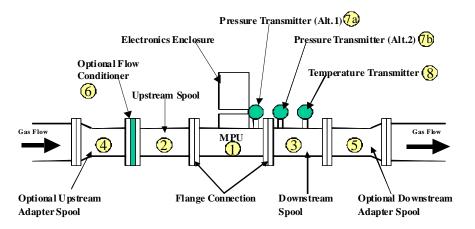
The Figure 2 below shows a typical block diagram of the test set-up for one MPU. Pressure and temperature readings will be done both at the location of the reference meter and at the location of the MPU. Flow measurements from the reference meter and of the MPU will be recorded simultaneously and compared to calculate the deviations.
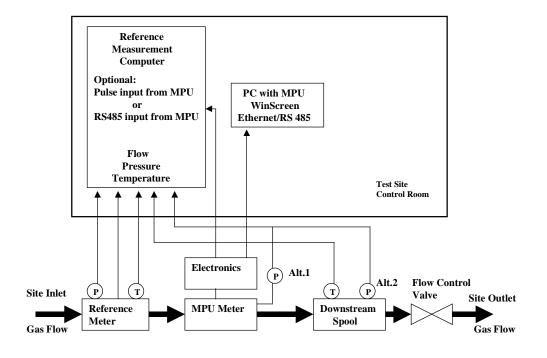

Figure 2 Block diagram of the test set-up

3. HARDWARE INSPECTION AND INSTALLATION

A. Check that there is no damage on the meter or piping from transportation. If this is the case, FMC Kongsberg must be notified immediately, and the damage must be documented and photographed.

B. Check that pressure test certificates are available for the MPU and up- and downstream piping.

C. Check the inner diameters at each end of the spools upstream and downstream of the MPU. Note the results in the table in Chapter 7.5.

D. Install the MPU with corresponding pipes and, if applicable, flow straightener mechanically. The installation must be done in accordance with general procedures for the task.

E. Install the cables between the meter and the control room in safe area and connect all wires.

F. Check that the junction boxes are properly closed to prevent water intrusion.

G. Check that reference instrumentation is properly installed.

H. Place the PC for logging the MPU measurements in-house in safe area.

I. Do not switch power on until cable installation and safety grounding is verified and allowance is given by the test site operator.

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4. INITIAL CHECKING

The initial checking is done for the MPU and must be performed by competent and qualified personnel.

A. Verify cable installation and protective grounding.

B. Before applying power to the pulse loop, check that the current through the pulse loop is limited by a resistor or internal circuitry in the reference system or flow computer. If in doubt, unplug the pulse output cable on the meter and measure the current through the loop with a multi-meter. If the current is higher than 10 mA, a resistor needs to be inserted in the loop (5kOhm). A high current through the pulse output will cause permanent damage to the UDSP board.

C. Switch the power on.

D. Establish contact with the PC and start the WinScreen-program. Check the signals for all paths.

E. Perform flow system tests to verify that the MPU is working satisfactory.

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5. FLOW TEST

5.1. Flow Test Description

Project specific details for this flow test are given in Section 0.

The flow meter shall be flow calibrated at an accredited gas flow calibration facility (See list of various facilities in Appendix 1).

The test below is performed for a predefined set of flow velocities

Each run has a fixed duration (typically 100 seconds), and the same nominal flow rate will be repeated a number of times (typically 3 to 5 times).

The flow calibration is done by the calibration facility based on the flow rate from the pulse/frequency output of the meter. The average flow rate from the MPU is compared with the reference measurements converted to the same conditions (Pressure/Temperatue) as the MPU. At each run at each flow rate the error is found (in %).

During the complete flow calibration, the Winscreen shall be logging data from the MPU in a trendlog file. This file contains flow rate, flow velocity VOS, path velocities, path VOS, signal gains, signal percentages, signal to noise levels and all alarms that is flagged during the calibration. The content of the file should be checked to ensure that the MPU was measuring without any errors or faults during the calibration.

VOS should be checked at least at one flow rate against theoretical VOS calculated from gas composition. This is typically done at about 0.5Qmax-test. AGA 10 should be used to calculate the theoretical VOS.

After all calibration points have been completed, the calibration factor(s) should be calculated and put into the meter.

Then at least one verification point should be taken. Normally this point is taken at about 0.5QMax. AGA9 require two verification points if a linearization algorithm is used (Ax+B or multipoint.)

