Client	**:**	**SCOTIA GAS NETWORKS**
Project Title	**:**	**BRAISHFIELD "B" MEASUREMENT ERROR REVIEW**
Document Title	**:**	**INDEPENDENT EXPERT SIGNIFICANT METER ERROR (SMER) - FINAL REPORT**
Document Ref.	**:**	**NK3173 – 006**
Client Ref.	**:**	**SO00114052010**

REV	ISSUE DATE	DESCRIPTION	PREP. BY	APP. BY
1	22/11/10	Draft - Issue for Comment	KV	
2	10/03/10	Additional Data Included - Final	KV	

Kelton Engineering Ltd, 2nd. Floor, Oakland Court, 26 Market Square, South Woodham Ferrers, Essex CM3 5XA
t: +44(0)1245 327707, f: +44(0)1245 327708, w: www.kelton.co.uk, e: info@kelton.co.uk

CONTENTS

1.0 INTRODUCTION

This report details the work carried out by the Appointed Independent Technical Expert (Keith Vugler of KELTON®) to complete a technical evaluation of a Significant Meter Error Report (SMER) raised by Southern Gas Networks (SGN) on their Braishfield "B" metering facility in Hampshire, England.

This SMER has been allocated a unique reference number by the Joint Office of Gas Transporters, SO001

In accordance with the "Measurement Error Notification Guidelines for NTS to LDZ Measurement Installations" document V2, 16/10/08, the SMER technical evaluation report will incorporate the requirements of section 10 (Generic Terms for an Appointed Independent Technical Expert) and additionally the requirements of section 14 (Business Rules for the Compilation of a SMER).

The report deliverables are therefore interpreted as follows;

- Define the technical methodology to derive a robust evaluation of the magnitude of the SMER
- Define the data requirements (supportive data) of the SMER
- Provide detailed data rules (for the evaluation methodology of the SMER)
- Define the technical evidence used in the evaluation methodology of the SMER
- Define the SMER period
- Application of the defined methodology in quantifying the SMER
- Presentation of the defined methodology to the technical work stream
- Review of all technical SMER issues
- Define the magnitude of the SMER for every day during the period on a Standard Volume basis and clearly identifying whether it's an over or under registration

2.0 EXECUTIVE SUMMARY

Section 3.0 of this report provides an overview of the SMER and confirms (with supportive data) the start and finish dates of the SMER period.

It must be recognised that unlike the methodologies available to define a measurement error that is associated with an incorrect numerical factor or indeed a "well defined" systematic bias which can be relatively precise in its retrospective calculation of the error, the cause of the Braishfield "B" SMER requires a more practical approach which will at best, be an informed estimate.

As the effect(s) of the cause cannot be quantified by substituting a corrective parameter within say a flow rate algorithm, the requirement to perform a series of controlled site tests, to replicate the cause and effect(s) under the same (or very similar) operational conditions seen during the SMER period was identified by the Independent Expert as the most appropriate technical methodology.

A site test procedure was developed (section 5.2 refers) and implemented at site on 4 separate occasions (providing a total of 12 individual tests – 3 per site visit) to ensure a representative coverage of the operational conditions seen during the SMER period.

The results obtained achieved good correlation and appeared to be unaffected by changes in operational conditions. The spread of test results were within 1% of each other which can be attributed to a function of the inherent uncertainty and repeatability of the test environment.

The SMER error has been calculated as an under-read of 40.737% and it is the recommendation of this report that a correction factor of 1.687 is used to multiply each of the Gemini end-of-day standard volume totals reported during the SMER period, to redress the effect of the flow measurement error.

The following "Significant Meter Error Notification" was first raised on 12/05/10;

Measurement Error Notification			
Unique Reference Number (Allocated by Joint Office)			
Error Status	Error Notified		
Brief Description	Differential pressure transmitter equalising valve open		
Reason Measurement Error Detected	System Operator linepack checks		
Process Dates	**Latest Notification Update**	12/05/2010	
	Anticipated MER/SMER Publication	12/11/2010	
Measurement Error Dates	**First Notified**	12/05/2010	
	Discovered	26/04/2010	
	Started (or last good read)	26/01/2010	
	Corrected	26/04/2010	
Offtake		Braishfield B MTB	BRABOF
Transporter	**Upstream**	National Grid - NTS	
	Downstream	Scotia Gas - DN	
Meter Type		Orifice	
LDZ		SO	
Average flow rates for the meter for the perceived duration of the Measurement Error (MCM/Day)		2.85	
Assessed volume of error (MCM)		107	
Estimated quantity of error (GWh)		1161	
Estimated Significance		High	>= 50 GWh
Systematic Bias?		Yes	
Over or Under Read?		Under	

Figure 3.1 – Measurement Error Notification

The cause of the Braishfield "B" SMER has been identified as being the result of an OPEN equalising valve on the common differential pressure transmitter (ΔP) isolation manifold.

It has transpired that following a visit on the **26th January 2010** to change-out the low range ΔP transmitter that had previously failed a routine ME2 check, the isolation manifold equalising value was left open on completion of the change-out activity.

The chart extract from the incident report (Figure 3.3 over page) supports the start date and time of the measurement error.

OFGEM SITE STATUS REPORT

Start Date: 20 JAN 2010

End Date: 20 FEB 2010

Location: BRAISHFIELD B OFON

Start Time	End Time	Stream Sample Point	Visit Type	Instrument Type	Danalyser Serial Number	Instrument
26-JAN-2010 09:30	26-JAN-2010 16:30	4/0 SO	NETWORK ENGINEERING MAINTENANCE	CHRO	UK52K667	DANI TURBO 500
Fault/ Maint Type	Rprtd	System 1 Alarm Status	Fault Rslvd	Comments	Signature	Tested Date
ME2	No	NONE	No Fault Found	CHANGED OUT LDP TRANSMITTER AND CALIBRATED NEW TRANSMITTER. ALL ME2 CHECKS COMPLETE EXCEPT FOR ORIFICE PLATE CHANGE AFTER LIGHTING STRIKE	NO LONGER USED	26-JAN-2010 16:30
Start Time	End Time	Stream Sample Point	Visit Type	Instrument Type	Danalyser Serial Number	Instrument
08-FEB-2010 05:30	08-FEB-2010 07:00	4/0 SO	NETWORK ENGINEERING FAULT	GATR	E030455997	EURO PEM1
Fault/ Maint Type	Rprtd	System 1 Alarm Status	Fault Rslvd	Comments	Signature	Tested Date
NEF	No	NONE	Resolved	METER SUSPECT ALARM B SYSTEM FOUND M1 OUT OF TOLERANCE ALARM ON OMNI AFTER CHECKING TRANSMITTERS FOUND HIGH HAD LOCKED UP POWERED DOWN TRANSMITTER AND POWERED BACK UP ALARM CLEARED.	NO LONGER USED	08-FEB-2010 08:16

Figure 3.2 – Braishfield "B" Site Log for 26/01/2010

Figure 3.2 above supports the ME2 site activity that took place during 26th January when the low range ΔP transmitter was changed-out.

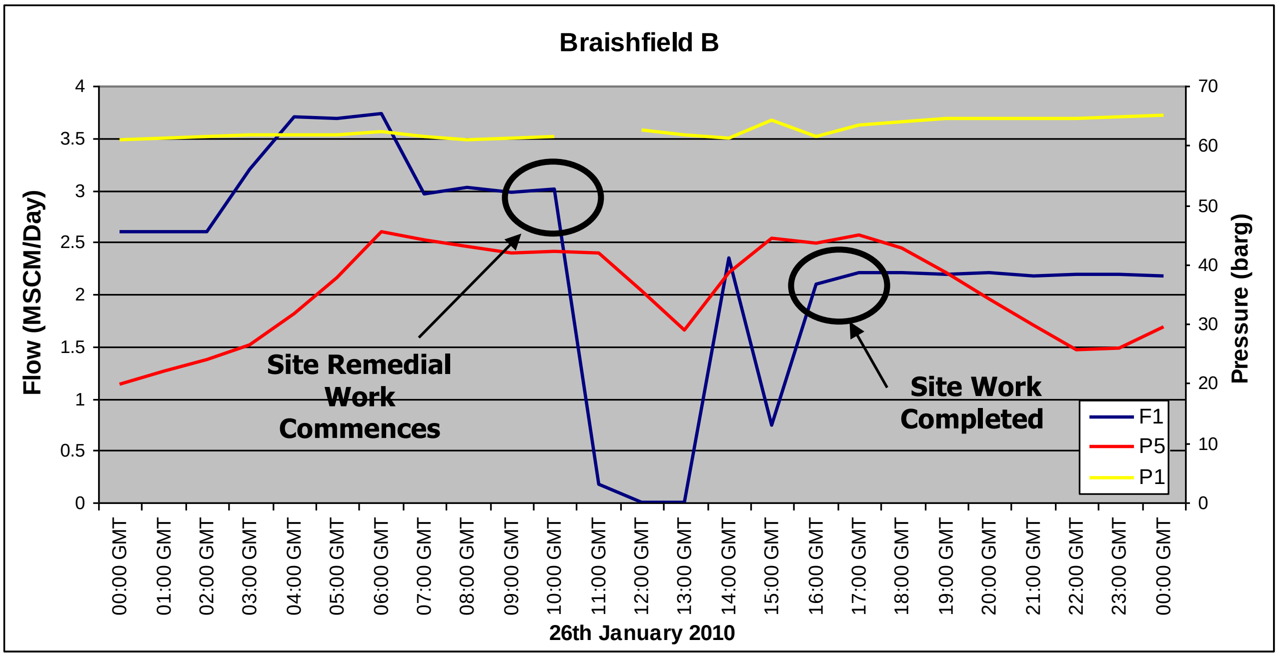


Figure 3.3 – Braishfield "B" Operating Data for 26/01/2010

The equalising value fault was identified on **26th April 2010** supported by the following statement of the C&I Technician attending site; "*On the 26th April 2010, I was made aware of the metering issue by Richard Keat and went to site to investigate, suspecting a configuration error of sorts. It was then I found the equaliser valve in the fully open position. I closed the valve and asked System Control to recheck the metering calculations and they confirmed the metering errors had cleared. I advised Richard Keat of what I found and he contacted Network Integrity to notify the metering error and to begin the investigation process".*

Figure 3.4 below supports the site activity that identified the low ΔP transmitter issue.

OFGEM SITE STATUS REPORT

Start Date: 20 DEC 2009

End Date: 30 APR 2010

Location: BRAISHFIELD B OFON

Start Time	End Time	Stream Sample Point	Visit Type	Instrument Type	Danalyser Serial Number	Instrument
26-APR-2010 15:09	26-APR-2010 15:09	4/O SO	NETWORK ENGINEERING FAULT	GATR	E030455997	EURO PEM1

Fault/ Maint Type	Rprtd	System 1 Alarm Status	Fault Rslvd	Comments	Signature	Tested Date
NEF	Yes	NONE	Resolved	CALL TO ATTEND METERING FAULT BRAISH B. INVESTIGATION FOUND DP EQ VALVE IN OPEN POSITION. CLOSED VALVE AT APPROX 12:00, METERING RESTORED. ADVISED HPMIS TEAM.	NO LONGER USED	26-APR-2010 15:09

Start Time	End Time	Stream Sample Point	Visit Type	Instrument Type	Danalyser Serial Number	Instrument
27-APR-2010 15:42	27-APR-2010 15:42	4/O SO	NETWORK ENGINEERING FAULT	GATR	E030455997	EURO PEM1

Fault/ Maint Type	Rprtd	System 1 Alarm Status	Fault Rslvd	Comments	Signature	Tested Date
NEF	Yes	GT8H	Resolved	INTERMITTANT ALARM. HIGH DP CELL SLIPPED CALIBRATION - CREATING METER SUSPECT AND HPD OUT OF TOL ALARMS. RECALIBRATE CELL AND REINSTATE. FAULTS CLEARED.	NO LONGER USED	27-APR-2010 15:42

Figure 3.4 – Braishfield "B" Site Log for 26/04/2010

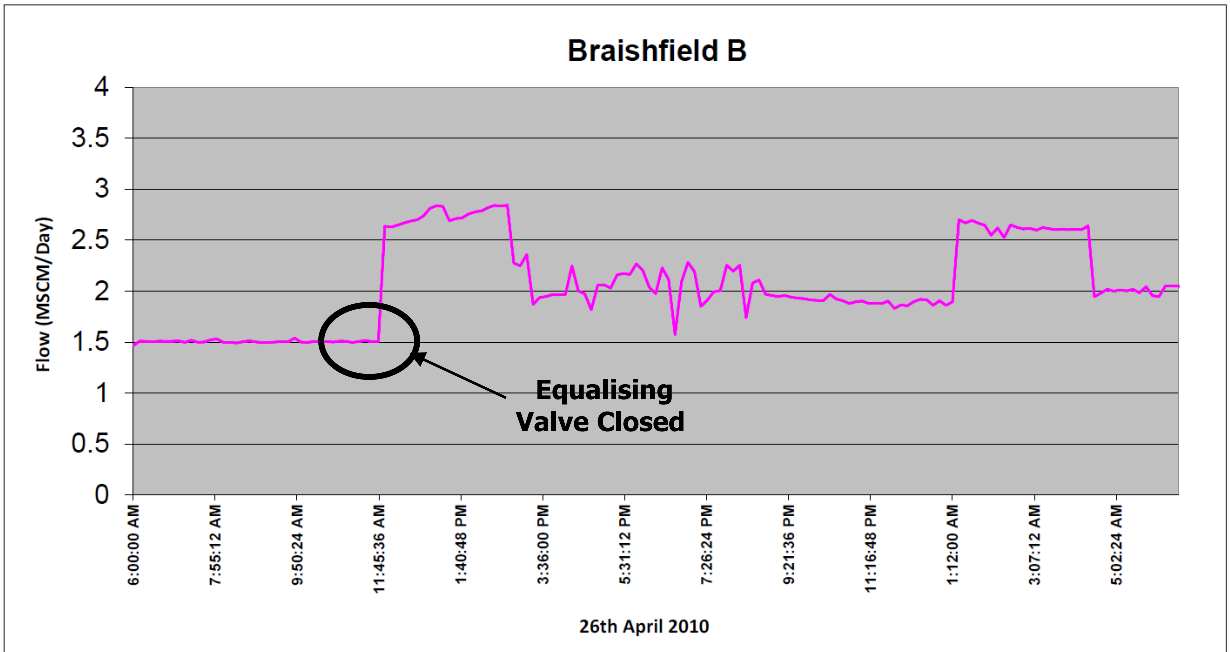


Figure 3.5 – Braishfield "B" HPMIS Data for 26/04/2010

The graph within Figure 3.5 supports the date and time that the measurement error was rectified. This graph is populated from the High Pressure Metering Information System (HPMIS) which is updated (locally at site) typically every 8 minutes. The OMNI flow computer flow rate data & all field measurement data is then held within the Allen-Bradley database and communicated with HPMIS at the end of each gas day at 06:00. The Calorific Value (CV) is additionally transmitted to National Grid at Warwick where it is used to calculate the total Energy flow from the HVOL figures (Hourly Volume) within GEMINI (Figure 3.6 below refers).

