METER ERROR REPORT

FINAL

Reconcile?	Y

Safety Issue?	N

Thesis Report No.	

1. EXECUTIVE SUMMARY

SITE NAME	Weston Point MTB
LDZ	NW
START DATE (actual)	25/08/2011 12:51:00
LAST GOOD DATE	25/08/2011
END DATE	05/10/2011
SIZE OF ERROR (No reconciliation required if under 0.1%)	0.186% (23486 scm) over-registration
ESTIMATE – Y/N?	N
ROOT CAUSE	During a validation on 25th August 2011 the site technician did a double correction to derive another effective (erroneous) bore from the already corrected data.
ANALYSIS	Detailed within this report
METER TYPE	Orifice plate meter
AUTHOR	Piers Eldridge
CHECKED BY	Andrew Finch

2. BACKGROUND

Weston Point is a single orifice plate meter stream with a gas chromatograph for CV determination and PTZ correction.

During a validation on 25th August 2011 the site technician did a double correction to derive another effective (erroneous) bore from the already corrected data. The incorrect orifice bore was spotted by Gas Examiner (Phil Hensman) on 5th October 2011 and was corrected at noon.

3. ERROR QUANTIFICATION AND IMPACT

An orifice bore of 162.0716mm was entered into the flow computer configuration instead of the correct value of 162.2105mm.

$$Qm = \frac{C}{\sqrt{1-\beta^4}} \varepsilon \frac{\pi}{4} d^2 \sqrt{2 \cdot \Delta p \cdot \rho} \qquad -1$$

The maximum measured used DP during the period of the MER was 64.57mb. However the DP was around 4mb throughout the majority of the MER.

Therefore ignoring the upstream temperature correction the MER correction factor is defined in equation 2.

$$CF_{Qm} = \frac{C_1 \cdot \sqrt{1-\beta_2^{\ 4}} \cdot \varepsilon_1 \cdot d_1^{\ 2}}{C_2 \cdot \sqrt{1-\beta_1^{\ 4}} \cdot \varepsilon_2 \cdot d_2^{\ 2}} \qquad -2$$

CF_{Qm} is the correction factor.

The subscript 1 indicates the correct value and the subscript 2 indicates the incorrect value.

d is the bore diameter.

ε is the expansibility factor.

β is the beta ratio.

C is the coefficient of discharge.

$$CF_{Qm} = C_r \cdot \varepsilon_r \cdot d_r \cdot \frac{\sqrt{1-\beta_2^{\ 4}}}{\sqrt{1-\beta_1^{\ 4}}} \qquad -3$$

Where

$$C_r = \frac{C_1}{C_2} \qquad -4$$

$$\varepsilon_r = \frac{1-\left(0.41+0.35\beta_1^4\right)\frac{\Delta p}{\kappa P}}{1-\left(0.41+0.35\beta_2^4\right)\frac{\Delta p}{\kappa P}} \approx 1 \qquad -5$$

$$d_r = \frac{d_1^2}{d_2^2} \qquad -6$$

$$d = d_c\left(1+\alpha_o\left(T_o - T_{oc}\right)\right) \qquad -7$$

Where d_c is the certified bore

α_o is the orifice plate expansion coefficient.

T_o is the operating temperature.

T_{oc} is the temperature at which the plate was calibrated.

$$d_r = \frac{\left(d_{1c}\left(1+\alpha_o\left(T_o - T_{oc}\right)\right)\right)^2}{\left(d_{2c}\left(1+\alpha_o\left(T_o - T_{oc}\right)\right)\right)^2} \qquad -8$$

Therefore d_r is temperature dependant.

$$\beta = \frac{d}{D} \qquad -9$$

Where D is the pipe diameter.

$$D = D_c\left(1+\alpha_p\left(T_o - T_{pc}\right)\right) \qquad -10$$

Where D_c is the certified pipe diameter.
α_p is the pipe expansion coefficient.
T_{pc} is the temperature at which the pipe was calibrated.

$$\beta = \frac{d_c\left(1+\alpha_o\left(T_o - T_{oc}\right)\right)}{D_c\left(1+\alpha_p\left(T_o - T_{pc}\right)\right)} \qquad -11$$

Therefore $\frac{\sqrt{1-\beta_2^4}}{\sqrt{1-\beta_1^4}}$ is temperature dependant.

$$C = 0.5959 + 0.0312\beta^{2.1} - 0.184\beta^8 + 0.0029\beta^{2.5}\left(\frac{10^6}{\text{Re}}\right)^{0.75} + 0.9L_1\frac{\beta^4}{1-\beta^4} - 0.0337L_2\beta^3 \qquad -12$$

Where $\text{Re} = \frac{4 \cdot Qm}{\pi\mu_1 D}$ -13

$$L_1 = L_2 = \frac{0.0254}{D} \qquad -14$$

Therefore C_r is temperature and flowrate dependant.