The test will result in an official flow calibration certificate for each meter, issued by the test site.

5.2. Flow Ranges

Size	6 – 16 inch		18 – 30 inch		32 – 52 inch	
Flow	m/s	ft/s	m/s	ft/s	m/s	ft/s
$Q_{min\text{-}spec}$	0.4	1.3	0.3	1.0	0.2	0.7
$Q_{max\text{-}spec}$	30	98	26	82	20	60
Q_t	3	9.8	2.6	8.2	2.0	6.0

NOTE: $Q_{max\text{-}test}$: This is a value that is according to customer requirements, which is limited to
$Q_{max\text{-}spec}$.($Q_{max\text{-}test}$ £ $Q_{max\text{-}spec}$)

$Q_{min\text{-}test}$: This is a value that is according to customer requirements, which is limited to
$Q_{min\text{-}spec}$.($Q_{min\text{-}test}$ ³ $Q_{min\text{-}spec}$)

5.3. Flow Test Documentation

· This test procedure completed with results.

· Calibration certificates from the test site.

· Print-out of database values – verified by FMC / Contractor.

5.4. Post-Test Procedure

A. Dismount the test equipment.

B. Prepare the MPU for delivery by preserving and packing the MPU, in accordance with USM-0000020565 "User Manual, MPU Series B" [7].

6. ACCEPTANCE CRITERIA

6.1. Acceptance Criteria for the MPU (according to AGA–9)

6.1.1. Accuracy

- The accuracy <u>before</u> flow calibration shall be according to "Large Meter Accuracy" or "Small Meter Accuracy" as stated below. The uncertainty of the reference measurement of the volume flow must be taken into account when evaluating this point.
- The uncertainty of the reference measurement will be documented in the calibration certificates.
- The average error on each flow rate is used to calculate the accuracy.

<u>Large Meter Accuracy Requirements</u>

NOTE: UMs of 12" (nominal) diameter size and larger shall meet the following flow-measurement accuracy requirements, prior to making any calibration-factor adjustment.

Maximum Error:	$\pm 0.7\%$ for $Q_t \pounds Q_i \pounds Q_{max\text{-}test}$
(Ref AGA 9, Ch. 5.1)	$\pm 1.4\%$ for $Q_{min\text{-}test} \pounds Q_i \pounds Q_t$

where
$$Q_t <= 0.1 Q_{max\text{-}spec*}$$

* Ref. definition of $Q_{max\text{-}spec}$ in section **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Small Meter Accuracy Requirements

UMs less than 12" (nominal) diameter shall meet the following flow-measurement accuracy requirements, prior to making any calibration-factor adjustment.

Maximum Error:	$\pm 1.0\%$ for $Q_t £ Q_i £ Q_{max\text{-}test}$
(Ref AGA 9, Ch. 5.1 [3])	$\pm 1.4\%$ for $Q_{min\text{-}test} £ Q_i £ Q_t$

where
$$Q_t <= 0.1 Q_{max\text{-}spec*}$$
* Ref. definition of $Q_{max\text{-}spec}$ in section **Fehler! Verweisquelle konnte nicht gefunden werden.**.

6.1.2. Repeatability – AGA 9

· Less than $\pm 0,2$ % for $Q_t £ Q_i £ Q_{max\text{-}test}$.
· Less than $\pm 0,4$ % for $Q_{min\text{-}test} £ Q_i £ Q_t$.

The repeatability shall correspond to the 95% confidence interval (alpha = 0.05) of the mean of the deviations for each flow rate based on the assumption that the deviations are normally distributed.

The repeatability for each flow velocity is calculated the following way:

$$\text{Repeatability} = \pm 1.96 * \frac{s}{\sqrt{n}}$$

where   1.96 is the area under the standard normal curve
that equals (1 - alpha), or 95%.
s is the standard deviation of the flow deviations
n is the number of repetitions

The standard deviation calculation method used is the one that estimates values based on a sample of the population.

$$\text{Standard deviation} = \sqrt{\frac{n\sum x^2 - \left(\sum x\right)^2}{n(n-1)}}$$

6.1.3. Linearity - AGA9

The linearity is found by calculating the average flow deviation in percent for each flow rate, picking the maximum and the minimum value of these and calculate the difference between them. This is called the peak-to-peak error.

The calculation of repeatability and linearity will be performed by putting the recorded flow data with reference measurements and flow deviations into a prepared Excel-file.