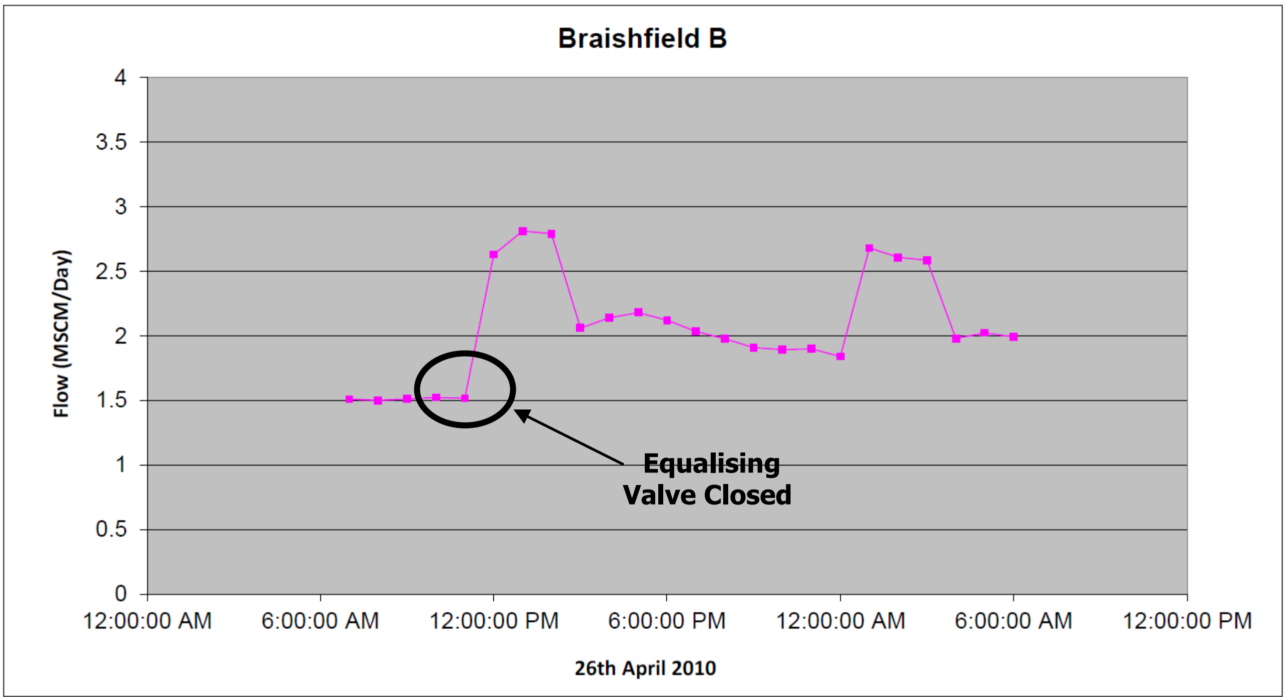


Figure 3.6 – Braishfield "B" HVOL Data for 26/04/2010

Additionally, the graph within Figure 3.6 again supports the date and time that the measurement error was rectified. However, this graph is populated from the HVOL data which is the result of 2 minute telemetry scans of the OMNI integrated total & instantaneous flow values. The Gas Transmission Measurement System (GTMS) receives these scans & produces hourly volume data. These hourly volumes are communicated with National Grid at Warwick (GEMINI data) where it is used to calculate the total Energy flow from the CV received from HPMIS (Figure 3.5 refers).

From the information shown within Figures 3.2 to 3.6, the period of the SMER can be confirmed as;

- **Start – 16:00 hrs on 26th January 2010**
- **Finish – 12:00 hrs on 26th April 2010**

It can be confirmed that additional calculations performed by Gas Control, based on comparing the indicated flow rates at Braishfield B with the exit flows and line-pack change within the downstream system, were reviewed in detail by the ITE.

These calculations conclude that an error in the order of 42% was evident during the duration of the SMER period and therefore supported the results obtained from the site testing activities.

These calculations were typically derived using the following formula;

"Line-pack [or HP storage] hourly change = Braishfield B hourly volume less total hourly exit flows"

The system downstream of Braishfield B was relatively simple to analyse as there is only 4 exit points, all of which are metered to contractual quality requirements (and hence low uncertainty) with associated flow data made available to Gas Control via telemetry.

As previously stated, the cause of the Braishfield "B" SMER has been identified as being the result of an OPEN equalising valve on the common differential pressure transmitter (ΔP) isolation manifold. The manifold design is shown below;

Figure 3.7 – Common ΔP Isolation Manifold

Figure 4.1 – Site Layout

The Braishfield "B" metering system comprises a single 12" meter run fitted with a Daniel Junior (single chamber) orifice fitting.

Figure 4.2 – Daniel Orifice Fitting

The meter run has a total upstream straight length of approximately 57 pipe diameters (D) after which the pipe goes underground by means of a 45^o bend. 41D upstream of the orifice fitting is a full bore inlet isolation valve.

Figure 4.3 – Upstream Pipe Section

Figure 4.4 – Upstream Pipe Section Inlet

Figure 4.5 – Normally Buried Inlet Section

Immediately downstream of the orifice fitting there is a flanged section of straight pipe approximately 6D long. 4D downstream of the flange the pipe goes underground by means of a 45^{o} bend.

A 4-wire RTD temperature element is installed in an insertion pocket approximately 7D downstream of the primary device, downstream of the flanged section of pipe.

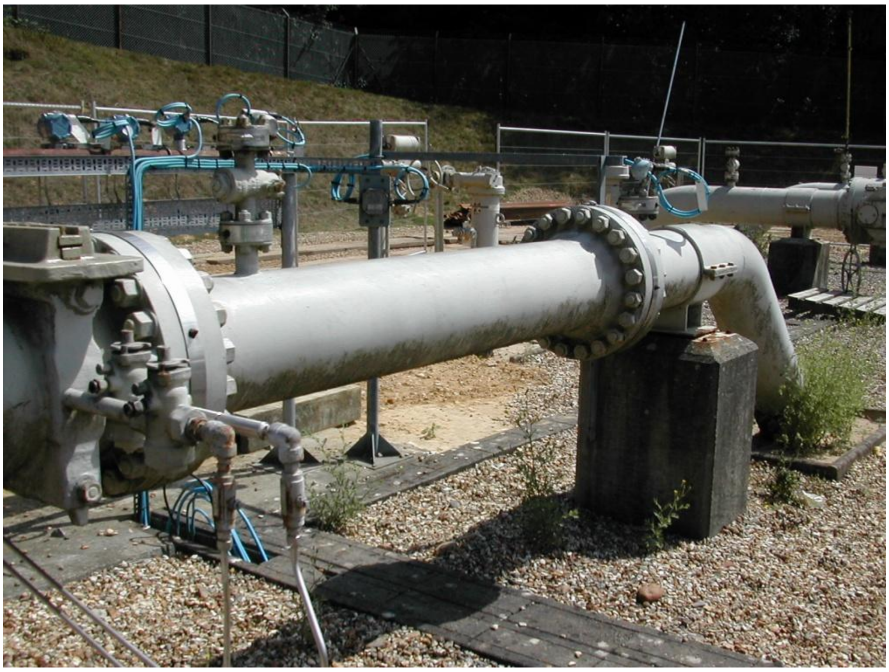


Figure 4.6 – Downstream Pipe Section

The upstream and downstream straight lengths, including the orifice fitting and temperature flange are not insulated. An orifice plate with β = 0.639 was installed at the time of the site visit.

There is a nominal 450 mm diameter underground by-pass line common to the Braishfield A and B meter runs with an isolation valve at each end. Both of the by-pass valves were closed and the upstream valve actuator had been sealed on behalf of OFGEM.

Differential pressure (ΔP) is measured by two high range and a single low range transmitter (calibrated 0-500 and 0-50 mbar respectively). The high range ΔP transmitters are operated in duty/standby mode. The high (duty) transmitter is a Rosemount type 1151, the high (standby) transmitter is a Rosemount type 3051 and the low transmitter is a Rosemount type 1151. The ΔP transmitters are isolated with a single 5-valve manifold with a single equalising valve. A Honeywell ST 170G pressure transmitter is used to measure line pressure.

The pressure impulse lines are installed with a fall from the orifice fitting tappings and the transmitters to catchpots fitted with drain valves. The lines are not insulated.

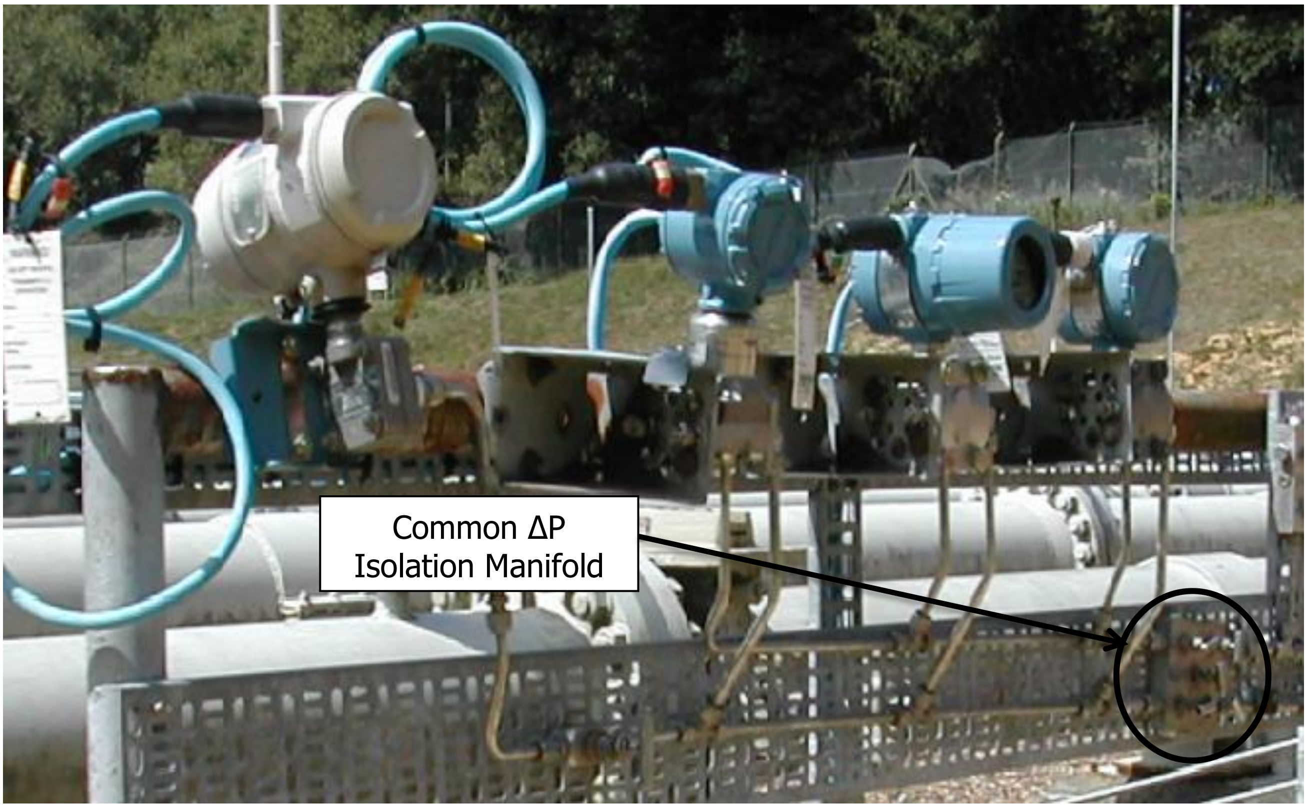


Figure 4.7 – Transmitter Mounting Rack

Figure 4.8 – Transmitter Impulse Lines and Catchpots

All transmitters communicate with a single dedicated OMNI flow computer installed in the site computer/communications room.

Figure 4.9 – Metering Panel

Sample gas is taken from an underground tapping point and the needle valve was sealed open with a seal on behalf of OFGEM. It could not be ascertained if a sample probe is fitted but it is unlikely.

The sample gas is conditioned using a two stage pressure letdown system, (58 - 10 – 2.65 barg at the time of the visit) installed within a dedicated enclosure approximately 4m from the sample take-off, the first stage of which is with dual, parallel base heated regulators. The sample line is routed from the cabinet to a nearby Daniel Series 500 on-line gas chromatograph (OGC). There was insulation on most of the sample line but the ends were not insulated.

