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Perforator Performance Study Determines Optimum System and Achieves Field Performance Projections

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Abstract

The selection of the appropriate perforating gun system provides an essential element of maximizing the potential recovery of an oil or gas field. Perforating guns are often selected with minimal knowledge of the likely downhole charge performance, which commonly includes API 19B Section I test data that evaluates only cement penetration among competing systems. Unfortunately, cement penetration does not always correlate to the penetration in a downhole environment or inflow potential.

A study was recently conducted to evaluate the charge performance in downhole conditions for a gas reservoir in a perforation flow lab (PFL) based on API 19B Section IV[1] methods to identify the best performing charge design for a 3-3/8-in. 6 spf gun system. The study evaluated the effects of cement sheath thickness and casing wall material (hard stainless steel vs. carbon steel). The magnitude of pressure in the simulated wellbore was varied to compare slight underbalance with high underbalance to determine the effect of offline perforating limitations. In addition, the separate testing variable of target core diameter was investigated and resulted in a dramatic effect on the perforator performance.

These testing results identified the optimum gun system for use in the Talisman Bunga Orkid gas field. The productivity estimates derived during the charge evaluation were used to validate inflow models, which to date closely match actual production.

An advanced evaluation of perforating systems can provide valuable insight into what is not always intuitive from available published cement penetration data and can be used to further advance production models. The parameters used in the models should be well understood to confidently predict the perforation hole size, penetration, and flow performance.

Introduction

The quest to identify an optimum perforating solution for a given field condition can always be influenced by operational efficiency, as seen in the Talisman Bunga Orkid gas field, whereby the need to maintain continuous drilling operation was imperative to improve rig use. In this case, offline perforating, a unique method of perforating during continuous drilling operations on adjacent wells, was developed. This method used limited vertical height below the rig floor to perforate, while drilling operations continued in another well slot, providing a simultaneous operation (**Fig. A1**). Unfortunately, establishing a significant static underbalance in the monobore completions was cost and time prohibitive. The required flow area, gun volume, and short gun lengths, because of the limited rig-up height, minimized the dynamic underbalance cleanup. Therefore, a new approach was needed to optimize the perforating design for this field. The approach taken was to evaluate various available perforating gun systems and to identify the best performing system at field conditions.

Evaluating shaped charge performance is conventionally conducted by correcting API 19B Section I penetration data to downhole conditions. Numerous calculations are used for this correction, some of which account for only target compressive strength, and others use complex neural network calculations. However, the majority of these penetration simulators use API 19B Section I target penetration in cement, which is a poor analog to a reservoir target.

The approach taken for the Bunga Orkid gas field was to use an API 19B Section IV test method to evaluate candidate perorating systems available in the appropriate size, and to take an in-depth look at how the perforator would truly perform under reservoir conditions.

The API RP 19B Section IV test can be used to determine the productivity index for a single perforation under the downhole conditions during the offline perforating process, accounting for actual gun and well hardware, stress conditions, and formation or close-to-formation matching rock.