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Client : ELSTER METERING LTD

Project Title : MEASUREMENT ERROR REPORT

Document Title : MER WM015 MINWORTH BNEF

Document Ref. : NK3224 – 001

Client Ref. : PO 3756176 / 9740

REV	ISSUE DATE	DESCRIPTION	PREP. BY	APP. BY
1	27/03/2018	Issue for Comment	BK	KV
1.1	09/01/2019	Revised for Comment	BK	KV
2	15/02/2019	Final	BK	KV

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1.0 EXECUTIVE SUMMARY

Site Name	Minworth BNEF
DNO	Cadent Gas Ltd
LDZ	West Midlands
Error Start Date	
(Or) Last Good Date	24th September 2014
Error Corrected Date	1st September 2015 @15:09
Size of Error (over or under read)	9,020 Sm^3 under-registration (0.17%)
Error Description	Pressure transmitter failed validation; Calibration data entered incorrectly
Methodology	Correction of volumes using validation results and correct calibration data
Meter Type	Rotary Positive Displacement
MER Unique Reference Number	WM015
DN Reference	MER/CAD/194/15

2.0 ERROR DESCRIPTION

Minworth BNEF has one Elster Instromet IRM rotary meter stream with an Elster EnCal 3000 for determination of gas quality. The measurement system commenced operation on 24th September 2014. The pressure transmitter was validated on 1st September 2015 and found to have errors of approximately 0.25 %span across the range. The transmitter was subsequently successfully calibrated. During the same validation it was noticed that the meter calibration error correction table in the flow computer had been entered incorrectly. The atmospheric air calibration data had been entered instead of the high-pressure natural gas calibration data. This was corrected on 1st September 2015.

3.0 METHODOLOGY

3.1 Pressure Errors

The pressure transmitter 'As Found' validation results were averaged (rising and falling) as shown in Table 1.

Applied Pressure (barg)	Displayed Pressure (barg)		Error (% of Span)		
	Rising	Falling	Rising	Falling	**Average**
0.00	0.0573	0.0583	0.23	0.23	**0.230**
6.25	6.3143	*6.7164	0.26	*1.87	**1.065**
12.50	12.5661	12.5651	0.26	0.26	**0.260**
18.75	18.8065	18.8159	0.23	0.26	**0.245**
25.00	25.0552	25.0646	0.22	0.26	**0.240**

Table 1 – As Found Validation Results

*The 6.25 barg falling result is not consistent with the rest of the results. This is outside the normal operating pressure range and therefore does not impact the error quantification.

Extracts of the 'As Found' and 'As Left' validation forms are included in Appendix B. The pressure measurement test equipment calibration certificate is included in Appendix C.

For the error period, the corrected pressure, recorded on a 3-minutely basis, was recalculated using the pressure errors described above. The pressure error was interpolated from the points above and below the current operating pressure. Two sets of daily Standard volumes calculations were performed; one using the measured pressure and another using corrected pressure. The pressure error (Error1) being the difference between the two.

[Note: Both above sets of calculations were performed using the K-factors calculated from the atmospheric air calibration data.]

3.2 Flow Calibration Errors

The RPD meter atmospheric air calibration results are shown in Table 2 and the high-pressure natural gas calibration results are shown in Table 3. The calibration certificates are included in Appendix D & E. The calibration facility ISO 17025 accreditation schedule is included in Appendix F.

Flow Rate (m^3/h)	Calculated Frequency (Hz)	Error (%)	Calculated K-Factor ($pulses/m^3$)
0.8	1.73	-1.94	7622.61
3	6.48	-0.70	7716.47
10	21.6	-0.02	7768.94
16	34.5	0.12	7779.83
26	56.1	0.36	7798.56
46	99.3	0.30	7793.87
65	140.3	0.35	7797.78

Table 2 – Atmospheric Air Calibration Results

Flow Rate (m^3/h)	Calculated Frequency (Hz)	Error (%)	K-Factor ($pulses/m^3$)
3	6.48	-0.88	7702.71
10.05	21.7	-0.63	7721.84
16.04	34.6	0.71	7826.05
25.94	56.0	-0.22	7753.43
45.98	99.2	0.04	7773.60
65.2	141	-0.06	7765.83

Table 3 – High Pressure Natural Gas Calibration Results

For the error period, the gross volume flow rate was recalculated on a 3-minutely basis using two sets of K-factors; one using the atmospheric air calibration data and another using the high-pressure natural gas calibration data in Table 3.

The K-Factor was interpolated from the points above and below the current operating frequency. Two sets of daily Standard volumes calculations were performed; one using the atmospheric air calibration data and another using the high-pressure natural gas calibration data. The flow calibration error (Error2) being the difference between the two.

[Note: Both above sets of calculations were performed using the measured (uncorrected) pressure.]

3.3 Combined Errors

As the start of the pressure transmitter error cannot be determined the combined error is calculated by adding half of the pressure error to the flow calibration errors for each day.

4.0 ERROR QUANTIFICATION

The total error for the period is 9,020 Sm^3 under-registration or -0.17% (taking into account half of the pressure error). As the start of the pressure transmitter error cannot be determined the daily correction factors have been calculated to reconcile half the pressure transmitter error and the whole error from the calibration data error. The error should be corrected using the daily correction factors in Appendix A (which include only half of the pressure error).

