Test Report

Compressed Gaseous Fuel Measuring Systems for Vehicles

Test report for a coriolis mass flow meter

Projectnumber: 10201016
Test report N°: NMi-10201016-01

Issued by	:	NMi Certin B.V. Hugo de Grootplein 1 3314 EG DORDRECHT The Netherlands
Test Address	:	Electrabel CNG installation Waggelwaterstraat 1 Brugge Belgium
Test specifications	:	Investigation of a coriolis mass flow meter for compliance with the applicable parts of OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles", Edition 2007 (E). Investigation if the meter can be used for the verification of installed "Compressed Gaseous Fuel Measuring Systems for Vehicles".
Applicant	:	Tulsa Gas Technologies, Inc. 4809 S 101st East Ave Tulsa, OK, USA 74146
Manufacturer	:	Tulsa Gas Technologies, Inc.
Equipment under test	:	Prover PROV-50 with CNG050 Emerson meter
Testing period	:	24 April 2002
Signature	:	

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Date : 13 December 2010

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Test Report

General information

Application No.	:	10201016
Applicant	:	Tulsa Gas Technologies, Inc. 4809 S 101st East Ave Tulsa, OK, USA 74146

A coriolis mass flow meter intended to be used as a master meter for verification of installed "Compressed Gaseous Fuel Measuring Systems for Vehicles":

Pattern designation	:	CNG050, fitted with MVD electronics, model 700 and 2700.
Q_{max}	:	77 kg/min
Q_{min}	:	1,13 kg/min
Sensor type	:	CNG050S239NCAAEZZZ
Serial number sensor	:	880127
Transmitter type	:	2700
Serial number transmitter	:	2231529
FlowCalFactor	:	112.534,50 g/s/μsec
Mass flow damping	:	0,8 seconds
Temperature damping	:	2,4 seconds
Low Flow Cutoff	:	20 grams per minute

Scope

Scope of investigation:

Investigation of the coriolis mass flow meter given above, for compliance with the applicable parts of OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles", Edition 2007 (E).
Investigation if the above mentioned meter can be used for the verification of installed "Compressed Gaseous Fuel Measuring Systems for Vehicles".

Tests

The meter given above was submitted to accuracy tests on Compressed Natural Gas by weighing. An identical coriolis meter as a part of a CNG dispenser was used upstream. This meter was always "filled" with CNG, while the portable meter was "empty" when test started and full when test ended (see further details in Annex 2).
The MVD electronics were submitted to the environmental tests specified by OIML R 117 and OIML R 139 as reported in Test Report No. CVN/201269.

Conclusions

The meter given above meets the applicable requirements given in OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles", Edition 2007 (E) for batches with an average flow rate of 2 kg/min and higher.
The meter given above can be used as master meter to verify installed "Compressed Gaseous Fuel Measuring Systems for Vehicles".
The CNG050 meter performs well within the maximum permissible errors on CNG (MPE = 1%), when calibrated on water without changing meter settings in the electronics.

References

- OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles", Edition 2007 (E).
- Dutch national Test Certificate No. TC3478 of the MVD electronics
- Test report No. CVN/201269 on the MVD electronics

Annexes

Annex 1 : Test Results of the downstream meter
Annex 2 : Test setup, schematic
Annex 3 : Water Calibration Data of the meter

Introduction

A growing number of motor vehicles are equipped with engines which operate on natural gas. For the supply of gas to such vehicles special measuring systems are developed. An essential part of such a measuring system is the meter. OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles", Edition 2007 (E), specifies the metrological requirements applicable to these devices.

The submitted Micro Motion Coriolis mass flow meter basically consist of two components: a measurement sensor, known as CNG050, and an electronic flow transmitter, known as MVD. The MVD electronics, consisting of models 700 and 2700, have been submitted to the tests specified by OIML International Recommendation R117, edition 1995 "Measuring Systems for Liquids other than Water"; results are given in NMi test report No. CVN/201269.

The intention of the tests was to verify that the meter meets the OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles", Edition 2007 (E), applicable to CNG installations. Please note that this test report does not describe tests on a complete system, but tests on the meter only. Because the MVD electronics had already proven to meet metrological requirements, only accuracy tests were performed on the meter.

