Full Length Research Paper

Parameters monitoring and assessment in multiphase surface well testing using MonAssess iSheet

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Multiphase Surface well testing involves the use of multiphase flow meter to measure instantaneous flow rate of fluids. This could reduce flow periods and fasten the decision processes, create confidences in the information acquired and the reliability of the results. The aim of this study is to illustrate how a soft ware, MonAssess iSheet can properly and timely monitor and assess data acquired from multiphase flow well testing. The MonAssess iSheet or shortly MonAssess is a Microsoft Excel template developed by Usman et al., with the capability of Monitoring and Assessing well test data either in real time or later after data acquisition has been completed. Real field multiphase well test data was used to develop the MonAssess. This write up did not discuss details of development of the MonAssess, but rather discusses its functions, significance and usage as well as the well testing process. Real field multiphase well test data for three wells (Well X, Y and Z) from Niger Delta fields of Nigeria was tested using this software. The results showed that the use of the soft ware has reduced the spiky curves on the plots and increased the information available from the well test data. It also reduced the well test period and helped to sieve the off- range data.

Keywords: MonAssess iSheet, multiphase well testing, drill stem test, DST, multiphase flow meters (mpfm).

INTRODUCTION

In multiphase surface well testing, individual rates of oil, gas and water are measured without separating the phases. The technology uses multiphase flow meters (MPFM) instead of test separators (that requires phase separation). Most MPFMs uses radioactive sources to achieve this measurement based on the principle of different levels of gamma rays absorption by matter. Using the amount of gamma rays absorbed to determine a substance absorption coefficient with a cross correlation, the MPFM is able to measure the rates of oil, gas and water even while they are still in their "multiphase" state i.e even while they are still mixed together; However, multiphase meters that do not use radioactive sources have being developed (manabu et al., 1998; Iroh, 2007).

In the multiphase system used for this study (haimo technology), data is being acquired through an upstream computer which is connected to a downstream computer (a computer built in within the MPFM) that communicates with the MPFM data acquisition unit (DAU) which receives signals from the gamma sensors and venturi installed on the MPFM, do the necessary calculations and convert them into electrical signals (Singer, 2009). The upstream computer which is the interface the user uses to communicate with the MPFM, uses the Haimo MFM2000 flow meter software for the display of acquired data. Acquired data ready for use is exported from the Haimo MFM2000 to a spreadsheet in Microsoft excel format (.xls)(Singer, 2009). Data is usually recorded over a range of period and averages are computed.

Conventional Surface Well Test

The conventional well testing involves the use of test separator(s) in which the well's effluent is separated and each phase's rate is measured and recorded. The individual pieces of equipment that make up the surface testing layout are put together for the purpose of producing the well at the surface, measuring the different components of the well effluent, taking component samples, and disposing of the well effluent in an environmentally safe manner. Some of the problems ass-

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Figure 1. A typical conventional surface well testing layout



Figure 2. A typical multiphase surface well testing layout

ociated with this process include poor fluid separation, flow instability and poor metal calibration. In addition, flow measurements the resolution to identify small flow events or transient behavior because of the large vessel to separate the fluids phases. The basic elements on a typical conventional surface testing can be seen in figure. 1 above:

Multiphase Surface Well Testing (MPSWT)

This type of well testing uses multiphase flow meters in place of test separator for testing of wells. A major difference between the two is that while the well effluent is disposed off after a conventional well test (figure 1), the effluent is channeled back to the wells production line after an MPSWT. This eliminates the need for gauge tank/surge tank, excessive lines (pipes), booms/burners and other equipments that might be required while using a test separator. Another difference is in the principle of measurement; MPFM measures the individual rates of oil, gas and water without separating the phases. Most MPFMs uses radioactive sources to achieve this measurement based on the principle of gamma rays absorption by matter. Using the amount of gamma rays absorbed to determine a substances' absorption coefficient with a cross correlation, the MPFM is able to measure the rates of oil, gas and water even while they are still in their "multiphase" state. Multiphase meters are used both topside and subsea to measure the flowing conditions; pressure, temperature, volume flow rates of oil, water and gas (Mus et al., 2002). Below is a typical layout for a multiphase surface well testing.(Figure 2)

METHODOLOGY

Parameters recorded during the tests used in this study are: gross liquid flow rate (bpd), oil flow rate (bpd), gas flow rate (mscfpd), water flow rate (bpd), basic sediments and water (BS&W) (%), Gas volume fraction (GVF) (%), flow line temperature (°C), flow line pressure (psi), tubing head pressure (psi) and the gas oil ratio (scf/bbl).

