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Horizontal Production Logging Service Quality Best Practices Utilizing Procedural Flow Chart Methods

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Abstract

Over the past 20 years the industry has focused on drilling and completing horizontal producing wells, in order to develop better deliverability and better UER across the reservoir. The past 10 years igniting the unconventional reservoirs across the US the majority of wells drilled and completed are horizontal wells. These types of wells are traditionally drilled with various inclinations, trajectories which porpoise across the reservoir interval. Horizontal lateral sections consist of numerous selectively stimulated stages containing greater than 20 stages spread out across 2,000 ft to 15,000 ft of horizontal interval.

In order to understand how a producing horizontal lateral section contributes, is to deploy production log technology across the lateral while the well is flowing back. The production log system & survey is the only direct method to measure the performance of the well, how each stage and perforation cluster contributes, oil, water and gas. The production log tool comprises of various measurements such as fluid capacitance, fluid density, holdup, which measures the oil, water gas content, cross sectional holdup and velocity as fluids enter the lateral section.

The production log system can be deployed with two separate methods, coiled tubing deployment or wireline with a well tractor situated on top of the production log tool string. It is highly recommended that the production log survey be performed using a procedure and program created by an experience specialist production logging personnel. This will increase the probability the service will deliver a representative result & value to the oil company. However, whether by customer decisions, inadequate service company knowledge, lack of experience in how the tools and deployment methods should be run & how the well should be performing during the survey; the production log surveys, at time may not deliver a quality product. A full service production log service including deployment, the price point offering is ~ $100,000 to > $1,000,000. A slip up in service quality leads to the service not being performed in the future or leaves a negative view on the service over all.

This paper will discuss the benefits pit falls of horizontal production log survey application, deployment & acquiring quality results. The paper will show case examples of productions logs run with various deployment methods & identify benefits and issues during the survey. This paper will present a best practices novel procedural flow-chart for the industry to follow, that can assist and help production logging, wireline, tractor, coiled tubing deployment service companies, and the oil company engineering group to execute properly a quality production log service survey.

Introduction

Production log data logged across a producing horizontal well can be the most important flow information an oil company operator will receive. In North America, Oil Company operators invest close to $10 million per well drilling and completing a well; however, production log results have concluded that only 20%-40% of the completed lateral actually is productive. The production log results informs the operator where all the costs that have been put into their investment, how much is actually paying out with production.

To properly deploy & measure a horizontal production log service that delivers high quality, high confident results, preparation and careful procedures need to be communicated and followed. Keys to a successful result are how well the operator understands the consistency of the well flow and the fluids composition downhole. Also how the well performs when the deployment system is run across the producing intervals.

Fluid Phase Types in the Wellbore

When oil company operators have wells that are either over or under performing a production log survey is usually considered to be run. Production Logs help determine exactly where all the production inflows from or where products such as water is producing.

Prior to setting up a production log survey, understanding the composition and PVT nature of the fluids is key. If the well and reservoir produces oil and gas on surface but it tends to be more of a retrograde oil, then there is a high probability at reservoir conditions the wellbore will be full of gas as oil condenses out on surface or at lower pressures in the tubing. In production log analysis terms, this would be considered as a single phase flowing wellbore, the majority phase being gas, with small amount of formation water in the wellbore.

Other wells and reservoirs are producing 3 phase flow, a small amount of water, some oil, but the majority of the gas volume produced comes from the oil in the separator, downhole conditions are considered to be a 2 phase reservoir the majority phase being oil with a very small % of water occupying the cross section of the pipe. Figure 1, illustrates a cross sectional image of production log data in a flowing 2 phase water and oil environment.

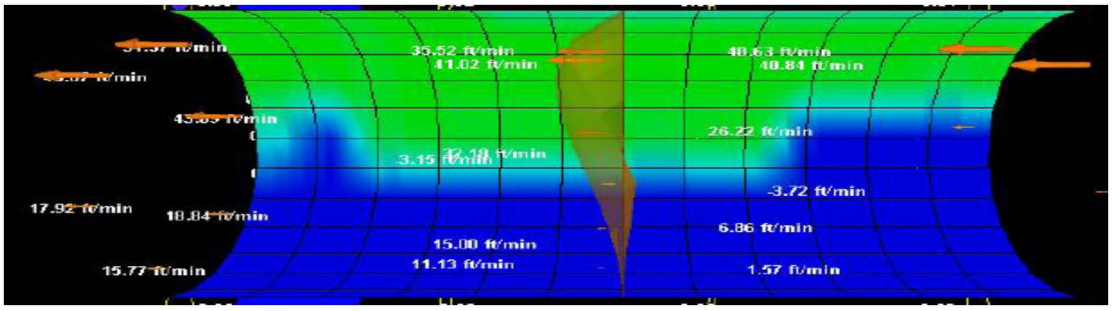

Figure 1—Cross sectional image of 2 phase holdup.

