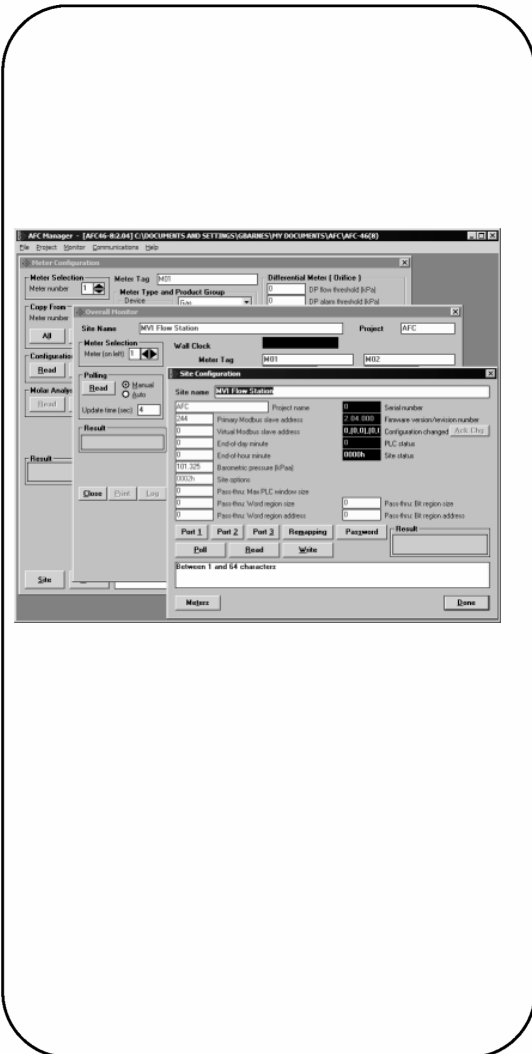


inRAx



MVI56-AFC

ControlLogix Platform

Gas and Liquid Flow Computer

Calculation Test Report (EUB Test Cases)

December 13, 2005



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1 Introduction

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This document provides the MVI56-AFC test procedures and results in order to verify the MVI56-AFC AGA calculation results. The Alberta Energy and Utilities Board (EUB) uses the test cases presented in this document. The test cases are listed in the EUB Production Audit Handbook Guide 46, section 3.2 (January 2003).

1.1 Test Assumptions

The Alberta Energy and Utilities Board (EUB) used the AGA3 (1990) test procedure for Orifice Calculation (using metric units) and the compressibility factors calculated using AGA8 (1992). Although the MVI56-AFC uses the AGA3 report (1992) the results are not affected, since the values are calculated in the same way in both reports.

The orifice plate was assumed to be made of 316 SS

The ideal gas relative density was converted to the real gas relative density.

The calculated values were rounded to four decimal places, since the theoretical values are given using the same format (EUB Guide 46).

The MVI56-AFC variables that are not mentioned in this document were not changed during the tests. These variables had the default value when a new AFC project is created with the AFC Manager.

1.2 Test Procedure

The tests consisted on reading the output values generated by the MVI56-AFC module through the AFC manager software and comparing the calculated results with the EUB expected results. Each meter was configured using the AFC Manager software and the input variables (Temperature, Pressure and Differential Pressure) were entered through the ladder logic. Each meter was used to test a different test case:

Meter Number	Test Case
1	1
2	2
3	3
4	4
5	5
6	6

Follows below the configuration used during the tests:

Firmware version	2.00.001
AFC Manager Software version	2.00.001
Controllogix processor	1756-L1/A (Logix 5550)

2 Test Cases

In This Chapter

➤ Test Case Number 1	7
➤ Test Case Number 2	9
➤ Test Case Number 3	11
➤ Test Case Number 4	13
➤ Test Case Number 5	15
➤ Test Case Number 6	17

In order to verify the MVI56-AFC calculation program the EUB uses 6 test cases that are described in this section. This section shows all input parameters and calculated results for each test case.

