NULL METER ERROR REPORT

FINAL

Reconcile?	N

Safety Issue?	N

Thesis Report No.	

1. EXECUTIVE SUMMARY

SITE NAME	Saltwick	
LDZ	NO	
START DATE (actual)	12th December 2016	
LAST GOOD DATE		
END DATE	12th December 2016	
SIZE OF ERROR (No reconciliation required if under 0.1%)	<0.1%	
ESTIMATE – Y/N?	Y	
ROOT CAUSE	A fault with the flow control valve.	
ANALYSIS	System operator data	
METER TYPE	Orifice plate	
AUTHOR	Piers Eldridge	
CHECKED BY	Ben Hanley	
ACCEPTED BY NGN NETWORK		
RECONCILIATION	Distribution	Transportation

2. BACKGROUND

The metering at Saltwick offtake consists of a single orifice plate meter with a gas chromatograph used for volume correction.

On 12th December 2016 at 16:27 an issue occurred with one of the volumetric regulators and the technician in attendance appeared to lack the relevant knowledge to rectify the fault resulting in the measurement stream being over ranged 13 times.

The fault was rectified by 17:55.

3. ERROR QUANTIFICATION AND IMPACT

The results of previous CP11 tests (differential pressure transmitter checks) were evaluated to determine an average saturation current of 20.715mA. The differential pressure transmitter was ranged from 0-500 mbar. Therefore, the saturation current is equivalent to a differential pressure of 522 mbar.
Although the meter was over ranged 13 times, the differential pressure data from system operator shows only two periods where the differential pressure appeared to increase above the transmitter saturation pressure. The two periods are shown in Figure 1.

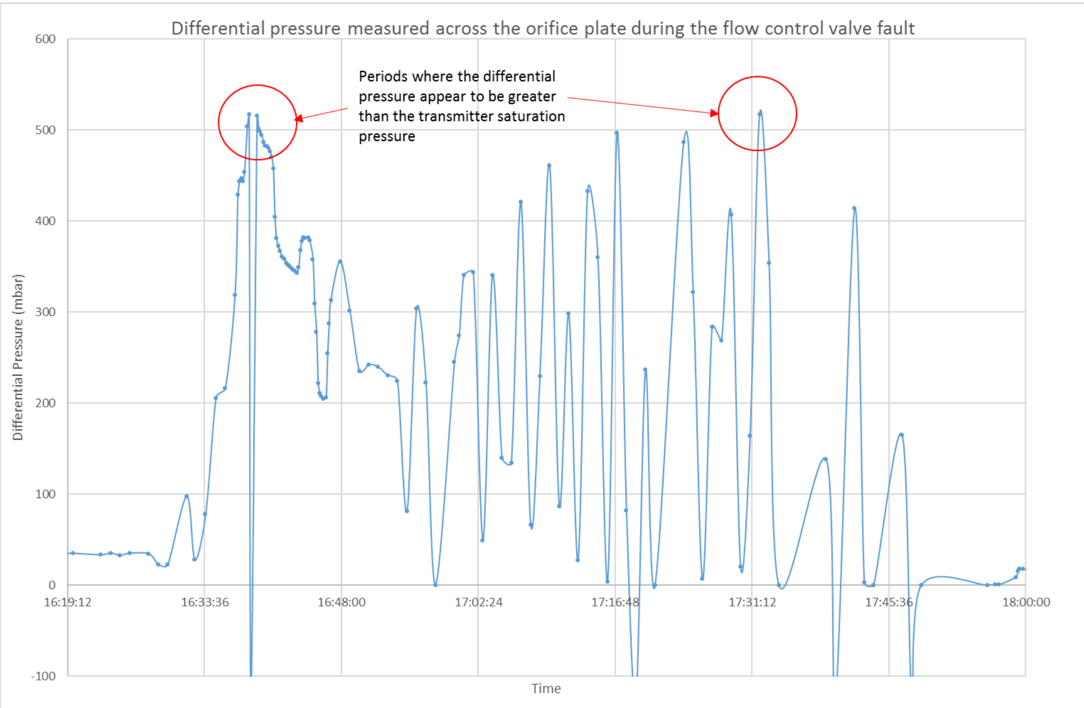


Figure 1 Differential pressure measured across the orifice plate during the flow control valve fault.