Test date : 24 April 2002
Test place : Electrabel CNG installation
Waggelwaterstraat 1
Brugge
Belgium

Test Method and Test Setup

During tests, two meters were installed in series. CNG was delivered into a container placed on a weighing device. Prior to testing, the weighing device was calibrated, using certified mass pieces. Thus, the test results are traceable to (inter)national standards. The expanded uncertainty in a single observation of the reference method during this test, based on a confidence level of 95% (k = 2), is no larger than 0,11%; type A is 0,10%, type B is 0,05%.

The upstream meter was well fixed, in December 2001, in an installation owned by Electrabel, intended for the measurement of CNG delivered to motor vehicles (CNG dispenser). This meter was mounted, case down orientated, in the installation with one upstream and one downstream plastic clamp. The CNG dispenser was designed in such a way that the meter always is pressurized and the flex hose emptied when no delivery takes place (see Annex 2).
The downstream meter was installed in a portable case; the sensor was mounted in a horizontal plane without up- and downstream clamp, lying in insulation foam. This meter was emptied after each test so that it was not pressurized at the beginning of every test.
The measurement data of both meters were gathered via connection of laptops to the service ports of the MVD electronics, model 2700.
The tests on the meters were intended for the Dutch national Approval of CNG meters and to prove the ability of the meter to operate as a master meter for the testing and verification of CNG dispensers, installed in the field.
Both meters were previously only calibrated on water, on the test facilities of the manufacturer, Emerson Process Management. The upstream meter was calibrated in November 2001 and already in use for a couple of months; the downstream meter was calibrated on 23 April 2002
(see the water calibration sheets in Annex 3).

Several types of tests were performed. Three times an empty tank was filled completely under pressures from about 0 to 200 bar. Twice a tank was half filled with pressures from about 0 to 110 bar, followed by a fill with a pressure from about 110 up to 200 bar.
Corrections for empty hoses/tubes were applied, based on theoretical calculation of corresponding volumes and actual densities. Confirmation for these corrections were obtained by observing the indication of the upstream meter when only the flex hose of the CNG dispenser was filled and by observing the indication of both meters when all hoses/tubes were filled up till the transfer point to the receiving tank (ball valve).
These corrections were also confirmed by placing the portable meter with its flex hose on the scale, before and after filling.
OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles", Edition 2007 (E), states different accuracy tests at constant mass flow rates. However, a test facility for performing such tests is not yet available in Europe. Therefore the tests, given above, were assumed to represent different worst case practical fills and therefore compatible with the OIML R 139.

Master Meter Method

In general Weights and Measures controlled measuring devices / systems, such as measuring systems for CNG, need to be tested using equipment with an expanded uncertainty (k = 2) at least five (for Pattern Approval) or three (for other Verifications) times better than the maximum permissible error applicable to that test (see opening paragraph of Chapter 8 of OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles", Edition 2007 (E)).
Other than that, there are no metrological requirements applicable to the method used for the investigation of measuring systems for CNG.

The first (or upstream) meter is the one built in the commercial installation owned by Electrabel. In series with this installation, a second meter with a valve and piping arrangement was installed. For a schematic overview of this proving setup, see Annex 2.
Tests on the meters were performed to prove whether or not they can be used for the verification of CNG measuring systems. As can be deducted from the opening paragraph of Chapter 8 of OIML R 139, one only needs to prove that the uncertainty of a proving method meets the general requirement given there.
In paragraph 3.1 of OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles", Edition 2007 (E), the maximum permissible errors applicable to the various investigations, are given. The strictest requirement applies to the Pattern Approval investigation of a meter alone: +/- 1%. This implies a maximum uncertainty in the test method for Pattern Approval of the meter of 0,20%; 0,30% for Pattern Approval of a system and 0,67% for all other verifications. An overview of the required maximum permissible errors and uncertainties in relation to the type of investigation, is given in the table below:

Description		Pattern Approval	Other Verifications
Meter alone	Maximum permissible error	+/- 1%	Not Applicable
	Maximum uncertainty	0,20%	
Complete measuring system	Maximum permissible error	+/- 1,5%	+/- 2%
	Maximum uncertainty	0,30%	0,67%

