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## Effects of H<sub>2</sub>S and CO<sub>2</sub> on Cement/Casing Interface Corrosion Integrity for Cold Climate Oil and Gas Well Applications

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A study has been carried out to investigate sweet and sour corrosion at the cement-casing interface for offshore oil and gas wells in cold climate. The test solution chemistry was determined by sampling pore water from cement exposed in an autoclave system to brine and CO<sub>2</sub> at 100 °C and 10 MPa. The extracted pore water was used to define the composition of a cement simulated pore solution (CSPS), which was then used for the ensuing corrosion tests. Samples made of high strength casing steel, grade Q125, were exposed to the CSPS at 4 °C and 10 MPa in CO<sub>2</sub>-only and two mixed CO<sub>2</sub>-H<sub>2</sub>S environments. The corrosion rate measured in-situ with linear polarization resistance and electrochemical impedance spectroscopy was generally found to range between 10 and 20 μm y<sup>-1</sup> after 60 hours of exposure, with the average corrosion rate decreasing slightly with increasing H<sub>2</sub>S content. The corrosion potential, measured versus a custom high pressure Ag/AgCl electrode, was also found to shift slightly in the negative direction as the H<sub>2</sub>S content increased. The corrosion products were determined using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS). The corrosion products had the chemical compositions close to iron carbonate and iron oxide. Sulfur was detected in the inner film region when H<sub>2</sub>S was present. These results were compared to the corrosion rates and Pourbaix diagrams modeled using commercial software. The reaction mechanisms are discussed in the paper based on the potentiodynamic polarization measurements and electrochemical impedance spectroscopy taking into account the modeled solution speciation of the CSPS and corrosion product film.