Large Meter Linearity Requirements

NOTE: UMs of 12" (nominal) diameter size and larger shall meet the following linearity requirements, prior to making any calibration-factor adjustment.

Maximum Peak-to-Peak Error:	$\pm 0.7\%$ for $Q_t \pounds Q_i \pounds Q_{max\text{-}test}$
(Ref AGA 9, Ch. 5.1)	$\pm 1.4\%$ for $Q_{min\text{-}test} \pounds Q_i \pounds Q_t$

where
$Q_t <= 0.1 Q_{max\text{-}spec*}$

* Ref. definition of $Q_{max\text{-}spec}$ in section **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Small Meter Linearity Requirements

UMs less than 12" (nominal) diameter shall meet the following linearity requirements, prior to making any calibration-factor adjustment.

Maximum Peak-to-Peak Error:	$\pm 1.0\%$ for $Q_t \pounds Q_i \pounds Q_{max\text{-}test}$
(Ref AGA 9, Ch. 5.1 [3])	$\pm 1.4\%$ for $Q_{min\text{-}test} \pounds Q_i \pounds Q_t$

where
$Q_t <= 0.1 Q_{max\text{-}spec*}$

* Ref. definition of $Q_{max\text{-}spec}$ in section **Fehler! Verweisquelle konnte nicht gefunden werden.**.

6.1.4. Velocity of Sound - AGA9

The MPU shall be able to measure the velocity of sound (VOS) with a variation between the paths of maximum 0.5 m/s (band). The average measured velocity of sound shall not deviate from externally calculated velocity of sound with more than 0.2%, provided sufficient accuracy of the externally calculated velocity of sound. This verifies that the measured travel times of the acoustic signals are correct. The accuracy of the reference measurement of the VOS and possible temperature variations within the pipe must be taken into account when evaluating this point.

6.2. Acceptance Criteria for the MPU (according to NPD)

6.2.1. Accuracy - NPD

- The accuracy <u>before</u> flow calibration shall be within 1.5% for velocities above 1.5m/s. The uncertainty of the reference measurement of the volume flow must be taken into account when evaluating this point.

- According to the NPD requirements the deviation from the reference shall be $< +/- 0.5\%$ for velocities above $0.05\ Q_{max-spec*}$ with flow calibration factors implemented.

- The uncertainty of the reference measurement will be documented in the calibration certificates.

6.2.2. Repeatability - NPD

The repeatability shall be better than $\pm 0.2\%$.

The limit for repeatability is according to the NORSOK standard, I-104, Fiscal Measurement systems for hydrocarbon gas, Rev. 3, November 2005 [3]. These requirements are applicable after application of zero flow point calibration but before application of any correction factors, for flow velocities above 1.5 m/s.

The repeatability shall correspond to the 95% confidence interval (alpha $= 0.05$) of the mean of the deviations for each flow rate based on the assumption that the deviations are normally distributed.

The repeatability for each flow velocity is calculated the following way:

$$\text{Repeatability} = c \pm 1.96 * \frac{s}{\sqrt{n}}$$

where
- c is the average flow deviation
- 1.96 is the area under the standard normal curve that equals (1 - alpha), or 95%.
- s is the standard deviation of the flow deviations
- n is the number of repetitions

The standard deviation calculation method used is the one that estimates values based on a sample of the population.

$$\text{Standard deviation} = \sqrt{\frac{n\sum x^2 - \left(\sum x\right)^2}{n(n-1)}}$$

Additionally the "Measurements regulations" from NPD [2] has a repeatability limit of 0.5% (band) for $Q \geq 0.05 Q_{max-spec}$.

6.2.3. Linearity - NPD

The limit for linearity is according to the NORSOK standard, I-104, Fiscal Measurement systems for hydrocarbon gas, Rev. 3, November 2005 [3]. These requirements are applicable after application of zero flow point calibration but before application of any correction factors, for flow velocities above 1.5m/s.

The linearity must be better than 1.0 % (band).

The linearity is found by calculating the average flow deviation in percent for each flow rate, picking the maximum and the minimum value of these and calculate the difference between them.

The calculation of repeatability and linearity will be performed by putting the recorded flow data with reference measurements and flow deviations into a prepared Excel-file.

