FLUID LEVEL MEASUREMENTS

BENEFITS AND COMMON APPLICATIONS

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Fluid Level Measurements – Benefits and Applications

Overview

- Fluid Level measurements can provide invaluable information to assist anyone that has an interest in both understanding and evaluating well, or reservoir, performance.
- When combined with a surface pressure measurement, the fluid depth in a wellbore can be used to calculate the pressure at the sandface, for either a producing or shut-in well status.
- Sandface pressure determination is paramount to help evaluate reservoir characteristics and pressure depletion, as well as determining the producing performance of a well.
- The fluid level approach for determining subsurface pressure can have a number of advantages over the method of installing permanent, or temporary, downhole gauges. These advantages mostly revolve around the economic savings and the ease of non-intrusive measurements, without having to perform costly and time consuming well servicing operations in running and/or tripping downhole gauges and then having to re-stabilize conditions after the interruption in normal well operation.

Discussion

Common applications of fluid level measurements include the following:

Pumping Well Surveillance:

Routine pumping fluid level surveys allow the well operations group to help understand any changes in expected production performance. A rise in annular fluid depth over time is typically a symptom of mechanical wear of the pump. A more sudden rise of fluid depth could signal other causes of mechanical equipment failure in the system such as a parted rod string, a hole in the tubing, or even a faulty casing check valve in the surface piping. A companion dynamometer survey would be an asset in to help evaluate the mechanical performance, and any possible subsurface problems, in a beam pump system.

Care should be taken when conducting “spot-check” fluid levels surveys to ensure that the producing sandface pressure is neither over nor under estimated, giving a false sense of well productivity. A very high annular fluid level may not necessarily be a problem if the annular liquid density is low (sometimes referred to as a “gasified” or “foamy” fluid column). This condition in a pumping well is the usually result of very good separation of free gas at the tubing inlet, which is a desirable operating parameter to help maximize liquid displacement efficiency of the pump.

Corresponding producing sandface pressure is usually low with very little, if any, production upside. In these cases an annular fluid depression (or suppression) test is recommended to avoid any misdiagnosis of relatively high liquid levels, or perhaps a false liquid level indication caused by up-hole paraffin or hydrate bridging. The depression test consists of closing the offside casing valve and simultaneously recording the change in liquid depth versus surface wellhead pressure increase over time, while the system is operating and production rates are being measured. For best results, the depression test should be monitored in progress to avoid changing the normal producing conditions. Test values can be processed and plotted (fluid depth versus gas-liquid interface pressure) to illustrate the calculated annular liquid gradient and resultant producing sandface pressure (please refer to Appendix 1 “Annular Fluid Depression Test Report”).

Conversely, a relatively low fluid level may not necessarily be an issue if the surface wellhead pressure is high, due to the casing valve being closed, or partially closed (regulated), or because of high flow line pressure. In these types of situations, displacement efficiency usually suffers at the hand of additional free-gas being forced through the pump. In most of these cases, oil production can in be increased if the casing back-pressure at surface can feasibly be lowered. To help evaluate any potential increase in production with knowledge of the flowing sandface pressure , the Inflow Performance Relationship, or IPR, can be calculated and studied (please refer to Appendix 2 “Inflow Performance Relationship Plot”).

On flowing wells that produce liquids, the IPR when overlain with tubing performance curves will allow the production engineer to design or evaluate the system for maximum lift efficiency.

Pressure Transient Testing:

Fluid level measurements can provide a very cost-effective solution to aid in the evaluation of reservoir performance be it related to declining pressure, skin and permeability assessment, or simply to comply with Government Regulatory requirements. For wells equipped with beam or rotary pump systems, the use of acoustic measurements saves the time and servicing costs of having to pull the rods and pump, install temporary gauges, rerun the pump, and then re-stabilize producing status prior to shut in for buildup. This well servicing process then has to be repeated when the gauges are retrieved and the well is returned to normal production.

Fluid Level Measurements – Benefits and Applications

Acoustic fluid level loggers can be prescheduled to simultaneously record wellhead casing pressure and fluid levels for gathering transient pressure data (both producing and shut in) required to perform a well analysis. By processing the measurements and using correlations that relate in-situ oil gradients to changes in pressure/temperature and the amount gas in solution, acoustic measurements are typically accurate to within 5 percent of subsurface gauge measurements based on comparative findings. (Please refer to Appendix 3 “Bottom Hole Pressure Survey Report”)

For best results when conducting acoustic buildup surveys, the wells should be properly conditioned before shut in. This includes having a stabilized operating condition, and performing an annular fluid depression test if necessary to suppress any foamy fluid. With any type of buildup survey, wells exhibiting recent declines in displacement performance and having a relatively high producing pressure, are generally poor candidates for a reliable pressure transient analysis of skin and permeability due to a state of marginal delta pressure.

With recent advancements in instrument technology, portable, automated, fluid level loggers can be scheduled and left in service for up to 30 days regardless of ambient weather conditions. This provides an attractive advantage for remote wells, or access-challenged wells. Routine downloading, either on-site or by remote telecommunications, permits on-going monitoring and evaluation of the acoustic survey in progress. This can help the reservoir engineer decide as to when sufficient transient data has been obtained avoiding either early termination of the survey, or prolonged and unnecessary delay in having the well returned to production. Even when subsurface gauge surveys are the clients’ method of choice (i.e. initial pressure measurements or flowing well status), this acoustic monitoring benefit can be applied to ensure sufficient data is obtained without having to interrupt the survey to trip the gauges, and in some cases, having to rerun them to continue the survey.

Shut In Well Pressure Surveys:

Acoustic shut-in well measurements (often called “Single-Shot Static Pressure Surveys”) are frequently the preferred choice for evaluating reservoir pressure in wells that have been shut in for some time, be it for reasons of waiting on servicing, processing plant turnaround, suspension status, or remote access limitations. This especially applies when the rods and pump remain in the well, prohibiting a wireline gradient run. For this type of survey on wells that produced oil and water, it is recommended that a pumping fluid level survey be obtained before the well is shut in to help in the evaluation of after-flow liquid composition into the wellbore (please refer to Appendix 4 “Static Pressure Calculation Report”).

Flood Performance Monitoring:

Routine annular fluid depression tests on selected wells within a field have been used to monitor and evaluate the performance of secondary, or tertiary, flood performance of reservoirs. For carbon-dioxide flood applications, correlations have been derived to allow the user to employ non-hydrocarbon properties to help improve the accuracy of sandface pressure calculations.

