

POWER PLANT EVALUATION OF THE EFFECT OF SCR TECHNOLOGY ON MERCURY

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ABSTRACT

Since the U.S. Environmental Protection Agency (EPA) determination in 2000 to regulate mercury emissions from coal-fired power plants, many utilities have stepped up proactive steps to investigate methods to control and reduce these emissions. While selective catalytic reduction (SCR) systems are designed for nitrogen oxides (NO_x) reduction, they may also convert elemental to oxidized mercury, which can be captured by a downstream wet flue gas desulfurization (FGD) system.

This project was originally designed to investigate the impact that SCR, selective non-catalytic reduction (SNCR), and flue gas-conditioning systems have on total mercury emissions and on the speciation of mercury. In the first phase of this work, only the SCR system was found to have a significant effect on mercury speciation; thus, this paper will only focus on the SCR results. If SCR systems enhance mercury conversion/capture, then they could be thought of as multi-pollutant technologies. The data from this project is leading to a better understanding of mercury science as applied to coal-fired boilers. Six power plants were chosen for full-scale, flue gas sampling to investigate the impact of SCR systems [as well as ammonia injection (NH₃)] on mercury speciation. Sampling was conducted both prior to and after the SCR unit using the wet-chemistry Ontario Hydro method. Mercury measurements at the particulate and sulfur dioxide (SO₂) control inlets and outlets were conducted using both the Ontario Hydro method as well as continuous mercury monitors (CMMs). Mercury concentration, speciation, and variability in the flue gas were evaluated. Additional sampling involved the use of EPA Method 26A to test for chlorides, a selective condensation method to measure sulfur trioxide (SO₃), and EPA Method 27 for NH₃ slip. Fly ash and coal samples were also collected to obtain the mercury balance across the control devices.

The project is continuing to evaluate additional power plants as well as interpret the most recent field studies. The preliminary results indicate that SCR systems can convert elemental to oxidized mercury and, thus, facilitate the downstream collection of the oxidized mercury in the FGD system. However, the effect appears to be coal- and possibly catalyst-specific.

INTRODUCTION

Coal combustion by electric utilities is a large source of anthropogenic mercury emissions in the United States, according to the U.S. Environmental Protection Agency (EPA).¹ Recent data indicate that the total mercury emissions from coal-fired power plants in the United States are about 45 tons/yr.²

Mercury emissions from coal-fired boilers can be empirically classified, based on the capabilities of currently available analytical methods, into three main forms: elemental mercury (Hg^0), oxidized mercury (Hg^{2+}), and particle-bound mercury (Hg_p). The flue gas concentration of Hg^0 , Hg^{2+} , and Hg_p are thought to primarily depend on coal composition and combustion conditions.³

During combustion, Hg^0 is liberated from coal. However, depending on the coal type, a significant fraction of the mercury can be oxidized as well as become associated with fly ash particles in the post combustion environment of a coal-fired boiler. Compared to Hg^0 , Hg^{2+} and Hg_p are more effectively captured in conventional pollution control systems such as flue gas desulfurization (FGD) systems, fabric filters, and electrostatic precipitators (ESPs).² The identification of a process for converting Hg^0 to Hg^{2+} and/or Hg_p forms has the potential to improve the mercury removal efficiencies of existing pollution control systems.

In addition to mercury, coal-burning power plants are a significant anthropogenic source of nitrogen oxides (NO_x) emissions to the atmosphere. NO_x emissions are an environmental concern primarily because they are associated with ozone formation as well as fine-particle formation and acid precipitation. Depending on the size and type of boiler, the 1990 Clean Air Act Amendments required specific reductions in NO_x emissions from coal-fired electric utilities. The most common NO_x reduction strategy employed initially was low- NO_x burners. These burners have the capability of reducing NO_x emissions by 40%–60%. However, the additional NO_x reductions that are required as a result of the NO_x State Implementation Plan (SIP) call to alleviate ambient ozone levels, has resulted in the need to reduce NO_x emissions to a level below what can be achieved using these low- NO_x burners. Selective catalytic reduction (SCR) technology, which can reduce NO_x emissions by up to 90%, is being installed on many power plants in the eastern US.