Note: the accuracy as specified by the manufacturer for the CNG050 meter:
+/- 0,5 % for flows between 2,95 and 77 kg/min

In Annex 1 the test results are given. When the combined expanded uncertainty in a single observation of these results is calculated one finds 0,22% uncertainty (k=2). Because this value also includes the type A uncertainty of the reference used during the investigation, the uncertainty of the tested meter must be smaller than that. During the tests, a weighing device was applied as reference to determine the mass of the delivered gas. The type A uncertainty in the test method (including ambient conditions and winds) is estimated to have been 0,10%. If this is subtracted from the 0,22% calculated above, the combined expanded uncertainty in a single observation of the Master Meter Method is 0,19%.
$((0{,}22^2 - 0{,}10^2)^{0{,}5} = 0{,}19)$
Therefore, this meter can be used as a reference for the Pattern Approval of a meter alone.

Water Calibration versus CNG results

In Annex 3 the water calibration data of the tested meter can be found. Without alteration of the meter settings within the electronics, the CNG tests were performed.

Given the results in Annex 1, one can conclude that a CNG050 can be calibrated on water and be applied on CNG without modification of the meter settings.

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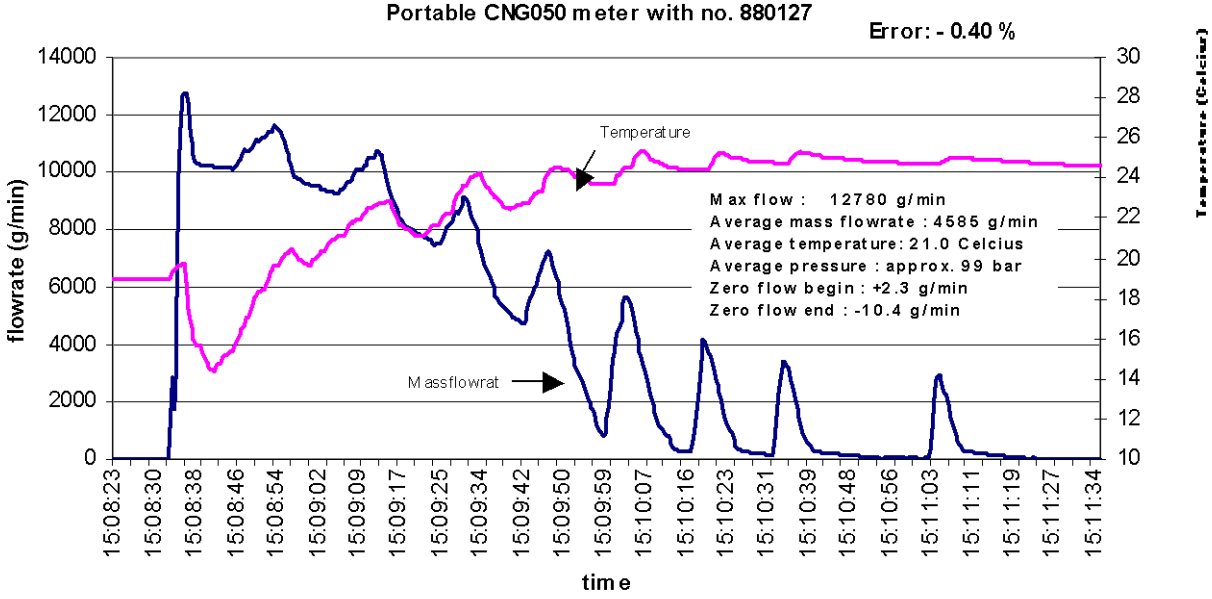
Results of downstream portable meter