Enhanced Well Performance Monitoring:

Over recent years the industry has witnessed an increase in number of operators that use acoustic fluid level loggers to monitor the performance of newly drilled wells, often to evaluate the success of post-drill fracture treatments, and in some cases to help understand what the stabilized IPR may amount to before finalizing the design of lift systems, flow lines, and field facilities. The process of choosing drill locations and the type of completion when attempting to add new reserves frequently begins with numerical reservoir models, or simulation studies, that in some cases do not match expectations for various reasons.

A global operating company, having a major gas play in the deep liquids-rich Canadian foothills region, has presented a concept to utilize fluid level measurements to enhance their understanding of reservoir dynamics and also improve current modeling techniques that presently consist of using analog well type-curves in conjunction with Rate-Transient-Analysis (RTA). The accuracy of these model estimations is challenged by not having actual subsurface pressure values.

The acquisition of fluid level measurements on multi-well pads having horizontal completions would provide benefits that include: improving the accuracy of RTA; helping understand offset well interference effects; monitoring the phase-envelope conditions to maximize liquid recovery and improve the modeling methods used for the reservoir/pipeline and facilities; data observation on offset vertical wells that experience flow problems. Long term drawdown monitoring (for 2-3 months) after wells are completed and treated with multi-stage hydraulic fractures, or for any shut-in periods allowing buildup capture, can be accomplished with fluid level loggers, whereas single-shot instruments would be adequate for gathering spot data to optimize liquid recovery. In the existing economic climate the production of gas by itself would not justify the costs of this type of development; therefore, it is felt to be imperative that subsurface pressures in both the reservoir and wellbore are determined and understood to help maximize condensate recovery. It is strongly believed that this field concept can also successfully be applied to other geographic areas of their production operations, and not limited to just NGL wells.

Fracture Treatment Offset Well Monitoring:

Continued development of infill well drilling together with advancements in hydraulic well fracturing technology, particularly in horizontal wellbores, has led to an increase in the number of wells being stimulated. This has also directly driven the application (government regulatory in some jurisdictions i.e. ERCB IRP 24 or Directive Draft 2012-XXX) to monitor the pressure on offset surrounding wells to evaluate any interwellbore communication responses during hydraulic fracturing operations. Automated fluid level loggers, combined with direct communication devices to a central site, are especially attractive for this service from both a cost-standpoint, and the ability to obtain near real-time data.

Plunger Lift Performance Evaluation:

Automated fluid level loggers can provide the transient sandface pressure data required to ideally tune the plunger cycle to the IPR of the well. This can often reduce the trial and error time delays and costs in order to maximize the efficiency of the lift system, as well as that of the operator.

APPENDIX 1

ACOUSTIC PRESSURE SURVEY
ANNULAR FLUID DEPRESSION TEST

SAMPLE et al ALBERTA 1-2-30-4
100/01-02-030-04W5/0
License: 0123456
Field: ALBERTA
Formation: GLWD
Pool: GILWOOD

2009-JUN-11
Analysis provided by NR-Tec Ltd.

Prepared by:	NR-TEC ANALYST
Date:	2009-Jun-12
Prepared for:	BOB LOBLAW SAMPLE COMPANY

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APPENDIX 1

ANNULAR FLUID DEPRESSION TEST

SAMPLE COMPANY
SAMPLE et al ALBERTA 1-2-30-4
100/01-02-030-04W5/0
Test Date: June 11, 2009

INTRODUCTION

An annular fluid depression test was conducted on the subject well in order to determine an annular fluid gradient and producing subsurface pressure at the mid-point of the perforated interval.

PROCEDURE

Pumping fluid levels and wellhead pressures were obtained using an automated acoustic fluid level instrument.

Backpressure was applied to the annulus by closing the casing valve on the "D" wing. The increasing gas/liquid interface pressure causes the fluid level to change. The fluid gradient is established by calculating the gas/liquid interface pressure and measuring the corresponding fluid level at various intervals after the backpressure is applied.

The fluid rates and properties were provided by SAMPLE COMPANY.

RESULTS

A producing pressure at the mid-point of the perforated interval of **3,175 kPaa** kPa (absolute) was determined from the test points.

Summary sheets showing test results, calculations and graphs of the annular fluid depression test are included with this report.

APPENDIX 1

ANNULAR FLUID DEPRESSION TEST

COMPANY:	SAMPLE COMPANY	POOL:	GILWOOD	U.W.I.:	100/01-02-030-04W5/0
FIELD:	ALBERTA	WELL STATUS:	Pumping Oil	WELL NAME:	SAMPLE et al ALBERTA 1-2-30-4
		LICENSE:	0123456		

ELEVATIONS:

Kelly Bushing (KB):	771.90	m
Casing Flange (CF):	767.55	m
KB to CF:	4.35	m

FLUID PROPERTIES:

Gas Gravity:	0.700	
Oil Gravity:	40.000	°API
Water Gravity:	1.050	

SURFACE UNIT:

Tubing Pressure:	494.0	kPa
Pumping Speed:	6.4	SPM
Stroke Length:	488.0/192.1	cm/inch

PRODUCTION RATES:

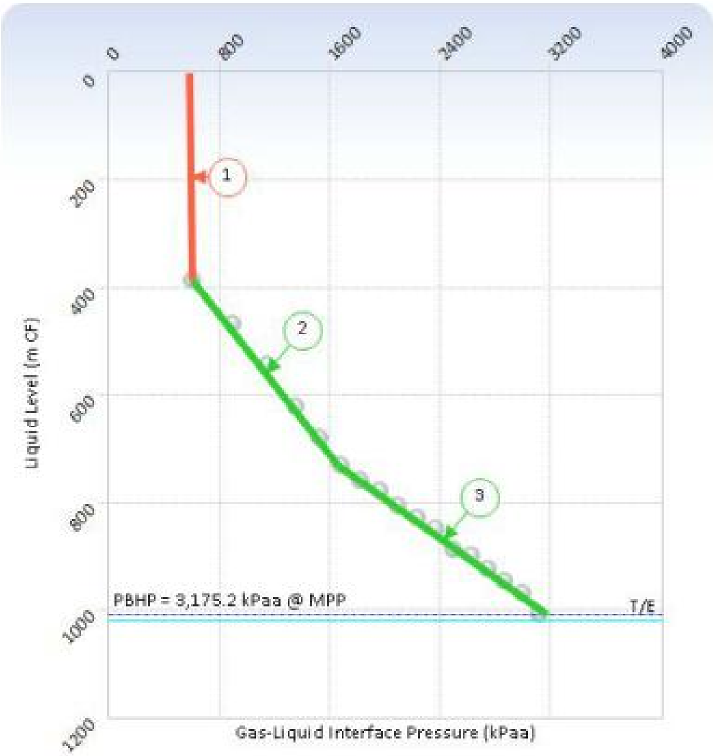
Gas:	8.00	E^3m^3/d
Oil:	35.00	m^3/d
Water:	35.00	m^3/d