The OGC is installed within a dedicated analyser house with thermostatically controlled heating. The associated 2551 controller is installed in the OMNI flow computer rack.

The OMNI flow computer is used to calculate Relative Density (RD) and Calorific Value (CV) from gas composition, derived by the OGC, in accordance with ISO 6976:1995(E). Density is calculated, using the full gas composition from the OGC with live pressure and temperature, in accordance with AGA8:1994 Detailed Method. Flow rate is calculated in accordance with ISO 5167-1:1991(E).

The OGC is configured to auto calibrate daily against a test gas cylinder certified by EffecTech Ltd - UKAS accreditation 0590 - located in a section of the analyser house. Sample flow and pressures are monitored on a frequent basis by SGN personnel. In addition, an auto "35 day" calibration is performed against a specially prepared test gas mixture, which has been certified by OFGEM. The OFGEM local inspector visits the site "at least" every 3 months to witness the test.

Standard volume instantaneous flow rate and integrated flow in addition to an instantaneous CV measurement are re-transmitted to SGN control at Horley via a locally installed telemetry unit. A metering database is also installed which provides a communications and metering data hub between the 2551 controller, OMNI 6000 flow computer and the telemetry unit. An ISDN link provides remote access to the metering database files for use by the HPMIS system server in Havant for review by SGN, OFGEM and NGG.

The metering system instrumentation and associated equipment are calibrated once every twelve months in accordance with the requirements of the SGN procedural document, ME2.

5.1 Introduction

Unlike the methodologies available to define a measurement error that is associated with an incorrect numerical factor (say an orifice plate or meter tube diameter) or indeed a well defined systematic bias associated with a measuring device which can be relatively precise in its retrospective calculation of the error, the cause of the Braishfield "B" SMER required a more practical approach and would at best, be an informed estimate.

As the effect(s) of the cause cannot be quantified by substituting a corrective parameter within say a flow rate algorithm, the requirement to perform a controlled site test, to replicate the cause and effect(s) under the same (or very similar) operational conditions seen during the SMER period was identified by the Independent Expert as the most appropriate technical methodology.

Firstly, the operating conditions seen throughout the SMER period were derived (the x-axis representing the number of data points collected during the SMER);

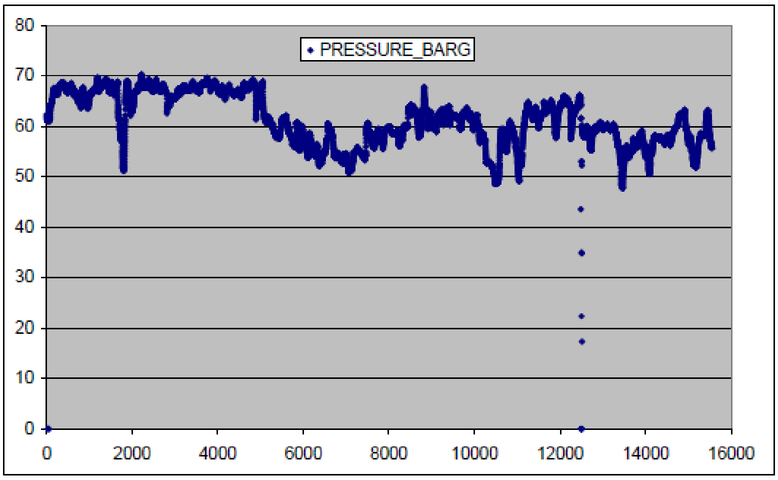


Figure 5.1.1 – SMER Period Pressure Change

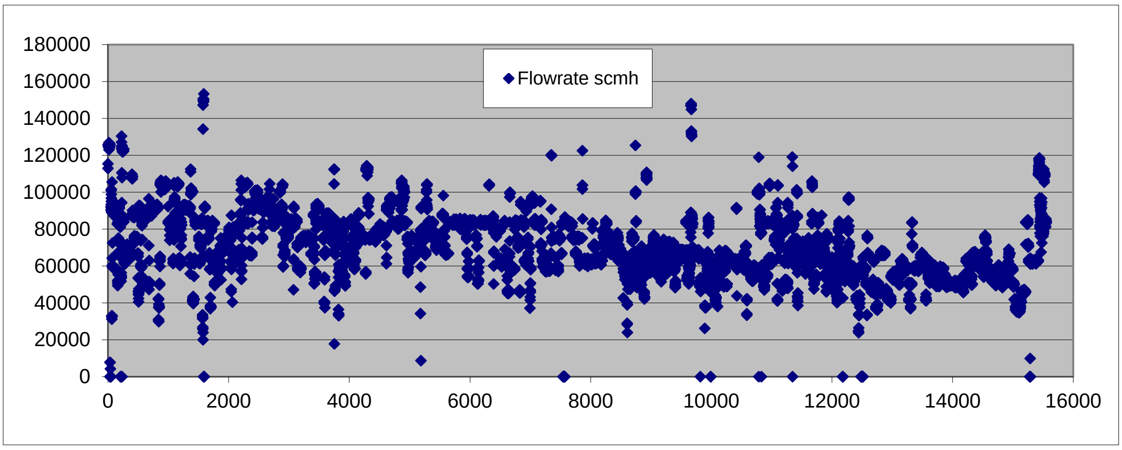


Figure 5.1.2 – SMER Period Flow Rate Change

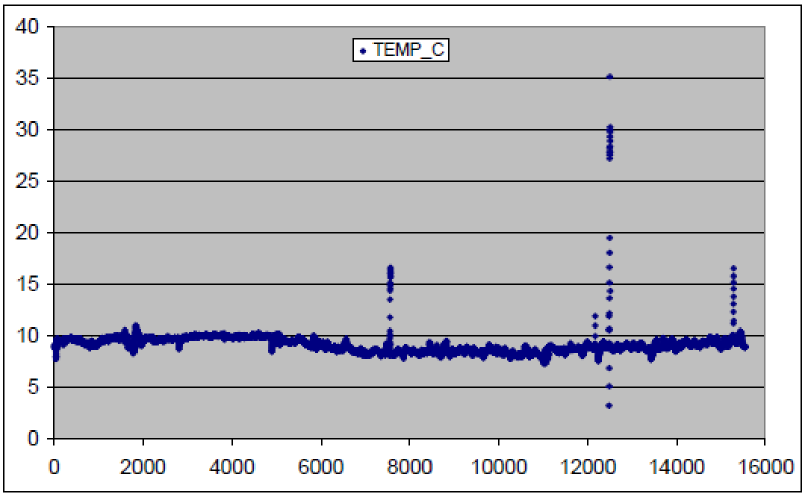


Figure 5.1.3 – SMER Period Temperature Change

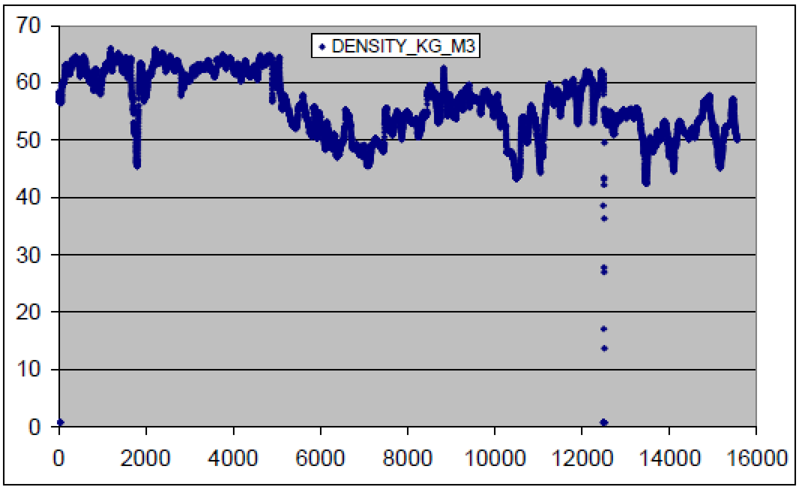


Figure 5.1.4 – SMER Period Density Change

From the tabulated data above, the range of operational conditions were established;

- Pressure 50 – 70 BarG
- Flow Rate 40 – 100 KSm^3/h
- Temperature 7 – 10ºC
- Density 42 – 65 kg/ m^3

Using the operating data derived above, a site testing procedure was subsequently prepared (section 5.2 refers).

5.2 Site Test Procedure

A site test procedure was developed as follows;

- Site testing to be performed at typically minimum, average and maximum flow rates seen during the SMER period;
  - 40 KSm^3/h
  - 70 KSm^3/h
  - 100 KSm^3/h
- Site testing to be performed with a range of inlet pressures that can be deemed representative of the operating pressures seen during the SMER period.
- Provision to graphically record in "real time" (10 second continuous update) the outputs of the following measured variables to be made available;
  - Low ΔP
  - High (Duty) ΔP
  - High (Standby) ΔP
  - Pressure
  - Temperature
  - Density
  - Instantaneous Standard Volume Flow
- For each of the flow scenarios, the configuration of the flow metering stream shall be replicated (i.e. ΔP transmitter manifold equalising valve closed).
- Once a flow scenario had been replicated and established, the following actions shall be implemented;
  - Ensure all measured variables are recording satisfactorily and ensure a "date and time stamp" of some description is incorporated.
  - Open the ΔP transmitter manifold equalising valve (in steps of 1, 2, 3, 4, 5, 6 turns and finally fully open).
  - Ensure that there is sufficient time (between each manifold equalising valve positional change) for flow rate stabilisation.
- Repeat the above for all selected flow scenarios;
- Collate all records on completion of testing.

- For each site test, calculate the difference in flow rate for each ΔP transmitter manifold equalising valve position as follows;

  - Calculate the reference standard volume flow rate value (i.e. that with a fully closed ΔP transmitter manifold equalising valve) by taking the average of each recorded start and finish test flow rate. Note the flow rate stability during the test……………………………………………………(1)

  - Calculate the average standard volume flow rate that represents each of the ΔP transmitter manifold equalising valve positions, from the OMNI flow computer flow rate output (10 second data) for the duration of each test…………………………………………………………(2)

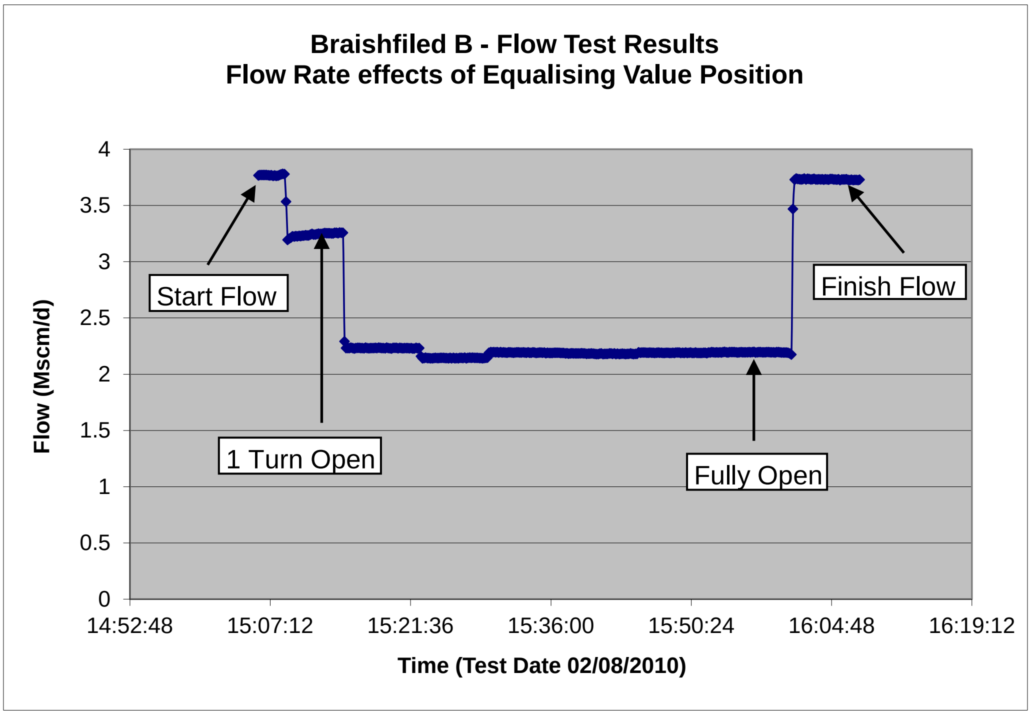


Figure 5.2 – Typical Test Flow Rate

  - For each ΔP transmitter manifold equalising valve position, calculate the % difference between (1) and (2) above.

- Collate results in graphical & tabular form to include within report section 6.0.