Some wells through the completion process, can connect directly to a water zones & various stages contribute high volume of water & some hydrocarbons, but due to the overwhelming effects of the water volume, the well downhole flows 99% water, this is considered to be a single phase flowing wellbore. Figure 2, illustrates horizontal production log showing evidence that a stage cluster was completed at a water bearing fault in the formation. (Heddleston, 2009).

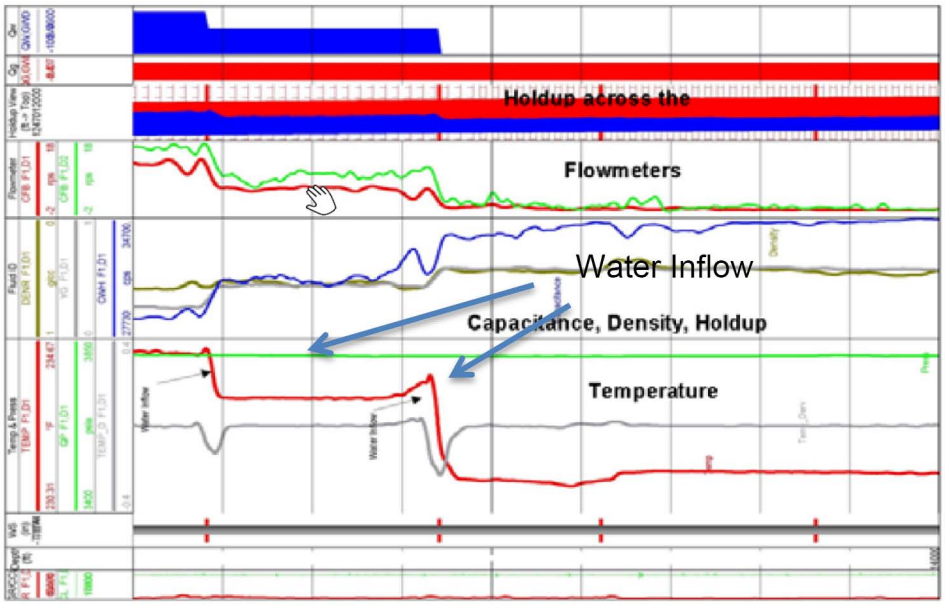

Figure 2—Illustrates a horizontal well stage connected to a fault producing water, (Heddleston, 2009).

An indepth knowledge of the reservoir phase composition in the wellbore as well as the PVT data will help assist the production logging lead expertise. This will help the logging team prepare the tools, technology and also assist with pre-log analysis expectations of flow and flow regime, velocities and pressures. It will help create an indepth production logging program, which will help eliminate any miss steps.

Well Trajectories

The majority of US HZ wells drilled is a hook shaped trajectory, meaning the toe section will be set higher than the heel section. Figure 3 illustrates a typical toe up completion, this method allows for effective drainage of liquids across the wellbore down to the heel.

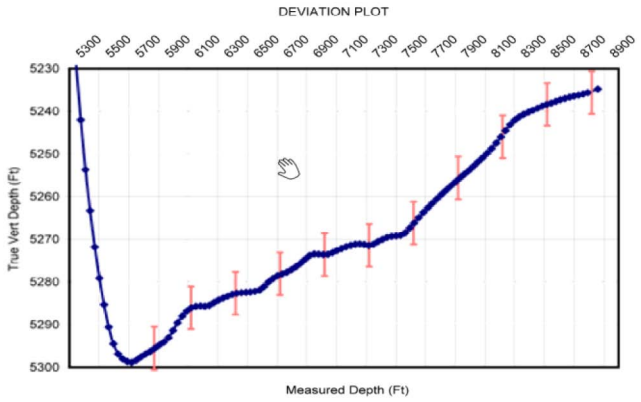

Figure 3—Illustrates a horizontal well toe up trajectory, (Heddleston, 2009).