The system of multiphase well testing technology used for data acquisition that is used in this study provides the final test output on a spreadsheet in Microsoft excel xls format. For the monitoring aspect, excel codes were developed and used to determine and record the maximum and minimum entries in each recorded parameter, pinpoint the cell location of the maximum and minimum entries, determine the amount of "offrange" entries (off-range values to be defined by the user,



Figure 3. Diagrammatic expression of the MPFM operating principle⁶



Figure 4. The haimo MFM2000 flow meter data acquisition interface (source: Haimo MFM2000)

creating an "approximated form" mirror image of the entire data sheet of the well test result (approximirror) and plotting them (for each parameter) against time of data acquisition and determine the statistical mode (the entry that appears most in the approximated data) of each recorded parameter.

The acquired data, excel codes were developed and used to determine the standard deviation of each recorded parameter, the statistical range of each recoded parameter, the amount of "off-range" entries (off-range values to be defined by the user) and Plot the approximated well test result for relevant parameters against time of data acquisition (approxiplots). All these above are conglomerated into one excel sheet that performs the entire listed functions effectively and is named the "MonAssess iSheet", (Monitoring and Assessment Interactive Sheet).

Measurement Principles in Multiphase Well Testing

The MPFM is designed to measure the volumetric flow rates of oil, water and gas of a producing well at flow line

conditions. Flow rates at line condition were converted to Standard Conditions with a PVT Package. Measurement process used by Haimo tech (2008) was adopted for this work as shown in figure 3 above:

Data Acquisition and the Raw Well Test Data

Data was acquired through an upstream computer (service computer) which is connected to a downstream computer (a computer built in within the MPFM) that communicates with the MPFM data acquisition unit (DAU). The DAU receives signals from the gamma sensors while the ventury installed on the MPFM do the necessary calculations and convert the data into electrical signals. The upstream computer which is the interface the user uses to communicate with the MPFM uses the Haimo MFM2000 flow meter software to display the acquired data. The interface for the display of the acquired data (or data under acquisition) is shown below:

Figure 4 above shows the ideal state of the haimo MFM2000 flow meter data acquisition interface, the top left black region displays the "test result chart" where

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8	15-1049-20 18 42	453.13	1.09	401.04	103.00	949.54	78.45	38-44	104-53	378.448	4518(2.83					
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11	10-31ay-20110-45	449.04	18.24	400.00	128-010	945.93	79.51	54.53	124.32	301.007	7017.18					
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47	10-10-p-01-51-51	4493.73	118.48	1014.015	134.00	144.115	10.71	546.778	181.44	100.005	11840.14					
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22	10-10-20-20-20-20	+01.00	40.00	200.00	140.00	100.00	100.00	24.64	110.00	202.000	1720.00					
23	10-01ay-2010-07	401.43	80.32	201.11	547.00	0124	77.65	28.14	218.46	201 80	1027.47					_
24	10-0032-2010-00.00	479.73	01.01	200 12	147.00	403.942	10.01	201.040	144.44	200.000	10140.00					_
25	10-10ay-20 10-50	49674	94.29	704.44	947.00	80.79	77.42	28-24	210.40	198.00	1510.00					- 8
26	10-818g-28 17:00	487.79	54.65	401.17	145.00	000 510	200.00	28-83	210.40	208.442	14909.50					_
27	40 may 24 41-14	+13 +1	01.01	+04.30	448.000	402.045	10.00	20.01	244.44	300-02	+2+8 10					- 8
10	10-00y-28 17 02	495.40	00.41	401.71	191.00	1211	22,23	20.50	210.00	2010.442	174(1.4)					- 1
2.2	10-1009-00 17 00	402.00	07.00	403.22	110.000	10.21	10.10	20.02	210.40	402.041	1710.72					
30	10-80ay-28 17-84	408.60	0.18	401.55	154.00	1218	78.33	38.98	210.40	402 84	1708-04					- 1
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Ready 2	, management management	THE FORM	Contraction (14						_	_			121		18

Figure 5. Raw well test data sheet (WTDS) showing acquired data.