2.1 Test Case Number 1

Input Parameters

The following input parameters were used:

Gas Analysis

Element	Concentration
N ₂	0,0184
CO ₂	0,0000
H ₂ S	0,0260
C ₁	0,7068
C ₂	0,1414
C ₃	0,0674
iC ₄	0,0081
nC ₄	0,0190
iC ₅	0,0038
nC ₅	0,0043
C ₆	0,0026
C ₇	0,0022

Ideal Gas relative density = 0,7792

Meter Data (Downstream Flange Taps)

Meter Run I.D. = 52,3700mm

Orifice I.D. = 9,5250mm

Flow Data (24Hrs)

Static Pressure = 2716.765 kPag

Differential Pressure = 10.2000 kPa

Flowing Temperature = 57.0000 oC

Test Result

The result calculated by the module are listed below:

	Calculated Result	Theoretical Result	Actual Difference (percentage)	Allowed Difference (percentage)	Result
Cd	0.5990	0.5990	0.0000	0.1000	PASS
Y ₁	0.9989	0.9989	0.0000	0.0100	PASS*
Ev	1.0005	1.0005	0.0000	0.0100	PASS
Zb	0.9959	0.9959	0.0000	0.1000	PASS
Zf	0.9277	0.9277	0.0000	0.2000	PASS
Q	2.7532	2.7532	0.0000	0.2500	PASS

Where:

Cd = Orifice coefficient

Y₁ = Expansion Factor

Ev = Velocity of Approach

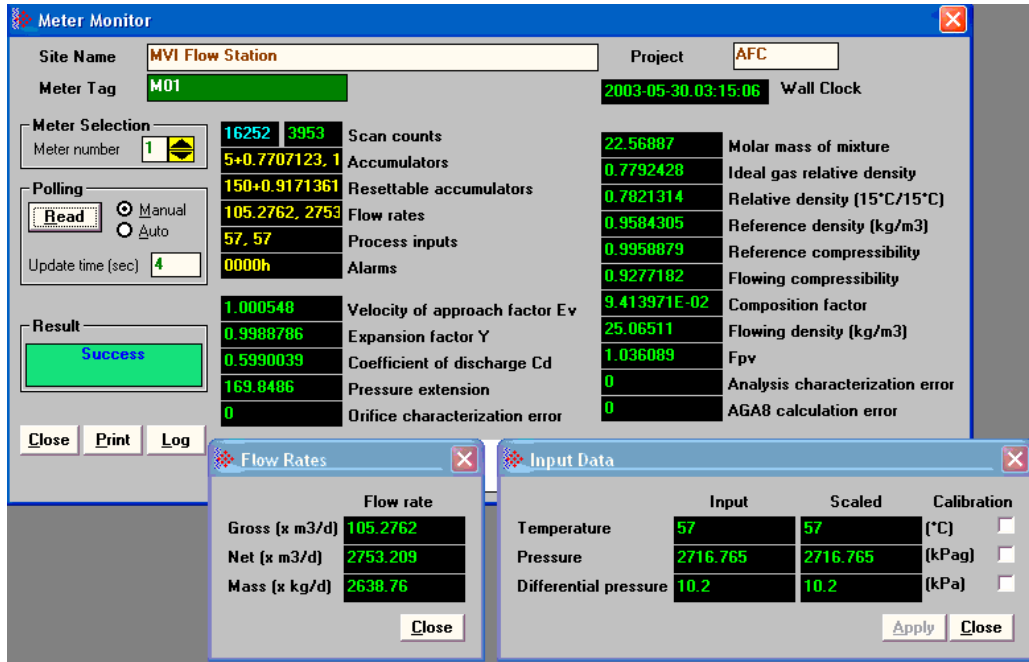
Zb = Reference Compressibility

Zf = Flowing Compressibility

Q = Flow Rate (103m³/24hours)

* Since the result is rounded to four decimal places, a maximum tolerance of 0.01% is interpreted as the maximum absolute deviation of 0.0001. Since the Y₁ result is usually a value less than 1.0000, the result is considered valid if the difference between the calculated and the theoretical values is less or equal than 0.0001.