6.0 SITE TEST RESULTS

6.1 2nd August 2010

Test Conditions;

Average Pressure 53.7 BarG

Average Temperature 13.9°C

Average Gas Composition;

Component	Mol %
C1	89.986
C2	5.297
C3	1.967
IC4	0.213
NC4	0.201
IC5	0.056
NC5	0.042
Neo C5	0.003
C6	0.073
N_2	1.705
CO_2	1.227

Average Density 47.234 kg/m^3

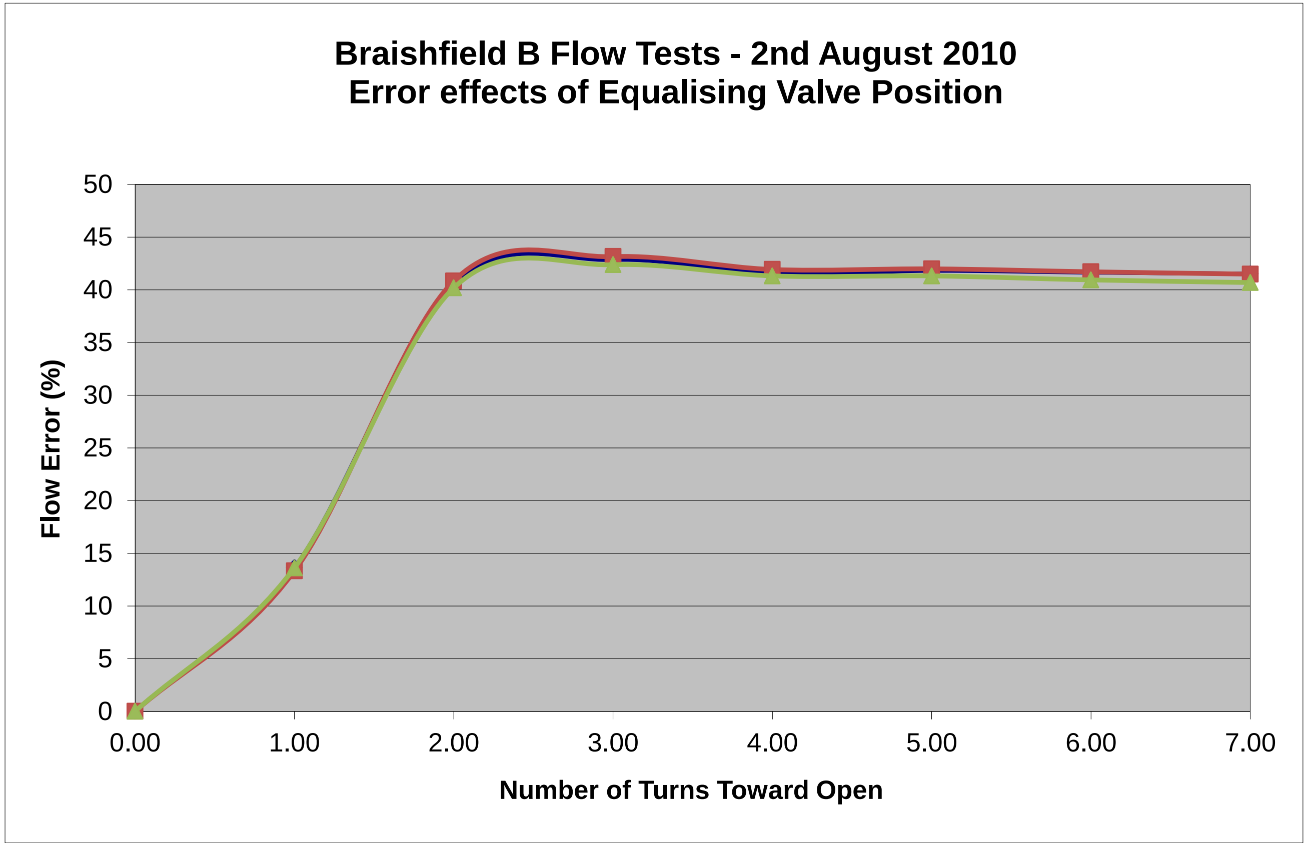
Average Base Density 0.76104

Average Test Flow Rate (High) 156 Ksm^3/h (SMER equivalent 91 Ksm^3/h)
[Test stability 0.99%]
[Typical differential pressure range during test 300 to 100 mbar]

Average Test Flow Rate (Mid) 125 Ksm^3/h (SMER equivalent 73 Ksm^3/h)
[Test stability 1.58%]
[Typical differential pressure range during test 195 to 65 mbar]

Average Test Flow Rate (Low) 73 Ksm^3/h (SMER equivalent 43 Ksm^3/h)
[Test stability 0.34%]
[Typical differential pressure range during test 65 to 23 mbar]

Duration of tests (15:00 – 18:30) 3.5 Hours



Test Results – Change in Flow Rate (%) vs Equalising Valve Position								
	Fully Closed	**1**	**2**	**3**	**4**	**5**	**6**	**Fully Open**
High Flow	**0**	**13.62**	**40.50**	**42.84**	**41.56**	**41.81**	**41.64**	**41.51**
Mid Flow	**0**	**13.32**	**40.82**	**43.14**	**41.92**	**41.98**	**41.70**	**41.48**
Low Flow	**0**	**13.61**	**39.46 (40.17)**	**41.62 (42.37)**	**40.58 (41.31)**	**40.58 (41.31)**	**40.21 (40.93)**	**39.96 (40.68)**

6.2 28th September 2010

Test Conditions;

Average Pressure 50.7 BarG

Average Temperature 13.4°C

Average Gas Composition;

Component	Mol %
C1	88.718
C2	6.065
C3	1.390
IC4	0.161
NC4	0.212
IC5	0.045
NC5	0.039
Neo C5	0
C6	0.050
N_2	1.966
CO_2	1.354

Average Density 44.987 kg/m^3

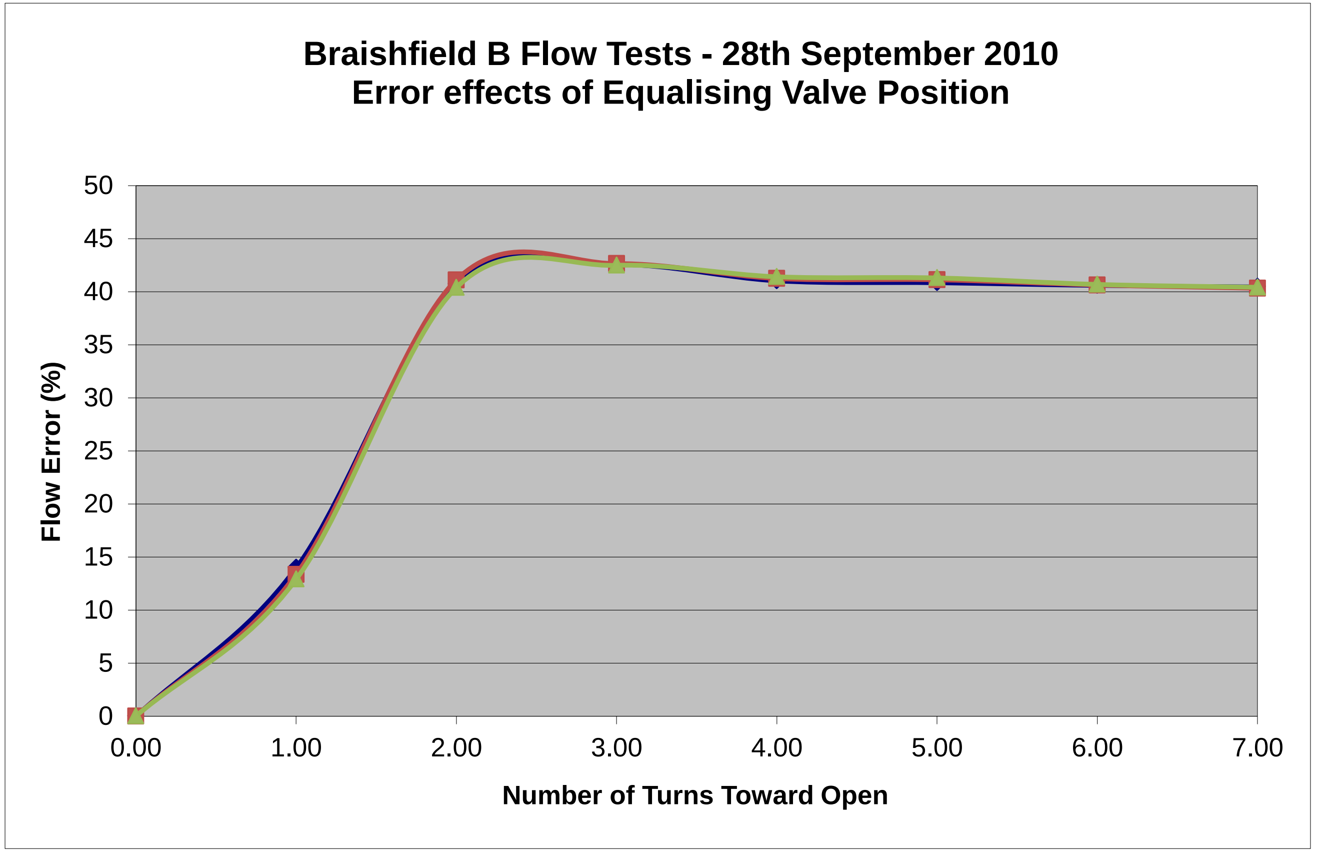
Average Base Density 0.76892

Average Test Flow Rate (High) 160 Ksm^3/h (SMER equivalent 96 Ksm^3/h)
[Test stability 0.92%]
[Typical differential pressure range during test 330 to 118 mbar]

Average Test Flow Rate (Mid) 126 Ksm^3/h (SMER equivalent 75 Ksm^3/h)
[Test stability 1.44%]
[Typical differential pressure range during test 206 to 75 mbar]

Average Test Flow Rate (Low) 72 Ksm^3/h (SMER equivalent 43 Ksm^3/h)
[Test stability 0.47%]
[Typical differential pressure range during test 68 to 24 mbar]

Duration of tests (13:00 – 17:00) 4.0 Hours



Test Results – Change in Flow Rate (%) vs Equalising Valve Position								
	Fully Closed	1	2	3	4	5	6	Fully Open
High Flow	0	13.99	40.72	42.53	41.00	40.82	40.57	40.47
Mid Flow	0	13.35	41.10	42.64	41.24	41.12	40.63	40.32
Low Flow	0	12.89	39.67 (40.38)	41.73 (42.48)	40.67 (41.4)	40.56 (41.29)	39.94 (40.66)	39.70 (40.41)

6.3 8th October 2010

Test Conditions;

Average Pressure 55 BarG

Average Temperature 13.2°C

Average Gas Composition;

Component	Mol %
C1	88.543
C2	5.637
C3	1.390
IC4	0.211
NC4	0.260
IC5	0.059
NC5	0.050
Neo C5	0
C6	0.067
N_2	1.988
CO_2	1.592

Average Density 49.788 kg/m^3

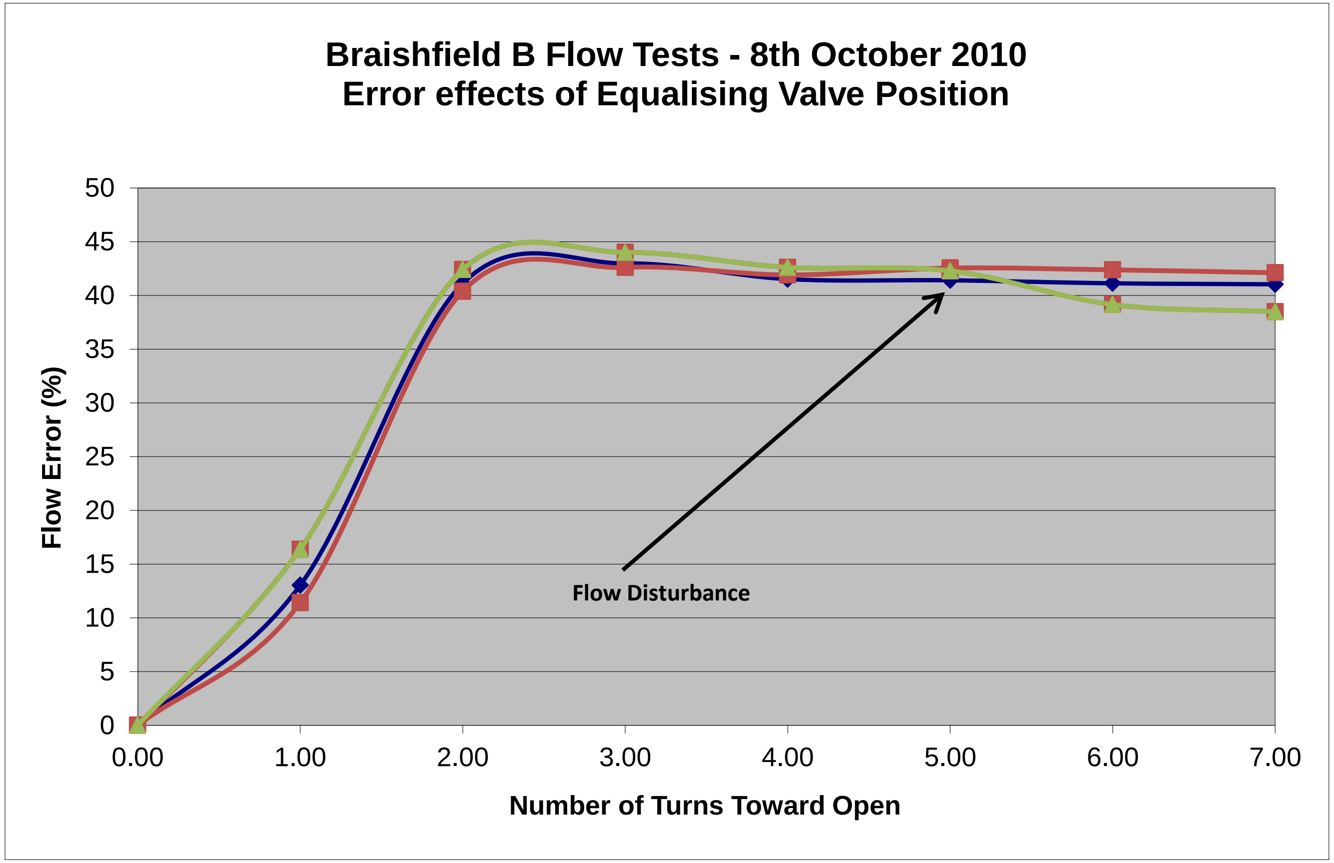
Average Base Density 0.77461

Average Test Flow Rate (High) 157 Ksm^3/h (SMER equivalent 92 Ksm^3/h)
[Test stability 0.76%]
[Typical differential pressure range during test 300 to 100 mbar]

