Production Control of Horizontal Wells in a Carbonate Reef Structure

Bill Ellsworth – *Husky Oil*
Marty Muir – *Husky Oil*
John Gray – *Allore Petroleum Management*
Dan Themig – *Halliburton/Guiberson AVA*

THIS PAPER IS TO BE PRESENTED AT THE SEVENTH ONE DAY CONFERENCE ON HORIZONTAL WELL TECHNOLOGY, CALGARY, ALBERTA, CANADA, NOVEMBER 3, 1999.

Abstract

Open hole completions have been the accepted practice for horizontal wells in the Rainbow Lake area of Northern Alberta. As these fields mature, and the oil bank in these structures thin, the use of effective production control technology has become particularly important. The design of the well trajectory, the ability to intervene to control production, and the incorporation of horizontals in a strategic producing plan for the area has pushed the edge of technology. Many aspects of the planned exploitation of these reef pools have changed based upon successful applications of evolving horizontal well technologies. Production control issues are paramount to these changes. This paper presents several well case histories that illustrate the application of advancements in establishing isolation in the open hole horizontal completions to accomplish various objectives in the successful application of horizontal wells in the Rainbow Lake field.

Figure 1 - The Rainb Field in Northern Alb Canada.

Introduction

The Rainbow Lake area of northern Alberta contains several pools with carbonate reef structures. The formation tends to be a prolific producer due to high matrix permeability and porosity. Vertical wells have generally served as the primary producers and injectors. However, as drilling capabilities have improved, the use of directional, horizontal, and multi-leg well geometry's have been utilized to both accelerate production, and improve ultimate recovery. While these wells have allowed improvements in the producing strategy of the field, it has also provided challenges, mainly concerning production methods and procedures. One of these challenges is providing long-term isolation in these mostly open hole horizontal completions.

Production Control of Horizontal Wells in a Carbonate Reef Structure

Bill Ellsworth – *Husky Oil*
Marty Muir – *Husky Oil*
John Gray – *Allore Petroleum Management*
Dan Themig – *Halliburton/Guiberson AVA*

THIS PAPER IS TO BE PRESENTED AT THE SEVENTH ONE DAY CONFERENCE ON HORIZONTAL WELL TECHNOLOGY, CALGARY, ALBERTA, CANADA, NOVEMBER 3, 1999.

Abstract

Open hole completions have been the accepted practice for horizontal wells in the Rainbow Lake area of Northern Alberta. As these fields mature, and the oil bank in these structures thin, the use of effective production control technology has become particularly important. The design of the well trajectory, the ability to intervene to control production, and the incorporation of horizontals in a strategic producing plan for the area has pushed the edge of technology. Many aspects of the planned exploitation of these reef pools have changed based upon successful applications of evolving horizontal well technologies. Production control issues are paramount to these changes. This paper presents several well case histories that illustrate the application of advancements in establishing isolation in the open hole horizontal completions to accomplish various objectives in the successful application of horizontal wells in the Rainbow Lake field.

Figure 1 - The Rainbow Lake Field in Northern Alberta, Canada.

Introduction

The Rainbow Lake area of northern Alberta contains several pools with carbonate reef structures. The formation tends to be a prolific producer due to high matrix permeability and porosity. Vertical wells have generally served as the primary producers and injectors. However, as drilling capabilities have improved, the use of directional, horizontal, and multi-leg well geometry's have been utilized to both accelerate production, and improve ultimate recovery. While these wells have allowed improvements in the producing strategy of the field, it has also provided challenges, mainly concerning production methods and procedures. One of these challenges is providing long-term isolation in these mostly open hole horizontal completions.

Field Background

Banff Oil and Gas discovered the first Keg River Pool of Rainbow Lake Field in the late 1960's. Through a series of ownership changes, this pool is now operated by Husky Oil. The field consists of several separate producing pools that are located in the Rainbow Lake area of Alberta. Some of the producing pools in the field contain vaulted reef structures (see figure 2), each with variations in horizontal and vertical permeability as well as substantial reserves of oil and gas. The field was initially produced through primary production, mainly using gas lift. Both gas re-injection and water injection have been used as recovery mechanisms and to provide pressure maintenance for the field. Part of the Rainbow Lake Field is now under tertiary recover utilizing a solvent flooding procedure (See figure 3). This process requires that rich solvent gas be injected into the upper portion of the reservoir followed by chase gas. The chase gas moves through the structure pushing solvent through the rock, and sweeps incremental oil from the reservoir. During the process, the solvent front is moved either up or down using both water and gas injection to move the oil/water and the gas/oil contacts vertically through the reservoir.

