Improved Wellbore Integrity via Sealing Small Cracks with CO$_2$-Soluble Polymers that Block Water, Oil, and Gas

In this study, the team exploited the adsorption of PFA onto the cement surfaces associated with cracks in wellbore cement. By injecting a PFA-CO$_2$ solution into a cement crack, a dramatic reduction in the apparent permeability of the crack resulted, thereby enhancing wellbore integrity. There are several other means of improving wellbore integrity. For example, cement squeezes are slurries that are well-suited for closing large voids and large cracks, while solids-free resin squeezes and aqueous Seal-Tite emulsions are generally regarded as better fluids for closing off smaller cracks. While being injected, cement and polymer squeezes and Seal-Tite typically exhibit viscosity values of 100’s – 1,000s of cP. In contrast, PFA-CO$_2$ solutions are unique in that they have an incredibly low viscosity (less than 1 cP) and can flow more easily and deeply into extremely small cement cracks than any of the other alternatives.

PFA deposition downstream of the cracked cement proved so problematic that continuous testing at NETL was abandoned for the multiple-step technique.
**Accomplishments:**

The team first demonstrated that PFA is indeed the best polymer for the proposed crack sealing application. They then generated an extensive set of phase behavior data and viscosity data for PFA-CO$_2$ solutions. Finally, they completed a series of crack sealing experiments in close conjunction with colleagues at NETL.

**NETL Collaboration:**

Small cylinders made of aged Portland cement were sawn in half to generate model cement cracks. The apparent permeability of the cracked cement was then measured at NETL before and after treatment with PFA-CO$_2$ solutions. The apparent permeability of the model crack always decreased, with the best results (ranging from an order-of-magnitude decrease in the apparent permeability of the crack to complete blocking of fluid flow) being achieved for the cracks with low apparent permeability (less than 1 mD) using concentrations of PFA above 2 wt%.

**Relevant Publication:**


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**Benefits:**

PFA-CO$_2$ solutions should not be viewed as a replacement for cement, solids-free resin or Seal-Tite emulsions, but the PFA-CO$_2$ solutions do provide operators with an additional tool for improving wellbore integrity.

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**Schematic of proposed low concentration PFA adsorption experiment**

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