

Furnace Injection of Alkaline Sorbents for Sulfuric Acid Control

Gary Blythe

URS Corporation, P.O. Box 201088, Austin, Texas 78720

E:mail: gary_blythe@urscorp.com; Telephone: (512) 419-5321; Fax: (512) 454-8807

Jake Davis

FirstEnergy Corporation, P.O. Box 128, Shippingport, Pennsylvania 15077

E:mail: davisj@firstenergycorp.com; Telephone: (330) 480-7825; Fax (330) 420-0235

Mike Durner

American Electric Power, 1 Riverside Plaza, Columbus, Ohio 43215

E:mail: mwdurner@aep.com; Telephone: (614) 223-1277

Richard Rhudy

EPRI, 3412 Hillview Avenue, Palo Alto, California 94304

E:mail: rrhudy@epri.com; Telephone: (650) 855-2421, Fax: (650) 855-8759

Joel Beeghly, Lew Benson

Carmeuse NA, 3600 Neville Road, Pittsburgh, Pennsylvania 15225

E:mail: joelb@carmeusena.com, lewb@carmeusena.com; Telephone: (412) 777-0711, (412) 777-0723;
Fax: (412) 777-0727

Summary

This project tested the effectiveness of alkaline reagents injected into the furnace of coal-fired boilers at controlling sulfuric acid emissions. The project was co-funded by the U.S. Department of Energy's National Energy Technology Laboratory, EPRI, FirstEnergy Corporation, the Tennessee Valley Authority, American Electric Power (AEP) and Carmeuse NA.

Sulfuric acid is present in most coal flue gases because a small percentage (about 0.5 to 1.5%) of the SO₂ produced is further oxidized to SO₃, which combines with flue gas moisture to form vapor-phase or condensed sulfuric acid. Sulfuric acid is a Toxic Release Inventory substance and a precursor to acid aerosol/condensable emissions from coal-fired boilers. Sulfuric acid can also lead to air heater corrosion, plugging and fouling; corrosion downstream of the air heater; and a visible plume at some plants. These effects can be exacerbated if selective catalytic reduction (SCR) is retrofitted for NO_x control, as SCR catalysts further oxidize a portion of the flue gas SO₂ to SO₃.

The project first tested the effectiveness of four calcium- and/or magnesium-based sorbents in one- to two-week furnace injection tests conducted at FirstEnergy's Bruce Mansfield Plant (BMP). The first test evaluated the effectiveness of dolomite injected as a powder through out-of-service burners, and the other three evaluated reagents injected as slurries into the upper furnace cavity: pressure hydrated dolomitic lime, commercially available magnesium hydroxide (commercial Mg), and a byproduct

magnesium hydroxide (byproduct Mg). The latter was a byproduct from a flue gas desulfurization system that employs a modified Thiosorbic Lime[®] wet scrubbing process.

The short-term test results showed that three of the four reagents: dolomite powder, commercial Mg slurry, and byproduct Mg slurry, were able to achieve 90% or greater sulfuric acid removal compared to baseline levels. The molar ratio of alkali to flue gas sulfuric acid content (at baseline conditions) required to achieve 90% sulfuric acid removal was lowest for the byproduct Mg slurry. However, this result may be confounded because byproduct Mg was the only slurry tested with injection near the top of the furnace, across from the pendant superheat platens. Injection at the higher level proved advantageous for this reagent over injection lower in the furnace. The other slurries were only tested with injection lower in the furnace, across from the nose of the boiler, and might have performed better if injected at the higher location.

After the four short-term tests were completed, two longer-term (~25-day) tests were conducted with the most promising sorbents, to confirm sorbent effectiveness over extended operation and to determine balance of plant impacts. The first longer-term test was conducted on BMP Unit 3 using byproduct Mg slurry, injected at sorbent to SO₃ mole ratios varying from about 2:1 to 5:1 (compared to SO₃ in the economizer outlet gas as measured under baseline conditions). Corresponding sulfuric acid removal efficiencies measured at the ESP outlet varied from 40% to 75%. Sorbent injection rates and sulfuric acid removal efficiencies were limited by ESP performance. As sulfuric acid removal increased, the power to the ESP electrical fields generally decreased and ESP outlet opacity increased, presumably because of increased fly ash resistivity due to the upstream sulfuric acid removal. However, at the beginning of the test, two of the four ESPs on Unit 3 were not performing well based on electrical conditions. Higher injection rates and higher sulfuric acid removal levels might have been possible with four well-performing ESPs.

The stack plume opacity was not quantified, but was observed to be greatly reduced during sorbent injection. No significant effect of sorbent injection was seen on air heater pressure drop or outlet flue gas temperatures, or on economizer outlet temperatures. Flue gas measurements did not detect a significant impact on ESP outlet particulate mass loading, and no significant effect was noted on boiler slagging tendencies.

The second long-term test was conducted on AEP's Gavin Plant, Unit 1. Both byproduct Mg and commercial Mg slurries were tested, with two different injection location schemes. This test was different from the BMP test because the Gavin Plant has operating SCR reactors that convert about 1% of the flue gas SO₂ to SO₃. This, combined with the furnace conversion, results in approximately 2.3% overall conversion of SO₂ to SO₃, and relatively high flue gas sulfuric acid concentrations.

There was no clear difference between the performance of the byproduct Mg and commercial Mg slurry purchased from the Dow Chemical Company, when the two were compared at equal Mg:SO₃ mole ratios. For this boiler it was more effective to inject about 40% of the sorbent slurry at the 13th floor of the boiler, and the remainder at the 17th floor, rather than inject all of the slurry at the 17th floor. The 13th floor is just above the nose of the boiler, and the 17th floor is adjacent to the tops of the pendant superheat platens. When injecting either sorbent with 40% to the 13th floor and 60% to the 17th floor, 90% of the furnace-formed SO₃ was removed at a Mg:SO₃ ratio of about 3.5:1. For injection all on the

17th floor, a Mg:SO₃ ratio of about 5:1 was required. These molar ratios are based on SCR outlet SO₃ concentrations, as measured during baseline unit operation.

The furnace-injected sorbent was less effective at removing SO₃ formed across the SCR catalyst. Measured at the ESP outlet, downstream of the SCR reactors, the overall sulfuric acid removal was only 70% at a Mg:SO₃ molar ratio of 5:1, with the maximum removal observed being about 78% at a molar ratio between 6:1 and 7:1. There was no significant reduction in conversion of SO₂ to SO₃ across the SCR reactors during sorbent injection, and only a modest improvement in sulfuric acid removal across the air heaters and ESPs compared to baseline.

Sorbent injection significantly reduced the observed plume opacity, and measurably lowered the opacity measured in-duct at the ESP outlet. ESP electrical conditions were not significantly impacted, and outlet particulate emissions remained low. As at BMP, other balance-of-plant impacts were minimal.