Average Test Flow Rate (Mid) 125 Ksm^3/h (SMER equivalent 73 Ksm^3/h)
[Test stability 3.30%]
[Typical differential pressure range during test 193 to 62 mbar]

Average Test Flow Rate (Low) 74 Ksm^3/h (SMER equivalent 46 Ksm^3/h)
[Test stability 5.41%]
[Typical differential pressure range during test 65 to 24 mbar]

Duration of tests (17:00 – 19:00) 2.0 Hours



Test Results – Change in Flow Rate (%) vs Equalising Valve Position								
	Fully Closed	1	2	3	4	5	6	Fully Open
High Flow	0	13.03	41.10	42.97	41.51	41.40	41.12	41.03
Mid Flow	0	11.40	40.38	42.60	41.90	42.54	42.37	42.10
Low Flow	0	16.38	41.64 (42.39)	43.22 (44.00)	41.85 (42.60)	41.53 (42.28)	38.45 (39.14)	37.80 (38.48)

6.4 22nd October 2010

Test Conditions;

Average Pressure 64.3 BarG

Average Temperature 14°C

Average Gas Composition;

Component	**Mol %**
C1	90.174
C2	5.120
C3	1.311
IC4	0.199
NC4	0.243
IC5	0.063
NC5	0.052
Neo C5	0.002
C6	0.062
N_2	1.745
CO_2	1.028

Average Density 56.461 kg/m^3

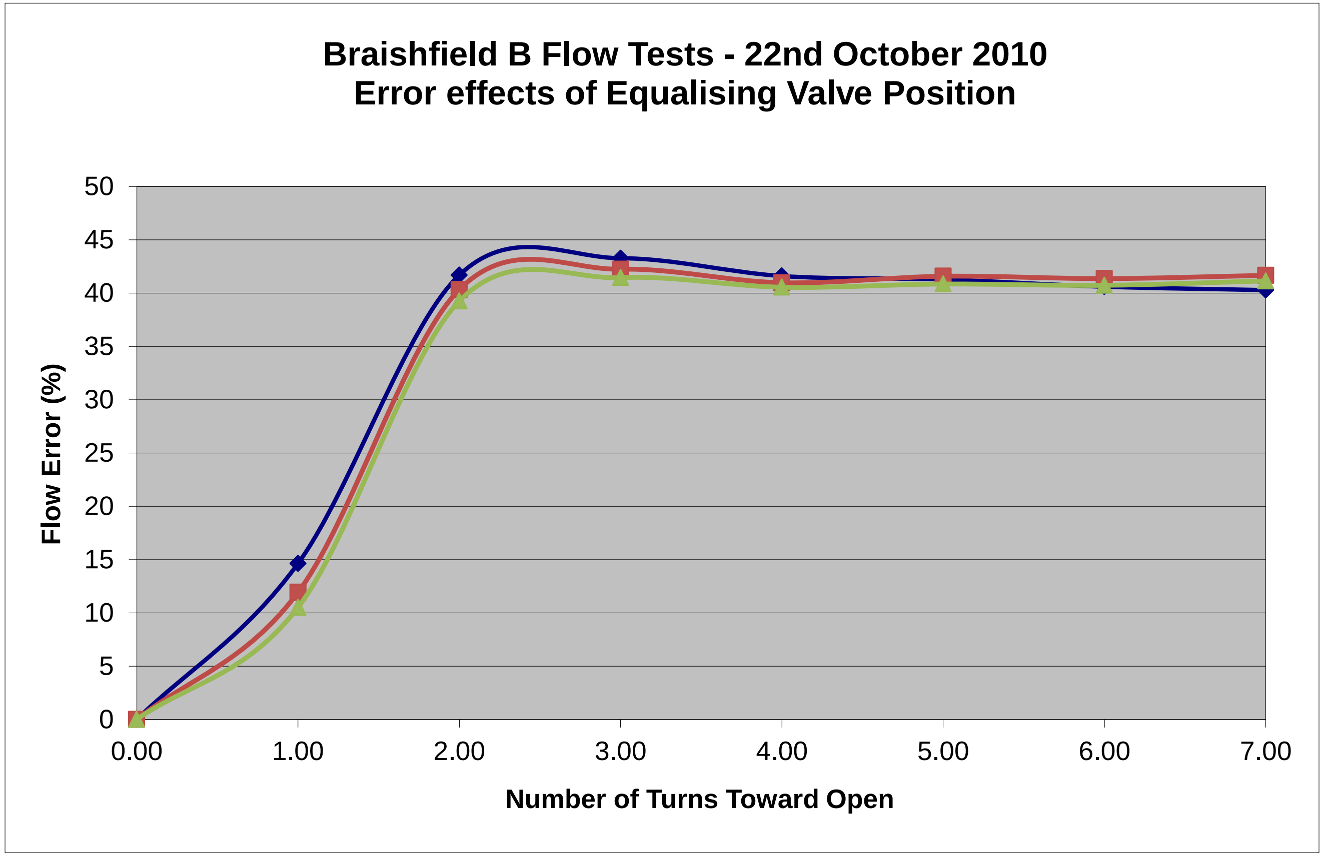
Average Base Density 0.75974

Average Test Flow Rate (High) 160 Ksm^3/h (SMER equivalent 95 Ksm^3/h)
[Test stability 3.08%]
[Typical differential pressure range during test 185 to 90 mbar]

Average Test Flow Rate (Mid) 123 Ksm^3/h (SMER equivalent 72 Ksm^3/h)
[Test stability 3.53%]
[Typical differential pressure range during test 195 to 51 mbar]

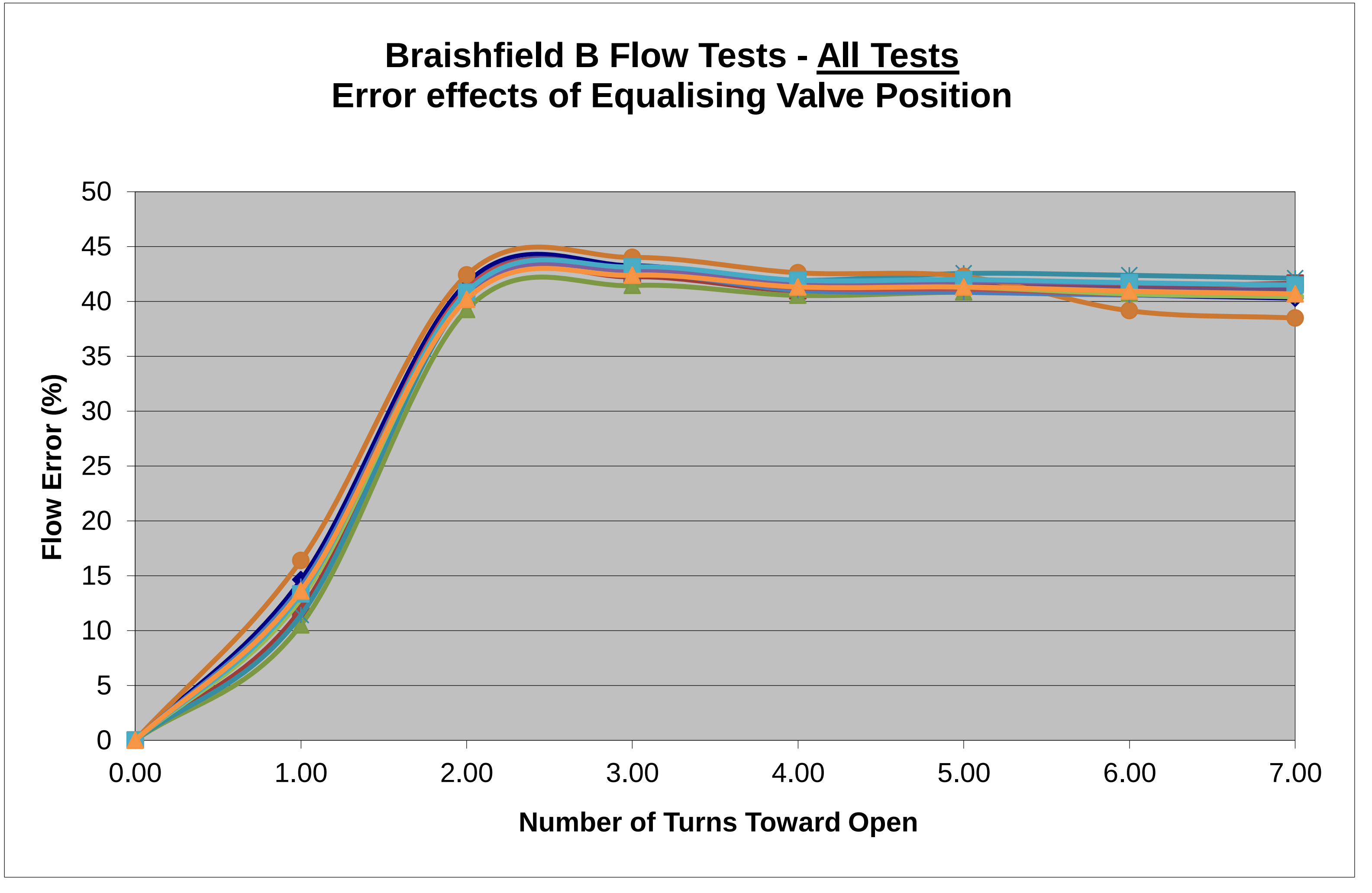
Average Test Flow Rate (Low) 77 Ksm^3/h (SMER equivalent 45 Ksm^3/h)
[Test stability 2.82%]
[Typical differential pressure range during test 60 to 19 mbar]

Duration of tests (13:00 – 16:00) 3.0 Hours



Test Results – Change in Flow Rate (%) vs Equalising Valve Position								
	Fully Closed	**1**	**2**	**3**	**4**	**5**	**6**	**Fully Open**
High Flow	0	14.63	41.68	43.26	41.59	41.27	40.59	40.27
Mid Flow	0	11.98	40.34	42.23	40.96	41.57	41.35	41.65
Low Flow	0	10.51	38.55 (39.24)	40.71 (41.44)	39.82 (40.54)	40.12 (40.84)	40.00 (40.72)	40.40 (41.13)

6.5 All Tests


Braishfield B Flow Tests - All Tests
Error effects of Equalising Valve Position
Flow Error (%)
50
45
40
35
30
25
20
15
10
5
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Number of Turns Toward Open

7.0 SITE TEST CONCLUSIONS

7.1 Introduction

During the review of all site test data, two key areas become apparent which required further investigation.

The first is the flow instability seen throughout some of the flow tests and the second is the difference in low differential pressure output (when selected by the OMNI during the low flow tests) to that used from the high differential pressure transmitter for all other flow test points (including the calculation of the reference flow value which forms the basis of the error calculation).

7.2 Flow Instability

The initial thoughts on how best to correlate the flow test results was to calculate the reference flow rate (i.e. with the ΔP transmitter manifold equalising valve closed) by taking the average of the start and finish flow rates for each test;

157.0204		TEST START FLOW RATE
155.4604		TEST END FLOW RATE
156.2404		TEST AVERAGE FLOW RATE
0.99		TEST STABILITY (%)

Whilst the example shows a stability of better than 1%, 5 of the 12 results exhibited test stabilities between 2.8 and 5.4% which may be deemed unacceptable due to the results spread (for the fully open ΔP transmitter manifold equalising valve) as tabulated below;

TEST	Error (%) - ΔP Transmitter Manifold Equalising Valve Fully Open
2/8 High	41.51
2/8 Mid	41.58
2/8 Low	40.68 (Corrected to High ΔP Value)
28/9 High	40.47
28/9 Mid	40.32
28/9 Low	40.41 (Corrected to High ΔP Value)
8/10 High	41.03
8/10 Mid	***42.03***
8/10 Low	***38.48*** (Corrected to High ΔP Value)
22/10 High	40.27
22/10 Mid	41.65
22/10 Low	41.13 (Corrected to High ΔP Value)
Spread of Results (inclusive) = 3.5% (Average Error = 40.797%)	
Spread of Results (without 38.48) = 1.8% (Average Error = 41.007%)	

Table 7.2.1

As it has been demonstrated that the ΔP transmitter manifold equalising valve was fully open during the entire period of the SMER (section 3.0 refers), a more representative value to use for the reference flow would be the recorded "Test End" flow value.

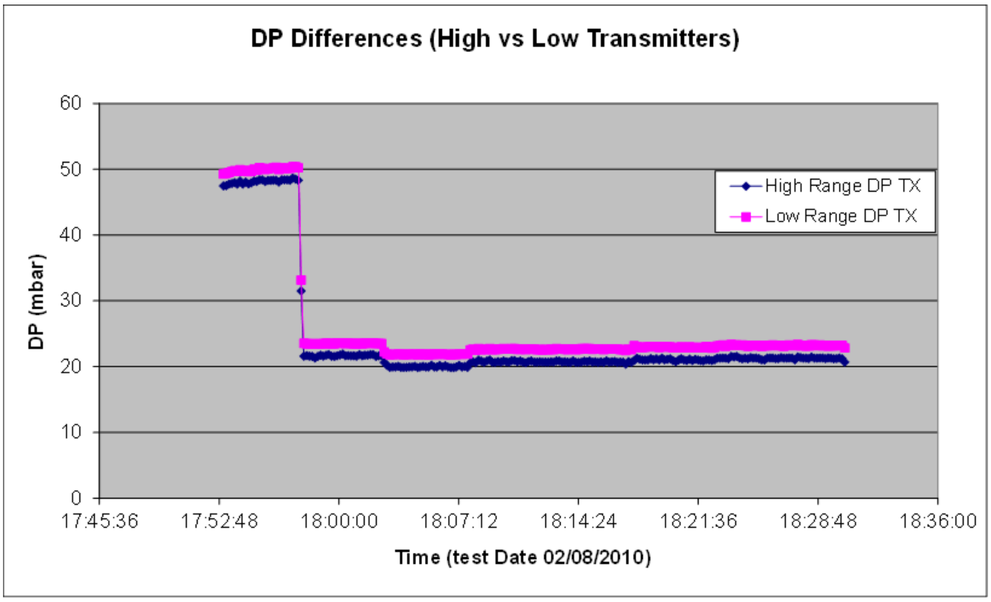
Therefore, recalculating the results spread (for the fully open ΔP transmitter manifold equalising valve) yields the following;

TEST	Error (%) - ΔP Transmitter Manifold Equalising Valve Fully Open
2/8 High	***41.21***
2/8 Mid	41.01
2/8 Low	40.58 (Corrected to High ΔP Value)
28/9 High	40.75
28/9 Mid	40.75
28/9 Low	40.27 (Corrected to High ΔP Value)
8/10 High	40.80
8/10 Mid	41.14
8/10 Low	***40.20*** (Corrected to High ΔP Value)
22/10 High	41.19
22/10 Mid	40.70
22/10 Low	40.24 (Corrected to High ΔP Value)
Spread of Results = 1.0% (Average Error = 40.737%)	

Table 7.2.2

7.3 Low Range Differential Pressure Transmitter Correction

It was noted during the testing that an uncharacteristic shift pattern was being recorded during the low flow testing. It was subsequently observed that there was a difference in the outputs of the low and high differential pressure transmitters;



The low range differential pressure transmitter was found to be reading typically 1.8 mbar higher (throughout the transmitter range) than the high differential pressure transmitter.