TUBING:

Total Joints:	108.000	
Tubing Bottom:	1021.43	m KB
Average Joint Length:	9.417	m

PRODUCING INTERVAL:

Top:	1,007.00	m KB
Bottom:	1,014.70	m KB
Mid-Point:	1,010.85	m KB



TEST START: 2009-JUN-11 @ 15:38:00

No.	Elapsed Time (hours)	Joints To Fluid	Liquid Level (m CF)	Surface Pressure (kPaa)	Interface Pressure (kPaa)
1	0.000	41.10	387.06	587.0	607.1
2	0.533	49.64	467.48	865.3	901.4
3	1.033	57.66	543.01	1097.6	1151.2
4	1.533	65.81	619.76	1288.8	1361.0
5	2.033	72.31	680.97	1440.6	1529.8
6	2.533	77.61	730.89	1574.9	1680.0
7	3.033	80.36	756.78	1705.9	1824.4
8	3.533	82.55	777.41	1832.1	1963.4
9	4.033	85.58	805.94	1954.8	2100.7
10	4.533	87.96	828.36	2076.8	2236.8
11	5.033	89.97	847.28	2194.6	2368.3
12	5.533	94.27	887.78	2307.8	2499.9
13	6.033	95.37	898.14	2420.9	2625.7
14	6.533	98.02	923.09	2531.5	2702.5
15	7.033	100.49	946.36	2637.0	2873.9
16	7.533	102.78	967.92	2741.8	2994.7
17	8.033	106.90	1,006.72	2844.3	3118.1

NO.	Column Length (m)	Average Gradient (kPa/m)	Column Pressure (kPa)	Column Type
1	387.1	0.046	18.0	Gas Column
2	343.8	3.092	1,063.2	Calculated
3	275.6	5.468	1,507.0	Calculated

APPENDIX 2

Inflow Performance Relationship (I.P.R.)

EFFICIENT et al PROLIFIC 1-2-30-4
100/01-02-030-04W5/0

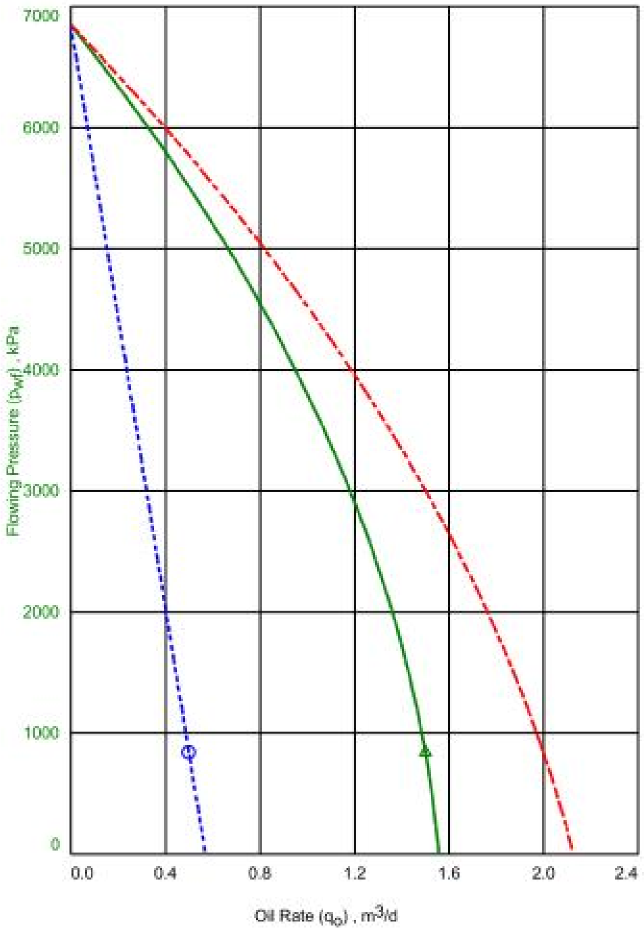
GOODSAND: 1000.0 - 1100.0 mKB
Test Date: March 22 - April 5, 2003

Test Data

Reservoir Pressure (p_R)	6846.00	kPa
Bubble Point Pressure (p_{bp})	7000.00	kPa
Test Pressure (p_{wf})	839.00	kPa
Oil Test Rate (q_o)	1.500	m^3/d
Water Test Rate (q_w)	0.500	m^3/d

Results

Maximum Oil Rate	1.557	m^3/d
Maximum Water Rate	0.570	m^3/d
Maximum Total Rate	2.127	m^3/d



Flowing Pressure kPa	Oil Rate m^3/d	Water Rate m^3/d	Total Rate m^3/d
0.00	1.557	0.570	2.127
500.00	1.527	0.528	2.056
839.00*	1.500	0.500	2.000
1000.00	1.485	0.487	1.971
1500.00	1.429	0.445	1.874
2000.00	1.360	0.403	1.763
2500.00	1.277	0.362	1.639
3000.00	1.181	0.320	1.501
3500.00	1.072	0.279	1.351
4000.00	0.950	0.237	1.187
4500.00	0.814	0.195	1.009
5000.00	0.665	0.154	0.819
5500.00	0.503	0.112	0.615
6000.00	0.327	0.070	0.398
6500.00	0.138	0.029	0.167
6846.00	0.000	0.000	0.000

Note : * Test Point
** Bubble Point
Oil IPR based on Vogel's Equation.
(Quadratic Curve Factor=0.2)

APPENDIX 3

ACOUSTIC PRESSURE SURVEY
BUILD-UP TEST

SAMPLE 1-2-3-4

100/01-02-003-04W5/0

Surface Location: 02-02-003-04W5 (DEV)

License: 1234567

Field: PROLIFIC

Formation: GDSD

Pool: GOODSANDS

DECEMBER 2011

Prepared by:	NR-Tec Analyst
Date:	2011-Dec-23
Prepared for:	BOB LOBLAW SAMPLE COMPANY

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APPENDIX 3

SAMPLE COMPANY

ACOUSTIC PRESSURE SURVEY (BUILD-UP)
SAMPLE 1-2-3-4
100/01-02-003-04W5/0
PROLIFIC
POOL: GOODSANDS
2011-DEC-13 TO 2011-DEC-20

TEST SUMMARY:

- An acoustic well sounder instrument was installed into the casing on 2011-12-13 at 13:04 hours. The fluid level was at 188.2 joints.
- The well was shut-in on 2011-12-13 at 13:04 hours to start the build-up.
- The build-up test was concluded on 2011-12-20 at 16:04 hours.
- A final bottomhole pressure of 8,810 kPa (absolute) was calculated at the mid-point of the producing interval after 7.1 days of shut-in.
- The rate of change in pressure during the last 8.0 hours of shut-in is 0.14 kPa/hr.

