Sealants for H2 Wells: A Summary of the Options

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Intro

With increasing emphasis placed on H2 wells (storage or production), long-term well sealant effectiveness is being scrutinized. Potential sealant issues affecting barrier durability include:

H2 diffusion through a sealant:

Low density, viscosity, and size of the H2 molecule translate to high diffusion rate through a porous sealant. Well sealant for H2 wells must be ultra-low permeability.

Significant stress cycling during well operation:

Additionally, H2 will flow through microchannels between sealant and casing or formation more readily than other gasses. Cyclic pressure changes during operation of a H2 storage well will induce significant stresses on the sealant resulting in barrier breach at an interface or internally in the sealant. Well sealant for H2 wells must resilient and durable.

Potential for chemical degradation of sealant:

H2 has very low solubility in water and is considered inert under most conditions. However, cement degradation has been observed following longer-term exposure testing. Precipitation reactions have been noted in cement porosity saturated with H2. Additionally, H2 can react with formation chemicals to produce H2S which is corrosive and degrades Portland cement. Insufficient study has been conducted to establish long-term effects of stability of hydrated Portland cement exposed to H2 in downhole environments. However, considering expectations that sealants for H2 storage or production wells should function effectively for decades, chemical degradation of sealant by H2 in downhole environment requires more study.

H2 wells may be new drills or existing petroleum wells recompleted for H2 storage. H2 well sealant options for either of these scenarios include ordinary Portland cement, Portland cement modified to reduce permeability, and organic polymer sealants such as RiLOCK Resin Sealant.
Several recent studies of Portland cement durability have yielded varying conclusions regarding Portland cement durability in H2 ranging from acceptable to questionable.

The National Energy Testing Laboratory (NETL) (2022) described their participation in SHASTA (Subsurface Hydrogen Assessment, Storage and Technology Acceleration), a multi-national laboratory effort initiated by DOE in 2021. NETL described application of oilfield cementing expertise to address well barrier durability. Their assessment of sealant durability pointed more to diffusivity rather than to H2 reaction with Portland cement. With the highest diffusivity rate of all gasses, H2 storage well success rests on prevention of gas leakage induced by inadequate sealant placement or permeability or mechanical degradation of barriers.

Current industry approach to sealants for H2 wells falls into 3 categories. Many in the industry refer to short-term studies such as Aftab et al (2023) which conclude that H2 does not chemically affect Portland cement as evidence that no special consideration is needed for H2 well sealants. Another group refers to studies such as Al-Yaseri et al (2023) which report no short-term detriment to Portland cement from H2 but caution that potential for gas leakage through permeability or long-term chemical or mechanical degradation exists and should not be ignored. This faction usually recommends Portland cement modified with latex or other permeability-reducing additives. The third industry subset, spearheaded by DOE, acknowledges potential for barrier integrity issues in H2 wells and supports long-term investigation to provide definite answers.

Considering the importance of creating durable barriers for H2 wells and the uncertainty of Portland cement's long-term function in H2 environment, the least risk of barrier failure is derived from impermeable, inert, resilient sealant such as RiLOCK epoxy sealant. Initial application cost may be higher, but risks of chemical degradation, mechanical degradation, or leakage through permeability are significantly reduced.

Sabins and Watters have a long history with effects of H2 in Portland cement dating from the late 1970's (GasCheck Cement). For most of that time, they dismissed the idea of barrier detriment from H2. Recently, however, that belief is changing. Too little information exists to ignore the possibility of long-term seal degradation in H2 wells. Until more is known, they recommend applying the most durable sealant for these wells.

References

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