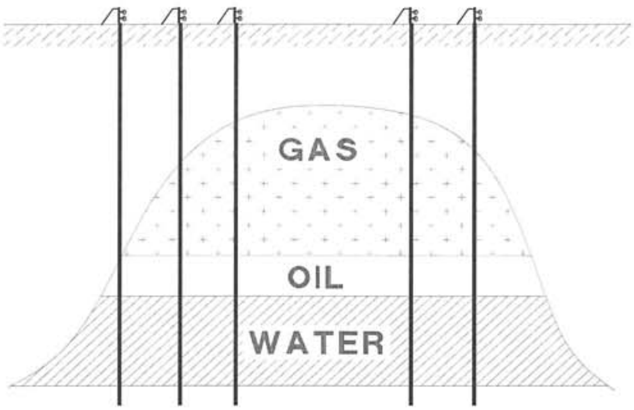

Figure 2 - Vertical injectors and producers have historically been used in the Rainbow Lake Field reef arch structures.

Rainbow Horizontal Program

Although many parts of the reservoir are prolific, with high expected recovery, there are portions of the field that contain significant reserves, but are held in lower quality reservoir rock. Also, some of these areas may not be effectively drained during the primary production or the solvent flooding process. The objectives of some of the horizontal wells drilled to date have been to access these portions of the reservoir. Some of these segments could not be reached economically using vertical wells due to surface and facilities costs. Producing unswept oil is a primary application of these horizontal wells. Innovative designs of well geometry and configuration are required to reach these segments of the reserves.

Improving the efficiency of the tertiary recovery is also a primary objective in the application of horizontal technology. This application is somewhat more difficult due to the vertical mobility and movement of the oil layer in the reservoir. Utilization of horizontal wells within the active solvent flood requires timing as well as precise well placement and segment isolation in the horizontal leg.

Challenges

The application of horizontals creates several challenges. The primary challenge is to produce oil without excessive gas or water breakthrough (coning). While most of the horizontal wells lie in the lower segment of the reservoir, the build section of the well must pass through the upper gas cap, sometimes in two or more formations. Isolation of the gas has historically been accomplished using liners and cement. New drill horizontal wells are generally cased through these gas layers. However, an added challenge in re-entry horizontal wells is to isolate these zones without the benefit of the primary casing string. When possible, a 114mm (4-1/2") liner is run and cemented through these gas intervals, and then the remainder of the horizontal is drilled with 98.4mm (3-7/8") slim hole MWD. This produces a smaller borehole, but is effective in isolating the gas while still allowing effective packer seats in the horizontal.

Achieving Isolation

With several hundred meters of open hole horizontal wellbore exposed, water or gas breakthrough can be a problem for some of these wells. Also, during drilling, the trajectory of a well may be low or high within the structure, causing a problem with premature coning of gas or water in the reservoir. The ability to establish long term isolation of segments within the

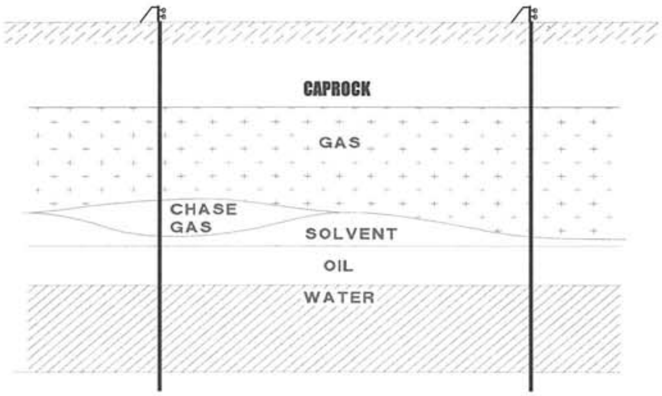

Figure 3 - Part of the field is under solvent flood, which is used to increase oil recovery.

reservoir is key to controlling and optimizing production from these horizontal wells.