PRESSURE DATA CALCULATIONS:

- The bottomhole pressures were calculated using the following information:

Atmospheric Pressure	93.0 kPa
Formation Depth	1,879.70 m KB (TVD) / 1,879.75 m KB
Oil Gravity	35.40 °API
Water Gravity	1.050
Gas Gravity	0.700
Oil Production	1.24 m^3/d
Water Production	16.46 m^3/d
Gas Production	0.03 E^3m^3/d
Bottomhole Temperature	62.20 °C

ATTACHMENTS:
ACOUSTIC WELLSOUNDER PRESSURE SURVEY DATA
TYPE CURVE PRE-PLOT
BOTTOMHOLE PRESSURE VERSUS TIME
CASING PRESSURE VERSUS TIME
FLUID LEVEL VERSUS TIME
PRESSURE FILE (PAS FORMAT)

APPENDIX 3

SAMPLE COMPANY
PROLIFIC

100/01-02-003-04W5/0
DECEMBER 2011

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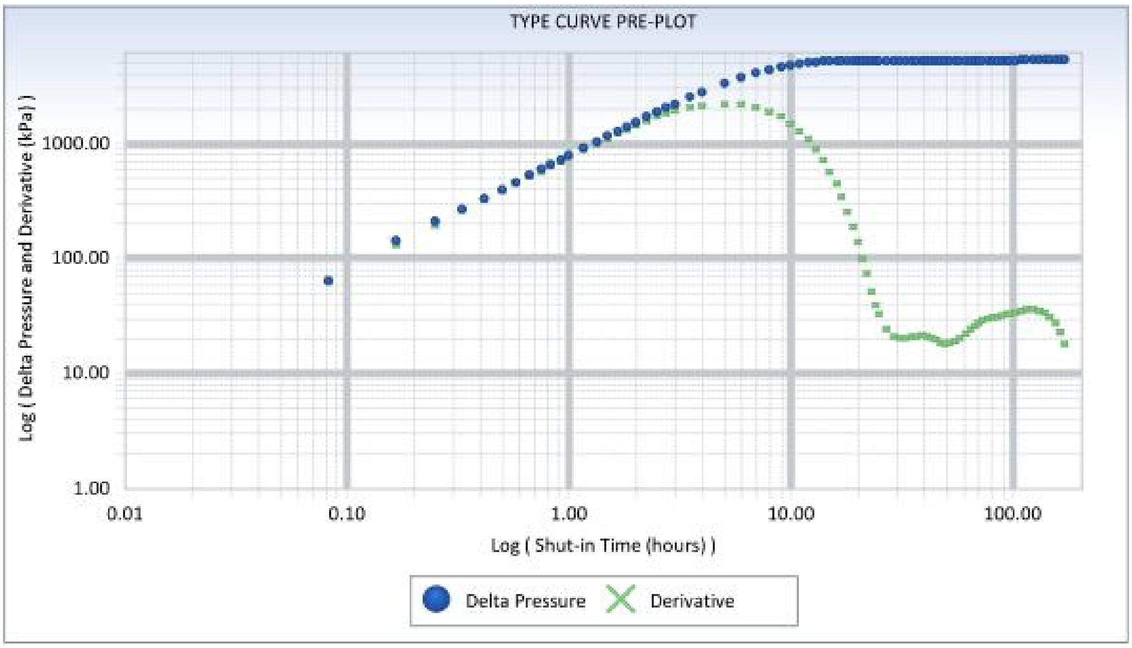
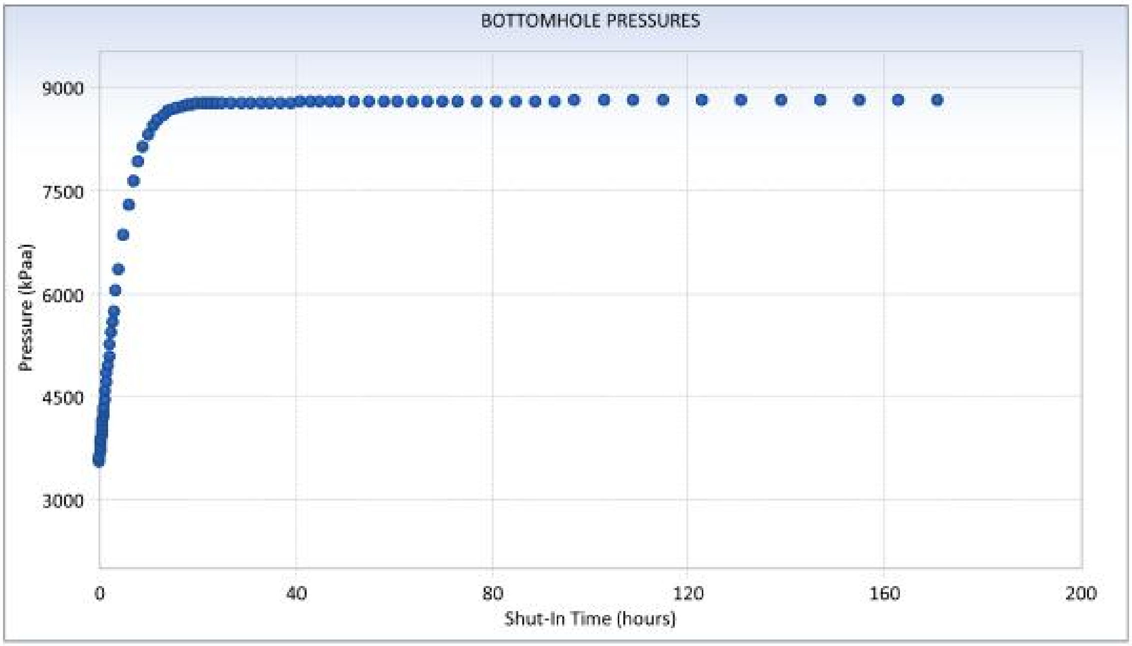
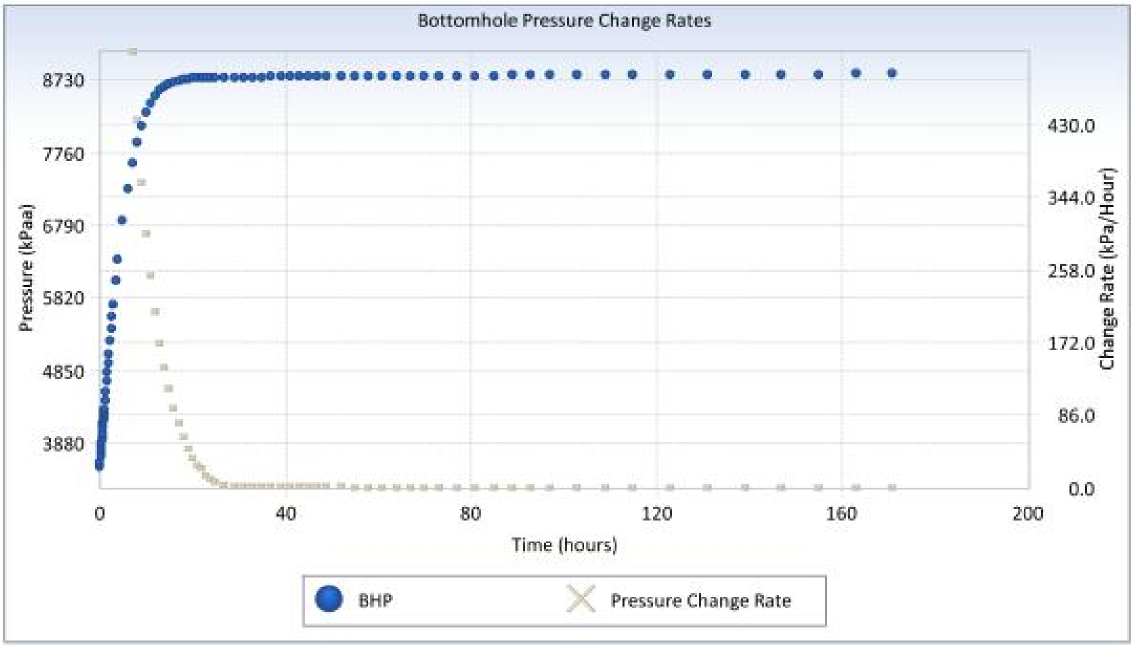