5.0 LEARNING

As part of the T/PR/ME/2 validation a pressure transmitter check is performed annually. This was the first validation of this transmitter. If the transmitter continues to show errors near to or outside the test tolerance, then consideration should be given to increasing the frequency of this check to 6-monthly.

Audits should be performed, particularly on commissioning or after significant system modification, by a party that is independent of upstream and downstream parties and not involved with the system commissioning/validation activities to provide assurance to all stakeholders that the system is fit for purpose.

6.0 REFERENCES

Minworth Site Data Files (DAT$####.ST3 and FLO$####.ST3)
Gemini Daily Volumes
MER_WM015_Minworth_R2_Data.xlsx - Calculation Data spreadsheet
MER_WM015_Minworth_R2_Summary.xlsx - Summary Data spreadsheet

APPENDIX A – Daily Correction Factors

The error should be corrected using the daily correction factors (DCF) applied to the Gemini DVols (DVol) as detailed below. As the start of the pressure transmitter error cannot be determined the daily correction factors have been calculated to reconcile half the pressure transmitter error and the whole error from the calibration data error.

Note: The Gemini final billed data shows a correction to zero on 26th September 2014 which is in agreement with the Reconciliation by Difference (RbD) file which also indicates no flow. The RbD file for 27th September 2014 also indicates no flow, but this was not corrected in the 'latest' Gemini billed data. This was manually corrected to zero post (D+5).

Gas Day	DVol	DCF
24-Sep-14	0.0	1
25-Sep-14	0.00121	1.003613
26-Sep-14	0.0	1
27-Sep-14	0.0	1
28-Sep-14	0.0	1
29-Sep-14	0.00050	1.003012
30-Sep-14	0.00149	1.003800
01-Oct-14	0.00189	1.003240
02-Oct-14	0.00198	1.002456
03-Oct-14	0.00213	1.001837
04-Oct-14	0.0	1
05-Oct-14	0.0	1
06-Oct-14	0.00562	1.002530
07-Oct-14	0.00400	1.002574
08-Oct-14	0.0	1
09-Oct-14	0.0	1
10-Oct-14	0.00419	1.002316
11-Oct-14	0.00675	1.002924
12-Oct-14	0.00306	1.003122
13-Oct-14	0.00475	1.003792
14-Oct-14	0.00386	1.002798
15-Oct-14	0.00617	1.002665
16-Oct-14	0.01639	1.002225
17-Oct-14	0.01784	1.002082
18-Oct-14	0.01828	1.002021
19-Oct-14	0.01799	1.002069
20-Oct-14	0.00466	1.002544
21-Oct-14	0.01537	1.002196
22-Oct-14	0.01421	1.002143
23-Oct-14	0.01277	1.002222
24-Oct-14	0.01737	1.002111
25-Oct-14	0.01540	1.002153
26-Oct-14	0.01860	1.002023
27-Oct-14	0.01807	1.002086

Gas Day	DVol	DCF
28-Oct-14	0.01846	1.001989
29-Oct-14	0.01790	1.002049
30-Oct-14	0.01772	1.001989
31-Oct-14	0.01117	1.001362
01-Nov-14	0.01170	1.002778
02-Nov-14	0.01193	1.003381
03-Nov-14	0.01175	1.002550
04-Nov-14	0.01558	1.002498
05-Nov-14	0.01221	1.002208
06-Nov-14	0.01312	1.002205
07-Nov-14	0.01811	1.002113
08-Nov-14	0.01350	1.001999
09-Nov-14	0.01330	1.002012
10-Nov-14	0.00953	1.002736
11-Nov-14	0.00773	1.002141
12-Nov-14	0.01268	1.002082
13-Nov-14	0.01400	1.002892
14-Nov-14	0.01109	1.001305
15-Nov-14	0.01167	1.002224
16-Nov-14	0.01014	1.003942
17-Nov-14	0.00991	1.001024
18-Nov-14	0.00326	1.000891
19-Nov-14	0.00486	1.001036
20-Nov-14	0.00652	1.000882
21-Nov-14	0.01525	1.001879
22-Nov-14	0.01816	1.002093
23-Nov-14	0.01331	1.002059
24-Nov-14	0.0	1
25-Nov-14	0.00035	1.000909
26-Nov-14	0.00780	1.002665
27-Nov-14	0.01140	1.002227
28-Nov-14	0.01030	1.003364
29-Nov-14	0.01503	1.003217
30-Nov-14	0.01427	1.003185