Liquid, Gas and Watercut Plots

Figure 6. Production Plot for well X (raw)

graphical plots of the recorded data are displayed against time. Each parameter is given a line colour that represents its curve on the plot. Definitions of the line colours were given next to the chart under "curve view". Next after the curve view on the top right is the "Well ID" where the name of the well under test is displayed.

And as test was completed, the final test result is exported from the Haimo MFM2000 software to a spreadsheet in Microsoft excel format as shown above:

In Figure 5, the acquired data by the MPFM is shown as exported from the haimo MFM2000 software at standard conditions; the well ID is shown as WELL XXX. Entries were recorded per minute and extend for hours, however a preliminary test is carried out (for about 2hrs) for the system to stabilize before main test commences. Averages of the recorded parameters are shown in the green colored cells.

Using this raw data, Production Plot for well X (raw) can be seen above:

RESULTS AND DISCUSSION

Figure below shows the raw data copied from (figure 5) and inputted into the MonAssess.obtained(Figure 6)

The above figure shows how well X data looks like after put into the MonAssess, MODE(APPROXIMATED) and the Plots cannot be used until after the APPROXIMI-

Table 1. Interactive	inputs	into the	MonAssess	for well X
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	Gross Liquid	Oil Flow	Water Flow	Gas Flow	BS&W	GVF	FLT	FLP	THP	GOR
APPROXIMIRROR S.F	2	2	2	2	1	1	1	2	2	2
LOWER LIMIT C	F									
WITHIN-RANGE	430	95	380	130	50	75	20	200	350	1100
UPPER LIMIT C	F									
WITHIN-RANGE	520	120	430	200	90	85	50	250	450	2000

Tubing Head Pressure, Flow Line Pressure and Temperature Plots (From 26-18ay: 10-16-38 To 26-May: 10-18-08)



Figure 7. THP, FLP & FLT plots for well X (raw)



Figure 8. GOR plot for well X (raw)

RROR S.F are inputted. PERCENTAGE OF ENTRIES </> also need to be defined to get the off-range percentages. Inputs were therefore made into the MonAssess correspondingly as shown in the table 1 above.

Inputting the values in the above table correspondingly into the MonAssess yields the following results (the well is also identified):(Figure 7 and 8)

Taking the Oil flow in Figure 6 for interpretation; the standard deviation is 26.84, comparing this with the ave-

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4	Α	8	¢	0	(F.	6	н	1	1	8	L.	
1	flan bases	APPROXIMIRROR S.F											_
2	922224001	STANDARD DEVIATION	231,70	26.04	17.17	18.13	5.09	1.02	0.57	6.34	15.14	1000.12	
3	litemeeed	MAXIMUM	\$26.53	134.54	442.88	182.00	99.90	81.52	40.33	231.75	424.68	28636-3.64	
4	TEST DURATION (hours)	LOCATION	\$6\$77	\$0\$80	\$6\$.02	\$4\$83	\$6522	54598	\$15306	\$1556	\$4500	\$4,522	
5	1.92	MINIMUM	423.98	0.44	157, 19	123.00	78,73	75.44	18.23	202.12	168.61	1943.16	
6		LOCATION	\$C\$16	\$0\$22	\$65-38	\$8\$36	\$6528	54521	\$1556	\$1500	\$6516-	\$4,528	
7		RANGE	95.55	134.10	85.48	\$9.00	26.29	6.08	2.12	29.63	56.47	285320.47	
6		MODE(APPROXIMATE)	1000	0	0	0	100	100			0	0	
9		PERCENTAGE OF ENTRIES <											
10			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
11		PERCENTAGE OF ENTRIES >											
12			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
13	startfy well have?	Test Date	Gross Liquid	OI Flow	Water Flow	Gas Flow	88&W	OVF	FLT	RP	THP	GOR	
и		yymm-dd hh.mm	tord	biblid	6646	49070	5	16	Deg C	PH	Pti	KRM	
13		Average	497.17	100.89	洲波	161.23	79.87	78.48	39.44	213.94	407.03	7119.53	6
14		15-Way-36 16:38	43138	68.44	381.95	125.68	64.00	75.402	38.25	29475	38.51	199730	
17		10-May-20 10:29	42.0	710.45	342.58	125.00	63.72	75.75	38.28	126.53	391.5	177438	
18		15-May-36 16:40	43154	67.99	321.81	134.00	64.54	75.550	38.33	20113	391.5	1823-819	
13		15-81ap-38 18-41	435.55	24.63	410.29	125.66	94.35	26.62	35.35	20153	321.5	494332	
20		15-May-36 18-42	63.0	1.09	431.24	125.66	99.58	75.43	22.44	20113	371.40	65102.005	
21		15-May-38-18-43	440.N	0.12	438.86	123.68	99.01	75.44	31.44	20113	370.40	150368.25	
22		15-17ay-26 18-44	443.32	0.44	442.88	128.85	98.98	8.9	32.49	228.93	371.48	204343-64	
23		15-84p-38 18 45	645.04	10,24	430.00	128.65	91.90	75.94	24.53	221.32	301.97	7017.148	
24		10-17ay-20-10-40	4(2.22	04.42	371.30	132.00	81.12	28.11	24.95	20132	301.97	1127.34	
35		15.0749-38.18.47	cut	114.60	201.05	132.65	78.84	75.54	38.65	22148	381.97	1151.88	
26		10.031/-28.04.48	4240	111.54	561.99	132.40	74.40	79.603	3442	221.32	381.92	1102.04	
11	• • MonAssess Sheet	APPROXIMINA PRODUCTOR	UR OTS TH	INPARTAR	V075 /0084	-R01 73		N.O.	11.44	*****	316.44	1551.51	

