

FINAL TECHNICAL REPORT
September 1, 1996, through August 31, 1997

Project Title: **CORRELATE COAL/SCRUBBER PARAMETERS WITH Hg REMOVAL
AND Hg SPECIES IN FLUE GAS**

ICCI Project Number: 96-1/2.4A-2
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ABSTRACT

The Clean Air Act Amendments (CAAA) of 1990 require EPA to evaluate the emissions of hazardous air pollutants (HAPs) from coal-fired utilities. Several organizations, including the Environmental Protection Agency (EPA), the U. S. Department of Energy (DOE), and the Electric Power Research Institute (EPRI), participated in this evaluation. The evaluation demonstrated that most of the HAPs are collected with the fly ash in the particulate collection equipment (ESPs and fabric filters). The exceptions are volatile HAPs such as elements or compounds of mercury, selenium, and acid gases (HF and HCl).

In this program, CONSOL conducted a field sampling program to evaluate mercury control at FGD-equipped coal-fired utility boilers in Illinois. The data obtained in this study will provide the Illinois coal and utility industries and emissions-regulating authorities valuable information on the effectiveness of wet scrubbers for mercury and acid gas removal.

The average Hg emissions for the two sites were 2.5 and 2.9 $\mu\text{g}/\text{m}^3$ (0.005 and 0.004 lb/hr or ~30 lb/year). The total Hg removals across the entire systems (ESP and FGD) averaged 56% and 72%. The averages for the Hg removals across the FGDs were 48% and 58%. Flue gas Hg speciation measurements indicate that the fraction of Hg estimated as oxidized by the Ontario Hydro sampling method is the species that is being removed across the FGD. The Hg material balance closures for the first site ranged between 75% and 104% and averaged 92%. The Hg material balance closures for the second plant ranged from 108% to 125% and averaged 116%. Of the total Hg in the coal, 7% to 14% reported in the ESP ash and 35% to 70% in the FGD solids. A statistical analysis of the process parameters influencing Hg removal was conducted by the Illinois State Geological Survey (ISGS). No strong correlations were observed between coal quality and scrubber parameters with Hg removal.

The average HCl emissions for the two sites were 66 and 26 lb/hr. The average HCl removal was 82%. The average HF emissions were <8 and 6 lb/hr with an average removal of 70%.

EXECUTIVE SUMMARY

The Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), the Electric Power Research Institute (EPRI), and their contractors have studied the partitioning of Hazardous Air Pollutants (HAPs) at coal-fired utility plants. The majority of HAPs were captured with the fly ash in existing particulate collection devices (ESPs, fabric filters). The exceptions are the elements or compounds denoted as Class III (Hg, Se, HF, HCl) which, because of their volatility, are vapors at the exit of conventional particulate control equipment. Potential HAP control regulations could have an adverse effect on the Illinois coal and utility industries.

Studies at coal-fired utilities have shown that wet scrubbers can remove mercury. However, these studies show a wide variation in removal (0 to 100%), indicating the need for additional data to define the cause of this variation. The goal of this program was to develop more precise data regarding the removal of mercury and other volatile HAPs including selenium (Se), hydrofluoric acid (HF), and hydrochloric acid (HCl) by wet FGD systems. These data will supply the Illinois utility industry with information to evaluate SO₂ scrubbers as volatile HAP control devices. The data will be used to develop a model to predict HAP removal by SO₂ scrubbers.

In this program, CONSOL R&D and the Illinois State Geological Survey:

1. Determined the mercury and acid gas removal at two scrubber-equipped boilers firing Illinois coal.
2. Completed correlation analysis of mercury removal with coal properties and/or scrubber operating parameters,
3. Compared the total mercury and mercury speciation results from EPA Method 29 and from a "state-of-the-art" method currently being developed by DOE and EPRI.

The project team contacted the owner/operators of all of the scrubber-equipped boilers operating in Illinois. Four of the owners agreed to participate in the program. Two units were scheduled for testing during 1996 and, assuming a second-year award, two will be sampled in 1997-1998.

Host site access agreements were negotiated with two Illinois utility sites. The first sampling program was completed during the week of October 21, 1996, and the second sampling program was completed the week of October 28, 1996. Testing at both plants consisted of triplicate flue gas Hg measurements across the FGD scrubber. Process stream samples (i.e., feed coal, fly ash, bottom ash, limestone, FGD sludge/product, etc.) were obtained to conduct a mercury material balance to verify data quality.

The average Hg emissions for the two sites were 2.5 and 2.9 µg/m³ (0.005 and 0.004 lb/hr or ~30 lb/year). The total Hg removals across the entire systems (ESP and FGD) averaged 56% and 72%. The average Hg removals across the FGDs were 48% and 58%. The Hg material balance closures for four tests conducted at the first plant ranged between 75% and 104% and averaged

92%. The Hg material balance closures for three tests conducted at the second plant ranged from 108% to 125% and averaged 116%. Of the total Hg in the coal, 7% to 14% reported to the ESP ash and 35% to 70% to the FGD solids. No measurable Hg was found in the ash samples obtained upstream of the air preheater (bottom ash and economizer ash), or in the FGD slurry filtrate water.

The flue gas Hg speciation data indicate that the Hg fraction collected in the KCl impingers of the Ontario Hydro sampling train at the scrubber inlet is the species that is removed across the FGD system. The inlet Hg speciation estimated from the KCl sampling method showed between 80% and 90% oxidized Hg at the ESP inlet. Outlet speciation data showed measurable particulate Hg emissions that may be a result of FGD solids carryover out of the FGD and mist eliminator or possibly artifact formation from a gas phase reaction of Hg with the filter media used in the sampling train.

Process parameters influencing Hg removal were correlated by the Illinois State Geological Survey (ISGS). The Illinois State Geological Survey conducted a literature search to identify available flue gas Hg sampling data from scrubbed units. From this activity, it was evident that little reliable data exists. Statistical analysis performed on data obtained at the EPRI High Sulfur Test Center (HSTC) showed no statistical significance at the 95% level for Hg removal with any of the observed process parameters. The information collected in this study and other CONSOL in-house test data from an eastern coal-fired, scrubber-equipped utility were used to assist in this activity. A statistical analysis of these data showed no strong correlation between scrubber parameters and Hg removal. Some minor coal quality parameters appeared to correlate with Hg removal across the ESP. The statistical analysis has been hindered by the lack of data. The project team has submitted a new proposal to ICCI to conduct additional testing in 1997-1998 to expand the data base.

This testing demonstrated that wet FGD systems installed and operated for SO₂ control are capable of removing 50-60% of the flue gas Hg. In addition, another 7-13% of the Hg is collected on the ESP ash for a total system removal of 60-70%. This information will provide utilities additional compliance options if a Hg emission reduction is proposed. If Hg regulations are enacted, wet scrubbers can be used to remove flue gas Hg, providing a cost benefit for using Illinois coal.

The average HCl emissions at the two sites were 66 lb/hr and 26 lb/hr (~200 and ~80 tons per year). The average HCl removal across the FGD scrubber at both sites was ~82%. The HF emissions at the first site were below the detection limit of 2 lb/hr. The HF emissions at the second site averaged 6 lb/hr (~20 tons per year) with an average FGD scrubber removal of 70%.