SPE 118248

Low Production Tester (LPT) - A Viable Solution for Marginal Wells Testing

Paul Hodgson, Petroleum Development Oman & Daniel Sequeira, Haimo Technologies

This paper was prepared for presentation at the 2008 Abu Dhabi International Petroleum Exhibition and Conference held in Abu Dhabi, UAE, 3–6 November 2008.

Abstract

At Petroleum Development Oman LLC (PDO), well testing has successfully been carried out for the past few years utilizing multiphase meters. Although this technology provides many benefits to PDO, the meters, being basically venturi based, had a low flow limitation of 20 -25 m3/day for gross liquid measurement. So in the past, these low flow wells used to go largely unmeasured or were measured using the older, conventional testing systems, which were not very reliable.

In order to overcome this issue, and provide a well testing solution for wells producing less than 20 m3/d, the operator of PDO's Mobile Well Testing Units was approached to try to develop a prototype, which could be tried in PDO under their existing Mobile Well Testing Contract. They came back with a skid based, mobile unit in October, 2006, that had a range of 3-25 m3/day of gross liquid flow as standard and could extend its range up to 100 m3/day. The unit measured 0-100 % water cut and could operate in 0-100% GVF conditions.

Following introduction of the unit in the PDO South concession areas, testing of wells has been carried out where multiphase meters have not been successful, and this has not been limited to wells producing less than 20m3/d as per the original intent but also for testing wells where the produced oil viscosity was outside the operating parameters. Results have been very favorable, with practically a 100% validation rate. The unit was thus deemed acceptable to use as an additional well testing tool and was subsequently included in the PDO Mobile Well Testing Contract, awarded in April 2007. The unit gives good reliable data for wells with low production rates and can also be used where high viscosity becomes a problem for testing by other means.

Introduction

The need for Low Production testers…

Most multiphase meters today can measure flow rates starting from 60 m^3/d of liquid. Some vendor's technologies take this figure down to 20 m^3/d. However, a large number of existing wells onshore produce less than 10 barrels/day and these largely go unmeasured or get measured using very old-fashioned conventional testing systems, which are prone to system inaccuracies. The industry is looking for more accurate measurement systems, while also for cheaper alternatives.

Definitions

PDO – Petroleum Development Oman
MFM – Multiphase Flow Meter
LPT – Low Production Tester
GVF – Gas Volume fraction
This is defined as the gas volume flow rate, relative to the multiphase volume flow rate, at the pressure and temperature prevailing in that section. The GVF is normally expressed as a fraction or percentage

WC – Water Cut
This is defined as the water volume flow rate, relative to the total liquid volume flow rate (oil and water), both converted to volumes at standard pressure and temperature. The WC is normally expressed as a percentage.
Measuring / Operating Envelope
The area in the two-phase flow map and the composition map, in which the MPFM performs according to its design specifications.

Low Production Tester (LPT) unit

Design Basis

Design pressure	ANSI 300#
Liquid flow rate	0~100m3/d (Refer Fig. 1)
Max. Slug flow rate	250 m3/d
Water cut in liquid	0~100%
GVF	0~100%
Operating temperature	20~80℃

Measurement Philosophy

The following parameters are MEASURED by the system:

- Gross Liquid flow rate
- Gas flow rate
- Water Cut (WC)
- Temperature
- Pressure

The following results are CALCULATED:

- Dry oil flow rate
- Gas void Fraction (GVF)
- Water flow rate
- Gas oil ratio (GOR)

Measurement Accuracies

- Liquid flow rate ≤±10 % (relative)
- Gas flow rate ≤±10 % (relative)
- Water cut ±2 % (absolute)

Operating Principle (Refer Fig. 2)

The multiphase flow enters the skid through a de-sanding system and then to a 2 phase vertical separator. The 2 phase vertical separator separates the liquid and gas. The separator has liquid accumulation section to accommodate low flow rate and intermittent liquid producing wells.

During the liquid accumulation phase, the liquid leg control valve remains closed and the gas leg control valve remains open allowing for direct measurement of the discharged gas by Vortex flow meter.

Liquid is measured using a Coriolis meter downstream of the Accumulator section. The liquid outlet valve is controlled by level control logic that always maintains a liquid seal to the single-phase liquid meter. The liquid flow meter and the water cut meter are installed on the liquid leg to measure the liquid flow rate and water cut measurement

The gas leg valve undergoes adjustment to its positioning when the liquid is discharged.