Gas Day	DVol	DCF
01-Dec-14	0.01678	1.002561
02-Dec-14	0.01549	1.002405
03-Dec-14	0.01502	1.002931
04-Dec-14	0.01264	1.002992
05-Dec-14	0.00814	1.002236
06-Dec-14	0.01019	1.002092
07-Dec-14	0.01842	1.002105
08-Dec-14	0.01680	1.002153
09-Dec-14	0.01847	1.002047
10-Dec-14	0.01834	1.002100
11-Dec-14	0.01735	1.002108
12-Dec-14	0.01737	1.001891
13-Dec-14	0.01518	1.001714
14-Dec-14	0.01915	1.001800
15-Dec-14	0.00340	1.001692
16-Dec-14	0.0	1
17-Dec-14	0.01208	1.001703
18-Dec-14	0.01523	1.001716
19-Dec-14	0.01662	1.001741
20-Dec-14	0.01948	1.001658
21-Dec-14	0.01933	1.001694
22-Dec-14	0.01569	1.001797
23-Dec-14	0.01378	1.001881
24-Dec-14	0.01873	1.001698
25-Dec-14	0.01947	1.001664
26-Dec-14	0.01694	1.002507
27-Dec-14	0.01151	1.000954
28-Dec-14	0.01380	1.002685
29-Dec-14	0.01519	1.003214
30-Dec-14	0.01517	1.003228
31-Dec-14	0.01504	1.003259
01-Jan-15	0.01451	1.003428
02-Jan-15	0.01519	1.003232
03-Jan-15	0.01517	1.003241
04-Jan-15	0.01523	1.003209
05-Jan-15	0.01519	1.003202
06-Jan-15	0.01510	1.003245
07-Jan-15	0.01469	1.003420
08-Jan-15	0.01181	1.002866
09-Jan-15	0.01520	1.003024
10-Jan-15	0.01549	1.003119
11-Jan-15	0.01556	1.003066
12-Jan-15	0.01517	1.002266
13-Jan-15	0.01648	1.002083
14-Jan-15	0.01762	1.002363
15-Jan-15	0.01787	1.002287
16-Jan-15	0.01501	1.002171
17-Jan-15	0.01739	1.002409

Gas Day	DVol	DCF
18-Jan-15	0.01161	1.001179
19-Jan-15	0.01039	1.000505
20-Jan-15	0.01040	0.999720
21-Jan-15	0.00443	0.999720
22-Jan-15	0.00996	1.000435
23-Jan-15	0.01481	1.002104
24-Jan-15	0.01831	1.002113
25-Jan-15	0.01797	1.002207
26-Jan-15	0.01627	1.001505
27-Jan-15	0.01607	1.001412
28-Jan-15	0.01657	1.001789
29-Jan-15	0.01831	1.001483
30-Jan-15	0.01917	1.001408
31-Jan-15	0.02056	1.001479
01-Feb-15	0.02061	1.001422
02-Feb-15	0.01627	1.001297
03-Feb-15	0.01768	1.001163
04-Feb-15	0.01662	1.001420
05-Feb-15	0.01859	1.001335
06-Feb-15	0.01962	1.001326
07-Feb-15	0.02057	1.001276
08-Feb-15	0.01482	1.001376
09-Feb-15	0.01727	1.001213
10-Feb-15	0.01651	1.001258
11-Feb-15	0.01863	1.001435
12-Feb-15	0.01994	1.001543
13-Feb-15	0.01931	1.001751
14-Feb-15	0.02057	1.001327
15-Feb-15	0.02062	1.001298
16-Feb-15	0.02058	1.001336
17-Feb-15	0.01939	1.001295
18-Feb-15	0.02027	1.001443
19-Feb-15	0.01868	1.001641
20-Feb-15	0.02035	1.001400
21-Feb-15	0.02046	1.001406
22-Feb-15	0.01982	1.001659
23-Feb-15	0.01823	1.001810
24-Feb-15	0.01986	1.001350
25-Feb-15	0.01812	1.001676
26-Feb-15	0.01917	1.001781
27-Feb-15	0.01938	1.001685
28-Feb-15	0.01865	1.001939
01-Mar-15	0.01858	1.002010
02-Mar-15	0.01320	1.001937
03-Mar-15	0.01645	1.001902
04-Mar-15	0.01933	1.001761
05-Mar-15	0.01840	1.001780
06-Mar-15	0.01912	1.001653

Gas Day	DVol	DCF
07-Mar-15	0.01998	1.001496
08-Mar-15	0.02004	1.001481
09-Mar-15	0.01535	1.001535
10-Mar-15	0.01848	1.001414
11-Mar-15	0.02002	1.001412
12-Mar-15	0.01811	1.001507
13-Mar-15	0.01985	1.001547
14-Mar-15	0.02002	1.001459
15-Mar-15	0.02005	1.001459
16-Mar-15	0.02003	1.001451
17-Mar-15	0.01997	1.001436
18-Mar-15	0.02001	1.001426
19-Mar-15	0.02010	1.001428
20-Mar-15	0.02007	1.001413
21-Mar-15	0.02006	1.001442
22-Mar-15	0.02003	1.001436
23-Mar-15	0.01900	1.001500
24-Mar-15	0.01430	1.001512
25-Mar-15	0.01999	1.001467
26-Mar-15	0.02002	1.001480
27-Mar-15	0.02001	1.001425
28-Mar-15	0.01306	1.001315
29-Mar-15	0.01628	1.002084
30-Mar-15	0.01798	1.002095
31-Mar-15	0.01814	1.002194
01-Apr-15	0.01875	1.001932
02-Apr-15	0.01836	1.001923
03-Apr-15	0.01721	1.001990
04-Apr-15	0.01769	1.001913
05-Apr-15	0.01781	1.001806
06-Apr-15	0.00235	1.001870
07-Apr-15	0.00828	1.001979
08-Apr-15	0.01258	1.001883
09-Apr-15	0.01405	1.002005
10-Apr-15	0.01656	1.002111
11-Apr-15	0.01667	1.002203
12-Apr-15	0.01388	1.002810
13-Apr-15	0.01345	1.002087
14-Apr-15	0.01233	1.002310
15-Apr-15	0.01550	1.002240
16-Apr-15	0.01661	1.002384
17-Apr-15	0.01757	1.002345
18-Apr-15	0.01620	1.002307
19-Apr-15	0.01708	1.002308
20-Apr-15	0.00827	1.002166
21-Apr-15	0.00425	1.003070
22-Apr-15	0.00822	1.002896
23-Apr-15	0.01273	1.003117

