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Overcoming the Weak Link in Cemented Hydraulic Isolation

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Abstract

Preventing unwanted migration of hydrocarbons has been an enduring challenge to the oil and gas industry. Regulations are in place to minimize the risk of leaking wells. However, future regulations are expected to become increasingly restrictive requiring operators to minimize the risks of potentially unwanted hydrocarbon migration during the well planning stage.

Hydrocarbon flows may originate from pay zones, or from non-commercial hydrocarbon-bearing formations. Some of the most hazardous gas flows have originated from unrecognized gas behind conductor, surface or intermediate casing. Often determining the precise source of annular flow is difficult.

There are numerous short-term solutions aimed at preventing the flow of hydrocarbons including optimizing stand-off, fluid placement, slurry design and mechanical methods. These techniques relate to working with the cement slurry in its liquid state prior to curing, and are aimed at preventing undesirable movement of hydrocarbons within the cemented annulus before the cement has set. However their effectiveness is lost once the cement has set, making it vulnerable to hydrocarbon migration should cement sheath damage occur.

The paper describes a unique isolation solution based on a responsive cement system with intrinsic self-healing properties automatically activated upon hydrocarbon exposure. Activation occurs whenever the integrity of the cement sheath is compromised, e.g. cracks and microannulus, and then efficiently seals the leak path by a swelling mechanism. The solution rapidly forms a complete hydraulic barrier by healing damage, and continues to re-seal should further damage occur. The technical advantages of this solution are shown, illustrated through successful field tests.

Introduction

The number of oil and gas wells worldwide that have zonal isolation issues, in the form of sustained casing pressure, or similar unwanted hydrocarbon migration issues, is a figure that can be measured in the thousands. Typically gas wells versus oil wells are more challenging to establish an effective hydraulic seal, and as the demand for natural gas increases the number of wells with these problems is likely to rise also.

Long term zonal isolation provided by cement is a must in underground gas storage (UGS) wells to guarantee safe operations during injection/production cycles. Herein is described how an integrated approach using an advanced sealant and advanced wireline cement evaluation methods is able to achieve optimum results.

It highlights a new concept for zonal isolation based on a novel sealant material with self-healing properties applicable for land and offshore use. This concept does not preclude good cementing practices, but has been designed to enhance the life and production capabilities of the well by potentially reducing the risk of any perceived long term hydrocarbon migratory issues such as sustained annulus pressure. The objective of the system named self-healing cement (SHC), is to provide a long-term hydraulic seal that has self-repairing and swelling properties. For example, this sealant enables automatic repair when a microannulus, internal sealant crack or other flow path is created, and thus prevents flow of formation fluids through potential leak paths along the annulus. The concept focuses on long-term durability of the hydraulic seal in oil and gas wells, and targets autonomous hydraulic seal repair without the need for well intervention.

SHC is a responsive sealant meaning that the characteristic swelling mechanism is initiated when any hydrocarbon fluid, originating from the formation, comes into contact with the sealant. The SHC system is currently under development and has been tested in different well configurations. This paper focuses on the application for underground gas storage wells in Italy.