		Downstream meter, incl.correction	Weighing Device		
Test No. [-]	Pressure [bar]	Mass [kg]	Mass [kg]	Error [%]	Remark [-]
1	0 - 197	13,076	13,129	-0,40	Average = -0,07 [%]
2	0 - 197	13,066	13,096	-0,23	
3	0 - 198	12,999	13,034	-0,27	
4A	0 - 110	7,240	7,252	-0,17	-
4B	110 - 197	5,593	5,622	-0,52	-
4C	0 - 197	12,833	12,874	-0,32	Calculated combination of A and B
5A	0 - 108	6,951	6,966	-0,22	-
5B	108 - 199	5,944	5,963	-0,32	-
5C	0 - 199	12,895	12,929	-0,27	Calculated combination of A and B
Average error of all observations : -0,30 %					
Type A expanded uncertainty in a single observation: 0,21%					
Combined expanded uncertainty in a single observation: 0,22 %					

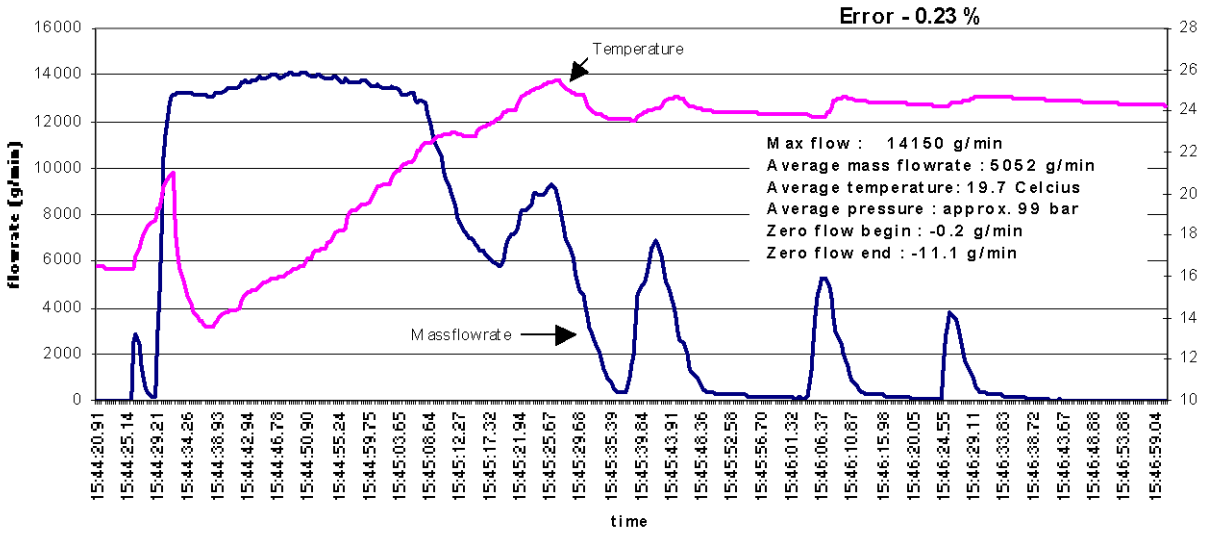
The graphs given below show plots of the flow rates and temperature over time during these tests, including data about maximum mass flow rate; average mass flow rate; average temperature; average pressure and zero flow rate at beginning and end.

Annex 1

Flowrate versus time during test 1
Portable CNG050 meter with no. 880127



Flowrate and temperature versus time during test 2
Portable CNG 050 meter with no. 880127