Follows below a screen shot of the AFC Manager Meter Monitor window which shows the data results for this test:



2.2 Test Case Number 2

Input Parameters

The following input parameters were used:

Gas Analysis

Element	Concentration
N ₂	0,0156
CO ₂	0,0216
H ₂ S	0,1166
C ₁	0,7334
C ₂	0,0697
C ₃	0,0228
iC ₄	0,0044
nC ₄	0,0075
iC ₅	0,0028
nC ₅	0,0024
C ₆	0,0017
C ₇	0,0015

Ideal Gas relative density = 0,7456

Meter Data (Downstream Flange Taps)

Meter Run I.D. = 102,26mm

Orifice I.D. = 47,625mm

Flow Data (24Hrs)

Static Pressure = 8999,615 kPag

Differential Pressure = 11,0000 kPa

Flowing Temperature = 50.0000 oC

Test Result

The result calculated by the module:

	Calculated Result	Theoretical Result	Actual Difference (percentage)	Allowed Difference (percentage)	Result
Cd	0.6019	0.6019	0.0000	0.1000	PASS
Y ₁	0.9996	0.9996	0.0000	0.0100	PASS*
Ev	1.0244	1.0244	0.0000	0.0100	PASS
Zb	0.9967	0.9967	0.0000	0.1000	PASS
Zf	0.8097	0.8097	0.0000	0.2000	PASS
Q	146.1876	146.1800	0.0052	0.2500	PASS

Where:

Cd = Orifice coefficient

Y₁ = Expansion Factor

Ev = Velocity of Approach

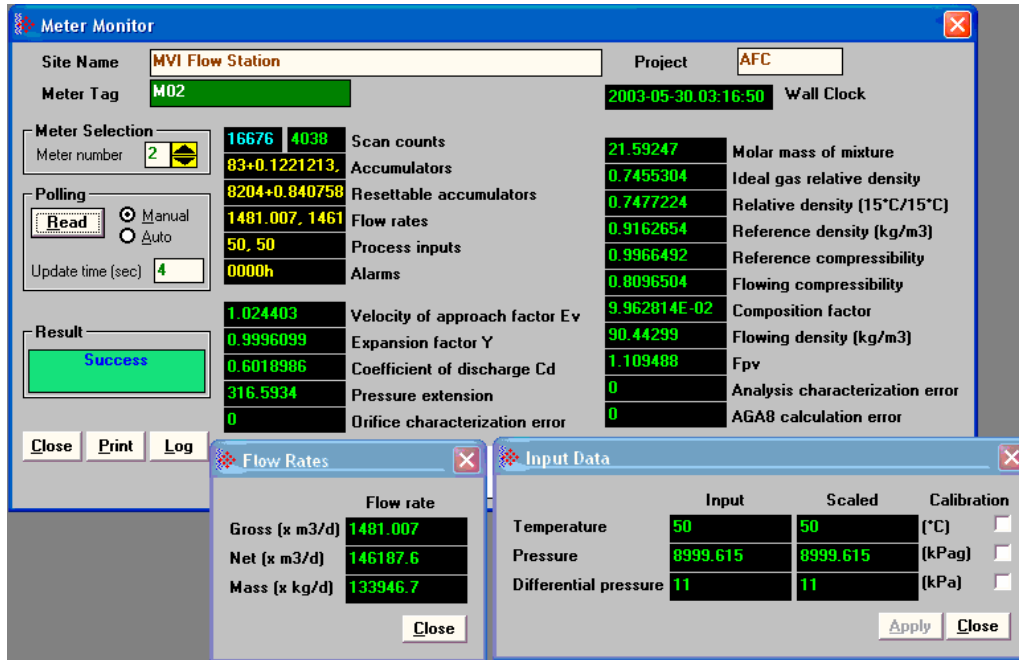
Zb = Reference Compressibility

Zf = Flowing Compressibility

Q = Flow Rate (103m³/24hours)

* Since the result is rounded to four decimal places, a maximum tolerance of 0.01% is interpreted as the maximum absolute deviation of 0.0001. Since the Y₁ result is usually a value less than 1.0000, the result is considered valid if the difference between the calculated and the theoretical values is less or equal than 0.0001.