Subsequently, when the flow rate fell below the high/low transmitter changeover value, the OMNI calculated flow rate increased and therefore a step change in the error values were observed (as the reference flow used to calculate the error had been derived from the output of the high range differential pressure transmitter).

To overcome this issue, the low flow test flow rates were recalculated “offline” using KELTON® FLOCALC® to correct the differences in transmitter readings so that the errors are being calculated comparatively.

These “corrected values” are incorporated (in parentheses) within the results tables in section 6.0 and have been used within the final results review.

7.4 Test Summary

Having minimised the effects of the flow test stability (section 7.2 refers) and corrected the effect of the low range differential pressure output difference during the low flow rate tests (section 7.3 refers), the test procedure and subsequent results obtained are deemed most satisfactory by the Independent Expert.

KELTON®

8.0 RECOMMENDATIONS

The recommendation of this review is to multiply each of the daily standard volume totals reported within Gemini by a single correction factor.

- For gas day 26th January 2010 (SMER commencement date) this will comprise a part day correction based on 1.194 mscm (16:00 – 06:00 hrs)
- For gas days 27th January 2010 to 25th April 2010 (inclusive) this will comprise a full day correction.
- For gas day 26th April 2010 (SMER remedial date) this will comprise a part day correction based on 0.382 mscm (06:00 – 12:00 hrs).

The correction factor recommended for use is calculated from the most representative average error obtained from the site tests (Table 7.2.2 refers);

- Calculated Correction Factor 1.687

The corrected Gemini daily totals have been calculated and appropriately referenced within Appendix A.

CORRECTED GEMINI TOTALS

APPENDIX A

BRAISHFIELD B			
Gemini Data			
Date	Volume (mscm)	Correction Factor	Corrected Volume (mscm)
26/01/2010	2.0287 (1.194)	1.687	**2.84828**
27/01/2010	1.90000	1.687	**3.20530**
28/01/2010	1.76410	1.687	**2.97604**
29/01/2010	1.92140	1.687	**3.24140**
30/01/2010	2.04120	1.687	**3.44350**
31/01/2010	2.35750	1.687	**3.97710**
01/02/2010	2.00960	1.687	**3.39020**
02/02/2010	2.12680	1.687	**3.58791**
03/02/2010	1.82980	1.687	**3.08687**
04/02/2010	1.81250	1.687	**3.05769**
05/02/2010	1.63100	1.687	**2.75150**
06/02/2010	1.76270	1.687	**2.97367**
07/02/2010	1.88920	1.687	**3.18708**
08/02/2010	2.06300	1.687	**3.48028**
09/02/2010	2.24140	1.687	**3.78124**
10/02/2010	2.21970	1.687	**3.74463**
11/02/2010	2.13620	1.687	**3.60377**
12/02/2010	1.94160	1.687	**3.27548**
13/02/2010	1.74210	1.687	**2.93892**
14/02/2010	1.76160	1.687	**2.97182**
15/02/2010	1.89080	1.687	**3.18978**
16/02/2010	1.92660	1.687	**3.25017**
17/02/2010	1.59070	1.687	**2.68351**
18/02/2010	1.71010	1.687	**2.88494**
19/02/2010	1.82440	1.687	**3.07776**
20/02/2010	2.03040	1.687	**3.42528**
21/02/2010	1.90310	1.687	**3.21053**
22/02/2010	2.12750	1.687	**3.58909**
23/02/2010	2.12990	1.687	**3.59314**
24/02/2010	1.62690	1.687	**2.74458**
25/02/2010	1.86240	1.687	**3.14187**
26/02/2010	1.89410	1.687	**3.19535**
27/02/2010	1.78200	1.687	**3.00623**
28/02/2010	2.00020	1.687	**3.37434**
01/03/2010	1.85710	1.687	**3.13293**
02/03/2010	1.86320	1.687	**3.14322**
03/03/2010	2.02260	1.687	**3.41213**
04/03/2010	1.92940	1.687	**3.25490**
05/03/2010	1.49580	1.687	**2.52341**
06/03/2010	1.60410	1.687	**2.70612**
07/03/2010	1.80090	1.687	**3.03812**
08/03/2010	2.11111	1.687	**3.56144**
09/03/2010	1.54269	1.687	**2.60252**
10/03/2010	1.69141	1.687	**2.85341**
11/03/2010	1.66399	1.687	**2.80715**
12/03/2010	1.72850	1.687	**2.91598**

KELTON®

APPENDIX A

BRAISHFIELD B			
Gemini Data			
Date	Volume (mscm)	Correction Factor	Corrected Volume (mscm)
13/03/2010	1.52440	1.687	**2.57166**
14/03/2010	1.58940	1.687	**2.68132**
15/03/2010	1.72590	1.687	**2.91159**
16/03/2010	1.68050	1.687	**2.83500**
17/03/2010	1.43370	1.687	**2.41865**
18/03/2010	1.46810	1.687	**2.47668**
19/03/2010	1.62660	1.687	**2.74407**
20/03/2010	1.44720	1.687	**2.44143**
21/03/2010	1.52920	1.687	**2.57976**
22/03/2010	1.60110	1.687	**2.70106**
23/03/2010	1.70860	1.687	**2.88241**
24/03/2010	1.28490	1.687	**2.16763**
25/03/2010	1.32600	1.687	**2.23696**
26/03/2010	1.40730	1.687	**2.37412**
27/03/2010	1.45640	1.687	**2.45695**
28/03/2010	1.49660	1.687	**2.52476**
29/03/2010	1.36870	1.687	**2.30900**
30/03/2010	1.68360	1.687	**2.84023**
31/03/2010	1.89260	1.687	**3.19282**
01/04/2010	1.66070	1.687	**2.80160**
02/04/2010	1.69905	1.687	**2.86630**
03/04/2010	1.56870	1.687	**2.64640**
04/04/2010	1.60400	1.687	**2.70595**
05/04/2010	1.60160	1.687	**2.70190**
06/04/2010	1.34760	1.687	**2.27340**
07/04/2010	1.55050	1.687	**2.61569**
08/04/2010	1.18820	1.687	**2.00449**
09/04/2010	1.12710	1.687	**1.90142**
10/04/2010	1.13600	1.687	**1.91643**
11/04/2010	1.28250	1.687	**2.16358**
12/04/2010	1.30690	1.687	**2.20474**
13/04/2010	1.31860	1.687	**2.22448**
14/04/2010	1.46790	1.687	**2.47635**
15/04/2010	1.37420	1.687	**2.31828**
16/04/2010	1.33310	1.687	**2.24894**
17/04/2010	1.23680	1.687	**2.08648**
18/04/2010	1.19790	1.687	**2.02086**
19/04/2010	1.43130	1.687	**2.41460**
20/04/2010	1.51120	1.687	**2.54939**
21/04/2010	1.42640	1.687	**2.40634**
22/04/2010	1.31880	1.687	**2.22482**
23/04/2010	1.36200	1.687	**2.29769**
24/04/2010	0.98940	1.687	**1.66912**
25/04/2010	1.55970	1.687	**2.63121**
26/04/2010	2.0366 (0.382)	1.687	**2.30143**

APPENDIX B

TYPICAL TEST RESULT SPREADSHEET

(MID FLOW TEST 28/9/10)

APPENDIX B

Time	Flow Day Rate	Flow Pressure	HighDP	LowDP	StandbyDP	Flow Hour Rate	Flow Temperature	Comments		
14:37:26	3.0149	50.6294	205.0126	Over-range	208.5374	125.6201	13.23			
14:37:36	3.0105	50.6221	205.9281	Over-range	209.041	125.4377	13.23			
14:37:46	3.0131	50.6294	205.8366	Over-range	208.5832	125.5441	13.23			
14:37:56	3.012	50.6294	205.4246	Over-range	208.3085	125.4985	13.23			
14:38:06	3.0167	50.6294	205.1499	Over-range	207.8966	125.6961	13.23			
14:38:16	3.0142	50.6294	205.8366	Over-range	208.9036	125.5897	13.23		125.5788	(TEST START STABILITY)
14:38:26	3.016	50.6294	206.2028	Over-range	208.9494	125.6657	13.23		127.419	(TEST END STABILITY)
14:38:37	3.0112	50.6294	205.2873	Over-range	207.9423	125.4681	13.23	Direct Valve Control Selected	126.4989	TEST AVERAGE
14:38:47	3.0112	50.6294	205.8366	Over-range	208.8579	125.4681	13.23		1.44	TEST STABILITY
14:38:57	3.0142	50.6294	206.2944	Over-range	209.3157	125.5897	13.23			
14:39:07	3.0182	50.6294	206.8895	Over-range	210.0481	125.7569	13.23		13.35	Open 1 Turn (%) DIFFERENCE
14:39:17	3.0236	50.6294	206.7063	Over-range	209.5445	125.9849	13.23			
14:39:27	3.0244	50.6148	207.4388	Over-range	210.6432	126.0153	13.51			
14:39:37	2.6216	50.6075	154.612	Over-range	156.8093	109.2325	13.51	Equalising Valve one turns open		
14:39:47	2.6136	50.5782	155.1156	Over-range	157.7707	108.8981	13.51			
14:39:57	2.6165	50.5928	155.4361	Over-range	158.0453	109.0197	13.51			
14:40:07	2.6165	50.6075	154.7036	Over-range	157.2213	109.0197	13.51			
14:40:17	2.6179	50.5782	155.1156	Over-range	157.4045	109.0805	13.51			
14:40:27	2.6179	50.5782	155.6192	Over-range	158.0453	109.0805	13.51			
14:40:37	2.6209	50.5782	155.7565	Over-range	157.6333	109.2021	13.51			
14:40:47	2.6198	50.5782	155.6192	Over-range	157.8622	109.1565	13.51			
14:40:57	2.6249	50.5782	155.5734	Over-range	157.9996	109.3693	13.51			
14:41:07	2.6263	50.6075	156.3974	Over-range	158.9151	109.4302	13.51			
14:41:17	2.6234	50.6075	155.7565	Over-range	158.2742	109.3085	13.51			
14:41:27	2.6238	50.6075	155.9396	Over-range	158.32	109.3237	13.51			
14:41:37	2.6267	50.6075	156.3516	Over-range	158.732	109.4454	13.51			
14:41:47	2.6267	50.6075	156.1227	Over-range	158.5489	109.4454	13.51			
14:41:57	2.6281	50.6075	156.0769	Over-range	159.0982	109.5062	13.51			
14:42:07	2.6292	50.6075	156.0311	Over-range	158.4573	109.5518	13.51			
14:42:17	2.6281	50.6075	156.7636	Over-range	159.1897	109.5062	13.51			
14:42:27	2.6365	50.6075	157.496	Over-range	160.0137	109.8558	13.51			
14:42:37	2.6351	50.6075	157.1298	Over-range	159.968	109.795	13.51			
14:42:47	2.6351	50.6075	156.8551	Over-range	159.6933	109.795	13.51			
14:42:57	2.6369	50.6075	157.3587	Over-range	159.5102	109.871	13.51			
14:43:07	2.6351	50.6075	157.0382	Over-range	159.4187	109.795	13.51			
14:43:17	2.6369	50.6075	157.6791	Over-range	159.6018	109.871	13.51			
14:43:27	2.6387	50.5782	157.0382	Over-range	159.2813	109.947	13.51			
14:43:37	2.6427	50.5782	157.8622	Over-range	160.1969	110.1142	13.51			
14:43:47	2.6442	50.5782	157.496	Over-range	159.6933	110.175	13.51			
14:43:57	2.6427	50.5782	158.32	Over-range	160.5173	110.1142	13.51			
14:44:07	2.642	50.5782	158.1827	Over-range	160.1969	110.0838	13.51			
14:44:17	2.6406	50.5782	158.3658	Over-range	160.7919	110.023	13.51			
14:44:27	2.6409	50.5782	158.0453	Over-range	160.1969	110.0382	13.51			
14:44:37	2.642	50.5782	158.0453	Over-range	160.2884	110.0838	13.51			
14:44:47	2.6409	50.5782	157.6791	Over-range	160.1969	110.0382	13.51			
14:44:57	2.6427	50.5782	158.2284	Over-range	160.5631	110.1142	13.51			
14:45:07	1.9455	50.5635	79.3545	Over-range	76.4706	81.0636	13.51	Equalising Valve two turns open		
14:45:17	1.7886	50.5562	72.3507	Over-range	73.9528	74.5268	13.51			
14:45:27	1.7854	50.5635	72.3049	Over-range	74.0444	74.39	13.51		41.10	Open 2 Turn (%) DIFFERENCE