Gas Day	DVol	DCF
24-Apr-15	0.01762	1.002072
25-Apr-15	0.01830	1.001922
26-Apr-15	0.01820	1.002024
27-Apr-15	0.01319	1.002039
28-Apr-15	0.01679	1.001996
29-Apr-15	0.01844	1.002027
30-Apr-15	0.01748	1.001995
01-May-15	0.01533	1.002117
02-May-15	0.01778	1.002257
03-May-15	0.01722	1.002329
04-May-15	0.01765	1.002242
05-May-15	0.01723	1.002412
06-May-15	0.01847	1.001950
07-May-15	0.01795	1.001301
08-May-15	0.01867	1.001087
09-May-15	0.01991	1.001074
10-May-15	0.02144	1.001039
11-May-15	0.01935	1.001051
12-May-15	0.02042	1.001080
13-May-15	0.02151	1.001063
14-May-15	0.02151	1.001038
15-May-15	0.02166	1.001094
16-May-15	0.02185	1.001112
17-May-15	0.02165	1.001093
18-May-15	0.02069	1.001182
19-May-15	0.02026	1.001070
20-May-15	0.02171	1.001083
21-May-15	0.02043	1.001150
22-May-15	0.02061	1.001154
23-May-15	0.02164	1.001132
24-May-15	0.01212	1.001215
25-May-15	0.01022	1.002692
26-May-15	0.01102	1.003770
27-May-15	0.01113	1.001707
28-May-15	0.01091	1.001359
29-May-15	0.01054	1.001095
30-May-15	0.01056	1.001831
31-May-15	0.01075	1.001007
01-Jun-15	0.01025	1.000666
02-Jun-15	0.01119	1.002302
03-Jun-15	0.00806	1.002468
04-Jun-15	0.01016	1.002179
05-Jun-15	0.00995	1.001907
06-Jun-15	0.00951	1.002505
07-Jun-15	0.01122	1.002532
08-Jun-15	0.00965	1.002384
09-Jun-15	0.01402	1.001596
10-Jun-15	0.02012	1.001259

Gas Day	DVol	DCF
11-Jun-15	0.02006	1.001214
12-Jun-15	0.01966	1.001242
13-Jun-15	0.01903	1.001287
14-Jun-15	0.02026	1.001233
15-Jun-15	0.01881	1.001063
16-Jun-15	0.01718	1.001107
17-Jun-15	0.02041	1.001100
18-Jun-15	0.02022	1.001176
19-Jun-15	0.01888	1.001174
20-Jun-15	0.01823	1.001209
21-Jun-15	0.01993	1.001280
22-Jun-15	0.02015	1.001219
23-Jun-15	0.02054	1.001049
24-Jun-15	0.01857	1.001095
25-Jun-15	0.02079	1.001068
26-Jun-15	0.02044	1.001106
27-Jun-15	0.02067	1.001068
28-Jun-15	0.01946	1.001126
29-Jun-15	0.02099	1.001061
30-Jun-15	0.01876	1.001093
01-Jul-15	0.01444	1.001142
02-Jul-15	0.01949	1.001066
03-Jul-15	0.02100	1.001064
04-Jul-15	0.01967	1.001045
05-Jul-15	0.02045	1.001078
06-Jul-15	0.02067	1.001028
07-Jul-15	0.02087	1.001026
08-Jul-15	0.02116	1.001157
09-Jul-15	0.01463	1.001289
10-Jul-15	0.02053	1.001193
11-Jul-15	0.01976	1.001301
12-Jul-15	0.02008	1.001206
13-Jul-15	0.01406	1.001705
14-Jul-15	0.01725	1.001560
15-Jul-15	0.01752	1.001756
16-Jul-15	0.01789	1.001463
17-Jul-15	0.01890	1.001427
18-Jul-15	0.01974	1.001325
19-Jul-15	0.01813	1.001508
20-Jul-15	0.01931	1.001344
21-Jul-15	0.01915	1.001197
22-Jul-15	0.01986	1.001177