Mokveld was consulted to calculate the maximum flowrates through the valve during the two periods of mismeasurement. The information from Mokveld is shown in the appendix A.
In the first period where the differential pressure transmitter was saturated the upstream pressure was 56.1 bar.g, the downstream pressure was 36.59 bar.g, the downstream temperature was 7.6°C and the valve position was at 74.65% of the stroke. This is labelled as case 1 in the calculations from Mokveld in Figure 2. Mokveld calculate the maximum flowrate in these conditions to be 525 000 kg/h

when the valve is fully open. The graph provided by Mokveld shows that the flowrate through the valve would be about 76% of the total capacity when the valve position is at 74.65% of the stroke. Therefore, the maximum flowrate through the valve in case 1 is 399 000 kg/h. The standard volumetric flowrate was calculated to be 145.35 sm^3/s using an average composition that was measured during the meter error. The flowrate would produce a differential pressure of 617.4 mbar across the orifice plate. The calculation was done with an orifice bore 289.97mm of and pipe diameter of 433.451mm and is shown in Figure 3.

The flow rates between the data points have been modelled as parabolic. A parabolic equation was determined for each period which fits the existing data points and a nominal maximum flow rate. The data points for the first period where the differential pressure transmitter was saturated are shown in Table 1. The data from the control room is highlighted in bold. The other values are calculated from equation 1 which is the parabolic equation used to model the differential pressure. From the calculated differential pressure points, GasVLe was used to calculate the flow rates using the temperature, pressure and composition averaged for the corresponding period and another parabolic equation (equation 2) is calculated to model the flowrate. The standard volumetric flowrate equation was integrated from the point where the DP transmitter saturates, t1 to the point where the DP transmitter is not saturated, t2 to give the unmetered volume. This is shown in equation 3. If the maximum differential pressure during the first period where the differential pressure transmitter was saturated was 617.4 mbar the unmetered volume would be 537.2 sm^3.

$DP= -0.1678t^2+8.1884t+517.56$ (1

Where DP is differential pressure in mbar
t is the time in seconds

$q_v=-0.0295t^2+1.4103t+128.51$ (2)

Where q_v is the standard volumetric flowrate in sm^3/s

$$Error = \int_{t1}^{t2} q_v dt$$ (3)

Time	Seconds from the first data point	Seconds from transmitter saturation	Differential pressure (mbar)	Flowrate (sm^3/s)
12/12/2016 16:39:08		49.0	**517.03**	
Point where the DP transmitter saturates	47.8	48.3	522.00	128.51
Nominal maximum flow rate	24.0	24.5	617.4	145.36
Point where the DP transmitter is not saturated	0.0	0.5	521.45	128.51
12/12/2016 16:38:19		48.82	**515.22**	

Table 1 The data points for the first period where the differential pressure transmitter was saturated.

In the second period where the differential pressure transmitter was saturated the upstream pressure was 49.63 bar.g, the downstream pressure was 38.11 bar.g, the temperature was 6.4°C and the valve position was at 79.25% of the stroke. This is labelled as case 2 in the calculations from Mokveld in Figure 2. Mokveld calculate the maximum flowrate in these conditions is 447 000 kg/h when the valve is fully open. The graph provided by Mokveld shows that the flowrate through the valve would be about 82% of the total capacity when the valve position is at 79.25% of the stroke. Therefore, the maximum flowrate through the valve in case 1 is 366 540 kg/h. The standard volumetric flowrate was calculated to be 133.5 sm^3/s using an average composition for the Northern network. The flowrate would produce a differential pressure of 596.8 mbar across the orifice plate. The calculation is shown in Figure 4.

The calculations were repeated for the second period where the differential pressure transmitter was saturated. The data points are shown in Table 2, the equation for the differential pressure is equation 4 and the equation for the volumetric flowrate is equation 5. Integrating equation 5 from t3 to t4 gives an unmetered volume of 165 sm^3. Therefore, the total meter error would be 702.2 sm^3.

$$DP= -0.1802t^2+8.1012t+516.48 \quad (4)$$

$$q_v=-0.012t^2+0.5224t+128.51 \quad (5)$$

Time	Seconds from the first data point	Seconds from transmitter saturation	Differential pressure (mbar)	Flowrate (sm^3/s)
12/12/2016 17:33:00		60.0	**516.71**	
Point where the DP transmitter saturates	43.6	44.3	522.00	128.51
Nominal maximum flow rate	29.3	30.0	596.80	133.53
Point where the DP transmitter is not saturated	0	0.7	522.00	128.51
12/12/2016 17:32:00		0.0	**353.61**	

Table 2 The data points for the second period where the differential pressure transmitter was saturated.

