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Responsive Cementing Material Prevents Annular Leaks in Gas Wells

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Abstract

In a traditionally cemented well, the integrity of the cement sheath surrounding the casing, and the bond between the cement and the formation or casing are essential components of hydraulic isolation. A well-cemented casing is designed to maintain hydraulic isolation throughout the productive life of the well and after abandonment. With advances in cementing technology, slurries have been designed that result in cement sheaths that can resist planned wellbore stresses without failure. Once the cement has set, however, the fixed set-cement properties do not address stresses that have not been planned for, and that may ultimately result in cement sheath failure.

This study considers the case of well construction as part of a new gas field exploration in Algeria. Wells drilled in this area have been prone to developing annular gas leaks in the weeks and months following cementing operations. To prevent the loss of isolation and reestablish hydraulic integrity in the event of cement failure, a new cement-based sealant was incorporated into the well construction plan. This reactive material responds to hydrocarbon leaks that occur because of fissures in the cement, debonding of cement from the formation or the development of a microannulus between the cement and the casing. These leaks trigger a self-healing response, sealing the leak path, and restoring well integrity. Using this sealant material has reduced the incidence and likelihood of leaking wells in an area where such problems are common, and eliminated the potential time and cost associated with leak remediation.

Introduction

As is the case in many oil producing countries, oil and gas development in Algeria has accelerated greatly in the last few years. With proven gas reserves of $4.55 \times 10^9 \text{ m}^3$ (160 Tcf), representing approximately 3% of the world's total, and easy access to European markets, Algeria has endeavored to increase gas production to meet the demands. Statistical data from Sonatrach, the national oil company of Algeria, shows that from the period 1996–2006, yearly natural gas production increased by 19% to $1.5 \times 10^8 \text{ m}^3$ (5.3 Tcf), with yearly oil production increasing by 69% over the same period to $6.37 \times 10^7 \text{ Mg}$ (approximately 460 million bbl). As such, Algeria is becoming an important energy provider for Europe, supplying $6.1 \times 10^{10} \text{ m}^3$ (2.1 Tcf) of gas in 2006. According to the BP Statistical Review of World Energy (2008), this represents just over 12% of the European Union's total consumption, and could be considered a valuable source as Europe seeks to diversify its gas supply.

The drive to increase production and exports has led to a predictable increase in drilling activity. The gas fields located in the In Salah area of the Tamanrasset Province, shown in **Fig. 1**, are considered important to the continued increase in the country's export capacity. Conditions in this area can be very harsh—an isolated desert environment where summer temperatures average above 45°C (113°F), and winter temperatures dip to near freezing—but Sonatrach has undertaken an aggressive exploration and development campaign in the area.

The remoteness of the field, as well as the need to maintain production, makes it complex and costly to perform workover operations to repair wells in the event that there is a loss in hydraulic isolation. Annular leaks and sustained casing pressure (SCP) can result in just such a workover, and it is the ultimate goal of most, if not all, primary cementing operations to prevent such fluid migration from occurring behind a cemented casing. Current cementing technologies, which for the most part focus on placement techniques and the properties of the liquid slurry, are limited in their ability to prevent liquid or gas migration that may occur due to cement damage or debonding that may occur long after the cement has been placed and has set.

This paper will describe the use of a new cementing material with intrinsic, self-healing properties first proposed by Cavanagh et al. (2007) as a means of assuring well integrity in the event of hydrocarbon leaks due to damaged or de-bonded cement. This self-healing cement (SHC) has the ability to respond to hydrocarbon leaks, either liquid or gaseous, occurring after the cement has set. Examples will be presented where SHC was used to prevent annular gas leaks in wells that had previously been difficult to isolate using current cements and placement techniques.