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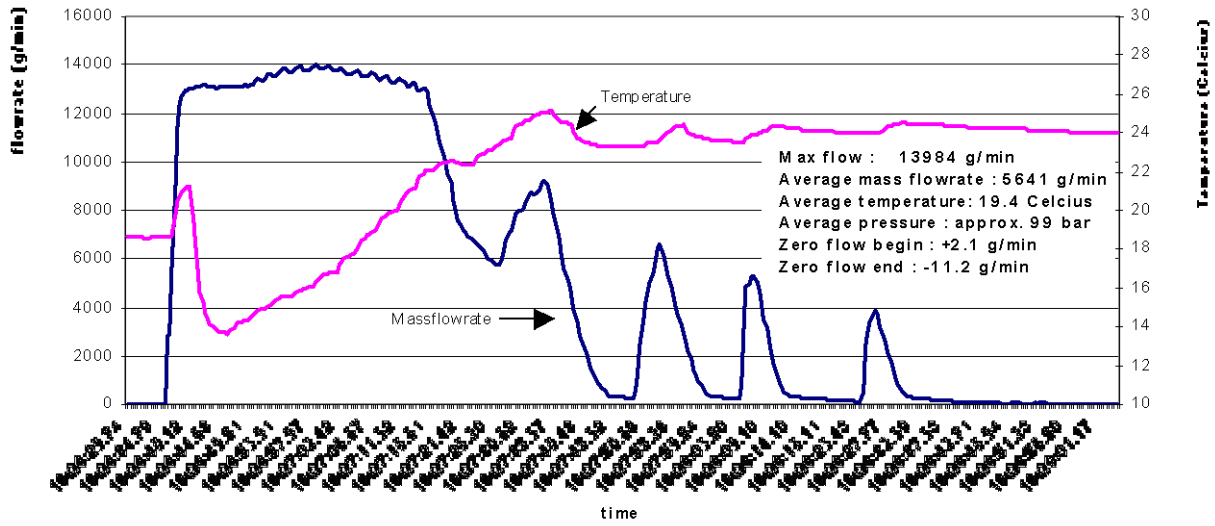
Flowrate and temperature versus time during test 3
Portable CNG050 meter with no. 880127