Follows below a screen shot of the AFC Manager Meter Monitor window which shows the data results for this test:



2.3 Test Case Number 3

Input Parameters

The following input parameters were used:

Gas Analysis

Element	Concentration
N ₂	0,0500
CO ₂	0,1000
H ₂ S	0,2000
C ₁	0,6000
C ₂	0,0500
C ₃	0,0000
iC ₄	0,0000
nC ₄	0,0000
iC ₅	0,0000
nC ₅	0,0000
C ₆	0,0000
C ₇	0,0000

Ideal Gas relative density = 0,8199

Meter Data (Downstream Flange Taps)

Meter Run I.D. = 590,55mm

Orifice I.D. = 304,80mm

Flow Data (24Hrs)

Static Pressure = 10240,815 kPag

Differential Pressure = 22,1600 kPa

Flowing Temperature = 60.0000 oC

Test Result

The result calculated by the module:

	Calculated Result	Theoretical Result	Actual Difference (percentage)	Allowed Difference (percentage)	Result
Cd	0.6029	0.6029	0.0000	0.1000	PASS
Y ₁	0.9993	0.9993	0.0000	0.0100	PASS*
Ev	1.0375	1.0375	0.0000	0.0100	PASS
Zb	0.9968	0.9968	0.0000	0.1000	PASS
Zf	0.8213	0.8213	0.0000	0.2000	PASS
Q	8575.6480	8575.6000	0.0006	0.2500	PASS

Where:

Cd = Orifice coefficient

Y₁ = Expansion Factor

Ev = Velocity of Approach

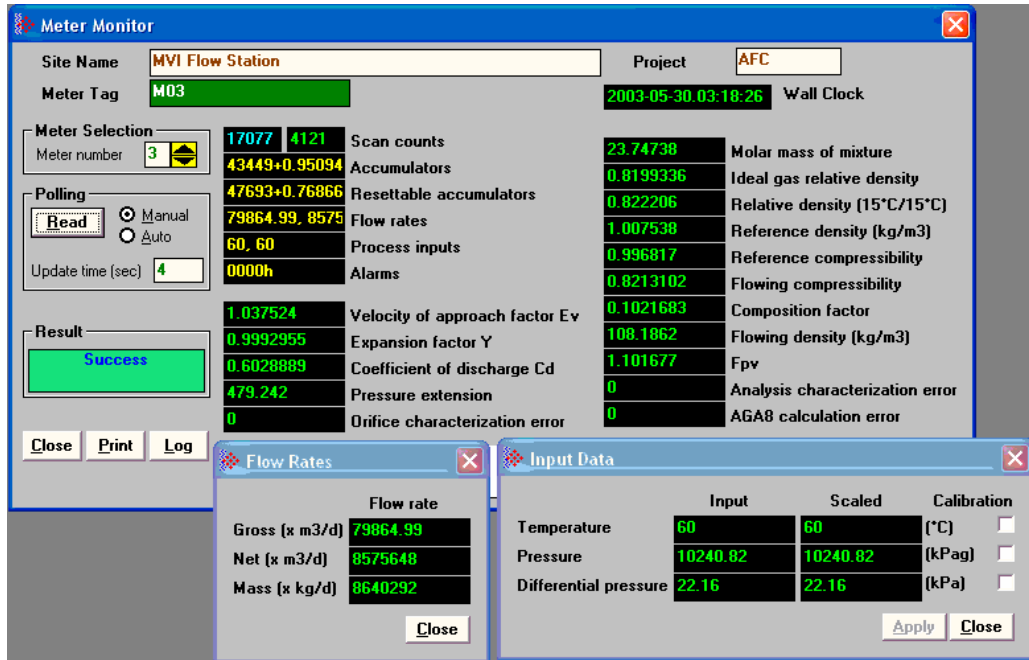
Zb = Reference Compressibility

Zf = Flowing Compressibility

Q = Flow Rate (103m³/24hours)

* Since the result is rounded to four decimal places, a maximum tolerance of 0.01% is interpreted as the maximum absolute deviation of 0.0001. Since the Y₁ result is usually a value less than 1.0000, the result is considered valid if the difference between the calculated and the theoretical values is less or equal than 0.0001.

