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EVALUATION OF A HAIMO 2-inch SPOOL PIECE MULTIPHASE FLOWMETER

A Report for

Haimo International FZE
PO Box 17256
Dubai
UAE

Report No: 2013/345 **Project No: HAI006** **Date: 30 July 2013**

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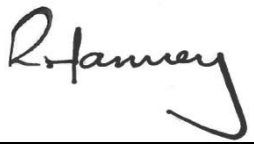
Prepared by:	Approved by:
	
Ian Nicholson	**Richard Harvey**

For
Brian Millington
Director

Date: 30 July 2013

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1 INTRODUCTION

This report presents the results from a flow test programme on a Haimo 2-inch spool piece multiphase flow meter. The aim of this evaluation was to assess the performance of the flowmeter with respect to the manufacturer's stated specification against a matrix of multiphase flow conditions. The test programme was conducted at the NEL Multiphase Flow Test Facility in East Kilbride, Scotland in July 2013.

This report describes the NEL Multiphase facility and the test set-up as well as data on the performance of the test meter at the conditions tested.

The Haimo 2" spool piece meter (SP MPFM) is a compact multiphase flow meter based around a Venturi flow meter, a multivariable transmitter and a dual energy gamma densitometer.

Total flow rate of the multiphase stream is measured by the Venturi flow meter. The multivariable transmitter (MVT) collects pressure, differential pressure and temperature data from appropriate locations on the SP MPFM. The raw signals from the MVT are processed by the Data Acquisition Unit and used to calculate the total flow rate and PVT parameters. The Dual Gamma Sensor is used to measure GVF and water liquid ratio (WLR) of the multiphase mixture. The pulses from the dual gamma detector are collected and processed by a new design of high-speed transmitter, assuring high WLR accuracy in the 0-80% GVF range.

2 NEL MULTIPHASE FLOW FACILITY

2.1 Layout and Test Fluids

A schematic of the NEL Multiphase Facility is shown in Figure 1. The facility is based around a 3-phase separator which contains the working bulk fluids. The oil and water are re-circulated around the test facility using two variable speed pumps. For safety reasons nitrogen is used as the gas phase and can be delivered at up to 0.5 kg/s by evaporation of liquid nitrogen on demand. The delivery pressure of the nitrogen is up to 13 bar at the injection point. After passing through the test section, the nitrogen is exhausted to atmosphere from the separator.

The test section can accommodate test set-ups of lengths up to 60 metres horizontal and 12 metres vertical. The standard test section is constructed in 4-inch schedule 40 pipework. Piping and adaptors are available to allow testing of 2, 3, 4 and 6-inch meters. The standard flange rating is ANSI class 150, but many other sizes can also be accommodated. The facility is manufactured entirely from stainless steel and can thus utilise brine substitutes and dead crude oils as the working fluids in addition to de-ionised water and refined oils. Perspex visualisation sections are available in 2, 4 and 6-inch pipe sizes.

Currently test fluids in use are:

- Ekofisk crude oil, topped to remove light ends and increase the flashpoint above 65ºC blended with approximately 30% odourless kerosene to restore its original viscosity (approximately 32° API gravity).

- An aqueous solution of Magnesium Sulphate of concentration 84g/l (based on $MgSO_4.7H_2O$).

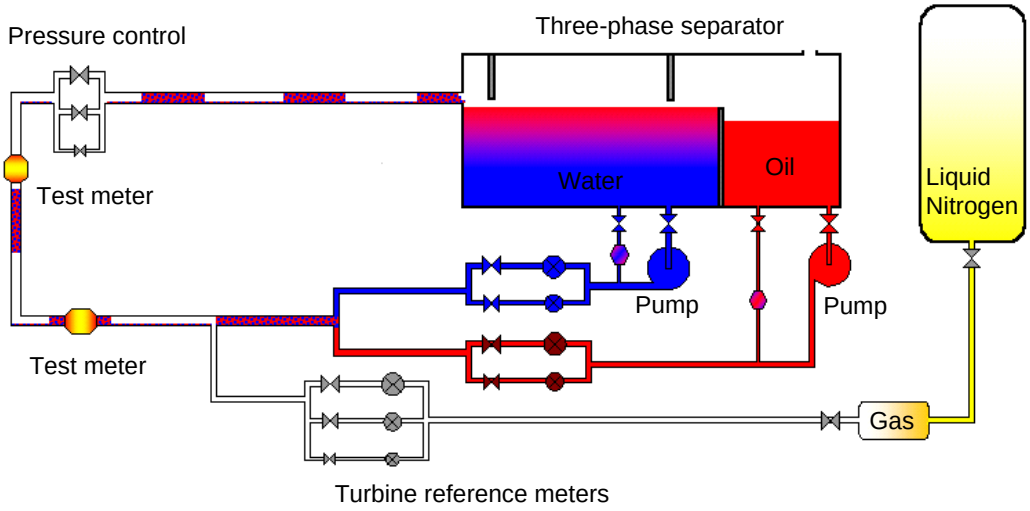

Figure 1 Schematic of NEL Multiphase Flow Facility

2.2 Control

An automated SCADA system allows a single operator to control the entire facility from a PC workstation. The PC is linked to the PLC via an Ethernet which permits a response time from command to action of less than one second. Field instrument data and test instrument information are collected via a separate data acquisition system.

2.3 Separation

At the centre of the facility is a large three-phase gravity separator, which contains approximately 25m^3 of water and 15m^3 of oil. This acts as the storage vessel for the liquids currently under test, in addition to separating the fluids for recirculation. Various devices are employed inside the separator to speed up separation including baffles and parallel plate pack systems. The liquids can be re-circulated indefinitely across much of the operating envelope of the facility; however, at certain high liquid flowrates it is sometimes necessary to shut down to allow the fluids to rest. The level of liquid cross-contamination is continually monitored and the reference liquid flowrates corrected. The separator is equipped with pumps and piping to allow transfer of settled liquids between the water and oil compartments. It is additionally equipped with heat exchangers which allow the temperature of the oil and water to be maintained within ±1°C over the range of approximately 10° to 50°C. Normal operating temperature is 35°C.