APPENDIX 3


SAMPLE COMPANY
PROLIFIC
100/01-02-003-04W5/0
DECEMBER 2011
Page 4 of 6
FLUID DEPTHS AND SURFACE PRESSURES
1200
1400
1600
1800
2000
Depth (m KB)
4000
3000
2000
1000
0
Pressure (kPag)
MPP
0
40
80
120
160
200
Shut-In Time (hours)
Fluid Depth
Surface Pressure
MPP


Bottomhole Pressure Change Rates
8730
7760
6790
5820
4850
3880
Pressure (kPaa)
430.0
344.0
258.0
172.0
86.0
0.0
Change Rate (kPa/Hour)
0
40
80
120
160
200
Time (hours)
BHP
Pressure Change Rate

APPENDIX 3

ACOUSTIC WELLSOUNDER PRESSURE SURVEY

COMPANY:	SAMPLE COMPANY	POOL:	GOODSANDS	U.W.I.:	100/01-02-003-04W5/0
FIELD:	PROLIFIC	WELL STATUS:	Pumping Oil	WELL NAME:	SAMPLE 1-2-3-4
SHUT-IN:	2011-Dec-13 @ 13:04:32	LICENSE:	1234567	SURFACE LCN.:	02-02-003-04W5 (DEV)

ELEVATIONS:
- Kelly Bushing (KB): 688.20 m
- Casing Flange (CF): 683.60 m
- KB to CF: 4.60 m

FLUID PROPERTIES:
- Gas Gravity: 0.700
- Oil Gravity: 35.400 °API
- Water Gravity: 1.050

TEMPERATURES:
- Surface: 0.00 °C
- Reservoir: 62.20 °C

PRODUCTION RATES:
- Gas: 0.03 E^3m^3/d
- Oil: 1.24 m^3/d
- Water: 16.46 m^3/d

TUBING:
- Total Joints: 196.000
- Tubing Bottom: 1880.50 m KB (MD)
- Average Joint Length: 9.571 m

PRODUCING INTERVAL:
- Top: 1,878.45 m KB (TVD); 1,878.50 m KB (MD)
- Bottom: 1,880.95 m KB (TVD); 1,881.00 m KB (MD)
- Mid-Point: 1,879.70 m KB (TVD); 1,879.75 m KB (MD)

NOTES:

All calculated depths have been corrected to True Vertical Depth.