Follows below a screen shot of the AFC Manager Meter Monitor window which shows the data results for this test:



2.4 Test Case Number 4

Input Parameters

The following input parameters were used:

Gas Analysis

Element	Concentration
N ₂	0,0029
CO ₂	0,0258
H ₂ S	0,0000
C ₁	0,9709
C ₂	0,0003
C ₃	0,0001
iC ₄	0,0000
nC ₄	0,0000
iC ₅	0,0000
nC ₅	0,0000
C ₆	0,0000
C ₇	0,0000

Ideal Gas relative density = 0,5803

Meter Data (Downstream Flange Taps)

Meter Run I.D. = 146,36mm

Orifice I.D. = 88,9000mm

Flow Data (24Hrs)

Static Pressure = 9738,665 kPag

Differential Pressure = 6,6130 kPa

Flowing Temperature = 22,3500 oC

Test Result

The result calculated by the module:

	Calculated Result	Theoretical Result	Actual Difference (percentage)	Allowed Difference (percentage)	Result
Cd	0.6047	0.6047	0.0000	0.1000	PASS
Y ₁	0.9998	0.9998	0.0000	0.0100	PASS*
Ev	1.0759	1.0759	0.0000	0.0100	PASS
Zb	0.9980	0.9980	0.0000	0.1000	PASS
Zf	0.8425	0.8425	0.0000	0.2000	PASS
Q	503.6474	503.6500	0.0005	0.2500	PASS

Where:

Cd = Orifice coefficient

Y₁ = Expansion Factor

Ev = Velocity of Approach

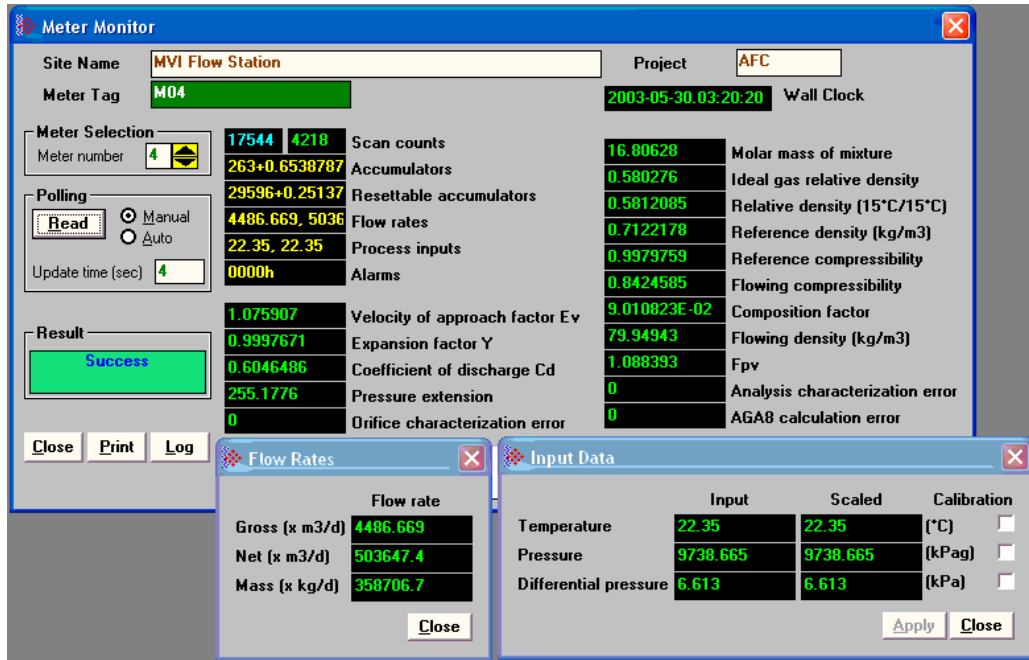
Zb = Reference Compressibility

Zf = Flowing Compressibility

Q = Flow Rate (103m³/24hours)