Historically, inflatable packers were used for water shut-off, stimulation, and segment testing. More recently, solid body packers (SBP's) (see Figure 4) have been used to establish open hole isolation. These tools provide a mechanical packing element that is hydraulically activated. The objective of using this type of tool is to provide a long-term solution to open hole isolation without the aid of cemented liners. Although the expansion ratios for these packers are as large as for inflatables, the carbonate formation in Rainbow Lake generally drills very close to gauge hole, and effective isolation is possible with these SBP's. Effective isolation in open hole greatly increases the capability to incorporate horizontal wells into the producing strategy for the Rainbow Lake field.

Establishing effective isolation points (packer seats) is approached both from a reservoir and a mechanical standpoint. First, the reservoir objectives are established. Issues such as seismic, log data, and drilling fluid losses and production are considered. Based upon this data, general areas of low porosity are selected to set packers in. The secondary consideration is the mechanical sealing of the SBP's. If a caliper log is available, it is used to choose competent packer seats. The formations in Rainbow Lake often contain vugs and fractures. When possible, the packers are run in pairs to minimize the chance of failure due to setting in a vug. When caliper logs for the horizontal wells are not available, alternative data is used including drilling ROP's and log data.

Case Histories

Case history #1 - Rainbow 14-12-110-8W6

This well was drilled in 1993, and was cased to 90 degrees using 245mm (9-5/8") casing. The producing leg was drilled using 216mm (8-1/2") bit from casing shoe to TD. Initially, the well produced clean oil. At the time of this workover, the well had excessive (unwanted) gas production. The objective of the workover was to isolate a segment of the well, to attempt reduce gas production. The well was to be segmented into three sections, with the ability to produce any or all of these sections.

Well and Completion Design

Two isolation points were selected and the SBP's were configured in pairs in order to improve the effectiveness of the isolation points. The tailpipe assembly consisted of a 73mm pump-out plug and no-go style profile nipple. The packers were supported with centralizers to aid in run-in. Between the sets of packers was a 73mm (2-7/8") sliding sleeve. This allows for either producing or shutting off the center segment of the well. 73mm tubing was run throughout the lateral. The tubing was crossed over to 88.9mm (3-1/2") inside the casing. An expansion joint was run to allow for testing of the open hole packers. A sliding sleeve was run in the vertical potion of the well. This provided an inflow point for the heel portion of the well. It also allows non-rig intervention (slickline) to control two of the three well segments. A cased hole double grip packer and on-off tool was run in the 244mm (9-5/8") casing to anchor the assembly as well as to provide well control. (Figure 5)

Installation and Operations

The assembly was run into the well, and tubing pressure was applied to selectively set all of the open hole packers. Once they were set, tubing weight was applied to confirm the set. The cased hole packer was then set, and the on-off tool was used to circulate inhibited fluid into the annulus.

Figure 4 - The solid body packer is hydraulic set instead of inflatable (Guiberson / Halliburton Wizard II packer shown)