Gas Day	DVol	DCF
23-Jul-15	0.01995	1.001137
24-Jul-15	0.01978	1.001349
25-Jul-15	0.01894	1.001245
26-Jul-15	0.01899	1.001537
27-Jul-15	0.01874	1.001411
28-Jul-15	0.02017	1.001132
29-Jul-15	0.02016	1.001131
30-Jul-15	0.02022	1.001082
31-Jul-15	0.01973	1.001176
01-Aug-15	0.02012	1.001109
02-Aug-15	0.01995	1.001162
03-Aug-15	0.02002	1.001166
04-Aug-15	0.02013	1.001123
05-Aug-15	0.02020	1.001066
06-Aug-15	0.01937	1.001095
07-Aug-15	0.01912	1.001118
08-Aug-15	0.02070	1.001030
09-Aug-15	0.01846	1.001053
10-Aug-15	0.01709	1.001093
11-Aug-15	0.01751	1.001104
12-Aug-15	0.01318	1.001192
13-Aug-15	0.01722	1.001557
14-Aug-15	0.01736	1.001507
15-Aug-15	0.01308	1.001163
16-Aug-15	0.01709	1.001757
17-Aug-15	0.01699	1.001772
18-Aug-15	0.01771	1.001777
19-Aug-15	0.01702	1.001783
20-Aug-15	0.01740	1.001473
21-Aug-15	0.01743	1.001346
22-Aug-15	0.01590	1.001431
23-Aug-15	0.01764	1.001543
24-Aug-15	0.01797	1.001496
25-Aug-15	0.01921	1.001415
26-Aug-15	0.01941	1.001414
27-Aug-15	0.01912	1.001278
28-Aug-15	0.01893	1.001240
29-Aug-15	0.01928	1.001380
30-Aug-15	0.01915	1.001466
31-Aug-15	0.01717	1.001517
01-Sep-15	0.01328	1.000374

APPENDIX B – Pressure Transmitter Validation Forms

Job Number 15/0797/02	Minworth BioGas Export to Grid - ME2 results Pressure Transmitter Calibration	Version 1.10

Installation:	Severn Trent Minworth Bio Gas site		**Manufacturer:**	Rosemount	**Local g:**	n/a	$m.s^{-2}$
Service:	BioGas export to local distribution		**Model:**	3051CG5A02A	**DWT g:**	n/a	$m.s^{-2}$
Tag number:	PT 1034		**Serial:**	9584574			
Device:	Gauge pressure transmitter		**Tolerance (Tx):**	0.2 % of span	**Calibration temperature:**	n/a	°C
Range:	0 to 25 bar				**DWT coefficient:**	n/a	K^{-1}

Validation Equipment

Type	Make	Model	Serial	Calibrated	Remarks
Pressure	Additel	681	211H139B0013	03/02/2015	

% Span	Nominal Applied Pressure (bar)	Corrected Applied Pressure (bar)	Expected Reading (bar)		Displayed Reading (bar)		Error (% of span)	
			Rising	Falling	Rising	Falling	Rising	Falling
0.0	0	0.0000	0.0000	0.0000	0.0573	0.0583	⊗ 0.23	⊗ 0.23
25.0	6.25	6.2500	6.2500	6.2500	6.3143	6.7164	⊗ 0.26	⊗ 1.87
50.0	12.5	12.5000	12.5000	12.5000	12.5661	12.5651	⊗ 0.26	⊗ 0.26
75.0	18.75	18.7500	18.7500	18.7500	18.8065	18.8159	⊗ 0.23	⊗ 0.26
100.0	25	25.0000	25.0000	25.0000	25.0552	25.0646	⊗ 0.22	⊗ 0.26

Ambient temperature:	n/a	°C	**Calibration Status: Pressure Transmitter**	**FAIL**
Transmitter temperature:	n/a	°C		
Ambient pressure:		bar		

Comments: Tolerance is 0.2% as per National Grid standards.	Calibrated by:	Bob Thomson - EffecTech
	Witnessed by:	
	Calibration date: 01 September 2015	**Fail**

Job Number 15/0797/02	Minworth BioGas Export to Grid - ME2 results Pressure Transmitter Calibration	Version 1.10

Installation:	Severn Trent Minworth Bio Gas site		**Manufacturer:**	Rosemount	**Local g:**	n/a	$m.s^{-2}$
Service:	BioGas export to local distribution		**Model:**	3051CG5A02A	**DWT g:**	n/a	$m.s^{-2}$
Tag number:	PT 1034		**Serial:**	9584574			
Device:	Gauge pressure transmitter		**Tolerance (Tx):**	0.2 % of span	**Calibration temperature:**	n/a	°C
Range:	0 to 25 bar				**DWT coefficient:**	n/a	K^{-1}

Validation Equipment

Type	Make	Model	Serial	Calibrated	Remarks
Pressure	Additel	681	211H139B0013	03/02/2015	

% Span	Nominal Applied Pressure (bar)	Corrected Applied Pressure (bar)	Expected Reading (bar)		Displayed Reading (bar)		Error (% of span)	
			Rising	Falling	Rising	Falling	Rising	Falling
0.0	0	0.0000	0.0000	0.0000	0.0011	0.0011	0.00	0.00
25.0	6.25	6.2500	6.2500	6.2500	6.2519	6.2592	0.01	0.04
50.0	12.5	12.5000	12.5000	12.5000	12.5068	12.5131	0.03	0.05
75.0	18.75	18.7500	18.7500	18.7500	18.7482	18.7586	-0.01	0.03
100.0	25	25.0000	25.0000	25.0000	24.9969	25.0032	-0.01	0.01

Ambient temperature:	n/a	°C	**Calibration Status: Pressure Transmitter**	**PASS**
Transmitter temperature:	n/a	°C		
Ambient pressure:		bar		

Comments: Tolerance is 0.2% as per National Grid standards.	Calibrated by:	Bob Thomson - EffecTech
	Witnessed by:	
	Calibration date: 01 September 2015	**Pass - As left**