* Since the result is rounded to four decimal places, a maximum tolerance of 0.01% is interpreted as the maximum absolute deviation of 0.0001. Since the Y₁ result is usually a value less than 1.0000, the result is considered valid if the difference between the calculated and the theoretical values is less or equal than 0.0001.

Follows below a screen shot of the AFC Manager Meter Monitor window which shows the data results for this test:



2.5 Test Case Number 5

Input Parameters

The following input parameters were used:

Gas Analysis

Element	Concentration
N ₂	0,0235
CO ₂	0,0082
H ₂ S	0,0021
C ₁	0,7358
C ₂	0,1296
C ₃	0,0664
iC ₄	0,0088
nC ₄	0,0169
iC ₅	0,0035
nC ₅	0,0031
C ₆	0,0014
C ₇	0,0007

Ideal Gas relative density = 0,7555

Meter Data (Downstream Flange Taps)

Meter Run I.D. = 154,05mm

Orifice I.D. = 95,250mm

Flow Data (24Hrs)

Static Pressure = 2398,575 kPag

Differential Pressure = 75,000 kPa

Flowing Temperature = 34,0 oC

Test Result

The result calculated by the module:

	Calculated Result	Theoretical Result	Actual Difference (percentage)	Allowed Difference (percentage)	Result
Cd	0.6041	0.6042	0.0166	0.1000	PASS
Y ₁	0.9898	0.9897	0.0101	0.0100	PASS*
Ev	1.0822	1.0822	0.0000	0.0100	PASS
Zb	0.9962	0.9962	0.0000	0.1000	PASS
Zf	0.9217	0.9217	0.0000	0.2000	PASS
Q	813.1285	813.0000	0.0158	0.2500	PASS

Where:

Cd = Orifice coefficient

Y₁ = Expansion Factor

Ev = Velocity of Approach

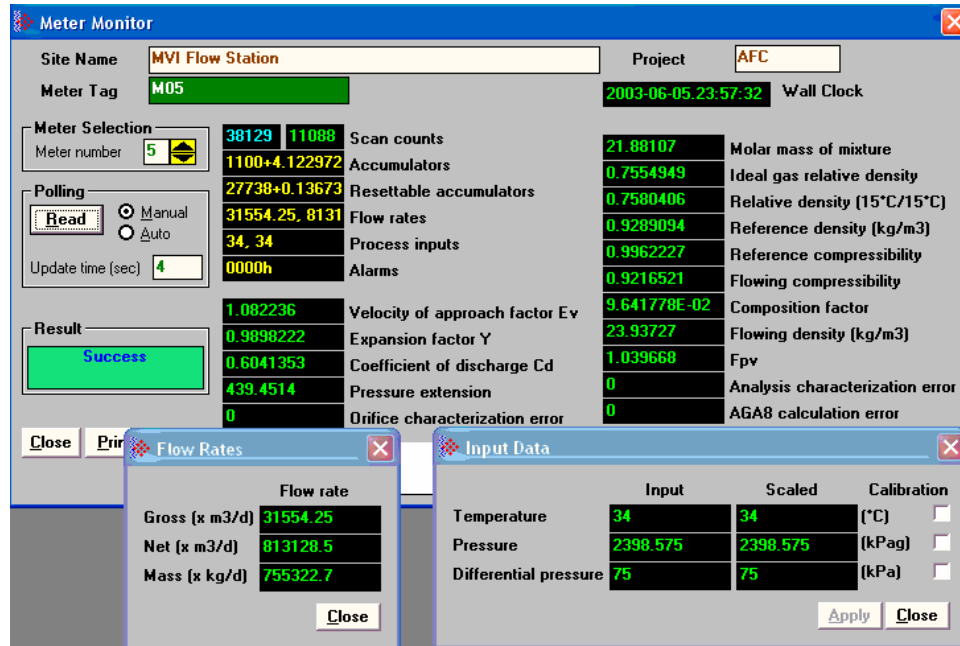
Zb = Reference Compressibility

Zf = Flowing Compressibility

Q = Flow Rate (103m³/24hours)