3 REFERENCE METERING SYSTEMS

3.1 Flowrate Measurements

The oil and water are separately drawn from the separator and pumped through the oil and water metering circuits respectively. Both metering circuits have a choice of two flowmeters, according to the flowrate required. Oil is metered using Faure Herman helical-blade turbine meters, with the following calibrated ranges:

1¼-inch turbine meter	0.5 to 5.5 l/s
3-inch turbine meter	5.0 to 40.0 l/s

The water is metered using flat-blade turbine meters with the following calibrated ranges:

1½-inch turbine meter	0.5 to 9.0 l/s
3-inch turbine meter	5.0 to 40.0 l/s

The nitrogen is metered through a choice of three gas turbine meters according to the flowrate required. The calibrated ranges of these flowmeters are:

½-inch turbine meter	0.38 to 2.19 l/s
1-inch turbine meter	1.53 to 19.2 l/s
3-inch turbine meter	6.3 to 38.6 l/s

The gas flowrate is measured at the gas supply pressure (typically 12 bar). However, by operating the test section at reduced pressures it is possible to cover the full range of gas volume fractions, with gas superficial velocities up to 20 m/s in the 4-inch test section.

3.2 Cross-contamination Monitoring

An additional bypass stream flows through monitors to measure the cross contamination of the liquid phases. This sample loop is taken from the main pump outlet, passed through a densitometer and returned to the separator. Prior to commencing a test programme clean test fluid samples are drawn from the separator and their densities are categorised over a range of temperatures using an Anton Paar DMA5000 laboratory densitometer. Cross contamination in the sample loops is calculated by:

$$Water\ Cut = (\rho_{indicated} - \rho_{oil}) / (\rho_{water} - \rho_{oil})$$

The water-in-oil content of the oil flow stream and the oil-in-water content of the water stream are determined from an online density measurement using a Parr Scientific vibrating tube densitometer.

3.3 Pressure and Temperature

For accurate volumetric metering of the gas phase, it is necessary to correct for expansion of the gas in the test section, so that the gas volume fraction and gas flowrate at the multiphase meter under test can be calculated. The pressure and temperature of the gas and of the multiphase mixture are therefore measured at a number of locations around the facility:

- At the reference gas meters
- At the inlet to the multiphase test section
- At intervals along the multiphase test section
- At the multiphase meter test location

Volume and, consequently, water-cut corrections are applied to local conditions at the test location.

4 REFERENCE MEASUREMENT QUALITY

4.1 Traceability of Reference Measurements

The instrumentation provided for the facility is of the highest accuracy practicable, and these instruments are calibrated against accurate standards, with a traceable record of the calibrations being maintained.

Most reference instruments are calibrated annually. The oil, water and gas reference turbine meters are calibrated against the UK primary national standard facilities at NEL. The pressure transmitters and platinum resistance thermometers are calibrated against standard equipment held in the multiphase laboratory.

The densities of the separate oil and water phases are also determined off-line prior to a customer's evaluation or test. The fluid densities are determined using an Anton Paar DMA5000 laboratory densitometer and are used in conjunction with the contamination measurement in-line densitometers to correct the reference liquid flow rates for the presence of second-phase contamination. The conductivity of the water phase can be determined using a standard conductivity meter.

4.2 Uncertainty Analysis

It is also important to be aware of the uncertainties which are present in the reference flowrates, taking into account the uncertainties of the calibrated instruments, observed fluctuations in flowrates during tests, and combination of the readings of a number of instruments to give the final values.

The exact uncertainties of a particular reference flowrate will depend on the values of the individual gas, oil and water flowrates and the ratio between them as well as pressure, temperature and liquid cross-contamination levels.

During 2010 NEL carried out a complete review of the uncertainty of the multiphase flow facility and achieved accreditation for the facility to ISO 17025. NEL is satisfied to quote a combined uncertainty that covers all aspects of the flow measurements including installation and process flow effects for this report. Over the majority of the operating range of the NEL multiphase flow facility the combined uncertainties are:

- Gas flow < 1.5%
- Liquid flow < 1.0%
- Water cut < 1.0% Absolute

One of the most significant contributing factors to the oil and water flowrate uncertainties is the uncertainty in the cross-contamination monitoring. This will lead to the greatest error in oil flowrate at high water-cut and the greatest error in water flowrate at low water-cut. The biggest contribution to the gas flowrate uncertainty is the test section pressure. The resulting error in gas flowrate is greatest at low test section pressure (which usually occurs when testing at high GVF). However, due to cancellation of errors, the uncertainties in GVF and in total liquid flowrate are much smaller than in the individual component flowrates.

All uncertainties quoted are expanded uncertainties based on a standard uncertainty multiplied by a coverage factor k=2. This provides a level of confidence of approximately 95%.

5 TEST SET-UP AND PROCEDURES

Figure 2: View Showing 2-inch SP MPFM Installation in Facility Test Section.

5.1 Meter Setup

The SP MPFM multiphase flowmeter was installed in the facility test section as shown in Figure 2. The source was then installed by Haimo personnel in the dual gamma sensor.

Next the parameters for the NEL multiphase test facility water, oil and gas properties were configured in the flow computer by Haimo. The meter was powered up and communication with the flow computer was established. The dual gamma sensor was then calibrated. Firstly, with the test section empty, then a calibration was done with single phase flows of oil and water. Finally, a static gas calibration of the dual gamma sensor was performed with the gas held at a pressure of 10 bar gauge.

With the on-site calibration process completed the testing commenced.

5.2 Test Procedure

At the beginning of each test point the NEL reference flow conditions were set by the facility operator and left to stabilise. A test point was logged once (a) the facility operator was satisfied that the required flow condition had been achieved and was stable and (b) the Haimo representative was satisfied that the SP MPFM output was also stable.

Data logging on the NEL facility reference system and the SP MPFM meter data acquisition flow computer were actuated simultaneously. Data logging was carried out for a period of 15 minutes per flow condition.