The daily volume on the 12th December 2016 was 2.6074 Msm^3.

The total unmetered volume is 702.2 sm^3 and is below the 0.1% of daily volume threshold required for reconciliation.

4. CAUSES

The meter error was cause by a fault with one of the volumetric regulators and the technician in attendance appeared to lack the relevant knowledge to rectify the fault. The Mokveld ERS valve is approximately 25 years old and is no longer supported by Mokveld.

5. RECOMMENDATIONS AND LEARNING

Training of the network technicians should be extended to cover faults with the flow control valve.

REFERENCES

average composition.xlsx
temperature and pressure.xlsx
Saturation.xlsx
MER.xlsx

VERSION HISTORY

Version	*Changes*	*Author*	*Date*
Rev 1	*Original*	*Piers Eldridge*	*18/05/2017*
Rev2	*Sign off and Amended to NGN format*	*Ben Hanley*	*24/10/2018*

DISTRIBUTION

Asset Owner
Energy Performance
Network Lead Group
Asset Strategy

APPENDIX A

mokveld

Valve sizing calculation
Axial control valve

Client		Mokveld ref.		File name	*MESA rev013*
Project		Calculated by		Issue date	*08/05/2017*
Client ref.		Tag number(s)		Version	*v013*

Application		Pipe size NPS	*8*	*inch*
Medium	*Natural gas*	Wall thickness	*0.5*	*inch*

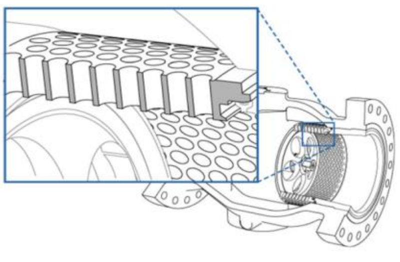
PROCESS CONDITIONS			***Case 1***	***Case 2***
Inlet pressure	P_1	[barg]	56.1	49.63
Outlet pressure	P_2	[barg]	36.59	38.11
Flow rate	Q	[kg/hr]	525000	447000
Inlet temperature	T_1	[deg. C]	8	6
Outlet temperature	T_2	[deg. C]	-2	1
Density gas	G_g	[MW]	18.16	18.16
Specific heat ratio (C_p/C_v)	κ	[-]	1.32	1.32
Compressibility in	Z_1	[-]	0.88	0.89
Compressibility out	Z_2	[-]	0.91	0.91

SIZING RESULTS				
Capacity required	C_v	[-]	792	853
% of selected capacity		[%]	76	82
Turndown ratio		[-]	1 : 233	1 : 251
Valve recovery factor	F_l	[-]	0.77	0.77
Valve outlet velocity	v	[m/s]	138	114
		[Mach]	0.36	0.29
Sound Pressure Level	SPL	[dBA]	104	100

SELECTED VALVE / TRIM CONFIGURATION

Valve model	*RZD-RCX*	Capacity Cv	*1045*
Size / rating	*8"* *ANSI 600*	Valve charact.	*Linear*

The RZD-RCX is a special control valve for both liquids and gases.
Its single-stage multi-orifice trim offers high capacity, low pressure recovery and relatively high noise abatement.



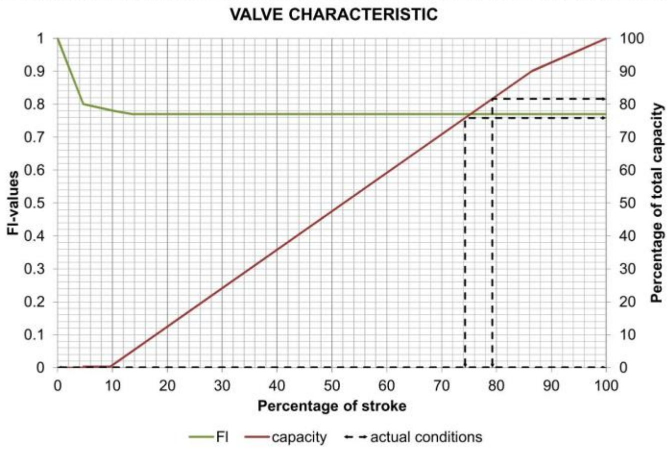


Figure 2 ERS Valve capacity calculations from Mokveld.

