SPE 109140

Cost-Effective Lateral-Junction Isolation in High-Pressure Air-Injector Wells

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This paper was prepared for presentation at the 2007 SPE Annual Technical Conference and Exhibition held in Anaheim, California, U.S.A., 11–14 November 2007.

Abstract

High-pressure air injection (HPAI) has proved to be a valuable improved oil recovery (IOR) process in fields where other recovery processes are uneconomical.

As in every upturn in the oil and gas industry, hydrocarbons in unconventional, tight, mature, and other challenging formations attract added interest when the economics appear to be positive. With more efficient technology to extract greater percentages of the reservoir, operating companies are re-entering old fields and successfully increasing production.

When exploiting existing wells, costs can be reduced by entering accessible main wellbores and sidetracking to new areas of the reservoir. In those fields where the production has naturally declined over the years, some type of injection program may be required. In certain situations, available injection resources and infrastructure will lead to a high-pressure air injection (HPAI) model. HPAI is an extremely corrosive and hostile environment, so ensuring proper well construction and isolation of the lateral junction is imperative. At the same time, the economics of these wells require a simple, cost-effective solution that is readily available for a high-volume field program.

This paper reviews solutions for these lateral-isolation instances and presents a simple, efficient and cost-effective system.

Introduction

HPAI is an IOR process in which compressed air is injected into a high-gravity, high- pressure oil reservoir, with the expectation that the oxygen in the injected air will react with a fraction of the reservoir oil at an elevated temperature to produce carbon dioxide. The resulting flue-gas mixture, which is primarily CO2 and nitrogen, provides the mobilizing force to the oil downstream of the reaction region, sweeping it to production wells. The gas-oil mixture may be immiscible, or partly or completely miscible. In some situations, the elevated temperature reaction zone itself may provide a critical part of the sweep mechanism (Moore 2002).

In its simplest implementation, the process is initiated simply by injecting air, which will spontaneously ignite the in-place oil because of the high temperature- and high-pressure conditions in the reservoir. In situations where spontaneous ignition of the native reservoir oil is not likely to occur (laboratory testing will provide an indication), ignition must be aided with the injection of a chemical mixture capable of spontaneous ignition at reservoir conditions, or by an input of energy, usually provided by a downhole heater or a burner (Moore 2002). Two temperature ranges are denoted as high-temperature oxidation (HTO) and low-temperature oxidation (LTO). HTO is above 350°C, and can be higher than 400° on occasion; LTO is below 350°C (Adagulu 2006). An additional benefit of air-injection projects is the generation of flue gases for pressure maintenance that also can be re-injected into the same reservoirs or others nearby (Greaves 2005).

For its operations in the northern Rocky Mountain area, Encore sought a completion system that would control injected air and withstand the equipment-damaging effects of the operating environment.

Encore's strategy was to drill sidetracks into existing vertical wells and extend a lateral section a great distance into the reservoir. Their oil-recovery process was enhanced through use of an air-injection process; this method required creation of a good junction between the main wellbore and the lateral. Air injection was known to be very corrosive, so corrosion-resistant alloy (CRA) materials and special cement were required for the junction section.

Encore had been completing these wells for several years; however, the success rate was poor. There were issues with the equipment functionality as well as getting the proper isolation at the junction. The original Halliburton solution followed traditional thinking and used an inflatable packer and port-collar system in the lateral with a permanent packer serving as the anchor in the main wellbore.

Two systems were run in this fashion and successfully completed; however, a concentric string was required to set the inflatable packer and make the port collar function. To eliminate the rotation of the concentric string, it was decided to change the inflatable packer to an openhole production packer and change the port collar to a standard production/circulation sleeve.

This setup alleviated the rotation; however, after further analysis it was decided that a system needed to be designed that eliminated the concentric string and gave an overall simpler completion. This was accomplished by the