Figure 9. Well X data inputted into the MonAssess.

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1	flag hanses	APPROXIMIRROR 5.7	2	2	2	2	1	1	1	2	2	2	
2	HANDSER	STANDARD DEVIATION	21.70	25.84	12.0	18.17	5.09	1.82	0.97	6.34	15.14	13893.12	
3	linamaaaaa	MAXIMUM	506.50	134.54	442.00	192.00	99,190	81.58	40.33	232.75	424.68	200303.64	
4	TEST DURATION (hours)	LOCATION	\$6577	\$0\$80	\$8\$22	\$1547	\$6\$32	54598	\$15106	\$1516	\$4\$43	\$1,520	
5	1.9	MINIMUM	405.98	0.44	157.19	123.49	71.71	75.44	18.21	202.12	368.05	1043.3.6	
-6		LOCATION	\$(\$16	\$0\$22	505.0	\$1556	\$6\$28	54521	\$1536	\$1509	\$4556	\$1,529	
2		RANGE	96.55	134.10	85.48	\$9.00	26.19	6.08	2.12	28.65	\$6.67	205120.42	
6		MOOE(APPROXIMATE)	520	150	400	100	80	10	40	210	400	1500	
9		PERCENTAGE OF ENTRIES <	430	95	380	130	50	75	20	200	150	1100	
30			1.10%	30.77%	17.58%	8,79%	0.00%	0.00%	0.00%	0.00%	0.00%	1.10%	
23		PERCENTAGE OF ENTRIES >	520	120	430	200	90	85	90	250	450	2000	
12			12.09%	19,70%	4.40%	0.00%	5,49%	0.00%	0.00%	0.00%	0.00%	5,49%	
33	Witt XI	Test Date	Gross Liquid	OI Flow	Water Flow	Gas Pow	888W	OVE	FLT	FLP	THP	COR	
14		yy-mm-dd bih mm	MAN	MAN	MARK	MICRO	5	- N.	Dep C	Pai	Pei	ectbbl	
13		Average	47.0	100.89	28.24	16123	79.87	78-86	39.44	213.94	417.03	7119-53	_
16		15-Key-28 14:38	49.96	62.44	301.08	(23.6)	04.00	75.42	36.21	201.75	368.01	1797.30	
17		15-Hay-28 14 39	42.81	19.45	302.50	(25.6)	6.72	8.26	38.38	126.53	321.5	1774.38	
23		10-09/-20190-00	428.34	47.89	21141	1,24.02	04.54	13.00	28.22	229.52	321.5	1022-09	
13		10-liay-20 50 st	435.33	35.63	410.29	123.68	94.25	8.62	38.38	104 53	381.5	4943.32	
20		10-10-20-20-20	00.10	1.89	40124	43.00	19.54	75.40	20.64	224.55	270.40	651(2.0)	
21		10-liay-20 140-40	640.74	0.42	631.58	123.68	19.01	25.44	21.4	206.53	373.48	150368.75	
22		10-01ay-20 140-44	40.32	0.44	442,000	1984	99.90	8.8	2.6	224.53	375.45	201313-04	
23		15-14y-2014-0	64(0)(54	18.24	400.00	128.60	96.80	5.94	58.93	2211.32	301.97	7017.16	
24		10/08/-2019/-00	42.2	8.42	271.38	1.32.55	81.12	3,11	38.95	221.32	381.97	1527.55	
25		10-liay-20.140.47	C10.0	114.60	201.00	132.00	71.04	21.54	20.40	221.60	301.97	1101.40	
26		10-10ay-20 tel 40	<i>c</i> 540	111.54	201.949	112.00	76.0	71.43	38.02	221.32	301.97	1102.02	
71		88.00au 59.04.00	10.10	818.54	101.00	100.00	10.00	No. 1	10.00	10.4.84	100.00	10010	_