* Since the result is rounded to four decimal places, a maximum tolerance of 0.01% is interpreted as the maximum absolute deviation of 0.0001. Since the Y₁ result is usually a value less than 1.0000, the result is considered valid if the difference between the calculated and the theoretical values is less or equal than 0.0001.

Follows below a screen shot of the AFC Manager Meter Monitor window which shows the data results for this test:



2.6 Test Case Number 6

Input Parameters

The following input parameters were used:

Gas Analysis

Element	Concentration
N ₂	0,0268
CO ₂	0,0030
H ₂ S	0,0000
C ₁	0,6668
C ₂	0,1434
C ₃	0,1023
iC ₄	0,0123
nC ₄	0,0274
iC ₅	0,0000
nC ₅	0,0000
C ₆	0,0180
C ₇	0,0000

Ideal Gas relative density = 0,8377

Meter Data (Downstream Flange Taps)

Meter Run I.D. = 52,500mm

Orifice I.D. = 19,050mm

Flow Data (24Hrs)

Static Pressure = 2405,005 kPag

Differential Pressure = 17,0500 kPa

Flowing Temperature = 7,200 oC

Test Result

The result calculated by the module:

	Calculated Result	Theoretical Result	Actual Difference (percentage)	Allowed Difference (percentage)	Result
Cd	0.6005	0.6005	0.0000	0.1000	PASS
Y ₁	0.9979	0.9978	0.0100	0.0100	PASS*
Ev	1.0088	1.0088	0.0000	0.0100	PASS
Zb	0.9951	0.9951	0.0000	0.1000	PASS
Zf	0.8577	0.8578	0.0117	0.2000	PASS
Q	14.7468	14.7460	0.0054	0.2500	PASS

Where:

Cd = Orifice coefficient

Y₁ = Expansion Factor

Ev = Velocity of Approach

Zb = Reference Compressibility

Zf = Flowing Compressibility

Q = Flow Rate (103m³/24hours)

* Since the result is rounded to four decimal places, a maximum tolerance of 0.01% is interpreted as the maximum absolute deviation of 0.0001. Since the Y₁ result is usually a value less than 1.0000, the result is considered valid if the difference between the calculated and the theoretical values is less or equal than 0.0001.

Follows below a screen shot of the AFC Manager Meter Monitor window which shows the data results for this test:

The screenshot displays the 'Meter Monitor' window for 'MVI Flow Station' (Project: AFC). It shows a 'Success' result and various data points. Two sub-windows are open: 'Flow Rates' and 'Input Data'.

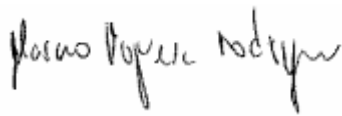
Flow Rates	
	Flow rate
Gross (x m3/d)	496.5763
Net (x m3/d)	14746.78
Mass (x kg/d)	15205.57

Input Data			
	Input	Scaled	Calibration
Temperature	7.2	7.2	(°C) <input type="checkbox"/>
Pressure	2405.005	2405.005	(kPag) <input type="checkbox"/>
Differential pressure	17.05	17.05	(kPa) <input type="checkbox"/>

3 Conclusion

The tests demonstrated that the MVI56-AFC correctly calculates the AGA results listed in this document with the accuracy given by the Alberta Energy and Utilities Board (EUB).

These tests were conducted by Eng Marcio N Rodrigues and were concluded on May 30th, 2003.



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