A flow computer with Exd enclosure is mounted on the skid to collect and analyze data from the field instruments and sensors, and to carry out the flow metering calculations.

The flow computer is provided with two RS485 serial ports, one of which is available for data transmission using MODBUS RTU protocol. Another serial port is held in standby for the calibration of the sensors in the field.

A laptop loaded with dedicated software provided by the supplier for each skid will be used for local display, meter calibration, and configuration and troubleshooting in the field.

In summary, the LPT acts similar to that of a conventional test separator system, but differs in the focus it lays on accuracy even at low flow rates. ***It eliminates the possibility of gas carry under and liquid carryover, which are the common factors for loss of accuracies in conventional systems, while retaining capability to measure very low flow rates.***

Data Analysis

Following introduction of the unit in the PDO South concession areas, testing of wells has been carried out where multiphase meters have not been successful, this has not been limited to wells producing less than 20m3/d as per the original intent but also for testing wells where the produced oil viscosity was outside the operating parameters, notably Rahab in Marmul and Tayfut in Rima. Results have been very favorable with 39 accepted tests and only 3 rejected (Refer Table 1). The rejected tests were most likely because of process upsets.

After that initial campaign in October of 2006, PDO has successfully conducted numerous tests (Refer Fig. 3) with the low production tester over the past years and currently 2 such units are deployed at PDO sites.

Conclusions & Recommendations

1. The LPT acts similar to that of a conventional test separator system, but differs in the focus it lays on accuracy even at low flow rates. ***It eliminates the possibility of gas carry under and liquid carryover, which are the common factors for loss of accuracies in conventional systems, while retaining capability to measure very low flow rates.***
2. The unit was deemed acceptable to use as an additional well testing tool and included in the Mobile Well Testing Contract awarded in April 2007.
3. The unit gives good reliable data for wells with low production rates and can also be used where high viscosity becomes a problem for testing by other means.
4. The only limitation with this unit is that it is specifically designed for low flow rates (typically less than 60m3/d).

Acknowledgements

This trial would not have been successful without the active co-operation and assistance of various departments at PDO and the vendor.

Some of them include:

- PDO Production Measurement Department, who initiated this requirement with vendor.
- PDO South field operations teams who provided day to day coordination and support.
- PDO South Production Chemistry Labs
- Haimo China R&D team, for their efforts in providing the solution as required by PDO.
- Haimo Oman field operations team, for carrying out the field trials.

