Assessment of the operating window of 13Cr-1Mo 110 ksi well tubulars in a mild sour gas environment

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Stainless steel alloys with 13 % Chromium are used in the oil and gas industry as well tubular material. Typical alloys are 13Cr, 13Cr4Ni1Mo and 13Cr5Ni2Mo, in strength ranging from 80 to 125 ksi (550 to 860 Mpa). This work concerns identification of the operating window of a 13Cr4Ni1Mo alloy, 110 ksi SMYS (758 Mpa). There is unclarity on the suitability and safe operating envelope of this alloy in mildly sour gas environments. The H₂S limits of 13Cr4Ni1Mo are assessed in order to evaluate future use, and to assess suitable operating limits for current applications with increasing H₂S due to well souring. Possible degradation mechanisms are Sulfide Stress Cracking (SSC) at low temperature, at high temperature (a combination of) Stress Corrosion Cracking (SCC), pitting and uniform corrosion.

Lab testing was performed with an artificial field brine, simulating gas well CO₂ and H₂S conditions at high chlorides and low in-situ pH. C-ring tests were used at 100% actual yield stress to take possible stress raisers in the tubing strings into account. A crevice former was applied on the APEX of the C-ring specimens. Replenishment of H₂S was found necessary for simulating realistic field conditions, especially when testing at low ppH₂S.

The work showed that the susceptibility of SSC is limiting the application window of the material more than SCC and pitting. SCC was found at as low as 2.5 mbar ppH₂S with 20 bar CO₂, 29 g/L chlorides at 25°C. Testing at ≤ 10 mbar ppH₂S results in a clear drop of ppH₂S in the autoclave. This is most probably due to the consumption of H₂S in the corrosion process and absorption of the H₂S on the autoclave wall during testing. Frequent H₂S replenishment was found to be necessary.