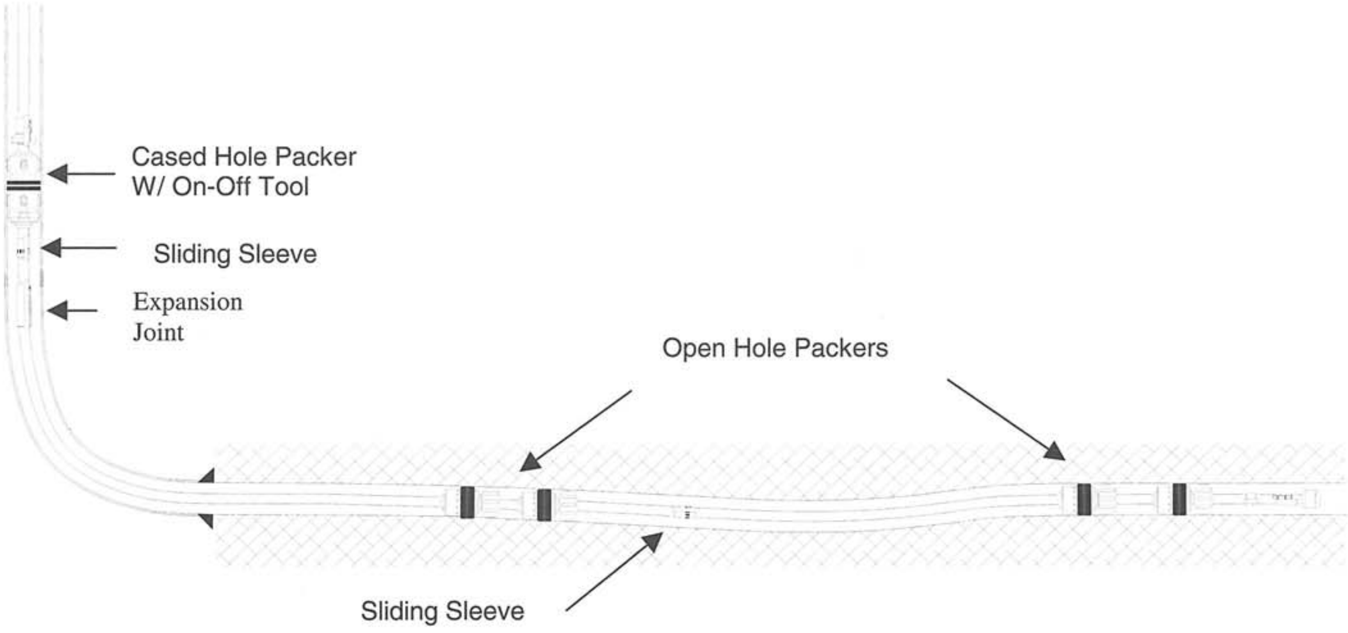

Figure 5 - The Solid Body Packers were used to segment the well, and provide isolation of the center portion of the well.

Results

This was the first installation of SBP's for Husky in Rainbow Lake. Although the radial clearance between packer OD and drilled hole was small, the packers were successfully run and set. Some operational problems were encountered in the use of a mule-shoe re-entry guide that hung up near the casing shoe. This item was changed on subsequent installations. Production testing afterwards indicted that successful isolation was achieved as fluid ratios changed with changes in inflow sleeve selection (figure 6).

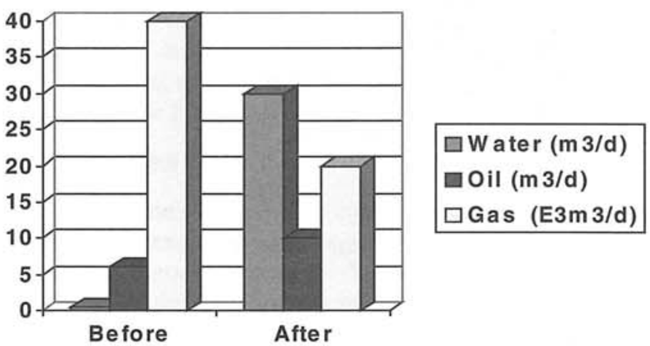

Figure 6 - Testing indicates change in production.

The well initially had a high (uneconomic) GOR. After the workover, the well was produced only from a single interval (section 3). The GOR was initially lowered and water production increased. Eventually, the high GOR returned. Later, a sleeve was shifted to add section 2 to production. The GOR remained unchanged, but the water production was reduced.

Case History #2 - Rainbow 13-32-109-8W6

Well #2 was designed to produce unswept oil from the reservoir structure. Based upon reservoir modeling, and seismic, it was determined that several "fingers" were present with recoverable reserves, that would not be swept with the existing recovery modes due to their location within the pool. This re-entry well included a 114.3mm (4-1/2") liner that was run and cemented through the build section to isolate unwanted productive intervals. The remainder of the well was drilled after the liner was set using a 98mm (3-7/8") bit.

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | sales@docketalarm.com | 1-866-77-FASTCASE