NO.	TEST TIME (hours)	DATE	TIME	JOINTS TO LIQUID	SURFACE PRESSURE (kPaa)	GAS COLUMN HEIGHT (m)	GAS COLUMN GRADIENT (kPa/m)	GAS COLUMN PRESSURE (kPa)	OIL COLUMN HEIGHT (m)	OIL COLUMN GRADIENT (kPa/m)	OIL COLUMN PRESSURE (kPa)	EMULSION COLUMN HEIGHT (m)	EMULSION COLUMN GRADIENT (kPa/m)	EMULSION COLUMN PRESSURE (kPa)	PRESSURE @ MPP (kPaa)
1	0.000	2011-Dec-13	13:04:32	188.21	2549.4	1801.3	0.237	426.1	72.6	7.793	565.5	1.2	9.944	12.4	3553.4
2	0.083	2011-Dec-13	13:09:30	187.64	2557.4	1795.8	0.237	426.3	72.6	7.794	565.5	6.8	9.945	67.1	3616.3
3	0.166	2011-Dec-13	13:14:30	186.90	2566.0	1788.8	0.238	426.2	72.5	7.795	565.5	13.8	9.945	137.1	3694.8
4	0.249	2011-Dec-13	13:19:30	186.29	2572.3	1783.0	0.239	426.0	72.5	7.796	565.5	19.6	9.946	194.9	3758.7
5	0.333	2011-Dec-13	13:24:30	185.72	2580.0	1777.5	0.240	426.2	72.5	7.797	565.6	25.1	9.946	249.6	3821.3
6	0.416	2011-Dec-13	13:29:30	185.18	2587.1	1772.3	0.241	426.2	72.5	7.797	565.6	30.3	9.947	301.3	3880.2
7	0.499	2011-Dec-13	13:34:30	184.54	2594.7	1766.2	0.241	426.2	72.5	7.798	565.6	36.4	9.947	362.1	3946.6
8	0.583	2011-Dec-13	13:39:30	184.00	2601.6	1761.0	0.242	426.2	72.5	7.799	565.6	41.6	9.947	413.8	4007.3
9	0.666	2011-Dec-13	13:44:30	183.36	2609.4	1754.9	0.243	426.2	72.5	7.800	565.7	47.7	9.948	474.7	4076.0
10	0.749	2011-Dec-13	13:49:30	182.75	2616.5	1749.1	0.244	426.1	72.5	7.801	565.7	53.5	9.948	532.5	4140.9
11	0.833	2011-Dec-13	13:54:30	182.21	2624.3	1743.9	0.244	426.3	72.5	7.801	565.7	58.7	9.949	584.2	4200.5
12	0.916	2011-Dec-13	13:59:30	181.60	2631.6	1738.1	0.245	426.2	72.5	7.802	565.8	64.5	9.949	642.0	4265.8
13	0.999	2011-Dec-13	14:04:30	181.06	2638.9	1732.9	0.246	426.3	72.5	7.803	565.8	69.7	9.950	693.7	4324.7
14	1.166	2011-Dec-13	14:14:30	179.88	2653.6	1721.6	0.248	426.2	72.5	7.805	565.8	81.0	9.950	806.3	4451.9
15	1.333	2011-Dec-13	14:24:30	178.76	2668.1	1710.9	0.249	426.2	72.5	7.806	565.8	91.7	9.951	912.9	4573.0
16	1.499	2011-Dec-13	14:34:30	177.58	2682.7	1699.6	0.251	426.0	72.5	7.808	565.9	103.0	9.952	1025.5	4700.1
17	1.666	2011-Dec-13	14:44:30	176.43	2697.1	1688.6	0.252	425.9	72.5	7.809	565.9	114.0	9.953	1135.1	4824.0
18	1.833	2011-Dec-13	14:54:30	175.28	2711.5	1677.6	0.254	425.7	72.5	7.811	566.0	125.1	9.954	1244.8	4948.0
19	1.999	2011-Dec-13	15:04:30	174.17	2725.7	1666.9	0.255	425.5	72.5	7.812	566.0	135.8	9.955	1351.3	5068.7
20	2.249	2011-Dec-13	15:19:30	172.57	2746.9	1651.6	0.258	425.4	72.4	7.815	566.1	151.0	9.956	1503.6	5242.0
21	2.499	2011-Dec-13	15:34:30	170.98	2767.7	1636.4	0.260	425.1	72.4	7.817	566.2	166.3	9.957	1655.9	5415.0
22	2.749	2011-Dec-13	15:49:30	169.51	2788.4	1622.3	0.262	425.1	72.4	7.819	566.3	180.4	9.958	1796.1	5575.8
23	2.999	2011-Dec-13	16:04:30	168.07	2808.7	1608.6	0.264	425.0	72.4	7.820	566.4	194.1	9.959	1933.2	5733.4
24	3.499	2011-Dec-13	16:34:30	165.26	2848.5	1581.7	0.269	424.7	72.4	7.824	566.6	221.0	9.961	2201.4	6041.3
25	3.999	2011-Dec-13	17:04:30	162.65	2887.1	1556.6	0.273	424.6	72.4	7.827	566.7	246.1	9.962	2451.5	6329.9
26	4.999	2011-Dec-13	18:04:30	158.02	2960.4	1512.3	0.281	424.6	72.4	7.832	567.0	290.4	9.965	2893.7	6845.7
27	5.999	2011-Dec-13	19:04:30	154.25	3026.6	1476.3	0.288	425.2	72.4	7.836	567.2	326.4	9.968	3253.8	7272.7
28	6.999	2011-Dec-13	20:04:30	151.22	3084.0	1447.3	0.294	425.9	72.4	7.838	567.4	355.4	9.970	3543.6	7621.0