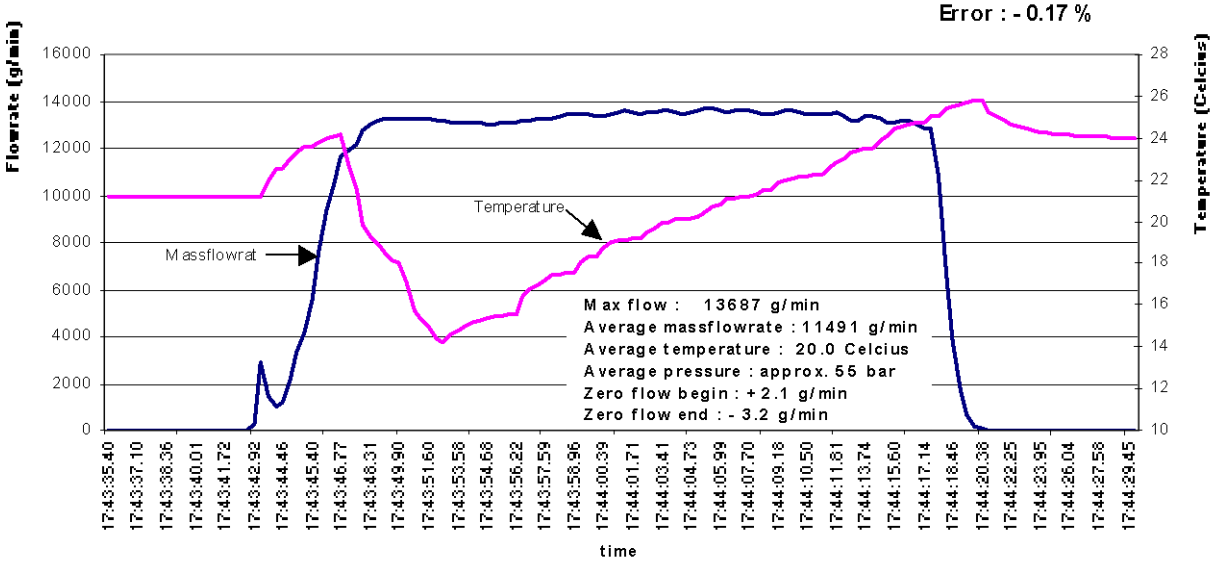
Error : - 0. 27 %



Annex 1

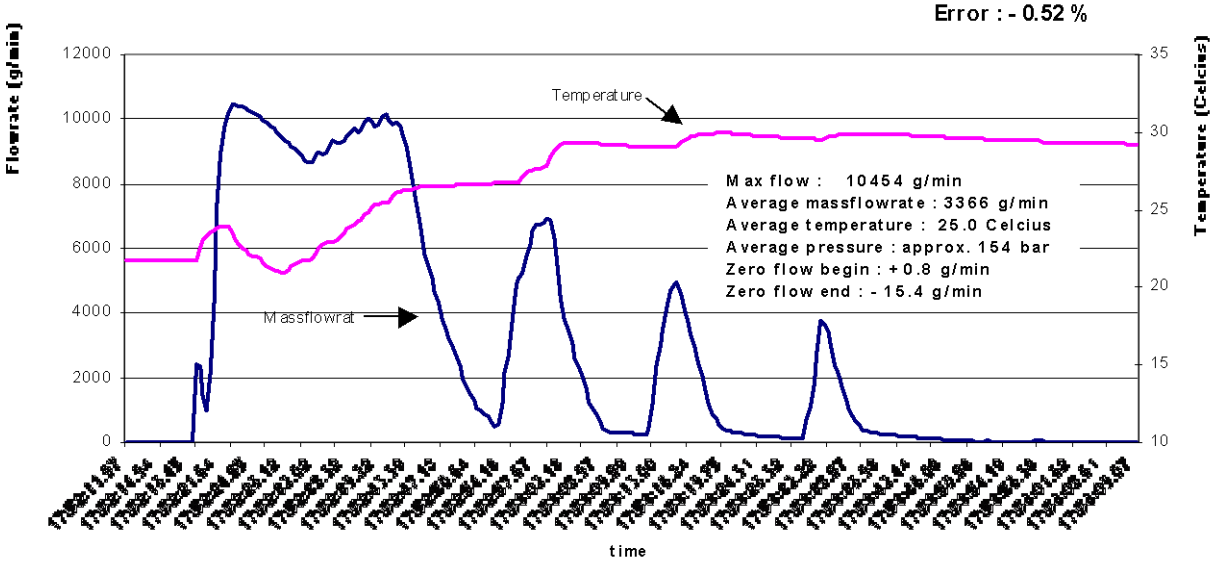
Flowrate and temperature versus time during test 4A
Portable CNG050 meter with no. 88017

Error : - 0.17 %



Flowrate and temperature versus time during test 4B
Portable CNG050 meter with no. 88017