Figure 10. The MonAssess showing result for Well X

rage flow of 100.86bbl/d, this shows a great amount of discrepancy in the tested result. This can be testified by reading the RANGE which reads 134.10 (an amount even much greater than the average). It can be seen that the MINIMUM entry is 0.44 recorded at cell D22 and the Maximum is 134.54 recorded at cell D80. The mode which reads 110 is in this case, a much reliable description of the well oil flow. Also the MonAssess shows that there are much entries that are off the

predefined limit of 95 to 120bbl/d; 19.78% of the entries are above 120 and 30.77% are below 95bbl/d. The remaining Parameters could also be interpreted in similar manner.(Figure 9 and 10)

Above are the Approxiplots obtained (compare the plots with the corresponding raw plots in figures 6, 7 and 8 respectively to see the rectification achieved. Degree of rectification could even be increased by reducing the APPROXIMIRROR S.F to 1 for the prod-



Figure 11. Production Approxiplot for well X



Figure 12. THP, FLP & FLT Aproxiplots for well X



Figure 13. GOR plot for well X

uction parameters):(Figure 11,12 and 13) Reading the TEST DURATION 1.52hrs, it can be understood that this result is for a preliminary test hence the discrepancies. However, the test result can also be

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	A	8	c	p	E I	F	Ģ	н	1		×		
1	(In the second	APPROXIMITROR 5.F	2	2	2	2	1	1	1	2	2	2	
2	1001-122-234	STANDARD DEVIATION	19.94	15.40	14.95	26.42	2.65	1.71	0.53	5.865	13.84	178.95	
3	litärn maaaad	MAXIMUM	\$26.53	134.54	418.09	182.00	84.54	81.52	40.13	231.7%	424.68	1859.89	
4	TEST DURATION (hours)	LOCATION	SC\$77	\$0580	56584	\$7587	56518	\$4508	\$15106	\$25316	\$2583	\$1,598	
5	1.42	MINIMUM	429.98	67.99	357.39	123.00	73.32	75.48	38.21	202.12	368.01	1043.16	
6		LOCATION	5C\$16	\$0\$18	\$6\$28	\$4546	\$6528	\$H\$27	\$#\$16	\$1599	5×516	\$1,529	
		RANGE	96.55	66.55	60.70	\$9.00	50.83	6.04	3.12	29.63	\$6.67	856.73	
8		MODE(APPROXIMATE)	\$29	119	499	189	89	89	40	230	429	1500	
.9		PERCENTAGE OF ENTRIES <	430	95	380	1,30	50	75	20	200	350	1,500	
10			1.18%	25.88%	18.82%	3.53%	0.00%	0.00%	0.0075	0.00%	0.00%	1.1.8%	
11		PERCENTAGE OF ENTRIES >	\$28	1.20	438	250	95	85	58	2540	458	2000	
12			12,94%	21.18%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.00%	0.00%	
23	WELL X2	Test Date	Gross Liquid	Oil Flow	Water Flow	Gas Flow	854W	GVF	PLT .	FUP	THIP	GOR	
14		yy-mm-dd hh mm	bbl/d	bblid	bblid	MSCFD	56	75	Dep C	Ppi	Pati	scfibbil	
15		Average	500.40	105.47	393.93	163.38	78.77	79.04	39.50	213.23	408:72	1554.27	_
16		10-May-28 18 38	429.94	48.44	361.55	123.00	84.08	78.62	38.21	231.75	368-01	1797.33	
17		10-May-26 16 29	452-81	70.45	362.50	125.00	63.72	715.76	36.26	226.515	379.5	1774.38	
18		10-May-26 16.40	439.54	47.99	371.61	124.00	04.54	75.50	38.33	226.515	3711.5	1623-69-	
19													
20													
23													
22			-										
34		15-Mar- 58 58 ed	457.72	24.42	171.55	122.66	84.42	20111	24.65	100.00	101 12	1010 14	
25		15-51-00-07	474.45	114.00	100.00	122.00	75.54	78.54	10.00	221 444	381.87	1000 000	
26		10.55 au. 26 tot ut.	473.43	111.54	361.00	132.00	78.43	28.65	14.42	204 322	384 87	1182 67	
33		18.10	483.43	110.50	373.05	133.00	10.00	10.00	10.04	7/14.414	334.44	1558.53	

