Electrochemical Investigation of Boiler Steel Corrosion Under Chloride and Sulphate Contamination

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Boiler water contaminant concentration limits are defined by operating guidance and specification limits as developed by multiple organizations, including IAPWS. These have been based on plant operating experience due to a lack of experimental data at representative conditions. While providing a reasonable degree of protection, the success of these specifications can be variable where some plants have experienced accelerated corrosion damage while maintaining recommended limits, while others have operated outside the specifications without any observable ill effects. A better understanding of threshold corrosion limits is expected to help identify these differences and formulate better directions for plant chemistry operations

A high-temperature electrochemical cell, suitable for in-situ corrosion rate measurements up to 350 °C, has been designed and commissioned using a custom-built Zircalloy-4 electrode housing that was pre-oxidized to form a thin ZrO_2 layer for electrical isolation. Using this design, threshold corrosion limits for combined Cl^- and SO_4^{2-} contamination have been experimentally determined under All-Volatile Treatment (AVT) and Phosphate Treatment (PT) chemistry regimes, with a series of experiments completed at both 310 °C (10 MPa) and 350 °C (17 MPa).

A simple concentration-factor model has been used to estimate the boiler drum concentrations required to achieve the experimentally determined corrosion threshold values within boiler tubes subjected to a typical heat flux profile. Using this approach with the experimental corrosion thresholds, the AVT results show good agreement with current guidelines outlined within the IAPWS volatile treatment technical guidance document (TGD). The PT results demonstrate a potential need for contaminant specification limits that are dependent upon the actual phosphate concentration in the boiler.