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Next-Generation Perforating System Enhances the Testing and Treatment of Fracture Stimulated Wells in Canada

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Abstract

Ineffective perforation can adversely affect the completion of fracture stimulated wells in several ways. If the interval is to be tested prior to fracturing, a clean connection to the formation is required to facilitate meaningful data acquisition. Excessive perforation damage can mask true formation potential and lead to incorrect diagnosis and decision making. Inadequate perforations can result in significant fracture tortuosity, increasing formation breakdown pressure – occasionally beyond the capacity of surface equipment or design rating of the well. Finally, limited entry perforation – a common technique for diverting a treatment across multiple fracture initiation points – demands that as many perforations as possible are open and can accept treatment fluids. Low perforating efficiency and variations in perforation cleanup associated with heterogeneous formations can cause uneven treatment distribution and suboptimal completion.

Traditional methods for achieving clean perforations depend on creating a pressure gradient between formation and wellbore to induce flow and remove debris from the perforation tunnels - this can be difficult to accomplish, especially in low-pressure reservoirs. Underbalance cleanup favors intervals with higher flow potential – typically those with greater permeability - and may result in low perforation efficiency in poor or variable quality zones. Operators of wells requiring fracture stimulation are therefore faced with a significant challenge to find reliable, cost-effective perforating methods.

A new class of reactive shaped charges has recently been introduced that generates a powerful secondary effect within each perforation tunnel immediately after it is formed. The reaction supercharges each tunnel, causing a surge of flow into the wellbore that removes all compacted debris and the near-tunnel crushed zone that would otherwise impair flow performance. Since this effect is independent of rock properties and wellbore conditions, a very high percentage of clean tunnels can be obtained across the entire interval without necessarily perforating in an underbalanced condition.

This paper describes the new charge technology in greater detail and reports on its successful deployment in more than a dozen wells for different operators in Canada. Specific examples are used to illustrate how the system facilitates pre-frac evaluation, fracture initiation and limited entry fracture stimulation.

Introduction

Shaped charge perforators are the dominant method used to create a flow path between formations of interest and the wellbore in a cased and perforated completion. The vast majority of perforated completions depend on the use of shaped charges because of the relative speed and simplicity of their deployment compared to alternatives, such as mechanical penetrators or hydro-abrasive jetting tools. However, despite these advantages shaped charges provide an imperfect solution.

Shaped charges are formed by compressing high explosive powder within a metal case using a conical or parabolic metal liner, as depicted in **Figure 1**. When the explosive is detonated, the symmetry of the charge causes the metal liner to collapse along its axis into a narrow, focused jet of fast moving metal particles (**Figures 2A-2C**). When the charge is positioned perpendicular to the wellbore casing, the jet penetrates the casing, and the surrounding cement sheath and formation rock (**Figures 2D-2E**). This is a displacement mechanism where the steel, cement and rock are pushed aside by the jet^[1], a process that continues until the speed of the jet falls below some critical velocity and cannot penetrate further^[2]. The effectiveness of this perforation tunnel is determined by both its geometry and quality.