Fig. 1 - Operating Envelope (2 phase map) of LPT

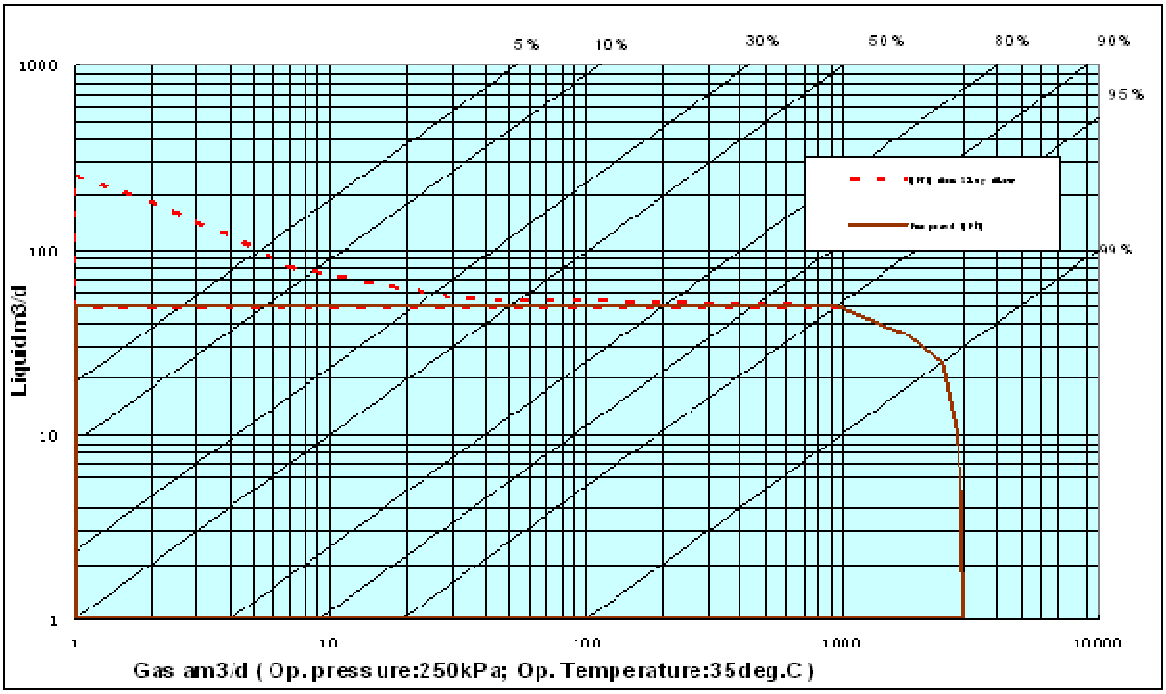

Fig. 2 - P&ID of LPT

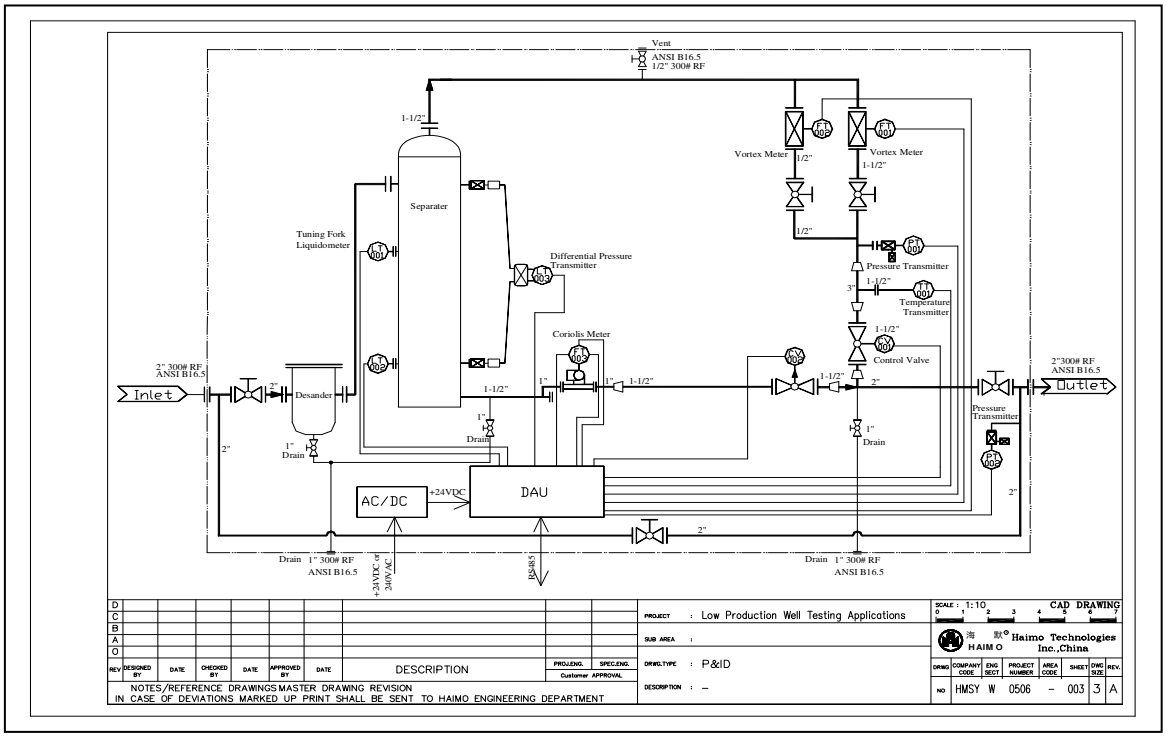

Table 1 - Average Test Results using Haimo LPT

	Well	Test Date	Liquid Flow (m3/d)	Oil Flow (m3/d)	Water Flow (m3/d)	Gas Flow (Sm3/d)	Water Cut (%)	GVF (%)	T (°C)	P (Mpa)
Accepted	RA01	2007-01-12	58.15	49.67	8.48	0.41	14.58	0.15	19.55	0.52
Accepted	RA11	24/11/2006	59.72	10.30	49.42	0.22	82.76	3.44	27.83	0.37
Accepted	RA11	9/10/2007	27.28	2.89	24.38	0.13	89.40	0.13	28.81	0.39
Accepted	RA13	2006-11-21	93.84	60.46	33.38	0.28	35.57	0.05	25.42	0.52
Accepted	RA13	18/10/2007	72.54	50.10	22.43	16.27	30.93	5.46	27.30	0.40
Accepted	RA14	2006-11-26	20.36	14.21	6.15	0.18	30.21	7.27	24.00	0.38
Accepted	RA14	2007-05-27	11.12	11.03	0.09	0.05	0.77	10.08	30.02	0.38
Rejected	RA15	2006-11-28	76.23	68.18	8.05	0.31	10.56	0.06	24.79	0.56
Accepted	RA15	10/10/2007	34.00	12.13	21.87	0.18	64.33	0.38	28.86	0.37
Accepted	RA18	2006-12-01	20.46	20.45	0.01	0.34	0.06	17.96	24.34	0.44
Accepted	RA18	2007-05-29	20.52	20.29	0.23	0.07	1.13	29.18	33.79	0.47
Accepted	RA19	2006-12-07	24.36	23.70	0.65	0.21	2.68	7.37	21.77	0.37
Accepted	RA19	2007-06-01	31.41	25.19	6.22	0.06	19.81	1.87	33.41	0.44
Accepted	RA19	16/10/2007	10.57	4.19	6.38	1.32	60.35	3.21	27.28	0.35
Accepted	RA20	2007-06-05	195.17	10.25	184.93	0.09	94.75	0.01	38.57	0.38
Accepted	RA20	12/10/2007	195.60	12.65	182.95	0.18	93.53	0.07	26.87	0.44
Accepted	RA21	2006-12-05	6.34	5.50	0.84	0.21	13.25	5.72	20.21	0.39
Accepted	RA22	2006-12-03	15.19	13.74	1.46	0.22	9.59	7.14	25.37	0.44
Accepted	RA22	2007-05-23	15.27	13.69	1.58	0.07	10.35	7.17	31.65	0.43