© Advantica Limited 2003 **Orifice Plate Design Calculations** GasVLe Add-in version 3.6 : GasVLe v6.1 : 17-May-2017 User: PJEL LOUL

Input quantities are shown in blue			Corrected inputs	Calculation options		Calculation results	
Gas Composition	nitrogen	0.925699	0.9257	Equation of State	AGA8		
	carbon dioxide	1.807321	1.8073			*T*	8 C
	methane	90.06426	90.0641			*P*	56.099998 bar
	ethane	5.271119	5.2711	Viscosity	NBS	Mass density	50.644196 kg/m^3
	propane	1.426467	1.4265			Isentropic index	1.3475449
	i-butane	0.162113	0.1621			Viscosity	0.0121056 mPa.s
	n-butane	0.234711	0.2347	*CV*	15°C / 15°C	*CV*	39.531891 MJ/m^3
	neo-pentane	0	0.0000			*RD*	0.6238
	i-pentane	0.041064	0.0411			*Z*	0.8543907
	n-pentane	0.039193	0.0392				
	n-hexane	0.028232	0.0282				
	total	100.0002 mol	100.0000 mol%				
Pipeline conditions	**Upstream**		**Downstream *T***			Flow	399079.32 kg/h
	Temperature *T*	8 C	7.55 C	*T* units	C		110.85537 kg/s
	Pressure *P*	56.1 bar		*P* units	bar	*dP*	617.40002 mbar
Meter Properties	**Calibration**		**Pipeline *T***			Reynolds Number	26901412
pipe diameter *D*	calibration *D*	433.451 mm	433.418 mm	Orifice type	Flange taps	Discharge Coefficient	0.6027513
	T coefficient	0.000011				Expansibility	0.996079
	calibration *T*	15 C		Flow method	5167:1991	Velocity of Approach	1.1182343
						P loss	0.3312454 bar
orifice diameter *d*	calibration *d*	289.970 mm	289.948 mm	*Q* units	kg	*CV*	51.715519 MJ/kg
	T coefficient	0.000011				Energy	20638594 MJ/h
	calibration *T*	15 C		*dP* units	mbar		5732.9428 MJ/s
Beta		0.669	0.669	Length units	mm		

Figure 3 orifice plate mass flow calculations for case 1.

© Advantica Limited 2003 **Orifice Plate Design Calculations** GasVLe Add-in version 3.6 : GasVLe v6.1 : 17-May-2017 User: PJEL LOUL

Input quantities are shown in blue			Corrected inputs	Calculation options		Calculation results	
Gas Composition	nitrogen	0.925699	0.9257	Equation of State	AGA8		
	carbon dioxide	1.807321	1.8073			*T*	6.9000001 C
	methane	90.06426	90.0641			*P*	49.630001 bar
	ethane	5.271119	5.2711	Viscosity	NBS	Mass density	44.235821 kg/m^3
	propane	1.426467	1.4265			Isentropic index	1.3337818
	i-butane	0.162113	0.1621			Viscosity	0.0118314 mPa.s
	n-butane	0.234711	0.2347	*CV*	15°C / 15°C	*CV*	39.531891 MJ/m^3
	neo-pentane	0	0.0000			*RD*	0.6238
	i-pentane	0.041064	0.0411			*Z*	0.8687524
	n-pentane	0.039193	0.0392				
	n-hexane	0.028232	0.0282				
	total	100.0002 mol	100.0000 mol%				
Pipeline conditions	**Upstream**		**Downstream *T***			Flow	366545.1 kg/h
	Temperature *T*	6.9 C	6.42 C	*T* units	C		101.81808 kg/s
	Pressure *P*	49.63 bar		*P* units	bar	*dP*	596.79999 mbar
Meter Properties	**Calibration**		**Pipeline *T***			Reynolds Number	25281300
pipe diameter *D*	calibration *D*	433.451 mm	433.412 mm	Orifice type	Flange taps	Discharge Coefficient	0.6027556
	T coefficient	0.000011				Expansibility	0.9956716
	calibration *T*	15 C		Flow method	5167:1991	Velocity of Approach	1.1182343
						P loss	0.3201917 bar
orifice diameter *d*	calibration *d*	289.970 mm	289.944 mm	*Q* units	kg	*CV*	51.715519 MJ/kg
	T coefficient	0.000011				Energy	18956070 MJ/h
	calibration *T*	15 C		*dP* units	mbar		5265.575 MJ/s
Beta		0.669	0.669	Length units	mm		

Figure 4 orifice plate mass flow calculations for case 2.