Error : - 0.52 %



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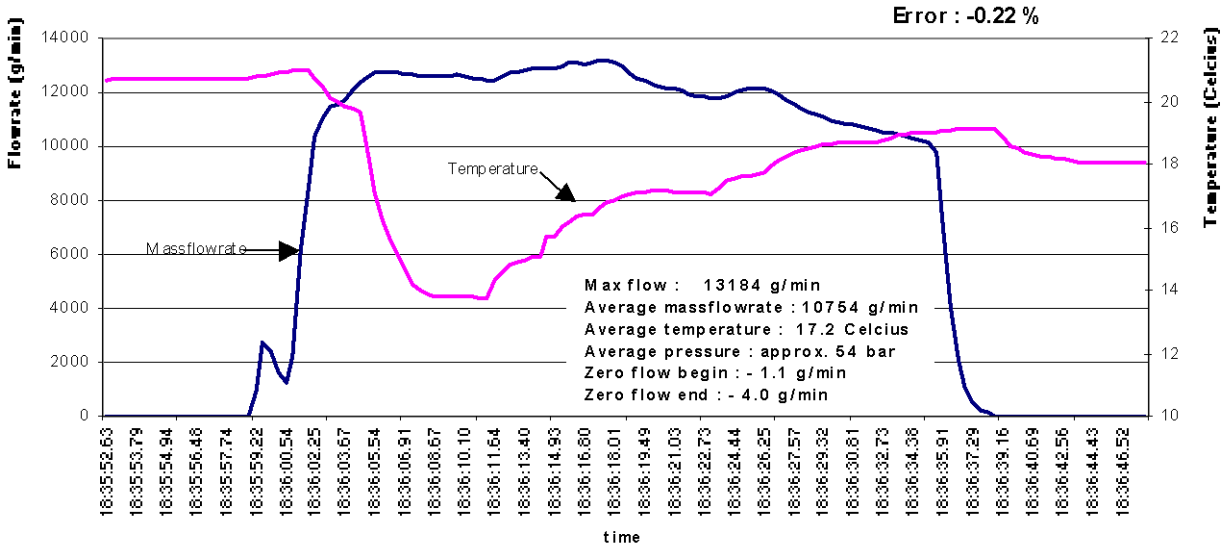
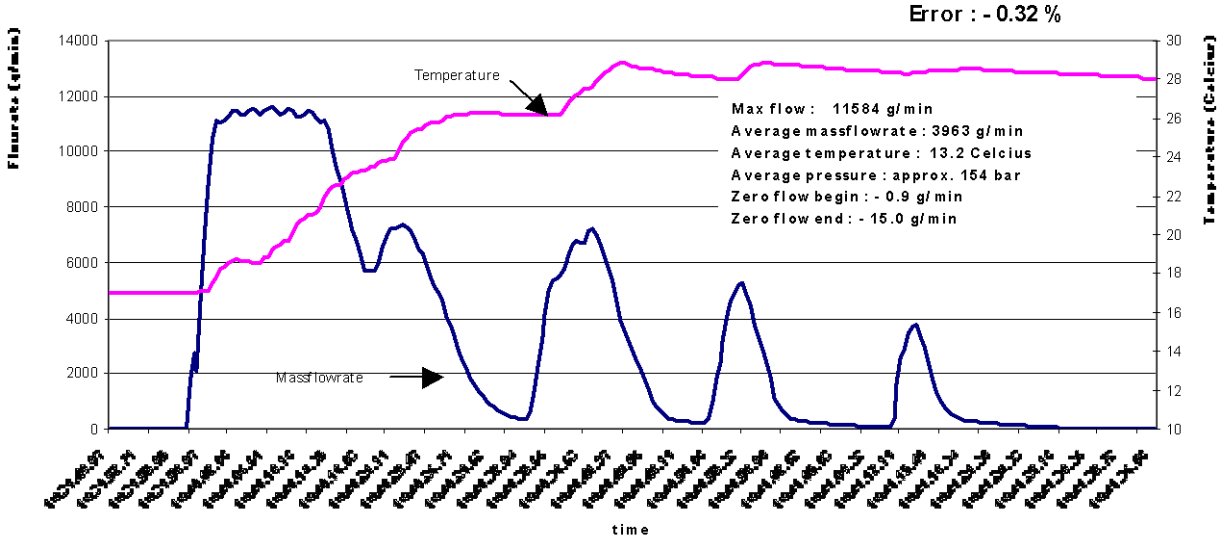
Flowrate and temperature versus time during test 5A
Portable CNG050 meter with no. 880127