6 TEST RESULTS

The agreed test matrix is given in Table 1

TABLE 1

TEST MATRIX FOR HAIMO 2-INCH SP MPFM

Test No	Pressure bar	Temperature oC	Q Liquid l/s	Water Cut %	GVF %	Oil Flow l/s	Water Flow l/s	Gas Flow l/s
1	5	34	2.31	100	0	0.00	2.31	0.00
2	5	34	6.94	100	0	0.00	6.94	0.00
3	5	34	2.31	0	0	2.31	0.00	0.00
4	5	34	6.94	0	0	6.94	0.00	0.00
5	5	34	1.75	30	45	1.23	0.53	1.42
6	5	34	1.75	30	58	1.23	0.53	2.40
7	5	34	1.75	30	70	1.23	0.53	4.05
8	5	34	1.75	30	80	1.23	0.53	6.94
9	5	34	2.31	40	0	1.38	0.92	0.00
10	5	34	2.31	40	40	1.38	0.92	1.54
11	5	34	2.31	40	50	1.38	0.92	2.31
12	5	34	2.31	40	60	1.38	0.92	3.47
13	5	34	2.31	50	70	1.15	1.15	5.40
14	5	34	2.31	50	80	1.15	1.15	9.26
15	5	34	3.47	20	77	2.78	0.69	11.57
16	5	34	3.47	20	30	2.78	0.69	1.49
17	5	34	3.47	20	50	2.78	0.69	3.47
18	5	34	3.47	20	70	2.78	0.69	8.10
19	5	34	3.47	60	25	1.39	2.08	1.16
20	5	34	3.47	60	40	1.39	2.08	2.31
21	5	34	3.47	60	60	1.39	2.08	5.21
22	5	34	3.47	60	80	1.39	2.08	13.89
23	5	34	4.64	70	0	1.39	3.25	0.00
24	5	34	4.64	70	20	1.39	3.25	1.16
25	5	34	4.64	70	30	1.39	3.25	1.98
26	5	34	4.64	70	50	1.39	3.25	4.63
27	5	34	4.64	70	60	1.39	3.25	6.94
28	5	34	4.64	80	40	0.93	3.71	3.09
29	5	34	4.64	80	68	0.93	3.71	9.84
30	5	34	5.78	90	0	0.58	5.20	0.00
31	5	34	5.78	90	20	0.58	5.20	1.45
32	5	34	5.78	10	30	5.20	0.58	2.48
33	5	34	5.78	10	40	5.20	0.58	3.86
34	5	34	5.78	10	50	5.20	0.58	5.79
35	5	34	6.94	50	15	3.47	3.47	1.23
36	5	34	6.94	50	20	3.47	3.47	1.74
37	5	34	6.94	50	30	3.47	3.47	2.98
38	5	34	6.94	30	15	4.86	2.08	1.23
39	5	34	6.94	30	20	4.86	2.08	1.74
40	5	34	6.94	30	30	4.86	2.08	2.98
41	5	34	5.78	60	40	2.31	3.47	3.86
42	5	34	5.78	60	50	2.31	3.47	5.79

NOTE: Test points were not necessarily conducted in the order given above, but were instead carried out in the most suitable order for facility operational efficiency.

The manufacturer's claimed uncertainty for the SP MPFM is shown in Table 2.

TABLE 2

HAIMO SP MPFM CLAIMED UNCERTAINTY

Measurement Range	Term of Measurement Output	Uncertainty at 90% Confidence Level	Repeatability
Gas Volume Fraction (GVF) 0 – 80%	Liquid Flow Rate	± 3%	± 1.5 %
	Gas Flow Rate	± 6 %	± 3 %
	WC	± 1.5 %	± 0.75 %

Figure 3 shows the test matrix conditions compared with the actual conditions achieved during the test. Volumetric flow rates measured by the reference gas meters have been converted to pressure conditions as reported by the SP MPFM to permit a direct comparison.

Figures 4 to 8 illustrate the performance of the test meter during the test programme. The graphs show the measurement capabilities of the meter with respect to phase flow rate, GVF and liquid water-cut for the test results reported.

The numerical results from the test programme are given in Table 4 at the end of this report.

6.1 Liquid Flow Performance

Figure 4 shows the liquid flow rate relative deviation plotted against the reference GVF for all tests conducted. It can be seen from Figure 4 that 41 of the 42 liquid flow measurements made are within the stated performance specification. The uncertainty bands shown on figure 4 represent the Haimo uncertainty specification for the SP MPFM, given in Table 2.

The largest deviation in the measured liquid flow rate was 3.59%.

The liquid flow deviations show a total spread of 6.12% with a mean offset of 0.01% and a standard deviation of 1.34%.

6.2 Gas Flow Performance

Figure 5 shows the gas flow rate deviation plotted against GVF for the Haimo SP MPFM. It can also be seen from Figure 5 that 39 of the 42 gas flow measurements are within the stated performance specification. The uncertainty bands shown on Figure 5 represent the Haimo uncertainty specification for the SP MPFM given in Table 2. Figure 6 shows the same deviations plotted against reference gas flow rate. It can be seen from Figure 6 that the gas flow deviation appears to have some dependence on gas flow rate, in that the highest deviations occur at the lowest gas flow rates.

The meter's gas flow performance displayed a maximum deviation of 8.67%.
The gas flow deviations show a total spread of 13.48% with a mean offset of 0.79% and a standard deviation of 3.2%.

6.3 Water-Cut Performance

Figures 7 and 8 show the test meter's performance with respect to reference water-cut and GVF respectively. It can be seen from these figures that no deterioration in water-cut measurement performance is evident across the water-cut or GVF ranges tested. The uncertainty bands shown on Figures 7 and 8 represent the Haimo uncertainty specification for the SP MPFM given in Table 2. It can be seen from these figures that 41 of the 42 water-cut measurements are within the stated water-cut uncertainty specification.

The largest deviation in the measured water cut was -1.61%.

The water-cut deviations show a total spread of 2.76% with a mean offset of -0.49% and a standard deviation of 0.6%.

7 CONCLUSIONS

The test programme results have been analysed and presented numerically and graphically showing the performance with respect to the specification published by Haimo shown in Table 2. During the test programme a total of 42 test conditions resulting in 126 individual measurements of liquid flow rate, gas flow rate and water-cut, were logged across an agreed matrix of multiphase mixtures on a Haimo 2-inch Multiphase Flow Meter (SP MPFM).

In a comparison against the manufacturer's performance specification 121 of the 126 individual measurements of liquid flow rate, gas flow rate and water-cut were within the current published uncertainty specification.

The relative errors for the Haimo 2-inch Multiphase Flow Meter (SP MPFM) are given in Table 3.

TABLE 3

RELATIVE ERRORS FOR HAIMO SP MPFM

Test Point Breakdown	RMS Errors (%)	Error at 90% Confidence Level (k=1.684) (%)
Liquid Flow Rate	1.32	2.25
Gas Flow Rate	3.57	5.39
Water Cut	0.77	1.01