APPENDIX C – Pressure Measurement Test Equipment Certificate

Chamois Metrology
Instrumentation Calibration Measurement Engineering

CERTIFICATE OF CALIBRATION

ISSUED BY: CHAMOIS METROLOGY LTD
DATE OF ISSUE: 03 February 2015
CERTIFICATE NUMBER: 19090

UKAS CALIBRATION 0822

Chamois Metrology Ltd
Unit 8 The Centre
Holywell Business Park
Northfield Rd, Southam
Warwickshire. CV47 0FP
Tel: 01926 812066
Fax: 01926 813569
e-mail: lab@chamois.net
www www.chamois.net

APPROVED SIGNATORY
N A Morgan B. Hemple
A Garthwaite S. Kelly

CUSTOMER DETAILS	Company	:	EffecTech Ltd
	Address	:	Dove House Dove Fields Uttoxeter Staffordshire ST14 8HU
	Order Number	:	5926
UNIT CALIBRATED	Date calibrated	:	03 February 2015
	Calibration site	:	Chamois Metrology Laboratory
	Manufacturer	:	Additel
	Model	:	681
	Serial No	:	211H139B0013
CALIBRATION PROCEDURE		:	PROC- 21
ENVIRONMENT TEMPERATURE		:	20°C ± 2°C

Customer Requirement:
UKAS Certification.

TRACEABILITY STATEMENT
All measuring equipment used for calibration purposes is traceable to National or Internationally recognised standards.

Certified By:

KELTON®

CERTIFICATE OF CALIBRATION

UKAS ACCREDITED CALIBRATION LABORATORY No 0822

CERTIFICATE NUMBER 19090

Condition: The instrument under test was received in working order.

Pressure media: Nitrogen.

Orientation: The unit under test was calibrated in a vertical position.

Pressure reference: Pressure measurements were referred to the sealing face on the pressure connector.

Zero: The instrument under test was zeroed prior to calibration.

Specification: The unit under test was calibrated to the manufacturers specification of 0.025% FS. The uncertainties shown in this certificate are not included in this specification.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor *k*=2, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

KELTON®

CERTIFICATE OF CALIBRATION

UKAS ACCREDITED CALIBRATION LABORATORY No 0822

CERTIFICATE NUMBER 19090

CUSTOMER	EFFECTECH LTD
FILE NAME	15020017
UNIT UNDER TEST	
MANUFACTURER	ADDITEL
MODEL	681
SERIAL NUMBER	211H139B0013
TEST CONDITIONS	
PRESSURE MEDIA	NITROGEN
CALIBRATION SITE	CHAMOIS METROLOGY CALIBRATION LABORATORY
CALIBRATION DATE	03 FEBRUARY 2015
AMBIENT TEMP(°C)	20.2

AS FOUND RESULTS

APPLIED PRESSURE bar	UUT READING bar	ERROR bar	ERROR %F.S.	ERROR % TOLERANCE
0.000	0.00	0.00	**0.000**	**0**
14.005	14.00	-0.01	**-0.004**	**-14**
28.010	28.01	-0.00	**-0.000**	**-0**
56.020	56.01	-0.01	**-0.007**	**-29**
84.065	84.06	-0.00	**-0.004**	**-14**
112.075	112.06	-0.02	**-0.011**	**-44**
140.086	140.07	-0.02	**-0.011**	**-45**
112.075	112.07	-0.01	**-0.004**	**-15**
84.065	84.06	-0.00	**-0.004**	**-14**
56.020	56.02	-0.00	**-0.000**	**-1**
28.010	28.01	-0.00	**-0.000**	**-0**
14.005	14.01	0.00	**0.004**	**14**
0.000	0.01	0.01	**0.007**	**29**

UNCERTAINTIES ON THE REPORTED MEASUREMENTS

	ppm +	bar
From 0 to 140 bar	50	0.01

SS0011.WB2 Version 1 07:02:05

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor *k*=2, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

APPENDIX D – Atmospheric Air Calibration Certificate

Certificate

Certificatenumber : G14/S/3408
Projectnumber : 31141001
Page : 1 of 2

Applicant : Elster - Instromet B.V.
Munstermanstraat 6
7064 KA Silvolde

Meter under test : Type of meter : Rotary gas meter
Manufacturer : ELSTER-INSTROMET
Type : IRM-HPB
Serial number : 20533620

Test Method : The actual flow rate of the gas meter is established with the aid of standard gas meters pressure- and temperature transmitters.
In the determination of this flow rate the pressure measurement point noted with P_{clm} is normatively established.

Test date : See page 2 of 2

Results : The measurement results are stated on page 2 of 2. The total measurement inaccuracy is based upon 2x the standard deviation (2s).

Traceability : The measurements have been executed using standards for which the traceability to primary, and/or (inter)national standards has been demonstrated.

Silvolde, June 2, 2014
NMi Nederland B.V.