Accepted	RA29	2007-06-03	182.88	8.27	174.60	0.10	95.48	0.01	32.69	0.40
Accepted	RA30	2006-12-22	25.34	19.52	5.82	0.28	22.97	2.66	16.08	0.55
Accepted	RA30	2007-05-25	33.85	25.19	8.67	0.08	25.60	13.13	24.73	0.48
Accepted	RA31	2006-12-09	59.12	17.66	41.46	0.23	70.13	0.09	22.49	0.40
Accepted	RA40	2007-01-18	59.56	5.85	53.71	0.22	90.18	0.08	21.97	0.45
Accepted	RA40	20/10/2007	35.25	13.31	21.94	5.00	62.24	4.71	25.61	0.29
Accepted	TFT03	14/3/2007	51.02	25.17	25.85	28.38	50.66	1.99	25.17	2.82
Rejected	TFT05	12/3/2007	10.50	10.48	0.03	1.01	0.26	0.62	24.87	1.56
Accepted	TFT06	2007-02-14	26.02	1.08	24.94	2.12	95.86	0.17	25.00	2.91
Accepted	TFT07	2007-03-06	25.79	20.22	5.57	2.89	21.58	17.09	24.13	2.79
Accepted	TFT08	2007-02-09	4.29	4.19	0.10	25.64	2.33	16.45	24.87	2.66
Accepted	TFT10	2007-02-05	24.51	23.96	0.55	9.89	2.23	1.33	24.38	2.76
Rejected	TFT11	2007-02-03	2.37	1.96	0.41	4.28	17.24	6.62	24.67	2.68
Accepted	TFT12	2007-01-30	46.94	33.66	13.28	9.39	28.29	0.64	21.27	3.06
Accepted	TFT13	2007-01-28	24.38	23.76	0.62	7.49	2.54	0.94	22.23	2.92
Accepted	TFT14	2007-03-07	26.46	24.70	1.76	4.56	6.64	0.59	31.88	3.06
Accepted	TFT15	2007-01-21	44.76	12.22	32.54	2.10	72.69	0.16	21.29	2.91
Accepted	TL90	2007-06-07	22.63	13.81	8.82	0.08	38.97	15.14	35.85	0.53
Accepted	MD05	2007-06-30	78.09	7.20	70.89	3.09	90.78	0.45	34.27	0.91
Accepted	MDNE005	2007-06-16	104.12	36.79	67.33	0.35	64.66	0.03	39.18	0.98
Accepted	MDNE006	2007-06-18	58.45	6.92	51.53	2.15	88.16	0.17	35.04	1.34
Accepted	MM269	07-Oct-20	33.70	7.80	25.90	17.99	76.85	4.91	31.65	1.08
Accepted	MM349	2007-05-21	15.86	15.80	0.06	234.33	0.38	38.09	31.63	0.35

Fig. 3 - LPT in operation at PDO site