Figure 4.12. Well X1 data after refining on the MonAssess iSheet

Table 2. Averages before and after refining for w	well X1
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Paramete	er	Gross Liquid	Oil Flow	Water Flow	Gas Flow	BS&W	GVF	FLT	FLP	THP	GOR
Average I refining	before	497.17	100.89	396.28	161.23	79.87	78.85	39.44	213.94	407.03	7119.53
Average refining	after	500.4	106.47	393.93	163.38	78.77	79.04	39.5	213.23	408.72	1554.27
change		-3.23	-5.58	2.35	-2.15	1.1	-0.19	-0.06	0.71	-1.69	5565.26

refined by discarding some of the off-range entries in the MonAssess as shown in Figure 4.12 above:

The table 2 above shows the respective averages of the recorded parameters before and after refining.

By discarding some of the off-range entries in Well X1 data, it can be seen how the averages of the parameters changed (this is more apparent in the GOR reading that dropped by 5565.26scf/bbl). There are also changes in the Approxiplots, the outrageous spikes are eliminated. Below are the production approxiplots after the refinining:

CONCLUSION

The MonAssess iSheet can handle any multiphase well test data (all length of well test, up to 100hrs data) once in the format of the Haimo MFM2000 software. For parameters of large size and high degree of fluctuation (e.g as in GOR of well Z shown in Appendix) rectification is not achieved rather the curve is "discretized" (i.e spikes peaking at regular intervals) which still offers better readability. The developed package is not only for field application to monitor and assess multiphase surface well test data but also for other purposes (such as data refining).

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APPENDIX

1. WELL Y



Gross Liquid, Net Oil, Gas Product on and Watercut Picts

Figure A1. Raw production plots for well Y.



Figure A2. Production Approxiplots for well Y



Tubing Head Pressure, Flow Line Pressure and Temperature Plots

Figure A3. THP, FLP & FLT raw plots for Well Y.



Figure A4. THP, FLP and FLT Approxiplots for well Y

GOR Plot



Figure A5. GOR raw plot for Well Y.



Figure A6. GOR Approxiplot for well Y

Making inputs similar to that shown for well X in the MonAssess, the following are obtained for well Y:

The general output can be read from the MonAssess iSheet tab shown in Fig 5.5. However the approxiplots turned out with spikes but still offers more readability as the spikes are discrete (for the GOR Approxiplot, no much rectification is achieved).

2. WELL Z



Gross Liquid, Net Oil, Gas Production and Waterout Plots

Figure B1. production plots for well Z (raw).



Figure B2. Production Approxiplots for well Z



Tubing Head Pressure, Flow Line Pressure and Temperature Plots

Figure B3. THP, FLP & FLT raw plots for Well Z.



Figure B4. THP, FLP & FLT Aproxiplots for Well Z

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Appendix cont.

j. Sec. et al. 5 m. . · CONTRACTORY a. х. 10000,1000 $((1,1))^{-1}$ tenaria. terra terra 0.041 ± 1.042 $1 \leq 1 \leq n \leq 1 \leq n \leq n$ -----GOR (scfbbl)

Figure B5. GOR raw plot for Well Z.



Figure B6. GOR Approxiplot for well Z.

GOR Plot