Potential Impacts of SCR Systems on Mercury Speciation

SCR units achieve lower NO_x emissions by catalytically reducing NO_x to N_2 and H_2O . Ammonia (NH_3) is the reductant used for the SCR of NO_x . The SCR process is generally performed on metal oxide catalysts such as titanium dioxide (TiO_2)-supported vanadium pentoxide catalysts (V_2O_5). Previous power plant measurements have indicated that SCR systems designed to significantly reduce NO_x emissions may also promote Hg^0 oxidation to

Hg^{2+} , and this effect appeared to be coal-specific and possibly catalyst-specific.⁴ The possible mechanisms or reasons for this effect include:

- Catalytically enhancing the oxidation of the elemental mercury by chlorine (Cl) in the flue gas.
- Enhancing the gas phase reactions between mercury and chlorine by changing the flue gas chemistry (e.g., increasing SO_3 , decreasing NO_x).
- Increasing flue gas residence time for these oxidation reactions.

DESCRIPTION OF THE POWER PLANTS AND COAL

A total of six power plants have been tested, with two sites (Sites S2 and S4) being tested twice, once in 2001 and again in 2002, yielding a database of eight data sets. The units tested ranged from 160 to 1300 MW in size. Five of these plants burned eastern bituminous coals (with various sulfur and chlorine content) while the sixth burned a Powder River Basin (PRB) coal. The plant configurations of air pollution control devices included cold-side ESPs, wet FGD systems, and a combined particulate/ SO_2 venturi/spray tower scrubber. Information about each of the plants is provided in Table 1. The coal analysis for each unit tested is shown in Table 2.

EXPERIMENTAL APPROACH

The overall objective of the project is to determine the effect of the SCR system on flue gas mercury speciation and removal. To achieve this objective, a sampling plan was developed to evaluate the effect of the SCR by two approaches:

1. Measurement of mercury speciation at the SCR inlet and outlet, thus comparing the increase in Hg^{2+} across the SCR,
2. Measurement of mercury speciation and emissions at the ESP inlet/outlet as well as the FGD outlet both with and without SCR operation. Data without an operating SCR system were obtained either by testing an identical sister unit without an SCR system or by testing after the SCR system was bypassed following the end of the ozone season (September 30).

The mercury measurements were conducted using the manual Ontario Hydro (OH) method as well as continuous mercury monitors (CMMs). The test crew obtained samples at the inlet and outlet of the SCR system, at the stack, and in between each of the air pollution control devices. Additional sampling involved the use of EPA Method 26A to test for chlorides, a selective condensation method to measure SO_3 , and EPA Method 27 for NH_3 slip. Fly ash and coal samples were also collected to obtain the mercury balance across the control devices.

Table 1. Information about the power plants tested

Plant	Coal	Boiler Type	Boiler Size, MW	Low-NO _x Burners	Catalyst Vendor and Type	Catalyst Age	SCR Space Velocity, hr ⁻¹	Particulate Control	Sulfur Control
S1	PRB Sub-bit	Cyclone	650	No	Cormetech honeycomb	~8000 hr	1800	ESP	None
S2	OH Bit.	Wall-fired	1300	Yes	Siemens/Westinghouse plate	~2500 hr	2125	ESP	Wet FGD
S3	PA Bit.	Tangential-fired	750	Yes, with overfire air	KWH honeycomb	~3600 hr	3930	ESP	None
S4	KY Bit.	Cyclone	650	No	Cormetech honeycomb	~3600 hr	2275	Venturi scrubber	Venturi scrubber
S5	Eastern Bit.	Wall-fired PC	684	Yes	Halder-Topsoe plate	3 months	~3700	ESP	Wet FGD
S6	Low Sulfur Eastern Bit.	Concentric Fired PC	700	Yes	Cormetech honeycomb	2 ozone season ^a	~3700	ESP	None
S2 - 2	OH Bit.	Wall-fired	1300	Yes	Siemens/Westinghouse plate	~5000 hr	2125	ESP	Wet FGD
S4 - 2	KY Bit.	Cyclone	650	No	Cormetech honeycomb	~7000 hr	2275	Venturi scrubber	Venturi scrubber

^a One layer of catalyst was replaced after one ozone season.