APPENDIX A

GRAPHICAL RESULTS

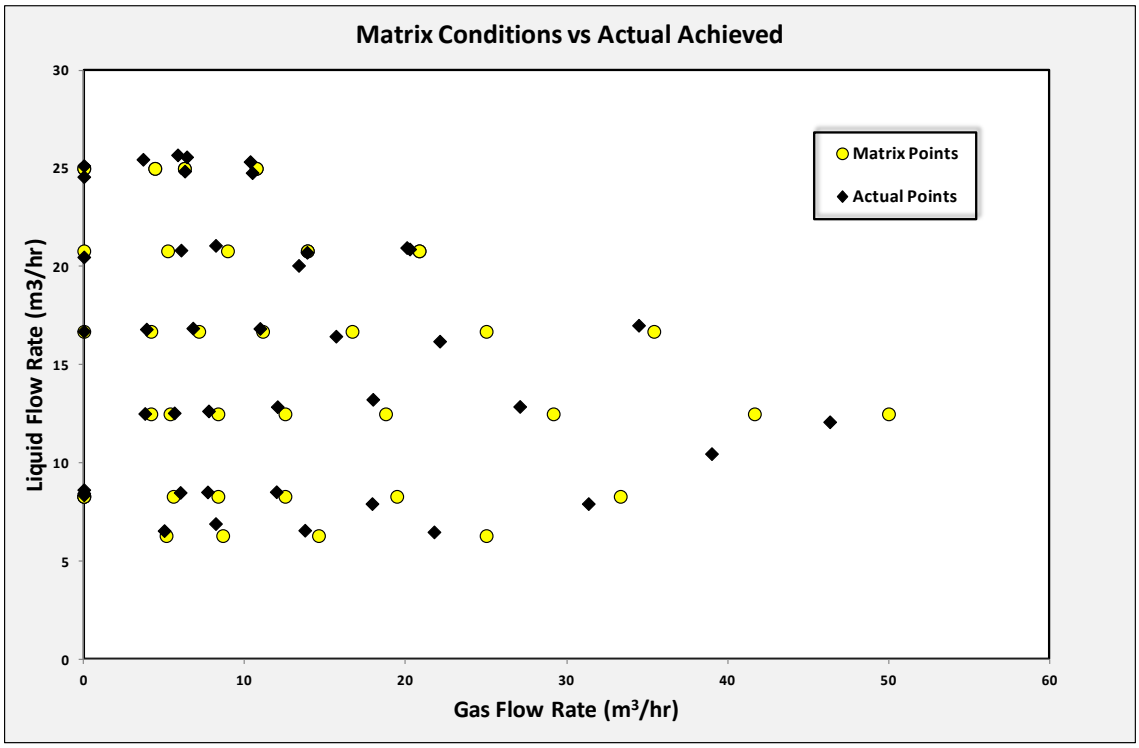

Figure 3 Test Matrix Conditions versus Actual Test Conditions Achieved

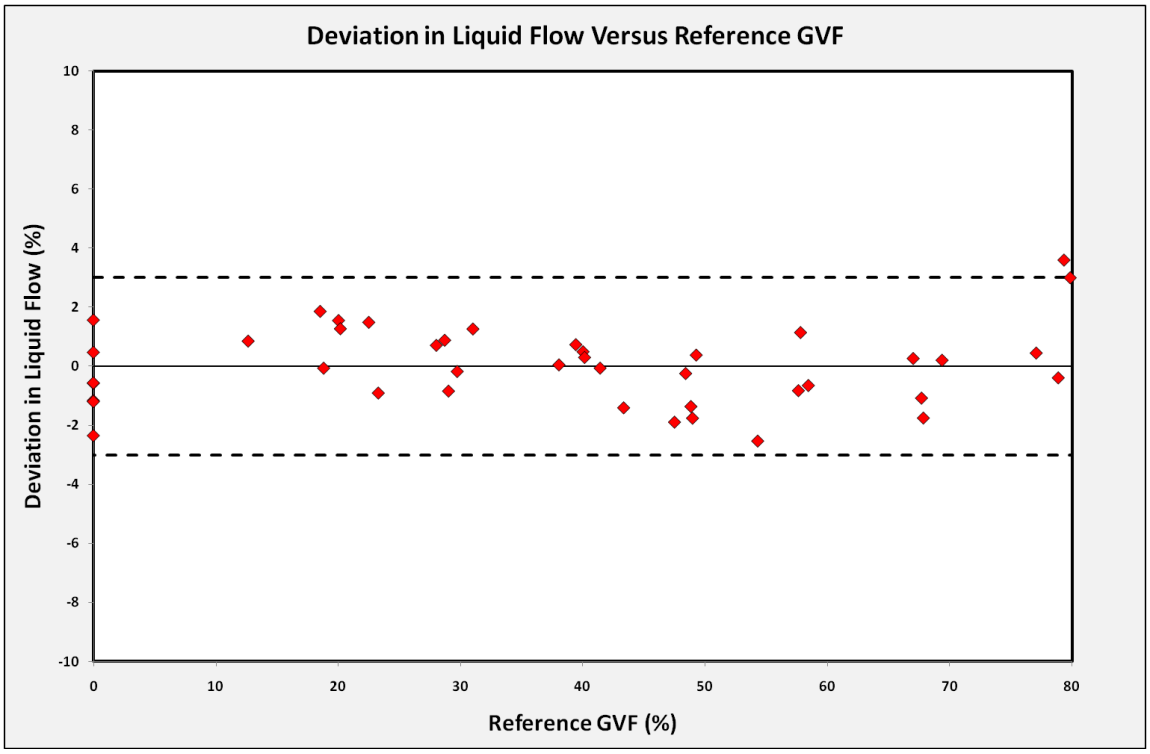

Figure 4 Deviation in Meter-Indicated Liquid Flow Rate versus Reference GVF for Haimo 2-inch Spool Piece Multiphase Flowmeter