APPENDIX 3

	TEST			JOINTS	SURFACE	GAS COLUMN			OIL COLUMN			EMULSION COLUMN			PRESSURE
	TIME			TO	PRESSURE	HEIGHT	GRADIENT	PRESSURE	HEIGHT	GRADIENT	PRESSURE	HEIGHT	GRADIENT	PRESSURE	@ MPP
NO.	(hours)	DATE	TIME	LIQUID	(kPaa)	(m)	(kPa/m)	(kPa)	(m)	(kPa/m)	(kPa)	(m)	(kPa/m)	(kPa)	(kPaa)
29	7.999	2011-Dec-13	21:04:30	148.78	3132.0	1423.7	0.300	426.6	72.4	7.840	567.8	379.0	9.971	3778.7	7904.9
30	8.999	2011-Dec-13	22:04:30	146.88	3171.1	1405.7	0.304	427.3	72.4	7.842	567.8	397.0	9.972	3958.8	8124.9
31	9.999	2011-Dec-13	23:04:30	145.44	3201.9	1392.0	0.307	427.9	72.4	7.843	567.9	410.7	9.973	4096.1	8293.8
32	10.999	2011-Dec-14	00:04:30	144.33	3225.5	1381.3	0.310	428.2	72.4	7.843	568.0	421.4	9.974	4203.0	8424.6
33	11.999	2011-Dec-14	01:04:30	143.53	3243.2	1373.6	0.312	428.6	72.4	7.844	568.0	429.0	9.974	4279.3	8519.1
34	12.999	2011-Dec-14	02:04:30	142.89	3256.4	1367.5	0.313	428.7	72.4	7.844	568.1	435.1	9.975	4340.4	8593.5
35	13.999	2011-Dec-14	03:04:30	142.47	3265.9	1363.6	0.315	428.9	72.4	7.845	568.1	439.1	9.975	4380.1	8643.1
36	14.999	2011-Dec-14	04:04:30	142.15	3272.8	1360.5	0.315	429.0	72.4	7.845	568.2	442.2	9.975	4410.6	8680.6
37	16.000	2011-Dec-14	05:04:31	141.96	3277.8	1358.7	0.316	429.2	72.4	7.845	568.2	444.0	9.975	4428.9	8704.1
38	16.999	2011-Dec-14	06:04:30	141.80	3281.4	1357.2	0.316	429.2	72.4	7.845	568.2	445.5	9.975	4444.2	8723.0
39	17.999	2011-Dec-14	07:04:30	141.68	3283.9	1355.9	0.317	429.2	72.4	7.845	568.2	446.7	9.975	4456.4	8737.8
40	18.999	2011-Dec-14	08:04:30	141.61	3285.8	1355.3	0.317	429.3	72.4	7.845	568.2	447.4	9.975	4462.5	8745.8
41	19.999	2011-Dec-14	09:04:30	141.55	3287.2	1354.7	0.317	429.3	72.4	7.845	568.2	448.0	9.975	4468.6	8753.4
42	20.999	2011-Dec-14	10:04:30	141.52	3288.3	1354.4	0.317	429.4	72.4	7.845	568.2	448.3	9.975	4471.7	8757.7
43	21.999	2011-Dec-14	11:04:30	141.52	3289.2	1354.4	0.317	429.6	72.4	7.845	568.2	448.3	9.975	4471.7	8758.6
44	22.999	2011-Dec-14	12:04:30	141.48	3289.6	1354.1	0.317	429.5	72.4	7.845	568.2	448.6	9.975	4474.7	8762.0
45	23.999	2011-Dec-14	13:04:30	141.48	3289.6	1354.1	0.317	429.5	72.4	7.845	568.2	448.6	9.975	4474.7	8762.0
46	24.999	2011-Dec-14	14:04:30	141.48	3289.3	1354.1	0.317	429.5	72.4	7.845	568.2	448.6	9.975	4474.7	8761.8
47	26.999	2011-Dec-14	16:04:30	141.48	3289.8	1354.1	0.317	429.5	72.4	7.845	568.2	448.6	9.975	4474.7	8762.3
48	28.999	2011-Dec-14	18:04:30	141.46	3289.1	1353.9	0.317	429.4	72.4	7.845	568.2	448.8	9.976	4476.7	8763.4
49	30.999	2011-Dec-14	20:04:30	141.45	3290.4	1353.8	0.317	429.6	72.4	7.845	568.2	448.9	9.976	4477.6	8765.8
50	32.999	2011-Dec-14	22:04:30	141.45	3290.8	1353.7	0.317	429.6	72.4	7.845	568.2	449.0	9.976	4478.5	8767.1
51	35.000	2011-Dec-15	00:04:31	141.44	3290.2	1353.6	0.317	429.5	72.4	7.845	568.2	449.0	9.976	4479.4	8767.4
52	37.000	2011-Dec-15	02:04:31	141.43	3290.8	1353.5	0.317	429.5	72.4	7.845	568.2	449.1	9.976	4480.3	8768.9
53	39.000	2011-Dec-15	04:04:31	141.42	3290.3	1353.4	0.317	429.4	72.4	7.845	568.2	449.2	9.976	4481.2	8768.2
54	41.000	2011-Dec-15	06:04:31	141.41	3290.0	1353.4	0.317	429.4	72.4	7.845	568.2	449.3	9.976	4482.1	8769.7
55	43.000	2011-Dec-15	08:04:31	141.40	3290.7	1353.3	0.317	429.4	72.4	7.845	568.2	449.4	9.976	4483.0	8771.3
56	45.000	2011-Dec-15	10:04:31	141.39	3291.4	1353.2	0.317	429.5	72.4	7.845	568.2	449.5	9.976	4483.9	8773.0
57	47.000	2011-Dec-15	12:04:31	141.38	3291.7	1353.1	0.317	429.5	72.4	7.845	568.2	449.6	9.976	4484.8	8774.2
58	49.000	2011-Dec-15	14:04:31	141.37	3291.8	1353.0	0.317	429.5	72.4	7.845	568.2	449.7	9.976	4485.7	8775.3
59	52.000	2011-Dec-15	17:04:31	141.36	3291.8	1352.9	0.317	429.5	72.4	7.845	568.2	449.8	9.976	4486.6	8776.1
60	55.000	2011-Dec-15	20:04:31	141.35	3291.9	1352.8	0.317	429.5	72.4	7.845	568.2	449.9	9.976	4487.5	8777.2
61	58.000	2011-Dec-15	23:04:31	141.34	3291.3	1352.7	0.317	429.3	72.4	7.845	568.2	449.9	9.976	4488.5	8777.3
62	61.000	2011-Dec-16	02:04:31	141.33	3291.6	1352.6	0.317	429.4	72.4	7.845	568.2	450.0	9.976	4489.4	8778.5
63	64.000	2011-Dec-16	05:04:31	141.32	3291.8	1352.5	0.317	429.4	72.4	7.845	568.2	450.1	9.976	4490.3	8779.7
64	67.000	2011-Dec-16	08:04:31	141.31	3291.2	1352.5	0.317	429.2	72.4	7.845	568.2	450.2	9.976	4491.2	8779.8
65	70.000	2011-Dec-16	11:04:31	141.30	3291.9	1352.4	0.317	429.3	72.4	7.845	568.2	450.3	9.976	4492.1	8781.5
66	73.000	2011-Dec-16	14:04:31	141.29	3291.2	1352.2	0.317	429.2	72.4	7.845	568.2	450.5	9.976	4493.8	8782.4
67	77.000	2011-Dec-16	18:04:31	141.27	3291.4	1352.0	0.317	429.1	72.4	7.845	568.2	450.6	9.976	4495.5	8784.2
68	81.000	2011-Dec-16	22:04:31	141.25	3291.8	1351.9	0.317	429.2	72.4	7.845	568.2	450.8	9.976	4497.1	8786.3
69	85.000	2011-Dec-17	02:04:31	141.23	3291.3	1351.7	0.317	429.0	72.4	7.846	568.2	451.0	9.976	4498.8	8787.4
70	89.000	2011-Dec-17	06:04:31	141.22	3291.8	1351.5	0.317	429.0	72.4	7.846	568.2	451.1	9.976	4500.4	8789.4
71	93.000	2011-Dec-17	10:04:31	141.20	3291.5	1351.4	0.317	429.0	72.4	7.846	568.2	451.3	9.976	4502.1	8790.8
72	97.000	2011-Dec-17	14:04:31	141.18	3292.0	1351.2	0.317	429.0	72.4	7.846	568.2	451.5	9.976	4503.8	8793.0
73	103.000	2011-Dec-17	20:04:31	141.16	3291.3	1351.0	0.317	428.8	72.4	7.846	568.2	451.6	9.976	4505.4	8793.8
74	109.000	2011-Dec-18	02:04:31	141.15	3291.8	1350.9	0.317	428.9	72.4	7.846	568.2	451.8	9.976	4507.1	8796.0
75	115.000	2011-Dec-18	08:04:31	141.13	3291.3	1350.7	0.317	428.7	72.4	7.846	568.2	452.0	9.976	4508.8	8797.0
76	123.000	2011-Dec-18	16:04:31	141.10	3291.3	1350.4	0.317	428.7	72.4	7.846	568.2	452.2	9.976	4511.4	8799.6
77	131.000	2011-Dec-19	00:04:31	141.08	3291.2	1350.2	0.317	428.6	72.4	7.846	568.2	452.5	9.976	4514.0	8802.0
78	139.000	2011-Dec-19	08:04:31	141.05	3292.0	1349.9	0.317	428.6	72.4	7.846	568.2	452.7	9.976	4516.5	8805.3
79	147.000	2011-Dec-19	16:04:31	141.03	3291.3	1349.8	0.317	428.4	72.4	7.846	568.2	452.9	9.976	4518.2	8806.2
80	155.000	2011-Dec-20	00:04:31	141.02	3291.9	1349.6	0.317	428.5	72.4	7.846	568.2	453.1	9.976	4519.7	8808.3
81	163.000	2011-Dec-20	08:04:31	141.00	3291.5	1349.5	0.317	428.4	72.4	7.846	568.2	453.2	9.976	4521.1	8809.2
82	171.000	2011-Dec-20	16:04:31	140.99	3291.4	1349.3	0.317	428.3	72.4	7.846	568.2	453.3	9.976	4522.4	8810.4