The measured downstream temperature varied from about 9℃ to 35℃ over the period of the MER.
The incorrectly calculated flowrate varied from about 0.83kg/s to 10.5kg/s.
Table 1 shows the dimensions and beta ratio defined in equations 7, 10 and 11 at the minimum and maximum temperatures in the MER.

	Temp	d_2	d_1	D	β_2	β_1
Max	35	162.2474	162.1084	288.8114	0.561776	0.561295
Min	9	162.1799	162.041	288.7288	0.561703	0.561222

Table 1

Tables 2 and 3 show the Reynolds numbers and the coefficients of discharge defined in equations 12 and 13 for the maximum and minimum temperatures and flowrate measured during the MER.

	Temp	Re	C2	C1
Max	35	307,487.11	0.605381	0.605371
Min	9	307,575.06	0.605379	0.605369

Table2 Reynolds numbers and the coefficients of discharge at a mass flow rate of 0.83kg/s

	Temp	Re	C2	C1
Max	35	3,889,897.13	0.603967	0.60396
Min	9	3,891,009.79	0.603966	0.60396

Table3 Reynolds numbers and the coefficients of discharge at a mass flow rate of 10.5kg/s
Substituting the values in the tables into the equations gives the MER correction factors in table 4.

		Flow (kg/s)	
		Max	Min
Temp (°C)		10.5	0.83
Max	35	0.9980882	0.9980832
Min	9	0.9980883	0.9980833

Table 4.

The average correction factor was applied throughout with daily correction factors for the last (partial) day being derived as shown in table 5. All other (complete) days are shown in Table 8.

Date	Daily integrator increase	integrator increase when the incorrect bore was applied	Corrected integrator reading when the incorrect bore was applied	Corrected daily integrator reading	Correction factor
05/10/2011	309482	77779	77630.11155	309333.1115	0.999519

Table 5

The daily volumes for the 25th and 26th of August was corrected by the operator. The amended values are shown in table 6.

Date	Original Value	Amended Value
25/08/11	0.3158	0.3224
26/08/11	0.6346	0.3236

Table 6

The correction factors for the 25th and 26th of August have been derived in table 7.

Date	Daily integrator increase	integrator increase when the incorrect bore was applied	Corrected integrator reading when the incorrect bore was applied	Corrected daily integrator reading	Correction factor
25/08/2011	322400	228976	228537.6827	321961.6827	0.998640
26/08/2011	323600	217259	216843.112	323184.112	0.998714

Table 7

4. CAUSES

The format of the orifice plate certificate has been changed recently. Although the effective bore is highlighted and states “*Flow computer Entry*” the technicians are in the habit of applying the drain hole correction. The technician mistakenly applied the correction to the already corrected effective bore.

5. RECOMMENDATIONS AND LEARNING

The daily volumes should be reconciled as per Table 8 in the Appendix.

REFERENCES

07074 Weston Point MTB.pdf

VERSION HISTORY

Version	*Changes*	*Author*	*Date*
1	*First version*	*Piers Eldridge*	*22/12/2011*
2	*Updated taking the operator correction into account*	*Piers Eldridge*	*19/4/2012*
3	*Calculations in table 7 corrected*	*Piers Eldridge*	*15/06/2012*

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National Grid Gas Transmission – Measurement Assurance Group

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Appendix 1
Table 8 - Daily Correction Factors

Gas Date	Correction factor
25/08/2011	0.998640
26/08/2011	0.998714
27/08/2011	0.99808575
28/08/2011	0.99808575
29/08/2011	0.99808575
30/08/2011	0.99808575
31/08/2011	0.99808575
01/09/2011	0.99808575
02/09/2011	0.99808575
03/09/2011	0.99808575
04/09/2011	0.99808575
05/09/2011	0.99808575
06/09/2011	0.99808575
07/09/2011	0.99808575
08/09/2011	0.99808575
09/09/2011	0.99808575
10/09/2011	0.99808575
11/09/2011	0.99808575
12/09/2011	0.99808575
13/09/2011	0.99808575
14/09/2011	0.99808575
15/09/2011	0.99808575
16/09/2011	0.99808575
17/09/2011	0.99808575
18/09/2011	0.99808575
19/09/2011	0.99808575
20/09/2011	0.99808575
21/09/2011	0.99808575
22/09/2011	0.99808575
23/09/2011	0.99808575
24/09/2011	0.99808575
25/09/2011	0.99808575
26/09/2011	0.99808575
27/09/2011	0.99808575
28/09/2011	0.99808575
29/09/2011	0.99808575
30/09/2011	0.99808575
01/10/2011	0.99808575
02/10/2011	0.99808575
03/10/2011	0.99808575
04/10/2011	0.99808575
05/10/2011	0.999518911