Table 2. Analysis of coals fired during field tests

	S1	S2	S3	S4	S5	S6	S2 - 2	S4 - 2
Moisture Content, %	27.5	7.6	7.0	10.5	4.6	6.1	6.1	7.4
Ash, %	3.73	11.67	14.04	9.08	12.13	11.55	9.38	8.54
Sulfur, %	0.19	3.90	1.67	2.88	3.63	1.00	3.86	2.94
Heating Value, BTU/lb	8,955	11,085	11,413	11,332	12,091	11,990	12,096	11,634
Mercury, µg/g dry	0.102	0.168	0.400	0.131	0.14	0.07	0.14	0.16
Chlorides, µg/g dry	<60	573-1910	721-1420	350-1280	430 - 500	635 - 1520	450 - 690	225 - 810

MERCURY RESULTS AND DISCUSSION

SCR Mercury Oxidation for Bituminous Coal-Fired Power Plants

Comparing SCR inlet and outlet – Using this approach, all seven data sets for bituminous coals indicate an increase in Hg^{2+} across the SCR system (Figure 1). This net increase ranges from 11 to 70 percentage points. The possible reasons for these disparate differences likely include a combination of the following:

1. Coal Cl concentration – The Cl level in the coal is the most straightforward approach to estimating Cl flue gas levels; although it is possible that alkalinity in the fly ash may tie up Cl and reduce its availability for some coals.
2. Inlet percentage of Hg^{2+} – for plants with a high proportion of the inlet mercury already oxidized, the potential increase is much lower.
3. Other flue gas constituents (e.g., Hg, alkalinity, SO_2 , SO_3)
4. SCR system/catalyst properties – e.g., space velocity, area velocity, catalyst type, and/or number of catalyst layers.

Comparing stack flue gas with and without SCR – A comparison of the SCR inlet/outlet is scientifically the most straightforward method for determining the effect of SCR. The most meaningful place to compare Hg speciation from a removal standpoint is the ESP outlet where future control strategies would be employed (e.g., activated carbon injection, FGD). Since Site S4 employed a combined particulate/ SO_2 control technology and did not have an ESP, the flue gas Hg speciation at the particulate control device (PCD) inlet was used since this location is consistent across all the sites tested. The net increase in Hg^{2+} at the PCD inlet with the SCR system operating as compared to that without the SCR system operating ranged from –1 to 37 percentage points, with an average increase of 17 percentage points (Figure 2). For the two sites with essentially no increase in Hg oxidation, the non-elemental Hg levels were greater than 90% both with and without the SCR system on-line. Thus, the conversion of the flue gas may have already reached its maximum value without the SCR system operating.

SCR Mercury Oxidation for PRB Coal-Fired Power Plants

Only Site S1 burned a PRB subbituminous coal. For this one site, the increase in Hg^{2+} across the SCR system was only 20 percentage points. The flue gas Hg speciation at the PCD inlet was generally the same both with and without the SCR system operating. Thus, at this site, the SCR catalyst may have sped up the mercury oxidation but did not have a significant, practical effect. The possible explanations for the much lower oxidation for this PRB site include:

1. Lower Cl flue gas concentrations – the coal Cl content was <60 ppm, compared with 500 – 1900 ppm for the bituminous coals. In addition, the high alkalinity in PRB coal ash may yield even lower levels of available Cl in the flue gas.
2. Catalyst deactivation – parallel pilot sidestream tests with a fresh catalyst indicated much higher oxidation rates (~80% compared with 20%).⁵ Other pilot studies by EPRI and DOE have suggested that catalyst activity for Hg oxidation may decrease

with operating time.⁵ However, an ongoing pilot study at a different PRB coal-fired power plant has not indicated any significant drop-off after 3200 hours. At this site, the oxidation rates are lower at a typical space velocity (2000 hr⁻¹) than they are for bituminous fired units.⁶

3. Cyclone boiler, high loss on ignition (LOI)— Site S1 employed a cyclone boiler, with an unexpectedly high LOI of ~15%, yielding a baseline Hg removal of ~60% by the ESP alone. Most pulverized coal (PC)-fired boilers burning PRB coals do not produce such high LOIs (which are typically <1%) and, therefore, are not expected to experience similarly high baseline Hg removal.

The majority of US power plants burning PRB coals are PC-fired boilers with very low levels of LOI. To further evaluate the effect of the SCR catalyst on flue gas mercury speciation for PRB coals, tests are planned at two PC-fired PRB sites in 2003 and 2004.

Co-benefit of SCR and FGD Systems

Since SCR systems may convert Hg⁰ to Hg²⁺, a downstream FGD system may be able to capture the resulting Hg²⁺ and, thus, provide a co-benefit of mercury reduction for the SCR and FGD combination. Sites S2, S4, and S5 were equipped with a combination of an SCR system followed by a wet FGD system, and two of these sites (S2 and S4) were tested in 2001 and retested in 2002. All of these plants burn an eastern bituminous coal. Figure 3 compares flue gas Hg concentrations at the FGD inlet and outlet. With SCR system operating, mercury removal efficiencies ranged from 84% to 92%, averaging 89%. Without the SCR system operating, the mercury removal efficiencies ranged from 43% to 51%, averaging 48%. Thus, the results to date indicate a potentially significant co-benefit mercury removal for a bituminous coal-fired plant equipped with the combination of the SCR and FGD systems. However, it is very important to note that only three power plants have been tested, and these results from this limited data set may not represent all other bituminous coal-fired plants.

Impact of SCR Systems on Mercury “Re-emissions” from FGD Systems

A review of the Information Collection Request (ICR)³ Part III, flue gas sampling data, suggested that there is an increase in flue gas Hg⁰ levels across the wet FGD systems. This would suggest that the FGD systems may be converting some of the absorbed Hg²⁺ back to Hg⁰, which is then re-emitted through the stack. The mechanism for these chemical reactions is not well understood, but speculation is that some Hg²⁺ captured in the FGD is not chemically stable and is then chemically reduced, possibly by the sulfites in the scrubber liquor. Particulates may also play an important role in this reduction reaction.⁷

Figure 4 compares the Hg⁰ concentration at the FGD inlet and outlet for the tests with and without the SCR system operating. For the non-SCR tests, there is a significant increase in the Hg⁰ concentrations across the FGD. For the five test sets with SCR operation, each indicates only a slight increase in Hg⁰ across the FGD. While the difference in Hg⁰ for any one site would not be statistically significant, five measurements of this effect becomes a more reliable indicator. Hence, these results suggest that the some conversion of Hg²⁺ to Hg⁰ (or mercury re-emissions) occurs across the FGD with the SCR system on-line.

From a mass loading perspective, it appears that mercury re-emissions are less with the SCR system on-line than without the SCR system operating. The reason for this possible effect is not well understood, and these intriguing results from only three power plants may not be representative of all other similar sites. Instead, additional research needs to be undertaken to better characterize this effect. There are possible concerns about the representativeness of the no-SCR measurements around the FGD. For sites S2 and S4, the measurements were conducted before the FGD system had reached equilibrium. For Site S2, the no-SCR tests were conducted over a several hour time period during which the power plant temporarily bypassed the SCR; thus, the FGD never reached equilibrium. For Site S4, both the 2001 and 2002 tests were conducted around the end of the ozone season. Thus, the no-SCR tests were conducted only days after the SCR was bypassed, which may not have been sufficiently long to allow the FGD to reach steady-state operation. Because the mechanism of mercury re-emissions is not well understood, it is impossible to determine whether the FGD equilibrium had any impact on mercury re-emissions.