APPENDIX B

14:45:37	1.7872	50.5562	72.3049	Over-range	74.2733	74.466	13.49			
14:45:47	1.7872	50.5635	72.076	Over-range	73.9528	74.466	13.49			
14:45:57	1.7868	50.5562	72.1675	Over-range	73.9528	74.4508	13.49			
14:46:07	1.7854	50.5562	72.3049	Over-range	74.1817	74.39	13.49			
14:46:17	1.7868	50.5562	72.1218	Over-range	73.9071	74.4508	13.49			
14:46:27	1.7828	50.5562	72.2591	Over-range	73.724	74.2836	13.49			
14:46:37	1.7846	50.5415	72.1218	Over-range	73.8613	74.3596	13.49			
14:46:47	1.7843	50.5342	71.9844	Over-range	73.7697	74.3444	13.49			
14:46:57	1.7868	50.5342	72.1675	Over-range	73.9071	74.4508	13.49			
14:47:07	1.789	50.5342	72.5795	Over-range	74.3191	74.542	13.49			
14:47:17	1.7886	50.5342	72.3507	Over-range	74.1817	74.5268	13.49			
14:47:27	1.7883	50.5342	72.3507	Over-range	74.2275	74.5116	13.49			
14:47:37	1.7919	50.5342	72.3049	Over-range	73.9986	74.6636	13.49			
14:47:47	1.789	50.5342	72.1675	Over-range	73.8155	74.542	13.49			
14:47:57	1.789	50.5342	72.4422	Over-range	74.2733	74.542	13.49			
14:48:07	1.7883	50.5342	72.3964	Over-range	74.1817	74.5116	13.49			
14:48:17	1.7868	50.5342	72.5338	Over-range	74.1817	74.4508	13.49			
14:48:27	1.7875	50.5342	72.2591	Over-range	73.9986	74.4812	13.49			
14:48:37	1.7886	50.5342	72.3964	Over-range	74.2275	74.5268	13.49			
14:48:47	1.789	50.5342	72.3507	Over-range	73.9986	74.542	13.49			
14:48:57	1.7875	50.5342	72.3049	Over-range	73.9986	74.4812	13.49			
14:49:07	1.789	50.5342	72.3964	Over-range	74.1817	74.542	13.49			
14:49:17	1.7857	50.5342	72.5795	Over-range	74.2733	74.4052	13.49			
14:49:27	1.7875	50.5342	72.6253	Over-range	74.3191	74.4812	13.49			
14:49:37	1.7905	50.5342	72.6253	Over-range	74.4106	74.6028	13.49			
14:49:47	1.7956	50.5342	72.9	Over-range	74.6395	74.8157	13.49			
14:49:57	1.7981	50.5342	73.2204	Over-range	74.7768	74.9221	13.49			
14:50:07	2.3735	50.5562	134.9737	Over-range	142.6185	98.8953	13.49			
14:50:17	1.7562	50.5196	69.3294	Over-range	70.1534	73.1739	13.49			
14:50:27	1.7387	50.5342	68.4138	Over-range	70.1534	72.4442	13.49	Equalising Valve three turns open		
14:50:37	1.7387	50.5196	68.4596	Over-range	70.1076	72.4442	13.49		42.64	Open 3 Turn (%) DIFFERENCE
14:50:47	1.7365	50.5122	68.368	Over-range	70.1534	72.353	13.42			
14:50:57	1.739	50.5122	68.4138	Over-range	70.1076	72.4594	13.42			
14:51:07	1.7379	50.5122	68.4596	Over-range	70.2907	72.4138	13.42			
14:51:17	1.7379	50.5122	68.6427	Over-range	70.2907	72.4138	13.42			
14:51:27	1.7379	50.5122	68.4138	Over-range	69.9245	72.4138	13.42			
14:51:37	1.7365	50.5122	68.4138	Over-range	70.1534	72.353	13.42			
14:51:47	1.7379	50.5122	68.4138	Over-range	70.1076	72.4138	13.42			
14:51:57	1.7387	50.5122	68.6427	Over-range	70.1076	72.4442	13.42			
14:52:07	1.7379	50.5122	68.4596	Over-range	70.1076	72.4138	13.42			
14:52:17	1.7423	50.5122	68.8258	Over-range	70.428	72.5962	13.42			
14:52:27	1.7467	50.5122	69.0089	Over-range	70.7027	72.7786	13.42			
14:52:37	1.7423	50.5122	68.8258	Over-range	70.6569	72.5962	13.42			
14:52:47	1.7452	50.5122	69.0089	Over-range	70.7027	72.7178	13.42			
14:52:57	1.7456	50.5122	69.0089	Over-range	70.6111	72.733	13.42			
14:53:07	1.7438	50.5196	68.9631	Over-range	70.4738	72.657	13.42			
14:53:17	1.7419	50.5122	69.192	Over-range	70.9316	72.581	13.42			
14:53:27	1.7427	50.5122	68.8716	Over-range	70.4738	72.6114	13.42			
14:53:37	1.7419	50.5122	68.7343	Over-range	70.7027	72.581	13.42			
14:53:47	1.7452	50.5196	68.7343	Over-range	70.6111	72.7178	13.42			
14:53:57	1.7438	50.5122	68.7343	Over-range	70.4738	72.657	13.42			

APPENDIX B

14:54:07	1.7434	50.5196	68.9174	Over-range	70.6569	72.6418	13.42			
14:54:17	1.7452	50.4976	68.7343	Over-range	70.4738	72.7178	13.42			
14:54:27	1.7452	50.4976	69.0547	Over-range	70.9316	72.7178	13.42			
14:54:37	1.7434	50.4976	69.0089	Over-range	70.7485	72.6418	13.42			
14:54:47	1.7423	50.4903	68.9631	Over-range	70.428	72.5962	13.42			
14:54:57	1.7452	50.4903	69.0089	Over-range	70.6569	72.7178	13.42			
14:55:07	1.7799	50.4976	71.9844	Over-range	73.9528	74.162	13.42			
14:55:17	1.785	50.4976	72.3507	Over-range	73.9986	74.3748	13.42			
14:55:27	1.7857	50.4976	72.2591	Over-range	73.9071	74.4052	13.42	Equalising Valve four turns open		
14:55:37	1.7839	50.4976	72.076	Over-range	73.724	74.3292	13.42		41.24	Open 4 Turn (%) DIFFERENCE
14:55:47	1.7846	50.4903	72.2591	Over-range	73.9071	74.3596	13.42			
14:55:57	1.7854	50.4976	72.3049	Over-range	73.9071	74.39	13.42			
14:56:07	1.7846	50.4976	72.3049	Over-range	73.9528	74.3596	13.42			
14:56:17	1.7854	50.4903	72.2591	Over-range	73.9071	74.39	13.42			
14:56:27	1.7843	50.4903	72.3049	Over-range	74.1817	74.3444	13.42			
14:56:37	1.7832	50.4903	72.2591	Over-range	73.7697	74.2988	13.42			
14:56:47	1.7835	50.4976	72.2591	Over-range	73.9071	74.314	13.42			
14:56:57	1.7832	50.4903	71.9387	Over-range	73.6782	74.2988	13.42			
14:57:07	1.7846	50.4903	72.3049	Over-range	73.9528	74.3596	13.42			
14:57:17	1.7872	50.4683	72.2591	Over-range	74.1817	74.466	13.42			
14:57:27	1.7846	50.4829	71.9844	Over-range	73.6782	74.3596	13.42			
14:57:37	1.7832	50.4683	71.9844	Over-range	73.8613	74.2988	13.42			
14:57:47	1.7846	50.4683	72.3049	Over-range	74.136	74.3596	13.42			
14:57:57	1.7832	50.4683	72.2133	Over-range	73.8155	74.2988	13.42			
14:58:07	1.7813	50.4683	72.2133	Over-range	73.8613	74.2228	13.42			
14:58:17	1.7839	50.4683	72.5338	Over-range	74.0444	74.3292	13.42			
14:58:27	1.7839	50.4683	72.2591	Over-range	73.8613	74.3292	13.42			
14:58:37	1.7813	50.4683	71.9844	Over-range	73.4951	74.2228	13.42			
14:58:47	1.7813	50.4683	72.3049	Over-range	73.8613	74.2228	13.42			
14:58:57	1.7854	50.4683	72.076	Over-range	73.7697	74.39	13.42			
14:59:07	1.7835	50.4683	72.3049	Over-range	73.9071	74.314	13.42			
14:59:17	1.7854	50.4683	72.2591	Over-range	73.8613	74.39	13.42			
14:59:27	1.7813	50.4683	72.076	Over-range	73.6324	74.2228	13.42			
14:59:37	1.785	50.4683	72.076	Over-range	73.724	74.3748	13.42			
14:59:47	1.7854	50.4683	72.6253	Over-range	74.2275	74.39	13.42			
14:59:57	1.785	50.4683	72.2133	Over-range	73.8613	74.3748	13.42			
15:00:07	1.7883	50.4683	72.7626	Over-range	74.4106	74.5116	13.42	Equalising Valve five turns open		
15:00:17	1.7883	50.4683	72.6711	Over-range	74.2275	74.5116	13.42		41.12	Open 5 Turn (%) DIFFERENCE
15:00:27	1.789	50.461	72.5338	Over-range	74.1817	74.542	13.42			
15:00:37	1.7872	50.4683	72.3507	Over-range	73.9528	74.466	13.42			
15:00:47	1.7886	50.4463	72.5795	Over-range	73.9986	74.5268	13.42			
15:00:57	1.7886	50.4463	72.3964	Over-range	73.9986	74.5268	13.51			
15:01:07	1.7886	50.4463	72.5338	Over-range	74.0444	74.5268	13.51			
15:01:17	1.789	50.4463	72.6253	Over-range	74.2733	74.542	13.51			
15:01:27	1.7861	50.4463	72.2133	Over-range	73.9071	74.4204	13.51			
15:01:37	1.7883	50.4463	72.5795	Over-range	74.2275	74.5116	13.51			
15:01:47	1.7886	50.4463	72.6711	Over-range	74.2275	74.5268	13.51			
15:01:57	1.785	50.4463	72.3964	Over-range	74.136	74.3748	13.51			
15:02:07	1.7905	50.4463	72.8084	Over-range	74.4564	74.6028	13.51			
15:02:17	1.7883	50.4463	72.3507	Over-range	74.1817	74.5116	13.51			
15:02:27	1.7861	50.4463	72.6253	Over-range	74.2275	74.4204	13.51			

APPENDIX B

15:02:37	1.7854	50.4463	72.5338	Over-range	74.1817	74.39	13.51								
15:02:47	1.7905	50.4463	72.5795	Over-range	74.1817	74.6028	13.51								
15:02:57	1.7868	50.4463	72.3049	Over-range	73.9986	74.4508	13.51								
15:03:07	1.7872	50.4463	72.5795	Over-range	74.2275	74.466	13.51								
15:03:17	1.7872	50.4463	72.3507	Over-range	74.136	74.466	13.51								
15:03:27	1.7868	50.4463	72.3049	Over-range	73.9528	74.4508	13.51								
15:03:37	1.7883	50.4463	72.5795	Over-range	74.136	74.5116	13.51								
15:03:47	1.7897	50.439	72.5338	Over-range	74.2275	74.5724	13.51								
15:03:57	1.7832	50.4463	72.2591	Over-range	73.9528	74.2988	13.51								
15:04:07	1.7897	50.439	72.8084	Over-range	74.3648	74.5724	13.51								
15:04:17	1.785	50.439	72.3507	Over-range	74.1817	74.3748	13.51								
15:04:27	1.7868	50.4244	72.7169	Over-range	74.3648	74.4508	13.51								
15:04:37	1.785	50.439	72.7626	Over-range	74.3648	74.3748	13.51								
15:04:47	1.7875	50.4244	72.3049	Over-range	73.9071	74.4812	13.51								
15:04:57	1.7857	50.4244	72.6711	Over-range	74.3648	74.4052	13.51								
15:05:07	1.8	50.439	73.5866	Over-range	75.3262	74.9981	13.51	Equalising Valve six turns open							
15:05:17	1.7967	50.439	73.4493	Over-range	75.2804	74.8613	13.51			40.63		Open 6 Turn (%) DIFFERENCE			
15:05:27	1.8021	50.4244	73.7697	Over-range	75.4177	75.0893	13.51								
15:05:37	1.8021	50.4244	73.5866	Over-range	75.1431	75.0893	13.51								
15:05:47	1.7992	50.4244	73.724	Over-range	75.3262	74.9677	13.51								
15:05:57	1.7985	50.4244	73.2662	Over-range	74.8226	74.9373	13.51								
15:06:07	1.7985	50.4244	73.6782	Over-range	75.3262	74.9373	13.51								
15:06:17	1.8003	50.4244	73.4493	Over-range	74.9599	75.0133	13.51								
15:06:27	1.7996	50.4244	73.2662	Over-range	74.8684	74.9829	13.51								
15:06:37	1.7996	50.439	73.724	Over-range	75.2346	74.9829	13.51								
15:06:47	1.7992	50.4244	73.5409	Over-range	75.2346	74.9677	13.51								
15:06:57	1.801	50.4244	73.724	Over-range	75.3719	75.0437	13.51								
15:07:07	1.8003	50.4244	73.4493	Over-range	75.0515	75.0133	13.51								
15:07:17	1.8021	50.4244	73.312	Over-range	75.0515	75.0893	13.51								
15:07:27	1.7992	50.4244	73.4493	Over-range	75.0515	74.9677	13.51								
15:07:37	1.8003	50.4244	73.1746	Over-range	74.7311	75.0133	13.51								
15:07:47	1.7996	50.4244	73.6782	Over-range	75.3262	74.9829	13.51								
15:07:57	1.804	50.4244	73.724	Over-range	75.3719	75.1653	13.51								
15:08:07	1.8007	50.4244	73.4951	Over-range	75.0973	75.0285	13.51								
15:08:17	1.7985	50.4244	73.4493	Over-range	74.9599	74.9373	13.51								
15:08:27	1.804	50.4244	74.0902	Over-range	75.8755	75.1653	13.51								
15:08:37	1.8094	50.4244	74.0902	Over-range	75.7382	75.3933	13.51								
15:08:47	1.8076	50.4244	74.1817	Over-range	75.967	75.3173	13.51								
15:08:57	1.8062	50.4244	74.0902	Over-range	75.6924	75.2565	13.51								
15:09:07	1.8076	50.4244	74.2275	Over-range	75.8755	75.3173	13.51								
15:09:17	1.8058	50.4244	74.2733	Over-range	75.8755	75.2413	13.51								
15:09:27	1.8076	50.4024	74.2275	Over-range	76.1044	75.3173	13.51								
15:09:37	1.808	50.4024	74.3648	Over-range	76.1044	75.3325	13.51								
15:09:47	1.8065	50.4024	74.3648	Over-range	75.8755	75.2717	13.51								
15:09:57	1.808	50.4024	74.3648	Over-range	76.0586	75.3325	13.51								
15:10:07	1.8105	50.4024	74.6395	Over-range	76.1502	75.4389	13.51	Equalising Valve six 3/4 turns open							
15:10:17	1.8149	50.4024	74.6395	Over-range	76.4706	75.6214	13.51			40.32		Open 7 Turn (%) DIFFERENCE			
15:10:27	1.8153	50.4024	74.5937	Over-range	76.2417	75.6366	13.51								
15:10:37	1.8149	50.4024	74.8226	Over-range	76.379	75.6214	13.51								
15:10:47	1.8138	50.4024	74.6853	Over-range	76.2417	75.5757	13.51			127.419					
15:10:57	1.8138	50.4024	74.9142	Over-range	76.5621	75.5757	13.53								
15:11:07	1.812	50.4024	74.9142	Over-range	76.6995	75.4997	13.53			40.75					
15:11:17	1.8109	50.4024	74.8226	Over-range	76.5164	75.4541	13.53								
15:11:27	1.812	50.4024	74.4106	Over-range	76.1502	75.4997	13.53								

