

## **Title: HORIZONTAL DRILLING IN THE PERMIAN BASIN: PAST, PRESENT, AND FUTURE**

**Authors: Ron Harrington, Baker Hughes INTEQ and Tony Cook, P.E., Baker Hughes INTEQ**

### **INTRODUCTION**

From its early beginnings in the 1920's, directional drilling has evolved to the point where it can truly be regarded as a science, although not always as an exact science. The offshore drilling industry is founded on directional drilling. Without the use of directional and horizontal drilling techniques, it would not be economical to produce hydrocarbons from most offshore fields. Improvements in directional and horizontal drilling tools and techniques along with advances in production techniques have led to a steady increase in utilizing this technology not only offshore but also on land. As more wells are drilled and further understood this trend will continue.

The Permian Basin is one of the more mature basins in the world. There are several producing horizons from the very shallow to the ultra deep. Horizontal Drilling has played a role or been tried in most of these horizons, some successful and some unsuccessful. There has been an increase in the amount of horizontal wells drilled in the Permian Basin over the past seven years. The growth has been seen recently from the major oil companies down to the small independents. Some of the larger companies drilling programs have included horizontal drilling in more than half of their drilling budget. These wells have been new drills and re-entries.

### **MAIN FORMATIONS OF INTEREST TO DATE**

#### **SAN ANDRES**

The San Andres has had more laterals drilled in it than any other formation in the Permian Basin. This was one of the first formations this technology was tried in and has continued to be a popular play throughout the Basin. The San Andres has been a great re-entry candidate due to the amount of well bores available. The wells are cost effective to drill because of their shallow depth. Most of the laterals are 4 3/4" hole size and vary from 500' - 2000' in length.

#### **DELAWARE**

There have been several wells drilled in the Delaware Formation. This formation was very active in the late 90's but is not currently being pursued heavily. Most of the laterals are 4 3/4" hole size and vary from 1000' - 2000' in length. They have been both new drill and re-entry wells.

#### **DEVONIAN/MONTOYA**

This has been the main horizontal play in the Permian Basin over the past 3 to 4 years. This play has continued to increase over the past 2 years. The lateral well bores typically range from 4 3/4" to 6 1/2" hole size. Lateral lengths have been anywhere from 1000' to over 8000'. The most common lateral lengths have been in 3000' to 5000' range. There have been several dual and multilateral wells drilled in this formation throughout the Basin.

## **STRAWN**

The Strawn formation is relatively new to horizontal drilling. It has shown good signs of success in several areas. These well bores have mainly been 4 3/4". Lateral lengths have been from 1000' to 3500'

## **ELLENBURGER**

Several horizontal wells in the Ellenburger have been drilled successfully but the jury is still out on the economical success of this formation.

Other formations with some horizontal activity: **Cisco, Canyon, Clearfork, Fusselman, Grayburg, Mississippian, Seven Rivers, Spraberry, & Wolfcamp**

## **WHAT ARE THE TECHNICAL LIMITS?**

The directionally drilled wells have two types: Type I profile "Build and Hold" or Type II profile "Build, Hold and Drop". The technical limits for these wells varies greatly with depth, formation type, and casing program. These hole sizes vary from 12-1/4" to 3-3/4", with build up rate and drop rates ranging from 2-5 degrees/100'.

Horizontal drilling is defined generally by the radius of curvature. Figure 1 attached has the accepted guidelines. The majority of the Permian Basin drilling is medium and intermediate radius wells. The medium radius wells are typically 8-12 deg/100' (Radius 450'-710') and intermediate are typically 40-65 deg/100' (Radius 90 - 150'). The lateral lengths are 1,000' to 5,000' depending on legal hardlines and formation integrity.

## **NEW TECHNOLOGIES**

### **GYRO MWD**

When magnetic interference dictates the use of a gyroscopic instruments for directional orientation of the BHA a gyro module can be ran in conjunction with the conventional MWD to eliminate the use of a wireline truck and additional gyro expenses.

### **ELECTRO MAGNETIC - MWD**

When the formation requires under balanced drilling this tool can be run to transfer directional surveys to the surface without a fluid column. With the increase of under balanced horizontal drilling in mature areas this tool is becoming more common.

### **ROTARY STEERABLE BOTTOM HOLE ASSEMBLIES**

This technology can be used to control deviation in deep straight well bores and directionally drill pre-programmed well paths for extended reach applications.

## **LOGGING WHILE DRILLING TOOLS**

A full line of logging while drilling formation evaluation logs are available in hole sizes down to 6". These logs will include multiple propagation resistivity, density porosity, neutron porosity, and gamma