APPENDIX 4

ACOUSTIC PRESSURE SURVEY
STATIC PRESSURE CALCULATION

SAMPLE et al ALBERTA 1-2-30-4
100/01-02-030-04W5/0
License: 0123456
Field: ALBERTA
Formation: GILWOOD
Pool: GILWOOD A

2012-JAN-30

Prepared by:	NR-Tec Analyst
Date:	2012-Feb-02
Prepared for:	BOB LOBLAW SAMPLE COMPANY

NR-Tec Ltd.
P.O. Box 36028 Lakeview RPO, Calgary, Alberta T3E 7C6
Tel: (403) 807-1644 Fax: (403) 206-7783
http://www.nr-tec.com

APPENDIX 4

SAMPLE COMPANY

ACOUSTIC PRESSURE SURVEY (STATIC CALCULATION)
SAMPLE ET AL ALBERTA 1-2-30-4
100/01-02-030-04W5/0
ALBERTA
POOL: GILWOOD A
January 30, 2012

TEST SUMMARY:

- A surface pressure and a fluid level were obtained with an acoustic well sounder instrument on 2012-01-30 at 13:20 hours to calculate a shut-in bottomhole pressure at the mid-point of the producing interval.
- The subject well had been shut-in for 1.2 year(s) (since 08:00 on 2010-11-17).
- Since this well was shut-in for an extended period of time, the fluid in the annulus is assumed to be 100% oil. This results in a calculated bottomhole pressure of 6,747 kPa (absolute) at the mid-point of the producing interval.
- Assuming the annulus contains an emulsion with the water oil ratio equal to the ratio of the last measured production rates results in a pressure of 8,236 kPa (absolute). Assuming the annulus contains 100% water results in a pressure of 8,980 kPa (absolute).

PRESSURE DATA CALCULATIONS:

- The bottomhole pressures were calculated using the following information:

Atmospheric Pressure	93.0 kPa
Formation Depth	1,737.80 m KB
Oil Gravity	40.43 °API
Water Gravity	1.050
Gas Gravity	0.780
Oil Production	5.16 m^3/d
Water Production	11.67 m^3/d
Gas Production	0.14 E^3m^3/d
Bottomhole Temperature	50.00 °C

ATTACHMENTS:
ACOUSTIC WELLSOUNDER PRESSURE SURVEY DATA
PRESSURE FILE (PAS FORMAT)

APPENDIX 4

ACOUSTIC WELLSOUNDER PRESSURE SURVEY

COMPANY:	**SAMPLE COMPANY**	POOL:	**GILWOOD A**	U.W.I.:	**100/01-02-030-04W5/0**
FIELD:	**ALBERTA**	WELL STATUS:	**Pumping Oil**	WELL NAME:	**SAMPLE et al ALBERTA 1-2-30-4**
SHUT-IN:	**2010-Nov-17 @ 08:00:00**	LICENSE:	**0123456**		

ELEVATIONS:		FLUID PROPERTIES:		TEMPERATURES:	
Kelly Bushing (KB):	650.30 m	Gas Gravity:	0.780	Surface:	-0.60 °C
Casing Flange (CF):	645.80 m	Oil Gravity:	40.430 °API	Reservoir:	50.00 °C
KB to CF:	4.50 m	Water Gravity:	1.050		
PRODUCTION RATES:		TUBING:		PRODUCING INTERVAL:	
Gas:	0.14 E^3m^3/d	Total Joints:	182.000	Top:	1,735.80 m KB
Oil:	5.16 m^3/d	Tubing Bottom:	1733.50 m KB	Bottom:	1,739.80 m KB
Water:	11.67 m^3/d	Average Joint Length:	9.500 m	Mid-Point:	1,737.80 m KB

NOTES:

	TEST			JOINTS	SURFACE	GAS COLUMN			OIL COLUMN			EMULSION COLUMN			PRESSURE
	TIME			TO	PRESSURE	HEIGHT	GRADIENT	PRESSURE	HEIGHT	GRADIENT	PRESSURE	HEIGHT	GRADIENT	PRESSURE	@ MPP
NO.	(hours)	DATE	TIME	LIQUID	(kPaa)	(m)	(kPa/m)	(kPa)	(m)	(kPa/m)	(kPa)	(m)	(kPa/m)	(kPa)	(kPaa)
1	10641.333	2012-Jan-30	13:20:00	91.50	120.0	869.3	0.012	10.2	864.1	7.658	6617.2	--	--	--	6747.4