6.2.4. Uncertainty limit for the MPU - NPD

The limit for the uncertainty of the MPU after the flow calibration is according to "Measurement regulation 1st. November 2001 [2]. These requirements are applicable after the flow calibration factors have been implemented. The uncertainty should be calculated for each flow rate. The uncertainty should be inside the limit of 0.7% for flow rates above 0.05 $Q_{max-spec.}$ The uncertainty should contain the uncertainty elements from the flow calibration site itself, error after flow calibration and repeatability. All uncertainties should be converted to 95% confidence before added using the root-square addition (independent uncertainties).

7. PROJECT SPECIFIC INFORMATION

7.1. Project Data

Project Name:	
End Customer:	
Contractor:	
Purchase Order:	
Final Installation Site:	

7.2. Meter Data

Meter Type:	
Serial Number:	
Tag Number:	
SWO/ Job Number for spool piece	
Nominal Meter Size (inches):	
Inside Diameter (mm, inches):	
Output Flow Range (m^3/h, ft^3/h):	
Output Frequency Range (Hz):	
Output Meter Factor (p/m^3, p/ft^3):	

Further details of the meter is given in the "Product Identification", PRD-0000022541 [6].

7.3. Calibration Data

Calibration Site:	
Flow Velocity (m/s, ft/s): **(Min. – Max.)**	
Volume Flow Rate (m^3/h, ft^3/h): **(Min. – Max.)**	
Nominal Temperature (°C, °F):	
Nominal Pressure (barA, psiA):	
Gas Type:	
Number of Test Points:	
Number of Repetitions:	
Run Duration (seconds):	
Accuracy Requirements:	
Repeatability Requirements:	
Linearity Requirements:	
$Q_{max\text{-}spec}$	
$Q_{min\text{-}spec}$	
Q_t	

7.4. Flow Test Points

Test Point	Nominal flow rates related to $Q_{min\text{-}test}$ and $Q_{max\text{-}test}$	Flow rate (m^3/h or ft^3/h)	Flow velocity (m/s or ft/s)
1			
2			
3			
4			
5			
6			
7			
8			
9			

Test Point	AGA-9 recommendation	NPD recommendation
1	$0.025Q_{max\text{-}test}$	$Q_{min\text{-}test}$
2	$0.05Q_{max\text{-}test}$	$0.2Q_{max\text{-}test}$
3	$0.1Q_{max\text{-}test}$	$0.45Q_{max\text{-}test}$
4	$0.25Q_{max\text{-}test}$	$0.8Q_{max\text{-}test}$
5	$0.5Q_{max\text{-}test}$	$Q_{max\text{-}test}$
6	$0.75Q_{max\text{-}test}$	
7	$Q_{max\text{-}test}$	

NOTE: $Q_{max\text{-}test}$: This is a value that is according to customer requirements, which is limited by $Q_{max\text{-}spec}$.

($Q_{max\text{-}test}$ £ $Q_{max\text{-}spec}$)

$Q_{min\text{-}test}$: This is a value that is according to customer requirements, which is limited by $Q_{min\text{-}spec}$.

($Q_{min\text{-}test}$ ³ $Q_{min\text{-}spec}$)

7.5. Additional Equipment Data

Fill in details on the parts listed.
Refer to Figure 1, Section 2.2:

Item	Part	Details
1	**MPU** Length, flange connections.	
2	**Upstream Spool** Length, flange connections, inside diameter.	
3	**Downstream Spool** Length, flange connections, inside diameter.	
4	**Optional Upstream Adapter Spool** Length, flange connections, inside diameter.	
5	**Optional Downstream Adapter Spool** Length, flange connections, inside diameter.	
6	**Optional Flow Conditioner** (Type)	
7a	**Pressure Transmitter** (Alternative 1) Type, tapping.	
7b	**Pressure Transmitter** (Alternative 2) Type, tapping.	
8	**Temperature Transmitter** Type, element, tapping.	