However, most wellbore trajectory will have high & low spots, porpoising up and down in & out of zones. These low spots can act as troughs where liquids settle & may not regularly produce, this can cause flow issues as part of the lateral can get shut off from production as water volumes build up in the various troughs.

Types of Deployment Methods

There are 2 main deployment methods 1) Coiled tubing deployed, 2) Wireline Tractor deployed.

The majority of HZ production logs run throughout the US have been deployed with coil tubing.

The positive side, it will deploy the tools across the lateral at various speeds, and can make cleanout trips which is needed for a production log survey. The negative side using coiled tubing it can have a choking effect on the flow stream, or a buckling effect. Figure 4, illustrates the conditions of coiled deployment.

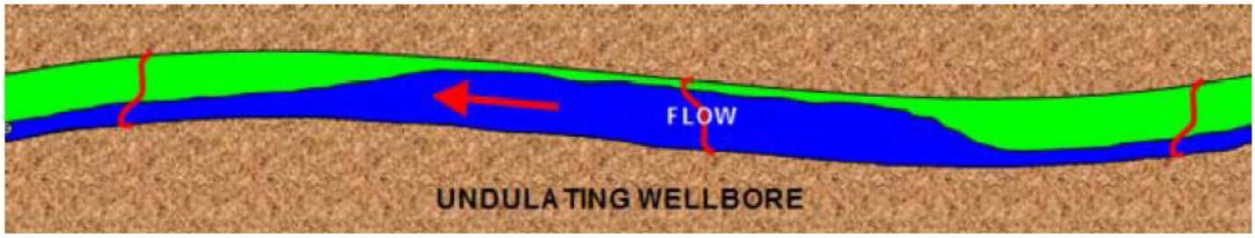

Figure 4—Illustrates undulations in a flowing horizontal lateral well, (Heddleston, 2009).

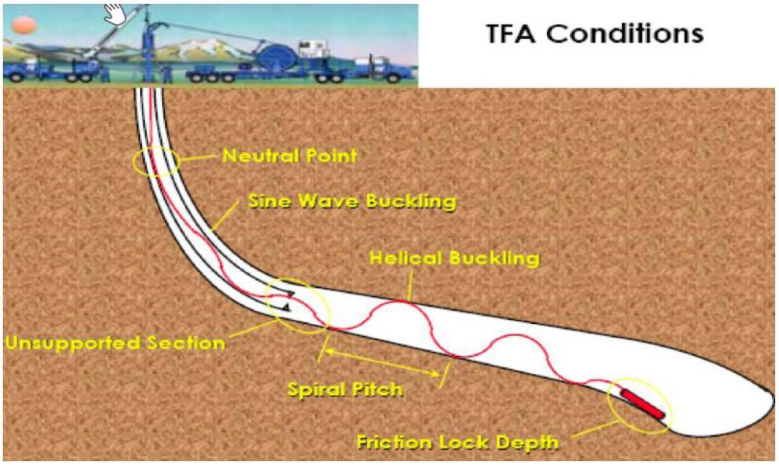

Figure 5—Illustrates the conditions of coiled tubing deployment, (BJ Services, 2008).

A well tractor deployed on wireline offers a smaller foot print on location and if the correct sized well tractor is deployed it should lessen the amount of choking effects on the flow stream, since the tractor length is only ~ 30 foot in length, thereafter is only a small wireline diameter occupying the pipe.

The negative is the well tractor deployment should require a cleanout trip with a coiled tubing run prior to running the production logging tools, the logging speed into the well will be only one speed & it's very slow, additional tractor passes increase in costs & at times if wells aren't cleaned or have a steep toe up trajectory, the tractor cannot make it to the end of the lateral. Significant sand and debris can cause tension with the cable and tractor stopping, while logging up same sanding issues can also occur. (Schwanitz, Gomez, Banks, Herard, 2015).