B.W. Pastoor
Dept. Kalibration & Validation

ELSTER - INSTROMET
TRUE COPY OF ORIGINAL

NMi Nederland B.V.
Hugo de Grootplein 1,
3314 EG Dordrecht
P.O. Box 394, 3300 AJ Dordrecht, NL
phone +31 78 6332 332
fax +31 78 6332 309
certinsales@nmi.nl www.nmi.nl

KELTON®

Certificatenumber : G14/5/3408
Projectnumber : 31141001
Page : 2 of 2

Meter kind	: Rotary gas meter
Manufacturer	: ELSTER-INSTROMET
Number/year	: 20533620/2014
G-size/type/diam.	: G40/IRM-HPB/50 mm
Q_{max}/Q_{min}	: 65/0,8 m³/h
P_{max}	: 48,8 bar
Volume	: 0,514 dm³
Seals	: MID
Final index reading	: 000027,44 m³

Gear wheel meterside	: 32
Gear wheel indexside	: 59
Pulses per m³	:
LF	: 10
HF	: 7770,49

Flow m³/h	Error [%]
65	0,35
46	0,30
26	0,36
16	0,12
10	-0,02
3	-0,70
0,8	-1,94

Comment Error
1. Silvolde, 140602, Air atm. 20 °C

$$Error = \frac{V_{indicated} - V_{real}}{V_{real}} \times 100\ \%$$

The measurement uncertainty equals to 0,25% .

ELSTER - INSTROMET
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APPENDIX E – High Pressure Natural Gas Calibration Certificate

Prüfstelle für Messgeräte für Gas
bei der EnBW AG
Inspection office for gas meters at the EnBW AG

DIE BEI DEN MESSUNGEN VERWENDETEN NORMALE SIND AUF DIE NATIONALEN NORMALE BEI DER PHYSIKALISCH-TECHNISCHEN BUNDESANSTALT ZURÜCKGEFÜHRT.
THE STANDARDS USED FOR THE MEASUREMENTS ARE TRACEABLE TO THE NATIONAL STANDARDS AT THE PHYSIKALISCH-TECHNISCHE BUNDESANSTALT.

Kalibrierschein
Calibration certificate

Nummer *Number*	**221.INS / 2014**
Messgerätebezeichnung *Object*	**IRM-HPB**
Seriennummer *Identification*	**20533620**
Hersteller *Manufacturer*	**Instromet**
Antragsteller *Applicant*	**Elster-Instromet B.V.** **Munstermanstraat 6** **NL - 7064 KA Silvolde**
Anzahl der Seiten der Anlage *Number of pages of the addendum*	**2**
Anzahl der Anhänge *Number of annexes*	**0**
Ort und Datum der Prüfung *Place and date of test*	**Stuttgart, 2014-06-30**

Die Gültigkeit der Prüfung richtet sich nach nationalem Recht.
The validity of the calibration is subject to national law.

Stempelzeichen EnBW / 14
Marking

ELSTER - INSTROMET
TRUE COPY OF ORIGINAL

Prüfzertifikate ohne Unterschrift und Dienststempel haben keine Gültigkeit.
Dieses Prüfzertifikat darf nur unverändert weiter verbreitet werden.
Test certificates without signature and official stamp are not valid. This test certificate may only be reproduced in unchanged form.

Ort und Datum *Place and date*	Dienststempel *Official stamp*	Im Auftrag *On behalf of*
Stuttgart, 2014-06-30	EnBW Energie Baden-Württemberg AG Hochdruckprüfstand PasCaLab Talstr. 131 70188 Stuttgart Germany	

Prüfstelle bei der EnBW AG

70188 Stuttgart, Talstraße 131

Telefon: +49 711 / 28944265
Softwarefax: +49 721 / 91420338
E-Mail: m.schauluss@enbw.com

Seite 1 der Anlage zum Kalibrierschein Nr. 221.INS / 2014
Page 1 of the addendum to calibration certificate number 221.INS / 2014

Zusätzliche Angaben zum Gegenstand
additional comments concerning the object

Angaben entsprechend der Bauartzulassung
specifications concerning the type approval

Manufacturer / Type	IRM-HPB
Nominal Size	2"
Approval ID	
Year of construction	2014
Nominal diameter of meter	50 mm
Nominal flange pressure	ANSI 300
Range of flowrate	Q_{min} = 3 m³/h bis Q_{max} = 65 m³/h

Angaben entsprechend den Ergebnissen der Hochdruckprüfung
specifications concerning the high pressure test results

a) Specification of the badge

For natural gas		
$Q_{min,HD}$	3	m³/h
$p_{e\,min}$	10	bar
$p_{e\,max}$	40	bar

b) Specification of pulseres and adjusting wheels

Pulser 1	7770,49	Pulse/m³
Pulser 2		Pulse/m³
Pulser 3		Pulse/m³
Pulser 4		Pulse/m³
Adjust wheel		

Umgebungsbedingungen
Environmental conditions at test facility

Ambient temperature	22,87	°C
Ambient pressure	989,19	mbar

Prüfbedingungen (Prüfling)
Test conditions

Gas temperature	22,94	°C
Gas pressure	21,09	bara
Operating density	15,00	kg/m³
Standard density	0,75	kg/m³
Dynamic viskosity	11,34	10^{-6} Pa s
Compressibility	0,9600	

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Gas analysis (in mol%, Hs in MJ/m³)

CH4	95,80	C2H6	2,26	C3H8	0,56	i-C4H10	0,09
nC4H10	0,09	i-C5H12	0,02	n-C5H12	0,01	C6H14+	0,00
CO2	0,33	N2	0,82	O2	0,00	Hs	40,60