8. FLOW TEST EVALUATION

Flow Meter Identification (Serial / Tag Number):	

	AGA 9 **Small Meter < 12"**	AGA 9 **Large Meter ≥ 12"**	**NPD**
Accuracy	$\pm 1.0\%$ $Q \geq 0.1 Q_{max-spec}$ $\pm 1.4\%$ $Q < 0.1 Q_{max-spec}$	$\pm 0.7\%$ $Q \geq 0.1 Q_{max-spec}$ $\pm 1.4\%$ $Q < 0.1 Q_{max-spec}$	$\pm 1.5\%$ $v > 1.5 m/s$
Linearity (Band)	1.0% $Q \geq 0.1 Q_{max-spec}$ 1.4% $Q < 0.1 Q_{max-spec}$	0.7% $Q \geq 0.1 Q_{max-spec}$ 1.4% $Q < 0.1 Q_{max-spec}$	1.0% $v > 1.5 m/s$
Repeatability	$\pm 0.2\%$ $Q \geq 0.1 Q_{max-spec}$ $\pm 0.4\%$ $Q < 0.1 Q_{max-spec}$	$\pm 0.2\%$ $Q \geq 0.1 Q_{max-spec}$ $\pm 0.4\%$ $Q < 0.1 Q_{max-spec}$	$\pm 0.2\%$ $v > 1.5 m/s$

Using the table above, are the calibration results inside the requirements?	Accuracy: ⊙ Yes ⊙ No Linearity: ⊙ Yes ⊙ No Repeatability: ⊙ Yes ⊙ No
What kind of calibration curve should be implemented?	⊙ None ⊙ FWME ⊙ Multipoint ⊙ Ax + B
Using theoretical calculations, is the deviation from the reference less than the specified limit while the calibration curve is implemented?	⊙ Yes ⊙ No
Comments:	

Witnessed: _____ _____ _____ _____
              Contractor   Customer   FMC   Date

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9. CONCLUSION

Flow Meter Identification (Serial / Tag Number):	

This Calibration Flow Test is approved without any remarks:

Sign:_____

This Calibration Flow Test is not approved:

Sign:_____

This Calibration Flow Test is approved with the following remarks:

For Contractor: For Customer: For FMC

_____   _____   _____
Date / Signature   Date / Signature   Date / Signature

10. APPENDIX

Appendix 1 - Reference Instrumentation, Advantica, Bishop Auckland, England

Selected amounts of natural gas from the British Gas natural gas pipe system is lead through the test site. While running larger flow rates than the gas consume, the pressure in the downstream pipe will increase. High flow rates can therefore only be run for a limited duration in order to keep the pressure in the natural gas pipe system below its maximum limit.

As the gas passes the test site, not in a loop, the possibilities for varying the pressure and the temperature of the gas are limited.

Gas turbine meters will be used as reference meters. Details of the reference meters, related temperature and pressure transmitters and the resulting uncertainty will be enclosed in the calibration certificates issued by Advantica.

Secondary instruments are calibrated and traceable to National standards.

Each test point comprises the following:

1) 100 second count of turbine meter output frequency.
2) 10 off readings of pressure and temperatures each set taken every ten second.

The pressures and temperatures are averaged and used with the turbine average frequencies to calculate the reference flow rates.

Gas samples will be taken during the course of the test.

The flow rate at the reference turbine meter is converted to the conditions prevailing at the ultrasonic flow meter using ratios of pressure, temperature and compressibility. Compressibility is calculated using the AGA 8 (1992) equation. The gas analysis needed for the compressibility
calculations is obtained using an on line gas chromatograph (Danalyser).

Quality assurance of the test site:
·   NAMAS Accreditation.
·   Complies with relevant requirements of the BS EN ISO 9000 series of standards.

Appendix 1 - Reference Instrumentation, Pigsar, Dorsten, Germany

Selected amounts of natural gas from the Ruhrgas natural gas pipe system is lead
through the test site.
As the gas passes the test site, not in a loop, the possibilities for varying the pressure
and the temperature of the gas are limited.

Gas turbine meters will be used as reference meters. Details of the reference meters,
related temperature and pressure transmitters and the resulting uncertainty will be
enclosed in the calibration certificates issued by Ruhrgas.

Secondary instruments are calibrated and traceable to National standards.
The pressures and temperatures are averaged and used with the turbine average
frequencies to calculate the reference flow rates.

Each run has a duration of approximately 180 seconds.

Gas samples will be taken during the course of the test.

The flow rate at the ultrasonic meters is calculated by converting the reference
measurement to mass flow rate. The densities at the reference meter and at the
ultrasonic meters are calculated using measured pressure and temperature at both places,
and chemical analysis and compressibilities using the AGA 8 z calculation method.