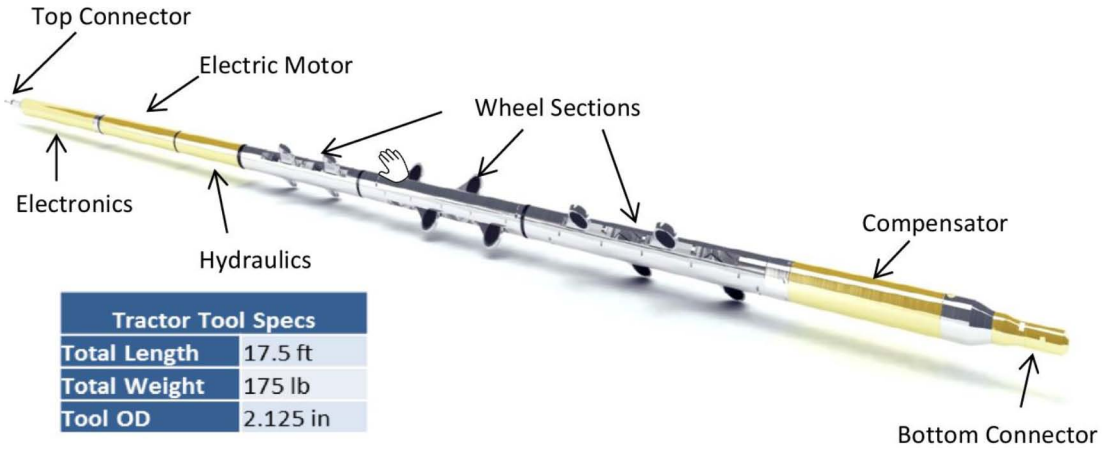

Figure 6—Illustration of a Well Tractor. (Welltec. 2008).

Production Log Measurements

Production Log measurements consist of GR/CCL/PRESSURE/TEMPERATURE/FLUID ID/FLOW METER.

The GR/CCL measurement is used to depth correlation and determining RA Trace material in the completion.

The PRESSURE/TEMPERATURE measurement is used to determine the bottom hole pressure and temperature, qualitative temperature changes from contributing intervals, also is used in the log analysis to correlate the PVT formation volume factors.

The FLUID ID measurements can consist of density, capacitance and resistivity type sensors to determine the phase ratios across the cross section of the pipe.

The FLOWMETER measurement determines the velocity of the phases flowing in the cross section area of the pipe.

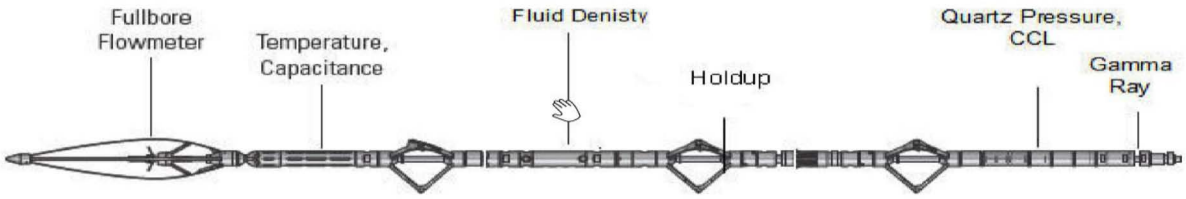

Figure 7—Is an illustration of a traditional production log tool. (Heddleston, 2009).

Horizontal Well Production Log Procedures Flow Chart

Horizontal Well Production Log Procedures Flow Chart starts with when a well candidate is chosen.

The first information that should be reviewed and investigated is the well data & production parameters. It is important to understand the surface flow rates & how the surface properties relate to the downhole phases.

The wellbore diagram shows the casing size & the intervals were completed. The trajectory should be plotted to show how the lateral porpoises through the reservoir and can high light some mechanical flow issues and traps along the lateral.

The well is to be accurately surface tested for a period of time, testing the well will deliver surface rate information over time so it is understood how the well performs. Fluid and gas composition are to be tested to help better understand what the phases and flow rates of the production downhole.

The well usually has produced frac sand & plug materials collected in various spots in the wellbore. A cleanout trip is to be performed; normally this is performed with jointed stick pipe or coiled tubing. Since

the clean out trip will usually use surface water and other liquids being introduced to the wellbore. The well will need to flowed back & through a test separator and into tanks so it can clean up and get back to its normal representative flow rates. The biggest challenge during the cleanout run (on single phase gas wells), is maintaining consistent gas flow and wellhead pressure, especially in a low pressure, low rate environment. (McCluskey, 2012). Careful documentation of the cleanout is to be taken, like for example flowrates of how the well production was affected due to the coiled tubing deployed across the lateral. Also the amount of surface material pumped into the wellbore during the cleanout process.