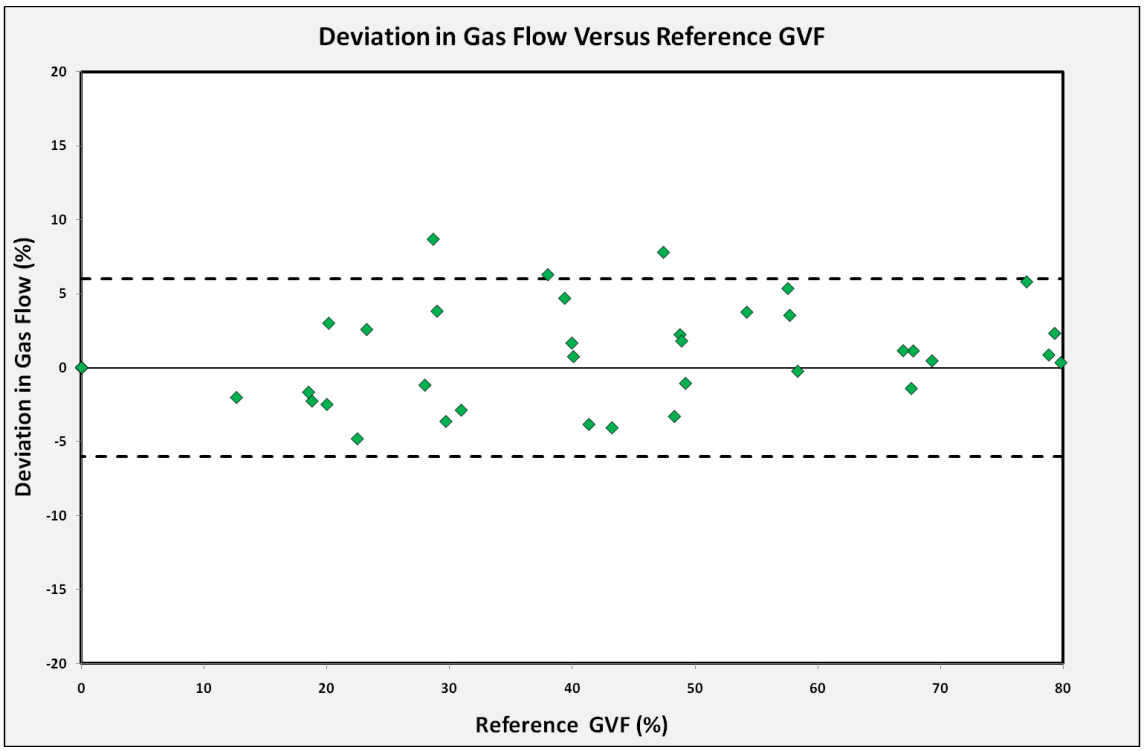

Figure 5 Deviation in Meter-Indicated Gas Flow Rate versus Reference GVF for Haimo 2-inch Spool Piece Multiphase Flowmeter

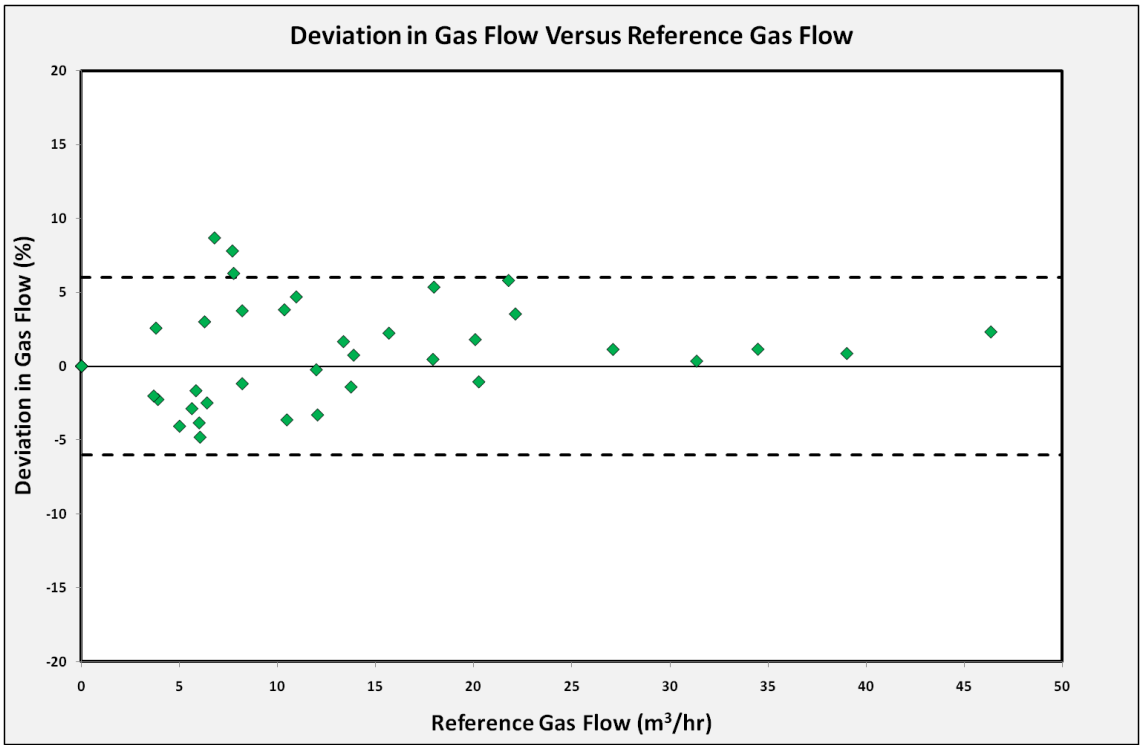

Figure 6 Deviation in Meter-Indicated Gas Flow Rate versus Reference Gas Flow Rate for Haimo 2-inch Spool Piece Multiphase Flowmeter

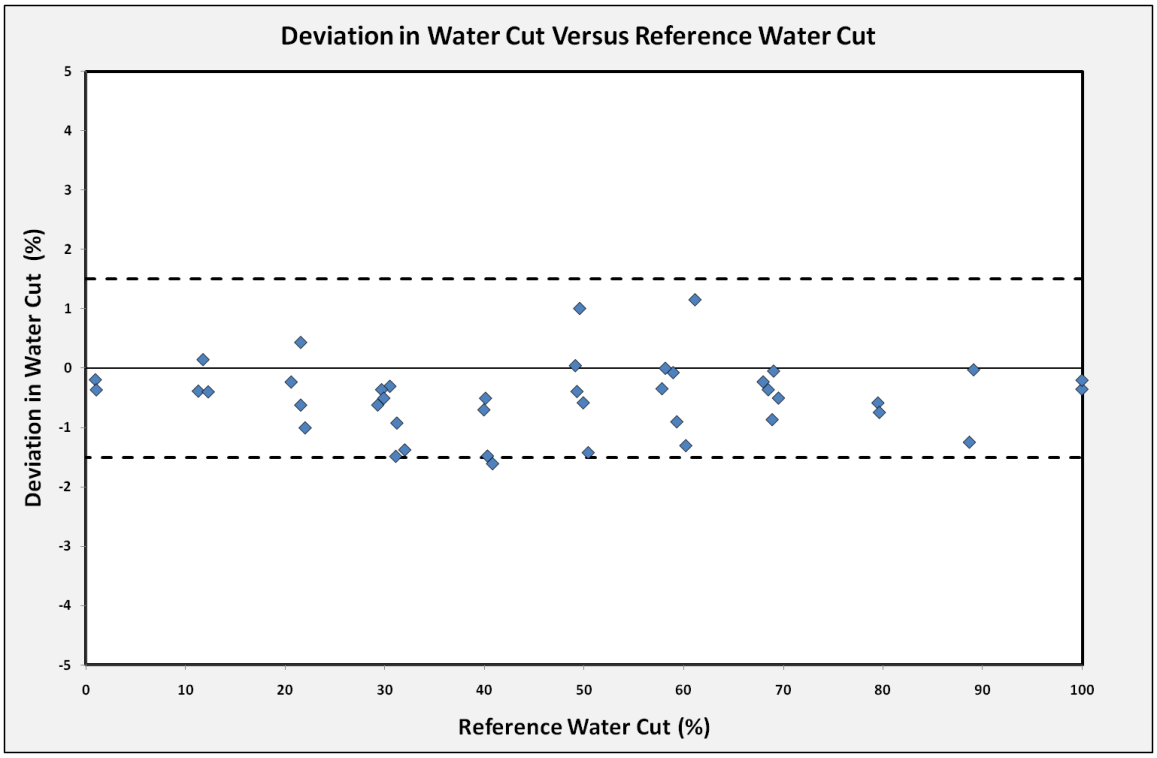

Figure 7 Deviation in Meter-Indicated Water-cut versus Reference Water-cut for Haimo 2-inch Spool Piece Multiphase Flowmeter