APPENDIX B

15:11:27	1.812	50.4024	74.4106	Over-range	76.1502	75.4997	13.53	
15:11:37	1.8193	50.4024	74.8684	Over-range	76.5164	75.8038	13.53	
15:11:47	1.8193	50.4024	75.2804	Over-range	76.8368	75.8038	13.53	
15:11:57	1.8193	50.4024	75.1888	Over-range	76.8368	75.8038	13.53	
15:12:07	1.8193	50.4024	75.4635	Over-range	76.9284	75.8038	13.53	
15:12:17	1.8197	50.3951	75.4177	Over-range	77.1115	75.819	13.53	
15:12:27	1.8211	50.4024	75.2804	Over-range	77.0199	75.8798	13.53	
15:12:37	1.8193	50.4024	75.3262	Over-range	77.1115	75.8038	13.53	
15:12:47	1.8211	50.3951	75.3262	Over-range	77.0657	75.8798	13.53	
15:12:57	1.8182	50.3804	74.9142	Over-range	76.6537	75.7582	13.53	
15:13:07	1.8193	50.4024	75.3262	Over-range	77.1115	75.8038	13.53	
15:13:17	1.8193	50.3804	75.4635	Over-range	77.1572	75.8038	13.53	
15:13:27	1.8233	50.3804	75.6008	Over-range	77.2946	75.971	13.53	
15:13:37	1.8211	50.3804	75.1888	Over-range	77.2488	75.8798	13.53	
15:13:47	1.8211	50.3804	75.0057	Over-range	76.9741	75.8798	13.53	
15:13:57	1.8153	50.3804	75.2804	Over-range	77.0657	75.6366	13.53	
15:14:07	1.8211	50.3804	75.2804	Over-range	77.0199	75.8798	13.53	
15:14:17	1.8237	50.3804	75.3262	Over-range	77.1572	75.9862	13.53	
15:14:27	1.8215	50.3804	75.3262	Over-range	77.1115	75.895	13.53	
15:14:37	1.8197	50.3804	75.3262	Over-range	77.1115	75.819	13.53	
15:14:47	1.8211	50.3804	75.3262	Over-range	77.1115	75.8798	13.53	
15:14:57	1.8182	50.3804	75.4635	Over-range	77.0199	75.7582	13.53	
15:15:07	1.8211	50.3877	75.1431	Over-range	76.7452	75.8798	13.53	
15:15:17	1.8197	50.3804	75.4177	Over-range	77.0657	75.819	13.53	
15:15:27	1.8193	50.3804	75.1888	Over-range	77.0199	75.8038	13.53	
15:15:37	1.8182	50.3804	75.555	Over-range	77.2946	75.7582	13.53	
15:15:47	1.8233	50.3804	75.4635	Over-range	77.2946	75.971	13.53	
15:15:57	1.8153	50.3804	75.2804	Over-range	77.0199	75.6366	13.53	
15:16:07	1.8211	50.3804	75.1888	Over-range	77.0199	75.8798	13.53	
15:16:17	1.8211	50.3804	75.1431	Over-range	77.0199	75.8798	13.53	
15:16:27	1.8189	50.3804	75.1431	Over-range	77.0657	75.7886	13.53	
15:16:38	1.8226	50.3804	75.2804	Over-range	77.0199	75.9406	13.53	
15:16:48	1.8211	50.3804	75.3262	Over-range	76.8368	75.8798	13.53	
15:16:58	1.8193	50.3804	75.1888	Over-range	77.0657	75.8038	13.53	
15:17:08	1.8211	50.3804	75.3262	Over-range	77.1115	75.8798	13.53	
15:17:18	1.8211	50.3804	75.3719	Over-range	77.1115	75.8798	13.53	
15:17:28	1.8193	50.3804	75.4177	Over-range	77.1572	75.8038	13.53	
15:17:38	1.8193	50.3804	75.6466	Over-range	77.3861	75.8038	13.53	
15:17:48	1.8237	50.3804	75.1888	Over-range	77.0657	75.9862	13.53	
15:17:58	1.8215	50.3804	75.5093	Over-range	77.0657	75.895	13.53	
15:18:08	1.8233	50.3804	75.4635	Over-range	77.1115	75.971	13.53	
15:18:18	1.8197	50.3804	75.3262	Over-range	77.0199	75.819	13.53	
15:18:28	1.8178	50.3804	75.1888	Over-range	77.0199	75.743	13.53	
15:18:38	1.8193	50.3804	75.2804	Over-range	77.2946	75.8038	13.53	
15:18:48	1.8197	50.3804	75.1888	Over-range	77.0657	75.819	13.53	
15:18:58	1.8229	50.3804	75.3262	Over-range	77.0657	75.9558	13.53	
15:19:08	1.8211	50.3804	75.2804	Over-range	77.0199	75.8798	13.53	
15:19:18	1.8211	50.3804	75.4177	Over-range	77.2946	75.8798	13.53	
15:19:28	1.8215	50.3804	75.3262	Over-range	77.0199	75.895	13.53	
15:19:38	1.8193	50.3804	75.3719	Over-range	77.2946	75.8038	13.53	
15:19:48	1.8226	50.3804	75.5093	Over-range	77.203	75.9406	13.53	
15:19:58	1.8226	50.3804	75.555	Over-range	77.2946	75.9406	13.53	
15:20:08	1.8197	50.3804	75.6008	Over-range	77.1572	75.819	13.53	
15:20:18	1.8197	50.3658	75.1888	Over-range	77.0199	75.819	13.53	
15:20:28	1.8182	50.3658	75.1888	Over-range	76.9741	75.7582	13.53	
15:20:38	1.8211	50.3658	75.1888	Over-range	76.8368	75.8798	13.53	
15:20:48	1.8226	50.3658	75.555	Over-range	77.203	75.9406	13.53	
15:20:58	1.8211	50.3658	75.4635	Over-range	77.0199	75.8798	13.53	
15:21:08	1.8226	50.3658	75.4635	Over-range	77.0199	75.9406	13.53	
15:21:18	1.8153	50.3658	74.9142	Over-range	76.7452	75.6366	13.53	
15:21:28	1.7784	50.3804	71.8929	Over-range	73.5409	74.1012	13.53	
15:21:38	1.7715	50.3804	71.6182	Over-range	73.2204	73.8123	13.53	

KELTON®

APPENDIX B

15:21:48	1.7762	50.3804	71.6182	Over-range	73.312	74.01	13.53	
15:21:58	1.7773	50.3804	71.4809	Over-range	73.2662	74.0556	13.53	
15:22:08	1.7744	50.3804	71.664	Over-range	72.9915	73.934	13.53	
15:22:18	1.7759	50.3804	71.7098	Over-range	73.4493	73.9948	13.53	
15:22:28	1.7795	50.3804	71.8929	Over-range	73.4493	74.1468	13.53	
15:22:38	1.7766	50.3804	71.7098	Over-range	73.4035	74.0252	13.53	
15:22:48	1.7737	50.3804	71.4809	Over-range	73.0831	73.9036	13.53	
15:22:58	1.7773	50.3804	71.8929	Over-range	73.3577	74.0556	13.53	
15:23:08	1.781	50.3658	72.5338	Over-range	74.0444	74.2076	13.53	
15:23:18	1.7985	50.3658	73.724	Over-range	75.2346	74.9373	13.53	
15:23:28	1.8051	50.3658	74.2275	Over-range	75.8755	75.2109	13.53	
15:23:38	1.8094	50.3658	74.0902	Over-range	75.4177	75.3933	13.53	
15:23:48	1.8065	50.3658	73.9986	Over-range	75.6466	75.2717	13.53	
15:23:58	1.8087	50.3658	74.548	Over-range	76.1044	75.3629	13.53	
15:24:08	1.8105	50.3658	74.4106	Over-range	76.0586	75.4389	13.53	
15:24:18	1.8058	50.3658	74.4106	Over-range	76.0128	75.2413	13.53	
15:24:28	1.8062	50.3658	74.3648	Over-range	75.4177	75.2565	13.53	
15:24:38	1.8083	50.3658	74.548	Over-range	76.1502	75.3477	13.53	
15:24:48	1.8073	50.3658	74.0902	Over-range	75.7839	75.3021	13.53	
15:24:58	1.8116	50.3658	74.3648	Over-range	75.8755	75.4845	13.53	
15:25:08	1.8051	50.3658	74.3648	Over-range	76.0586	75.2109	13.53	
15:25:18	1.8062	50.3658	74.3648	Over-range	75.8755	75.2565	13.53	
15:25:28	1.8076	50.3658	74.5937	Over-range	76.1959	75.3173	13.53	
15:25:38	1.8076	50.3658	74.3648	Over-range	75.967	75.3173	13.53	
15:25:48	1.8058	50.3658	73.9986	Over-range	75.3719	75.2413	13.53	
15:25:58	1.8094	50.3658	74.4106	Over-range	76.1959	75.3933	13.53	
15:26:08	1.8083	50.3658	74.0444	Over-range	75.6466	75.3477	13.53	
15:26:18	1.8083	50.3658	74.4106	Over-range	75.967	75.3477	13.53	
15:26:28	1.8076	50.3658	74.0902	Over-range	75.8297	75.3173	13.53	
15:26:38	1.8083	50.3658	74.2733	Over-range	75.8755	75.3477	13.53	
15:26:48	1.8087	50.3658	74.6395	Over-range	76.3333	75.3629	13.53	
15:26:58	1.812	50.3658	74.2733	Over-range	75.8755	75.4997	13.53	
15:27:08	1.8087	50.3658	74.3648	Over-range	75.967	75.3629	13.53	
15:27:18	1.8094	50.3511	74.0902	Over-range	75.8755	75.3933	13.53	
15:27:28	1.8065	50.3365	74.1817	Over-range	75.8297	75.2717	13.53	
15:27:38	1.8076	50.3365	74.5937	Over-range	76.1502	75.3173	13.53	
15:27:48	1.8105	50.3365	74.2275	Over-range	75.8297	75.4389	13.53	
15:27:58	1.8051	50.3365	74.5022	Over-range	76.1044	75.2109	13.53	
15:28:08	1.8076	50.3365	74.2733	Over-range	75.6466	75.3173	13.53	
15:28:18	3.0025	50.3877	209.453	Over-range	214.6716	125.1032	13.53	
15:28:28	3.0605	50.3804	212.52	Over-range	215.5871	127.5203	13.53	
15:28:38	3.0594	50.3804	212.8405	Over-range	215.6787	127.4747	13.53	
15:28:48	3.0601	50.3804	212.7947	Over-range	215.5871	127.5051	13.53	Equalising Valve fully closed
15:28:58	3.0583	50.3804	212.7947	Over-range	215.6787	127.4291	13.53	
15:29:08	3.0583	50.3804	212.6116	Over-range	216.1364	127.4291	13.53	
15:29:18	3.0598	50.3804	213.2525	Over-range	216.64	127.4899	13.53	
15:29:28	3.0539	50.3804	213.2067	Over-range	215.8618	127.2467	13.53	
15:29:38	3.0605	50.3804	213.0236	Over-range	215.816	127.5203	13.53	
15:29:48	3.0598	50.3804	212.932	Over-range	215.2667	127.4899	13.53	
15:29:58	3.0565	50.3804	212.7031	Over-range	215.5871	127.3531	13.53	
15:30:08	3.0554	50.3804	212.7031	Over-range	215.2209	127.3075	13.53	