When deploying the production log service, it is important that the well is being tested and the surface rate measurements are being recorded every 15 minutes. An ideal measurement is an Indepth well performance monitor, which in real time sends wellhead pressure data that can help correlate the downhole tool data with the surface flowrates. Keeping the deployment systems running without issues will make for a better-quality production log. Since production logging requires the tools making consistent steady passes across the producing interval, having a steady running deployment system is ideal to create quality log information.

The final results, production log analysis requires taking all the well information, fluid parameters, gas composition, PVT data, well test information, the Indepth well performance monitor data and compiling the data with the production log tool information. This array of information is reviewed with the sequence of events of the deployment run assists in the processing of the data into a final production log result, presented in surface conditions.

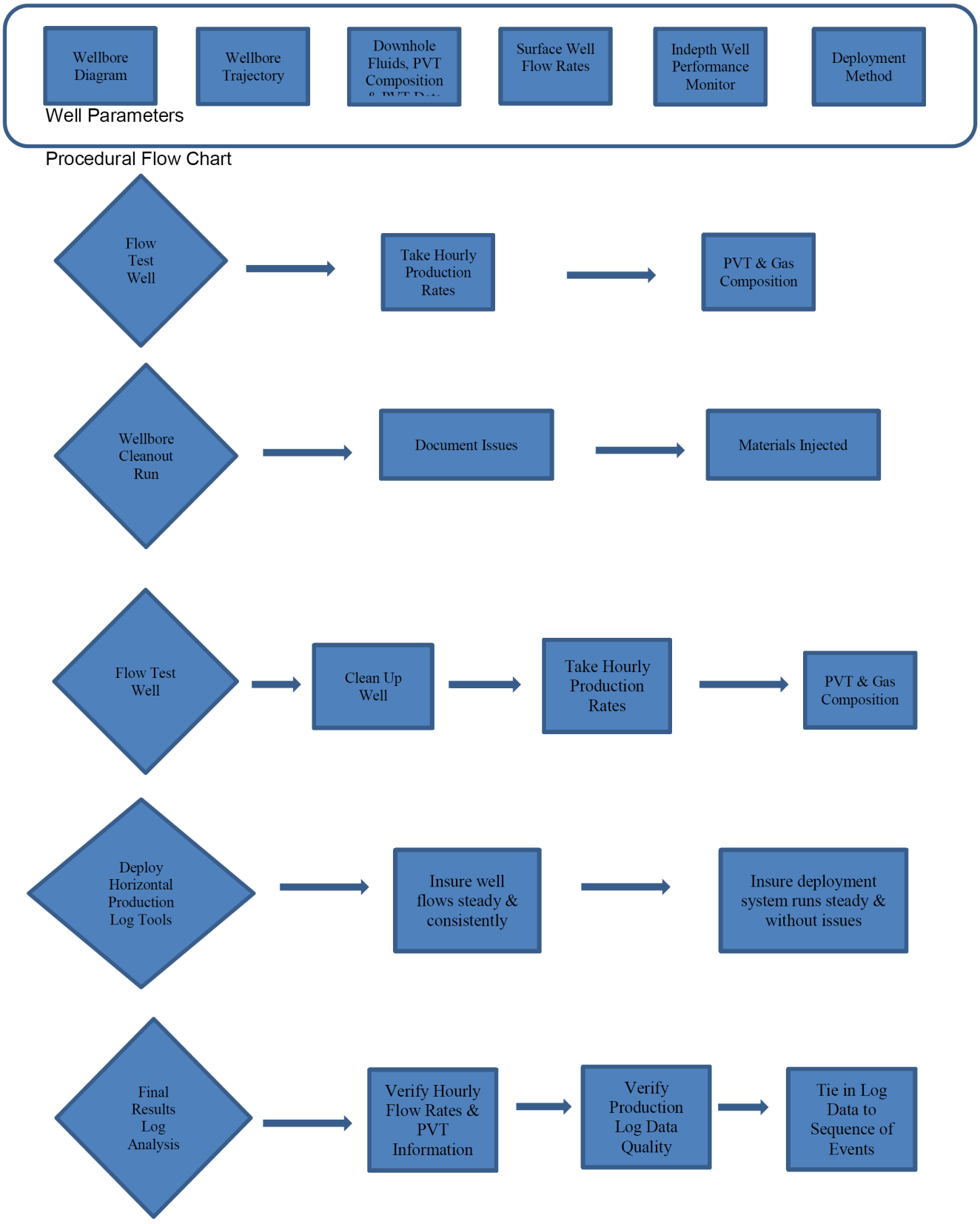

Figure 8—Horizontal Production Log Procedures Flow Chart

Case Study

This horizontal production log case study, illustrates a well with a trajectory toe up design. The well has approximately 5,000 ft of completed lateral. The well flows ~ 2,000 MMscfd, with 300 blpd.