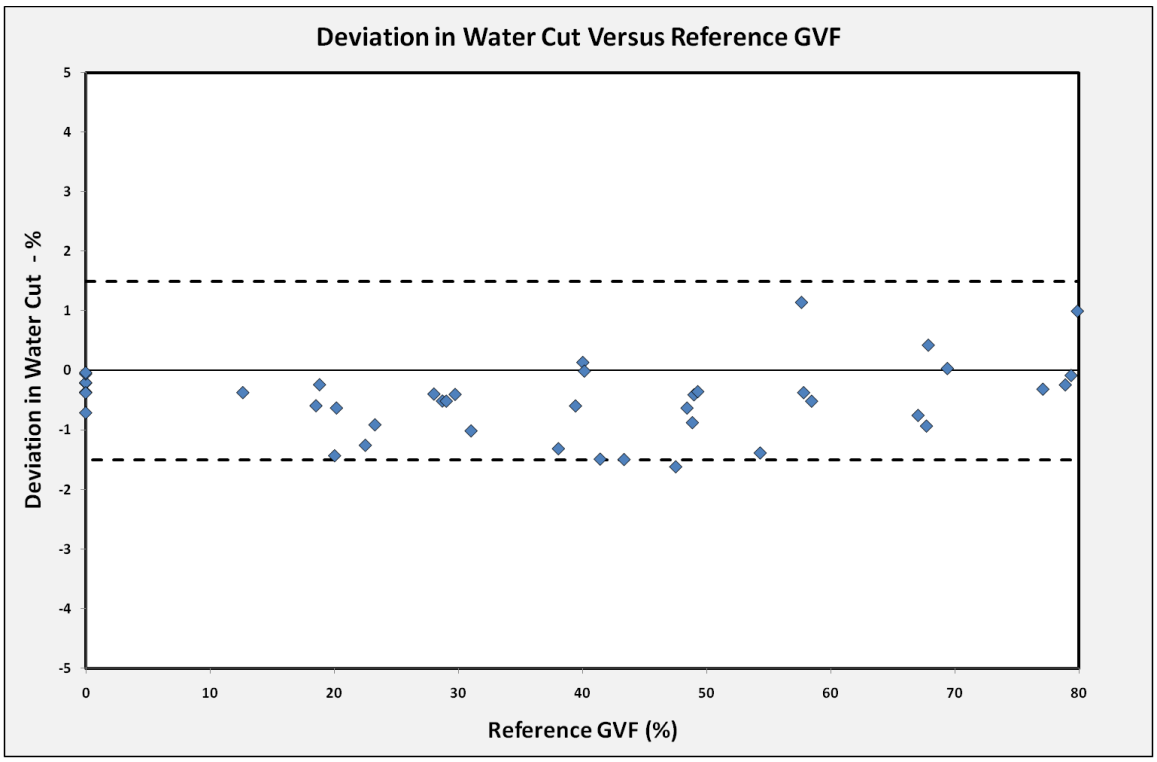

Figure 8 Deviation in Meter-Indicated Water-cut versus Reference GVF for Haimo 2-inch Spool Piece Multiphase Flowmeter

