

LARGE-SCALE MERCURY CONTROL TECHNOLOGY TESTING FOR LIGNITE-FIRED UTILITIES, OXIDATION SYSTEMS FOR WET FGD

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The Energy & Environmental Research Center (EERC) is leading a consortium involving Apogee, Babcock & Wilcox Company (B&W), the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL), the Electric Power Research Institute (EPRI), the North Dakota Industrial Commission, SaskPower, and URS Group as well as a Mercury Task Force consisting of Basin Electric Power Cooperative; BNI Coal, Ltd.; Dakota Westmoreland Corporation; Great River Energy; Minnkota Power Cooperative, Inc. (MPC); Montana–Dakota Utilities Co.; North American Coal Corporation; Otter Tail Power Company; and TXU Energy (TXU) to evaluate cost-effective approaches for capturing the mercury (Hg) occurring in lignitic combustion flue gases using a cold-side electrostatic precipitator (ESP) and/or wet flue gas desulfurization (FGD) system. Minnkota Power Cooperative's Milton R. Young (MRY) Station Unit 2 and TXU's Monticello Steam Electric Station (MoSES) Unit 3 were the host test sites. The EERC collaborated with Apogee, B&W, EPRI, and URS in performing the technical work involving Hg measurements upstream and downstream of ESP and FGD units before and during halogen compound additions and powdered activated carbon (PAC) injections; determining the Hg removal efficiencies of ESP and FGD units; evaluating the balance-of-plant effects of the control technologies; and facilitating technology commercialization. The primary project goal was to cost-effectively oxidize most of the Hg⁰ in lignitic combustion flue gases into a more soluble and reactive inorganic mercuric compound (Hg²⁺) that could subsequently improve ESP–FGD Hg removal efficiency to ≥55 %.

Mercury Control Field Testing at Milton R. Young Station

MRY Station Unit 2 is a 450-MW cyclone unit near Center, North Dakota. A cold-side ESP and FGD are used at MRY for controlling particulate and sulfur dioxide (SO₂) emissions, respectively. Calcium chloride (CaCl₂), magnesium chloride (MgCl₂), and a proprietary sorbent enhancement additive, hereafter referred to as SEA2, were added to the coal feed to potentially enhance Hg capture in the ESP and/or FGD. In addition, powdered activated carbon (PAC) was injected upstream of the ESP. Hg in the lignite coal fired at MRY Unit 2 varied from 0.05 to 0.25 ppm and averaged 0.112 ± 0.014 ppm (dry coal basis). Most of the Hg was associated with Hg-rich (average of 2.28 ppm Hg) pyrite grains that ranged in concentration from about 1 to 6 wt% (on a dry coal basis). Baseline analyses indicated that total Hg concentrations at the ESP and FGD inlets varied from about 12 to 16 µg/dNm³, whereas stack concentrations were consistently at about 13 µg/dNm³. The ESP and FGD were very inefficient at removing Hg primarily because Hg⁰ was dominant. MgCl₂ and CaCl₂ were relatively ineffective in promoting Hg⁰ oxidation and capture in the ESP–FGD. Relatively low additions of SEA2, however, significantly improved the Hg removal efficiency of the ESP–FGD, although the goal of ≥55% Hg removal was not achieved using as much as 75 ppm SEA2 (dry coal basis). Most of the Hg removal occurred in the ESP, suggesting that the SEA2 addition promoted the conversion of Hg⁰ to particulate-bound Hg. The SEA2 addition (50–100 ppm, dry coal basis) combined with 0.15 lb/Macf PAC injection was performed for a month during which Hg removals ranged from 50% to 65%.