Coiled tubing was used a few days prior to run a cleanout trip to ensure sand and debris has been cleaned out to surface. Also to verify the coil tubing can make the trip to TD and verify the impact of the coil on the production performance. Since the well makes 2 MMscfd gas and 200 bopd condensate, it can be determined that the downhole phase contribution is majority of gas and a small amount of water. Figure 3 illustrates on this well flow example how the toe up trajectory and little undulation shows the cross-sectional holdup profile to be 90-95% filled with gas. Even though, the well production on surface shows to be multiphase (3 phases), however across the lateral is in single phase.

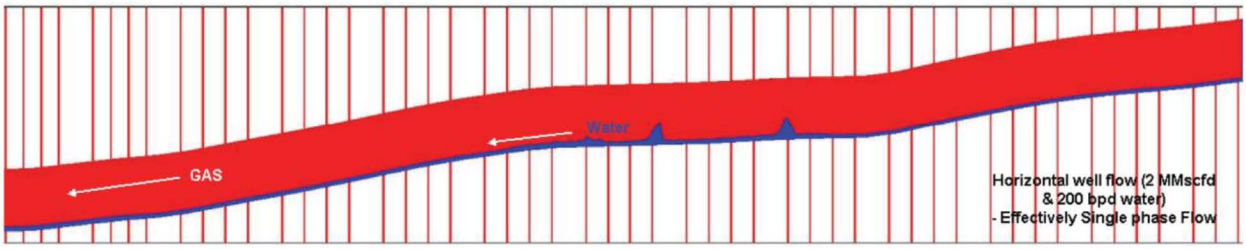

Figure 9—Horizontal wellbore with 2 phase Holdup cross-sectional image (2 mmscfd gas, 200-300 bbld).

The well was TD checked and cleaned out with coiled tubing. Then the well was setup on flow back and allowed to cleanup over a period of a few days, prior to deploying the production logging survey. After adequate time for the well to clean up the surface flowrates are monitored & recorded every 15 minutes.

The deployment system, coiled tubing was rigged up and the production log survey is deployed across the flowing lateral. Careful attention was taken to record the well test and the surface pressure with the Indepth Well Performance Monitor, in addition the document the sequence of events how the coiled tubing affected the well flow during the entire time the production log tools and coil were in the well.