APPENDIX B

TABULATED RESULTS

TABLE 4

RESULTS SHOWING REFERENCE METER FLOWRATES WITH ASSOCIATED DEVIATIONS FOR THE TEST METER

NEL Reference Data																	Corrected to Haimo P & T	
Test Point	Collection Date & Time	Atm.Press.	Abs. Pres. U/S	Local Temp	Oil Density	Water Density	Gas Density	Oil Vol. Flow	Water Vol. Flow	Liquid Vol. Flow	Gas Vol. Flow	Gas Vol. Fraction	Water Vol.Cut	Ref. Oil MFlow	Ref. Water MFlow	Ref. Gas MFlow	Gas Vol. Flow	Gas Vol. Fraction
		Pa	Pa	°C	kg/m³	kg/m³	kg/m³	m³/hr	m³/hr	m³/hr	m³/hr	%	%	kg/s	kg/s	kg/s	m³/hr	%
1	04/07/2013 09:13	98608	616328	34.39	850.10	1020.90	6.76	0.001	8.467	8.468	0.000	0.00	99.99	0.000	2.401	0.000	0.000	0.00
2	04/07/2013 09:35	98624	609173	34.37	850.11	1020.90	6.68	0.001	24.573	24.574	0.000	0.00	100.00	0.000	6.969	0.000	0.000	0.00
3	04/07/2013 10:09	98700	640333	33.87	850.45	1021.08	7.03	8.554	0.084	8.638	0.000	0.00	0.97	2.021	0.024	0.000	0.000	0.00
4	04/07/2013 10:32	98765	593275	34.19	850.23	1020.97	6.51	24.873	0.266	25.139	0.000	0.00	1.06	5.875	0.075	0.000	0.000	0.00
5	04/07/2013 11:16	98832	626086	35.01	849.67	1020.67	6.85	4.516	2.040	6.556	5.114	43.82	31.12	1.066	0.578	0.010	4.991	43.23
6	04/07/2013 11:42	98899	605781	34.65	849.92	1020.80	6.64	4.699	2.213	6.912	8.387	54.82	32.02	1.109	0.628	0.015	8.185	54.22
7	04/07/2013 12:10	98899	625033	34.46	850.05	1020.87	6.85	4.521	2.053	6.574	14.068	68.15	31.23	1.068	0.582	0.027	13.731	67.62
8	04/07/2013 12:52	99001	631479	34.27	850.18	1020.94	6.93	4.509	1.981	6.490	22.303	77.46	30.53	1.065	0.562	0.043	21.758	77.03
9	04/07/2013 13:18	99036	639177	35.36	849.43	1020.54	6.99	5.029	3.348	8.377	0.000	0.00	39.96	1.187	0.949	0.000	0.000	0.00
10	04/07/2013 13:51	99084	632749	34.09	850.31	1021.00	6.94	5.071	3.427	8.498	6.126	41.89	40.32	1.198	0.972	0.012	5.990	41.35
11	04/07/2013 14:21	99163	629510	34.77	849.84	1020.76	6.89	5.044	3.480	8.524	7.862	47.98	40.83	1.191	0.987	0.015	7.686	47.42
12	04/07/2013 14:46	99201	616475	35.24	849.52	1020.59	6.74	5.109	3.425	8.534	12.236	58.91	40.13	1.206	0.971	0.023	11.961	58.36
13	04/07/2013 15:22	99225	610739	35.81	849.12	1020.38	6.66	4.033	3.897	7.930	18.299	69.77	49.14	0.951	1.105	0.034	17.907	69.31
14	04/07/2013 15:49	99258	606757	36.19	848.86	1020.24	6.61	3.998	3.931	7.930	32.073	80.18	49.58	0.943	1.114	0.059	31.348	79.81
15	04/07/2013 16:16	99316	600428	37.04	848.28	1019.92	6.53	8.315	2.160	10.474	39.811	79.17	20.62	1.959	0.612	0.072	39.003	78.83
16	04/07/2013 16:46	99330	610029	37.74	847.80	1019.65	6.61	9.786	2.763	12.549	5.745	31.40	22.02	2.305	0.783	0.011	5.620	30.93
17	04/07/2013 17:11	99354	618499	37.85	847.72	1019.62	6.70	10.089	2.775	12.865	12.265	48.81	21.57	2.376	0.786	0.023	12.025	48.31
18	04/07/2013 17:36	99406	614188	37.61	847.89	1019.71	6.66	10.097	2.778	12.876	27.606	68.19	21.58	2.378	0.787	0.051	27.086	67.78
19	04/07/2013 18:12	99454	620391	35.92	849.05	1020.34	6.77	5.091	7.426	12.518	3.865	23.59	59.33	1.201	2.105	0.007	3.789	23.24
20	04/07/2013 18:35	99492	628011	35.94	849.03	1020.33	6.85	5.030	7.618	12.648	7.898	38.44	60.23	1.186	2.159	0.015	7.750	37.99
21	04/07/2013 18:59	99503	605998	36.18	848.87	1020.24	6.60	5.143	8.096	13.239	18.272	57.99	61.15	1.213	2.294	0.034	17.957	57.56
22	04/07/2013 19:28	99536	611717	36.47	848.67	1020.13	6.66	4.964	7.131	12.095	46.982	79.53	58.96	1.170	2.021	0.087	46.346	79.30
23	04/07/2013 19:50	99575	600288	36.91	848.37	1019.97	6.53	5.174	11.538	16.711	0.000	0.00	69.04	1.219	3.269	0.000	0.000	0.00
24	04/07/2013 20:21	99615	590849	36.87	848.39	1019.98	6.42	5.382	11.433	16.815	3.967	19.09	67.99	1.268	3.239	0.007	3.887	18.77
25	04/07/2013 20:47	99637	615500	37.06	848.26	1019.91	6.69	5.139	11.726	16.865	6.881	28.98	69.53	1.211	3.322	0.013	6.773	28.65
26	04/07/2013 21:14	99688	622599	37.14	848.21	1019.88	6.76	5.117	11.337	16.455	15.911	49.16	68.90	1.206	3.212	0.030	15.664	48.77
27	05/07/2013 09:26	100375	632812	35.05	849.65	1020.66	6.92	5.102	11.098	16.200	22.450	58.09	68.51	1.204	3.146	0.043	22.110	57.71
28	05/07/2013 09:55	100408	610355	34.56	849.98	1020.83	6.69	3.453	13.396	16.849	11.127	39.77	79.51	0.815	3.799	0.021	10.941	39.37
29	05/07/2013 10:30	100445	592472	34.87	849.77	1020.72	6.48	3.460	13.550	17.010	34.903	67.23	79.66	0.817	3.842	0.063	34.470	66.96
30	05/07/2013 10:59	100445	628605	34.82	849.80	1020.74	6.88	2.229	18.259	20.488	0.000	0.00	89.12	0.526	5.177	0.000	0.000	0.00
31	05/07/2013 11:25	100458	617443	34.93	849.72	1020.70	6.76	2.357	18.480	20.837	6.112	22.68	88.69	0.556	5.240	0.011	6.037	22.46
32	05/07/2013 11:56	100502	617174	34.25	850.19	1020.94	6.77	18.696	2.382	21.077	8.279	28.20	11.30	4.415	0.675	0.016	8.187	27.98
33	05/07/2013 12:24	100522	633772	34.82	849.80	1020.74	6.94	17.697	2.361	20.058	13.501	40.23	11.77	4.178	0.669	0.026	13.346	39.95
34	05/07/2013 12:53	100514	610419	34.81	849.81	1020.74	6.68	18.390	2.577	20.967	20.264	49.15	12.29	4.341	0.731	0.038	20.064	48.90
35	05/07/2013 13:23	100525	602822	35.39	849.41	1020.53	6.59	12.681	12.904	25.585	6.428	20.08	50.44	2.992	3.658	0.012	6.391	19.99
36	05/07/2013 13:49	100509	596296	35.60	849.26	1020.46	6.51	12.860	12.826	25.686	5.856	18.57	49.94	3.034	3.636	0.011	5.827	18.49
37	05/07/2013 14:13	100484	609697	35.61	849.26	1020.45	6.66	12.562	12.218	24.780	10.508	29.78	49.31	2.963	3.463	0.019	10.461	29.68
38	05/07/2013 14:36	100509	605312	36.15	848.89	1020.25	6.60	17.900	7.561	25.461	3.707	12.71	29.69	4.221	2.143	0.007	3.676	12.62
39	05/07/2013 14:58	100526	614266	36.47	848.67	1020.13	6.69	17.574	7.284	24.859	6.313	20.25	29.30	4.143	2.064	0.012	6.267	20.13
40	05/07/2013 15:20	100530	618631	36.67	848.53	1020.06	6.73	17.761	7.582	25.343	10.382	29.06	29.92	4.186	2.148	0.019	10.334	28.97
41	05/07/2013 15:46	100534	608243	36.46	848.68	1020.14	6.62	8.669	12.057	20.725	13.951	40.23	58.17	2.044	3.417	0.026	13.865	40.08
42	05/07/2013 16:09	100520	589530	36.59	848.59	1020.09	6.42	8.809	12.084	20.893	20.354	49.35	57.84	2.076	3.424	0.036	20.245	49.21