The potential corrosive effects of SEA2 and PAC injections were evaluated by installing air-cooled, stressed stainless steel, corrosion/ash deposition coupons at the economizer exit (ECM), air heater inlet (AHI), and air heater outlet (AHO) of MRY Unit 2. Two coupons for each location were fabricated by MRY personnel: a baseline coupon exposed to the normal flue gas environment for 8 weeks and a test coupon exposed to flue gas while SEA2 and PAC were being added to the coal feed for 6 weeks. Scanning electron microscopy analyses indicated that the baseline coupons from the ECM and AHI had a smooth surface, whereas the corresponding Hg control coupons had a rougher surface, suggesting that corrosion was enhanced during the SEA2 and PAC injections. Longer-term tests are required to verify these preliminary observations. In contrast to the ECM and AHI coupons, steel surfaces on the AHO baseline and Hg control coupons were similar in appearance.

The mobility of Hg in MRY fly ashes sampled before and after PAC and SEA2 injections was evaluated using a synthetic groundwater leaching procedure augmented with long-term treatments of 30 and 60 days. Hg was not detected in any of the leachates, indicating that it was relatively insoluble during the test conditions. The thermal stability of Hg in fly ash samples collected during baseline and Hg control technology testing conditions was evaluated by heating at 25°C/min to 750°C. The fly ash samples collected during baseline and Hg control technology testing conditions released Hg at about 375° and 400°C, respectively. The fly ash sampled during Hg control technology testing also released some Hg at >550°C. The Hg captured on fly ash and PAC during SEA2 injections was thermally more stable relative to the baseline fly ash.

Mercury Control Field Testing at Monticello Steam Electric Station

MoSES Unit 3 is a 793-MW unit near Mt. Pleasant, Texas, that fires a 50/50 blend of Texas lignite and Powder River Basin (PRB) coals. The unit is equipped with an ESP and limestone forced-oxidation spray tower FGD system for controlling particulate and SO₂ emissions, respectively. CaCl₂ and calcium bromide (CaBr₂) were added to the coal feed to potentially enhance Hg capture in the ESP and/or wet FGD. PRB coal Hg concentrations ranged only from 0.04 to 0.09 ppm dry, whereas the Texas lignite coal Hg concentrations were highly variable, ranging from 0.17 to 0.36 ppm dry. Baseline Hg measurements indicated that ESP inlet Hg concentrations ranged widely from 15 to 30 µg/dNm³ (composed of about 10%–40% Hg²⁺) and ESP Hg removal was insignificant.

CaCl₂ provided only nominal improvements in Hg⁰ oxidation even at the highest tested injection rate of 800 ppm Cl in the coal. CaCl₂ injection was untenable for sustaining the Hg⁰ oxidation necessary to achieve the project's Hg removal target of ≥55%. In contrast, parametric tests with CaBr₂ demonstrated ≤78% Hg⁰ oxidation at injection rates of ≤200 ppm Br in the coal. Based on these parametric test results, CaBr₂ was selected for two 2-week continuous-injection tests.

An initial CaBr₂ injection, corresponding to 55 ppm Br in the coal, achieved 67% Hg⁰ oxidation at the scrubber inlet and a 65% FGD Hg removal. These values represent averages over a 2-week injection test; however, the scrubber outlet total Hg concentration steadily increased during the test period. Therefore, a higher CaBr₂ injection rate corresponding to 113 ppm Br in coal was evaluated during the second 2-week injection test resulting in an average ESP inlet of 85% Hg²⁺ and ESP–FGD Hg removal efficiency of 86%. An injection rate of

113 ppm Br was generally sufficient to maintain scrubber outlet Hg concentrations at <5 $\mu\text{g}/\text{dNm}^3$.

During baseline and the first week of each long-term injection test, Hg partitioned to the FGD solids; however, during the second week of each test, the Hg partitioned more to the liquor. At an injection rate of 113 ppm Br in the coal, >85% of the Hg in the FGD by-product was contained in the liquor.

A unit inspection conducted after the test program did not indicate any Br-related corrosion; however, the test period was too short for an adequate corrosion evaluation. The effect of increased Br concentration in the FGD liquor on FGD performance and corrosion of FGD construction materials needs to be determined. Duct corrosion and air heater plugging also need to be evaluated during a longer-term test. Finally, the effect of increased Br concentrations on the marketability of coal combustion by-products should be addressed.