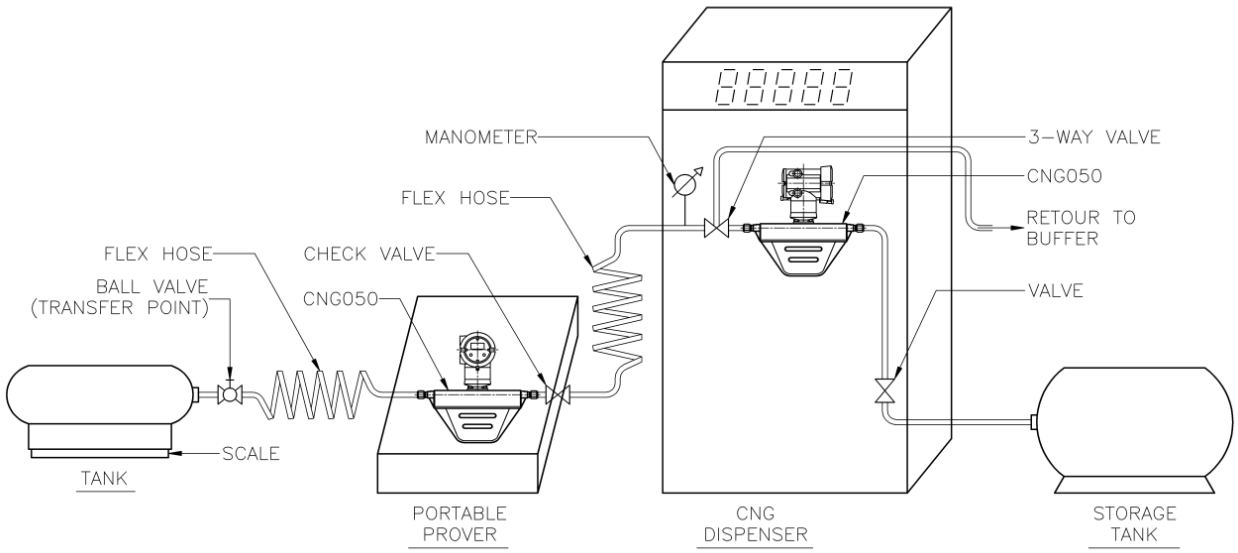


Flowrate and temperature versus time during test 5B
Portable CNG050 meter with no. 880127



Annex 2

Schematic drawing of test set up



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Water calibration data of downstream portable meter

Micro Motion, Inc. — Mass Flowmeter Calibration Certificate — **880127**

Product Code	Serial ID	Order ID	Line	Item	Customer Tag
CNG050S239NCAAEZZZ	880127	31014307	1	1	
2700R11DFZEZZZ	2231529				**STAND**

PUCK NO:014-00227

Process

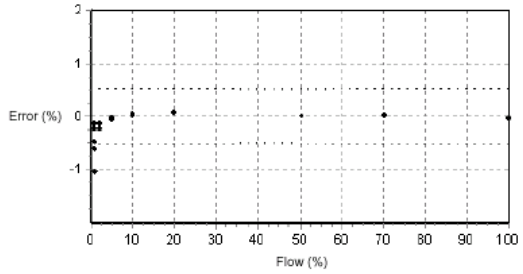
Process ID:2.2370034
Process Time:2002.04.23 11:26:31
Process Stand:32227 CMF050-300@SSCV
Stand Uncertainty:+/- 0.044%
Fluid:H20
100% Rate:77 KG/MIN
Pickoff:1

Results

Status:FAIL
D1:0
D2:1
K1:5111.891
K2:5307.754
DT:4.25
DensCal:05112053084.25
FD:0
DTG:0
DFQ1:0
DFQ2:0
FCF:112.53
FT:4.5
FlowCal:112.534.50
FFQ:0
FTG:0

BALLAST F.
Technician

Detail



Flow (%)	Nominal Flow Rate (kg/min)	Meter Total (kg)	Reference Total (kg)	Error (%)	Specification (±%)
100	77	77.956	77.992	-0.046	0.500
100	77	77.909	77.942	-0.042	0.500
100	77	77.703	77.752	-0.063	0.500
1	0.77	12.164	12.291	**-1.033**	
1	0.77	12.439	12.514	**-0.599**	
1	0.77	12.066	12.12	-0.446	
1	0.77	12.081	12.136	-0.453	
5	3.85	12.376	12.383	-0.057	0.500
5	3.85	13.514	13.524	-0.074	0.500
5	3.85	14.595	14.6	-0.034	0.500
10	7.7	19.33	19.329	0.005	0.500
10	7.7	13.099	13.096	0.023	0.500
10	7.7	12.79	12.787	0.023	0.500

Traceable to International Standards. Details at www.micromotion.com. 2002.05.16 10:36:41 1/2

Annex 3

Micro Motion, Inc.	Mass Flowmeter Calibration Certificate				880127
10	7.7	13.582	13.577	0.037	0.500
20	15.4	10.747	10.739	0.074	0.500
20	15.4	16.884	16.873	0.065	0.500
20	15.4	16.869	16.858	0.065	0.500
50	38.5	40.244	40.241	0.007	0.500
50	38.5	40.795	40.789	0.015	0.500
50	38.5	40.98	40.975	0.012	0.500
70	53.9	64.606	64.598	0.012	0.500
70	53.9	64.194	64.177	0.026	0.500
70	53.9	66.129	66.109	0.030	0.500
100	77	78.32	78.342	-0.028	0.500
1	0.77	12.115	12.131	-0.132	
1	0.77	12.358	12.388	-0.242	
2	1.54	12.107	12.135	-0.231	
2	1.54	12.774	12.792	-0.141	