Ergebnisse
Results

1. The requirement of the „Eichordnung Anlage 7-1" and on page 1 of the appendix 1 approved approval test are fulfilled.
2. The deviation specified down apply to the impulse values and adjusting wheels specified on page 1 of the appendix 1.
3. The deviation of the meter were intended for the volumetric gas flow indicated in the following table:

Qi Qmax	Q [m³/h]	Reynoldszahl *Re*	f_r [‰]	U_m [‰]
1,00	65,20	$6,07 \cdot 10^5$	-0,02	<0,23
1,00	65,19	$6,07 \cdot 10^5$	-0,09	<0,23
1,00	65,21	$6,07 \cdot 10^5$	-0,07	<0,23
0,70	46,00	$4,30 \cdot 10^5$	0,01	<0,23
0,70	45,97	$4,30 \cdot 10^5$	0,07	<0,23
0,70	45,98	$4,30 \cdot 10^5$	0,05	<0,23
0,40	25,87	$2,42 \cdot 10^5$	-0,22	<0,23
0,40	25,99	$2,43 \cdot 10^5$	-0,21	<0,23
0,40	25,96	$2,43 \cdot 10^5$	-0,22	<0,23
0,25	16,03	$1,50 \cdot 10^5$	0,69	<0,23
0,25	16,04	$1,50 \cdot 10^5$	0,71	<0,23
0,25	16,04	$1,50 \cdot 10^5$	0,72	<0,23
0,15	10,06	$9,38 \cdot 10^4$	-0,59	<0,23
0,15	10,03	$9,35 \cdot 10^4$	-0,61	<0,23
0,15	10,06	$9,37 \cdot 10^4$	-0,70	<0,23
0,05	3,02	$2,82 \cdot 10^4$	-0,94	<0,28
0,05	3,00	$2,81 \cdot 10^4$	-0,73	<0,28
0,05	2,99	$2,80 \cdot 10^4$	-0,97	<0,28

The weighted mean error (WME) amounts to 0,09 %.

Hinweise
Notes

The presented results of the calibration are based on the harmonized Dutch-German reference values for the unit volume for high-pressure gas-flow measurements.

In Dodrecht, on 1999-June-02, PTB (Physikalisch-Technische Bundesanstalt) and NMi VSL (Netherlands Measurements Institute Van Swinden Laboratorium) have agreed on the harmonization and the use of these reference values.

Ende der Anlage
End of the addendum

Stuttgart, 2014-June-30

APPENDIX F – Calibration Facility ISO 17025 Accreditation Schedule

DAkkS Deutsche Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Anlage zur Akkreditierungsurkunde D-K-14490-03-00
nach DIN EN ISO/IEC 17025:2005

Entfristet am: 05.12.2018

Ausstellungsdatum: 23.07.2018

Urkundeninhaber:

EnBW Energie Baden-Württemberg AG
Durlacher Allee 93, 76131 Karlsruhe

mit dem Kalibrierlaboratorium:

Kalibrierlabor für Gas der EnBW AG
Talstraße 131, 70188 Stuttgart

Leiter:	Dr.-Ing. Bernd Laipple
Stellvertreter:	Dipl.-Ing. (FH) Lars Bertram
	Dipl.-Ing. (FH) Stefan Engelbert
	Dipl.-Ing. (FH) Marcus Walter

Akkreditiert als Kalibrierlaboratorium seit: 23.07.2018

Kalibrierungen in den Bereichen:

Durchflussmessgrößen
- **Durchfluss von Gasen**
- **Volumen von strömenden Gasen**

verwendete Abkürzungen: siehe letzte Seite

Die Urkunde samt Urkundenanlage gibt den Stand zum Zeitpunkt des Ausstellungsdatums wieder. Der jeweils aktuelle Stand des Geltungsbereiches der Akkreditierung ist der Datenbank akkreditierter Stellen der Deutschen Akkreditierungsstelle GmbH (DAkkS) zu entnehmen. https://www.dakks.de/content/datenbank-akkreditierter-stellen

Seite 1 von 2

Anlage zur Akkreditierungsurkunde D-K-14490-03-00

DAkkS Deutsche Akkreditierungsstelle

Permanentes Laboratorium

Messgröße / Kalibriergegenstand	Messbereich / Messspanne	Messbedingungen / Verfahren	kleinste angebbare Messunsicherheit [1]	Bemerkungen
Volumendurchfluss und Volumen von strömenden Gasen (Hochdruck-Erdgas, 4 bar bis 41 bar)	1,6 m³/h bis 3 m³/h	PTB-Prüfregel Band 30, Vergleichsverfahren	0,46 %	Kalibrierung von Turbinenrad-, Ultraschall- und Drehkolbengaszähler
	3 m³/h bis 10 m³/h		0,39 %	
	10 m³/h bis 50 m³/h		0,24 %	
	50 m³/h bis 1000 m³/h		0,22 %	
	1000 m³/h bis 6500 m³/h		0,24 %	

verwendete Abkürzungen:

DIN Deutsches Institut für Normung e.V.
NDS Hausverfahren der KBS

Ausstellungsdatum: 23.07.2018
Entfristet am: 05.12.2018

Seite 2 von 2