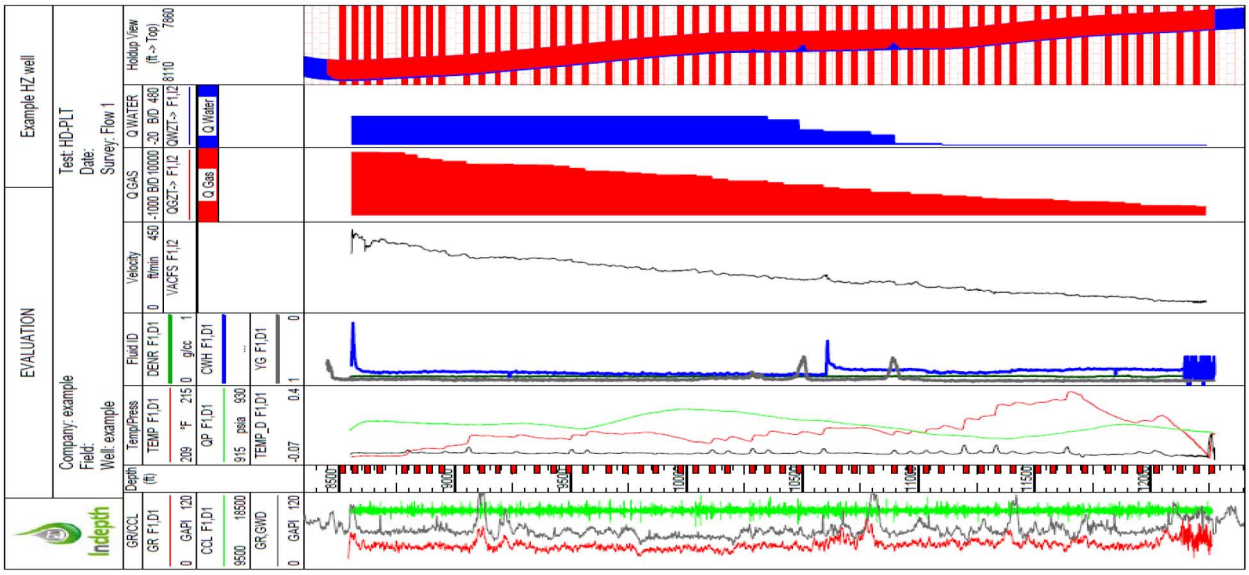

Figure 10—Example of Horizontal Production Log Analysis Results.

Conclusion

A horizontal production log survey takes careful planning by an expert in this particular field. Communication and pre-job planning following the above horizontal production logging procedures flow chart will aid all personnel to survey their wells and help deliver the best results. Many papers have been presented on horizontal production logging also include FO (DTS/DAS) logging, but the results seem to show many miss-steps, such as an operators failed attempts due to insufficient cleanout attempts (McClusky, 2012) and insufficient well-test and flowback monitoring. To create accurate high confident, representative production log result, these need to properly run.

Understanding how the well test is flowing back during the production log survey and the phases being produced is a main parameter. In most horizontal lateral phase segregations occurs, the lighter phases migrate to the high side and heavier phases flow on the bottom, understanding the significant of the degree of segregation is key in choosing the correct tool technology to measure this flow regime. Frisch, 2009). Pre-planning by observing the well information, wellbore diagrams, trajectory plots, and phase information will deliver quality results.

Recommendations

1. Always ensure a thorough and proper clean out are performed, at least 2 to 3 days prior to running the production log.
2. Multiple coil tubing or stick pipe sweeps are needed.
3. Adequately well test the flow back.
4. Take frequent fluids composition & PVT data tests.
5. Never shut in the well during the flowing part of the survey.
6. Care needs to be taken when using array probe type tools as they can easily be contaminated or wetted, water trapped in the holdup probes, rendering the array probes useless. (Zhett, 2011).

References

Heddleston, D., (2009), Horizontal Well Production Logging Deployment and Measurement Techniques for US Land Shale Hydrocarbon Plays, Paper 120591, presented at the Production and Operation Symposium, Oklahoma City, Oklahoma, 4-6 April

Schwanitz, B., (2015), Combines Distributed Temperature and Acoustic Sensing with Production Logging for Improved Horizontal Well Evaluations, Paper 173645, presented at the SPE/ICOTA Coiled Tubing Intervention Conference & Exhibition, Woodlands, Texas, 24-25 March.

McCluskey, A., (2012), Production Logging on Coil Tubing in a Marcellus Shale Horizontal Completion, Paper 154221, presented at the SPE/ICOTA Coiled Tubing Intervention Conference & Exhibition, Woodlands, Texas, 27-25 March.

Zhett, A. (2011), New Sensor Development Helps Optimize Production Logging Data Acquisition in Horizontal Wells, Paper 2011 YY, presented at SPWLA 52nd Annual Logging Symposium, Colorado Springs, 14-18 May.

Frisch, G. (2009), Improving the Process of Understanding Multiprobe Production Logging Tools From the Field to Final Answer, Paper 125028, presented 2009 SPE annual Technical Conference and Exhibition, New Orleans, Louisiana, 4-7 October.

BJ Services – Coiled tubing production logging manual, 2008.

Welltec Business Brochure, 2008.

About the Author

Duncan Heddleston (PE, MBA) owner of Indepth Production Solutions is a regarded as an industry leader in the product line of cased hole logging, production logging and production log analysis. With over 25 years experiences developing horizontal production log technology, analyzing many thousands of data sets the past two decade pioneering US Shale horizontal production logging techniques & production logging measurements & analysis for the EOR environment.