TABLE 4 CONTINUED

RESULTS SHOWING REFERENCE AND TEST METER FLOWRATES WITH ASSOCIATED DEVIATIONS FOR THE TEST METER

Haimo Data													Deviations		
No	Test Point	Test date dd-mm-yy	Start Time	Liquid Flow m^3/hr	Oil Flow m^3/hr	Water Flow m^3/hr	Gas flow m^3/hr	WLR %	GVF %	T	P kPa	Test duration min	Liquid Vol Flow Error %	Gas Vol flow Error %	Water Cut Error % Abs.
1	1P	04-07-2013	9:14	8.42	0.03	8.39	0.00	99.63	0.00	32.76	627.06	15	-0.58	0.00	-0.36
2	2P	04-07-2013	9:36	24.96	0.05	24.91	0.00	99.79	0.00	33.13	616.24	15	1.56	0.00	-0.21
3	3P	04-07-2013	10:10	8.44	8.37	0.06	0.00	0.77	0.00	32.47	652.03	15	-2.35	0.00	-0.20
4	4P	04-07-2013	10:33	24.85	24.68	0.17	0.00	0.69	0.00	32.94	600.14	15	-1.16	0.00	-0.37
5	5P	04-07-2013	11:16	6.46	4.55	1.92	4.91	29.63	43.15	33.32	637.85	15	-1.41	-4.06	-1.49
6	6P	04-07-2013	11:42	6.74	4.67	2.06	8.70	30.64	56.36	33.30	618.02	15	-2.53	3.74	-1.38
7	7P	04-07-2013	12:10	6.50	4.53	1.97	13.87	30.30	68.08	33.13	637.56	15	-1.08	-1.41	-0.93
8	8P	04-07-2013	12:52	6.52	4.55	1.97	23.60	30.22	78.35	33.03	644.63	15	0.44	5.79	-0.31
9	9P	04-07-2013	13:19	8.33	5.06	3.27	0.00	39.26	0.00	33.85	649.77	15	-0.57	0.00	-0.70
10	10P	04-07-2013	13:51	8.49	5.19	3.30	5.89	38.84	40.96	32.94	644.67	15	-0.07	-3.84	-1.48
11	11P	04-07-2013	14:21	8.36	5.08	3.28	8.47	39.22	50.33	33.46	641.18	15	-1.89	7.79	-1.61
12	12P	04-07-2013	14:46	8.48	5.12	3.36	12.21	39.62	59.01	33.89	627.89	15	-0.65	-0.24	-0.51
13	13P	04-07-2013	15:22	7.95	4.04	3.91	18.38	49.18	69.82	34.45	621.30	15	0.20	0.46	0.04
14	14P	04-07-2013	15:50	8.17	4.04	4.13	32.18	50.58	79.76	34.89	618.14	15	2.99	0.34	1.00
15	15P	04-07-2013	16:16	10.43	8.31	2.13	40.15	20.38	79.38	35.71	610.19	15	-0.40	0.86	-0.24
16	16P	04-07-2013	16:46	12.71	10.04	2.67	5.58	21.01	30.51	36.22	620.45	15	1.26	-2.87	-1.01
17	17P	04-07-2013	17:11	12.83	10.14	2.69	11.86	20.95	48.03	36.36	627.78	15	-0.25	-3.30	-0.62
18	18P	04-07-2013	17:36	12.65	9.87	2.78	27.92	22.01	68.82	36.34	623.39	15	-1.76	1.13	0.43
19	19P	04-07-2013	18:12	12.40	5.16	7.25	3.96	58.42	24.22	34.85	630.63	15	-0.91	2.57	-0.91
20	20P	04-07-2013	18:35	12.65	5.20	7.46	8.39	58.92	39.88	34.91	637.81	15	0.04	6.27	-1.31
21	21P	04-07-2013	19:00	13.13	4.95	8.18	19.25	62.30	60.83	35.02	614.30	15	-0.83	5.34	1.15
22	22P	04-07-2013	19:28	12.53	5.15	7.38	48.07	58.88	79.74	35.22	617.56	15	3.59	2.31	-0.08
23	23P	04-07-2013	19:51	16.51	5.12	11.39	0.00	68.99	0.00	35.55	609.25	15	-1.20	0.00	-0.05
24	24P	04-07-2013	20:21	16.80	5.59	11.22	3.88	67.76	18.75	35.70	600.76	15	-0.07	-2.26	-0.23
25	25P	04-07-2013	20:47	17.01	5.27	11.74	7.48	69.02	30.53	35.89	622.96	15	0.88	8.67	-0.51
26	26P	04-07-2013	21:14	16.23	5.19	11.04	16.27	68.03	50.06	35.97	630.01	15	-1.37	2.23	-0.87
27	27P	05-07-2013	9:27	16.38	5.22	11.16	23.24	68.14	59.86	33.65	639.57	15	1.14	3.53	-0.37
28	28P	05-07-2013	9:55	16.97	3.58	13.39	11.65	78.92	40.69	33.51	618.62	15	0.73	4.68	-0.59
29	29P	05-07-2013	10:31	17.05	3.60	13.46	35.30	78.91	67.43	33.75	597.69	15	0.26	1.14	-0.75
30	30P	05-07-2013	10:59	20.58	2.25	18.34	0.00	89.09	0.00	33.81	635.30	15	0.47	0.00	-0.03
31	31P	05-07-2013	11:25	21.15	2.66	18.49	5.82	87.44	21.58	33.93	623.01	15	1.48	-4.81	-1.25
32	32P	05-07-2013	11:56	21.23	18.91	2.32	8.18	10.91	27.81	33.16	621.91	15	0.71	-1.18	-0.39
33	33P	05-07-2013	12:24	20.16	17.76	2.40	13.72	11.91	40.50	33.67	638.73	15	0.49	1.66	0.14
34	34P	05-07-2013	12:53	20.60	18.15	2.45	20.63	11.89	47.92	33.64	614.15	15	-1.76	1.80	-0.40
35	36P	05-07-2013	13:24	25.98	13.25	12.73	6.27	49.01	19.42	34.24	603.96	15	1.54	-2.49	-1.43
36	35P	05-07-2013	13:50	26.16	13.25	12.91	5.76	49.35	18.03	34.46	597.04	15	1.85	-1.66	-0.59
37	37P	05-07-2013	14:13	24.74	12.64	12.10	10.13	48.91	28.17	34.54	610.29	15	-0.18	-3.63	-0.40
38	38P	05-07-2013	14:36	25.68	18.15	7.53	3.63	29.33	12.39	34.94	607.99	15	0.85	-2.02	-0.36
39	39P	05-07-2013	14:58	25.17	17.95	7.22	6.50	28.68	20.52	35.25	616.35	15	1.27	3.00	-0.62
40	40P	05-07-2013	15:21	25.13	17.74	7.39	10.78	29.41	30.00	35.50	619.14	15	-0.84	3.81	-0.51
41	41P	05-07-2013	15:46	20.79	8.69	12.09	14.05	58.17	40.32	35.39	609.85	15	0.29	0.74	0.00
42	42P	05-07-2013	16:10	20.97	8.91	12.06	20.14	57.49	48.99	35.53	590.62	15	0.38	-1.06	-0.35