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Formation and Prevention of Iron-Silicate Scales in Steam Generators, Cymric Field, California

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Abstract

Water geochemistry and scaling studies were conducted to reduce the formation of silica-based scales within steam generators in the San Joaquin Valley. A combination of laboratory tests and field data have improved understanding of chemical and operational parameters controlling scale formation and helped determine cost-effective solutions for reducing heat management costs in Chevron's Cymric Field steamflood operation.

Silicate scaling problems have been observed within and downstream of steam generators in the Cymric Field, San Joaquin Valley, California, as well as in producer wellhead chokes. The onset of such scaling problems correlated with the initiation of steam-assisted recovery from opal-rich siliceous shale reservoir units in the Cymric operation. The scale is primarily comprised of iron-rich silicates, acmite ($NaFe_2Si_2O_6$) and vermiculite ($Na_{0.7}Fe_2Si_4O_{10}(OH)_2$, a swelling clay). Formation of such scales causes (1) pipe erosion in the generator, resulting in steam leaks and increased frequency of generator repairs and downtime and (2) selective plugging of the surface steam distribution system and producer wellhead chokes, which impairs uniform heat distribution across the field.

Formation of these scale minerals has been successfully reproduced in laboratory autoclave experiments run under simulated steam conditions, using Cymric field feedwater and steel coupons. The laboratory results indicate that acmite scale formation requires the availability of iron (e.g., from pipe corrosion/erosion), and a minimum concentration of ~428-510 mg/L of dissolved SiO_2(aq), depending on the generator temperature. Such silica concentrations are easily exceeded in steam generator boiler liquid if, for example, the feedwater contains >100 mg/L SiO_2(aq) and the generator is operated at >75% steam quality. Formation of acmite scale can be cost-effectively prevented by maintaining a dissolved silica concentration in the boiler liquid that is below this critical threshold concentration. The ultimate silica concentration in the boiler liquid can be manipulated through freshwater dilution of the feedwater, adjustment of the generator steam quality, or silica removal treatments. Alternate silicate scale prevention methods currently under investigation include use of polymeric silicate scale inhibitors in steam generator feedwater.

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