NULL METER ERROR REPORT

FINAL (Delete as appropriate)

Reconcile?	N

Safety Issue?	N

Thesis Report No.	

1. EXECUTIVE SUMMARY

SITE NAME	Luxborough Lane	
LDZ		
START DATE (actual)	Approximately 2003	
LAST GOOD DATE		
END DATE	10/6/2020	
SIZE OF ERROR (No reconciliation required if under 0.1%)	-0.0004% in mass flow (and approximately in volume	
ESTIMATE – Y/N?	N	
ROOT CAUSE	Incorrect meter tube diameter	
ANALYSIS		
METER TYPE	Orifice	
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CHECKED BY	Piers Eldridge	
ACCEPTED BY CADENT NETWORK		
RECONCILIATION	Distribution	Transportation

2. BACKGROUND

Gas is supplied to part of the Cadent network at Luxborough Lane FWACV offtake. The site meter system comprises of two meter streams, MTA and MTB. Both meter streams use orifice plate meters.

During an audit carried out by Ben Kirkman of Kelton Engineering Ltd , it was noted that the incorrect upstream pipeline diameter was in use for flowrate calculation for one of the metering streams (MTA).

The MTA meter tube diameter (581.1605 mm or 22.880333”) has been calculated from the average of 12 diameters (cross-sections W,X,Y,Z taken at points 1, 2 and 3. The X-1 value has been incorrectly taken as 22.863” instead of 22.868”, due to human error reading data from the original British Gas databooks when these were interpreted in 2003. Therefore, the correct average should be 22.88075” (or 581.1711 mm).

3. THEORY

3.1. Calculation of Flow

The technology of an orifice plate meter is well established, with design and installation requirements described in ISO 5167 / AGA 3. The meter consists of a plate housed in a carrier, with sufficient lengths of upstream and downstream straight pipe to ensure fully developed uniform flow at the plate. The gas flow through the meter causes a pressure difference across the orifice plate, which is measured by differential pressure transmitters. The metering system at Luxborough Lane utilise three differential pressure transmitters:

low	0-50 mbar
high	0-500 mbar
standby	0-500 mbar

The low and high range transmitters are used in a switching arrangement, such that the low range reading is used in the flow calculation if the differential pressure is below approximately its maximum calibrated span and the high range value is used otherwise.

The mass flow rate is determined by the following formula:

$$q_m = \frac{C}{\sqrt{1-\beta^4}} \varepsilon \frac{\pi}{4} d^2 \sqrt{2\Delta P \rho}$$

Where:

q_m Mass rate of flow

C Coefficient of discharge

d Orifice plate diameter

Δp Differential pressure

β Diameter ratio

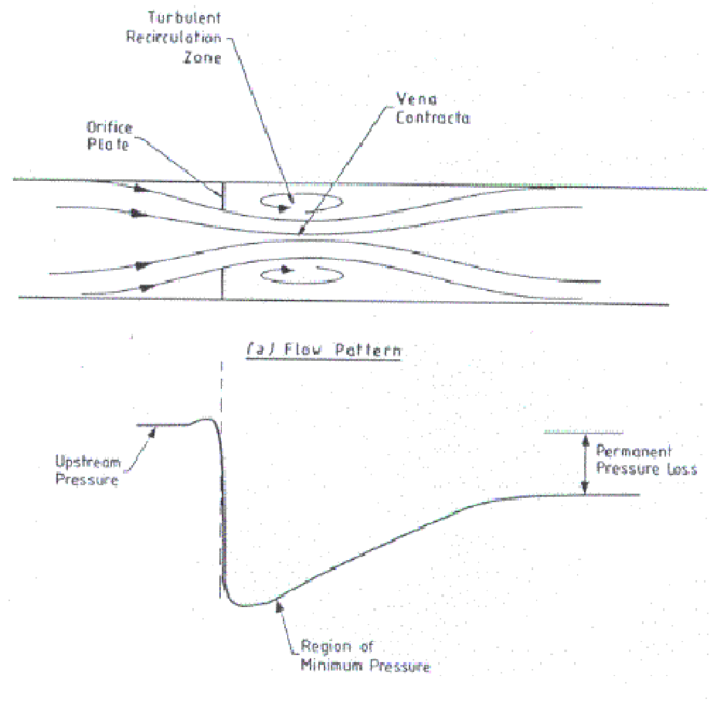
ε Expansibility (expansion) factor

ρ Mass density of fluid

The values for C and ε should be continuously computed to reflect prevailing flow conditions.

From the above equations it can be seen that the mass flow rate for orifice plates is a function of the discharge coefficient, which is a function of the Reynolds number, which in turn is a function of mass flow rate. An iterative procedure is therefore necessary to enable the value calculated for flow rate to converge to a final value. Details of this process are included in the ISO 5167.

Any deviation from the design conditions of the orifice plate and meter tube will lead to flow errors through the system. Examples of this are contamination of the orifice plate or the inside of the meter tube, rounded edges or damage to the sharp edge of the orifice plate, elastically or plastically deformed plates etc.



(b) Pressure Variation

3.2. Extracts from PD ISO TR 12767:2007 [2]

The following extracts from PD ISO TR 12767: 2007 highlight the importance of using correct measurement of upstream pipeline diameter.

7.1 Pipe diameter

The internal diameter of the pipe upstream and downstream of the primary device should always be measured to ensure that it is in accordance with 6.4 of ISO 5167-2:2003, 6.4 of ISO 5167-3:2003 or 6.4.1 of ISO 5167-4:2003. Errors in the upstream internal diameter measurement cause errors in the calculated flowrate, which are given by:

$$\frac{\delta q_m}{q_m} = \frac{-2\beta^4}{1-\beta^4}\frac{\delta D}{D}$$

These errors become significant for large β , e.g. with $\beta = 0{,}75$, a positive 1 % error in D will cause a negative 1 % error in q_m.

3. ERROR QUANTIFICATION AND IMPACT

The meter in operation had a bore diameter of 329.8308mm and a beta ratio of 0.5675. The error in meter tube diameter is calculated to have caused an error in mass flowrate of -0.0004%. Approximately the same error can be applied to volumetric flowrate, as the error in pipe diameter has a very limited impact on downstream temperature and therefore density.

4. CAUSES

The cause of the meter error was the incorrect taking of the upstream pipe diameter as 581.1605mm instead of the correct value of 581.1771mm, an error of 0.01055mm.

5. RECOMMENDATIONS AND LEARNING

No reconciliation is required. All meter tubes should be measured in compliance with ISO 5167.

REFERENCES

[1] ISO 5167 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full.

[2] PD ISO TR 12767:2007 Measurement of fluid flow by means of pressure-differential devices – Guidelines to the effect of departure from the specifications and operating conditions given in ISO 5167-1.

[3] FWACV Compliance Audits, Luxborough Lane NTS to LDZ Offtake Audit Report, Kelton Engineering Ltd

VERSION HISTORY

Version	*Changes*	*Author*	*Date*
1	*First issue*	W. van Woerden	27/07/2020
2	*Cadent comments included*		07/08/2020
3	*Cadent comments included*		14/09/2020