Quality assurance:
· Calibrated against DVGW piston prover, which is recognized as a reference standard
   by PTB. (DVGW = German Gas and Water Association)
· Complies with EN-45001

Appendix 1 - Reference Instrumentation, CEESI, Clear Lake, Iowa, USA

Selected amounts of natural gas from the Northen Border Gas Company naturual gas pipe system is lead through the test site.

As the gas passes the test site, not in a loop, the possibilities for varying the pressure and the temperature of the gas are limited.

Gas turbine meters will be used as reference meters. Details of the reference meters, related temperature and pressure transmitters and the resulting uncertainty will be enclosed in the calibration certificates issued by CEESI, Iowa.

Calibrations are performed in accordance with the American Gas Association Transmission Committee Report Number 9 using calibration standards that are traceable to the National Institute of Standards and Technology.
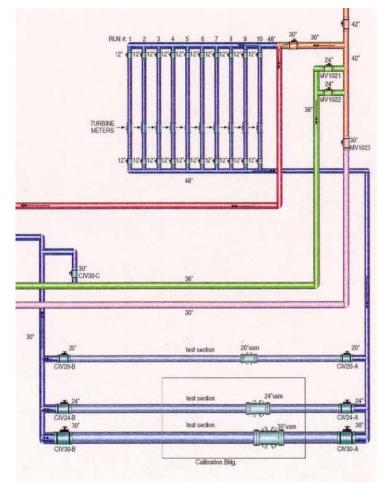
Each test point comprises the following:

1) 120 second count of turbine meter output frequency.
2) Pressure and temperature readings during each run.

Gas volume flow measurements can be transmitted from the MPU to the reference system using RS485 communication.

The flow rate at the reference turbine meter is converted to the conditions prevailing at the ultrasonic flow meter using ratios of pressure, temperature and real gas properties.

Data supplied to client may include the reading from the clients meter, the volumetric flowrate from the reference system, the meter calibration factor for each flow rate and the FWME (Flow Weighed Mean Error) for the complete calibration.

Appendix 1 - Reference Instrumentation, Force Technology, Vejen, Denmark

Force Technology is accredited by DANAK – the Danish Accreditation Body – for calibration and verification of all types of gas and flow meters, including ultrasonic meters. Since 1990 FORCE Technology has been the National Reference Laboratory for gas flow measurement.

The calibration bench includes six working standards and one meter section for building in meters for calibration. The natural gas is circulated in a loop by an axial compressor.

The calibration may be performed on pulse output, counters, mA and voltage outputs.

During calibration, gas temperatures, gas pressure, compressibility factor and pulses from the meter to be tested and the applied working standard/s are registered. All data is registered electronically and the meter's errors are determined and calculated.

Capacity:
Volume flow: 8 – 10000 am³/h
Dimensions: 2" – 16"
Pressure range: 0 – 50 bar
Uncertainty: <0,2%
Medium: Natural gas
Gas temperature: 10°C - 30°C
Traceability: PTB and NMI

Certificates hold all relevant information including gas composition and Reynolds numbers if any. The certificate will be issued in Danish or English languages, as requested by the customer.

Contact information is subject to change. For the current contact information, visit our website at www.fmctechnologies.com/measurement and click on the "Contact US" link in the left-hand column.

Headquarters:
500 North Sam Houston Parkway West, Suite 100 Houston, TX 77067 USA, Phone: +1(281) 260 2190, Fax: +1(281) 260 2191

Gas Measurement Products:
Erie, PA USA +1 (814) 898-5000
Ellerbek, Germany +49 (4101) 3040
Thetford, England +44 (1842) 82-2900
Kongsberg, Norway +47 (32) 286 700
Buenos Aires, Argentina +54 (11) 4312 4736

Integrated Measurement Systems:
Corpus Christi, TX USA +1 (361) 289 3400
Kongsberg, Norway +47 (32) 28 67 00
San Juan, Puerto Rico +1 (787) 772 8100
United Arab Emirates, Dubai +971 (4) 883 0303

Liquid Measurement Products:
Erie, PA USA +1 (814) 898-5000
Ellerbek, Germany +49 (4101) 304-0
Los Angeles, CA USA +1 (310) 328-1236
Slough, England +44 (1753) 57-1515
Barcelona, Spain +34 (93) 201 0989
Moscow, Russia +7 (495) 564 8705
Melbourne, Australia +61(3) 9807 2818

Beijing, China +86 (10) 6500 2251
Singapore +65 6861 3011
Chennai, India +91 (44) 450 4400

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