A better understanding of the mechanism of mercury re-emissions is a critical research need. These mercury re-emissions may significantly affect the ability of a power plant to achieve sufficient removal to meet future mercury regulations. Field tests are planned to further evaluate this effect at more power plants with the SCR and FGD combination and to better characterize mercury removals both with and without SCR operations.

Effect of Space Velocity

Of the five bituminous coal-fired sites, Sites S3, S5, and S6 employed SCR catalyst designs with a space velocity (a ratio of the flue gas to catalyst volumes) of about $\sim 3800 \text{ hr}^{-1}$, while Sites S2 and S4 were in the range of $\sim 2000 \text{ hr}^{-1}$. The sites with lower space velocity have a higher net increase in oxidation across the SCR system, as would be expected with the larger catalyst and longer residence times (Figure 5). However, comparing the actual percentage of non-elemental mercury at both the SCR outlet and the PCD inlet indicates that there is no significant difference. In all five sites, the mercury speciation at both locations is predominately non-elemental mercury and consistently greater than 90% at the PCD inlet. “Non-elemental mercury” means both oxidized and particulate mercury, and this term is used here because the SCR could convert elemental mercury to either form, and both forms would be captured in a combination of a particulate and an SO_2 control. The limited results to date would suggest that “significant” oxidation could be expected for the “high” space velocity SCR designs for bituminous coal-fired applications.

Effect of Catalyst Operating Time

Sites S2 and S4 were retested after an additional ozone season of operation. Both sites burn a bituminous coal and employ large SCR systems ($\sim 2000 \text{ hr}^{-1}$ space velocity). Figures 6 and 7 compare the results in 2001 with 2002 and suggest the following:

Site S2 – Although the net increase in Hg^{2+} across the SCR system decreased from 43 percentage points in 2001 to 33 percentage points in 2002, the percent non-elemental mercury at the SCR outlet was comparable-91% in 2001 as compared to 87% in 2002. More importantly, the mercury speciation at the PCD inlet showed that about 97% of the flue gas

mercury was Hg^{2+} in both 2001 and 2002. Also the operation of Site S2 in 2002 was somewhat different than in 2001. To help mitigate SO_3 emissions, the plant employed calcium injection into both the furnace and ESP inlet, as well as humidification to reduce the SCR operating temperature. When all the factors are considered, a definitive conclusion cannot be made that the SCR catalyst at Site S2 is operating at a lower or equivalent level of effectiveness to that of 2001 for converting Hg^0 to Hg^{2+} .

Site S4 - The net increase in Hg^{2+} across the SCR system at Site S4 appeared to decrease significantly from 70 percentage points in 2001 to only 29 percentage points in 2002. The non-elemental mercury at the SCR outlet was 80% in 2001 as compared to 62% in 2002. However, if one possible “outlier” run is not included for the 2002 tests, the SCR outlet is 70% non-elemental mercury, and the net SCR oxidation increases to 37 percentage points. In either case, these comparisons would suggest that the SCR catalyst effectiveness might have decreased after an additional ozone season. However, comparing the PCD inlet mercury speciation with and without the SCR system operating indicates that comparable levels of Hg^{2+} (i.e., 93% in 2001 and 95% in 2002) were measured.

While the results at Site S4 would suggest that catalyst activity might have dropped after an additional ozone season of operation, the bottom line is that the mercury speciation at the venturi scrubber inlet is comparable, and the overall mercury removals are not significantly affected. However, there are some possible concerns that warrant continued follow-up to further evaluate the catalyst aging effect.

CONCLUSIONS

Based on mercury measurements at six power plants with SCR systems, the preliminary conclusions of this important study are:

- SCR catalysts appear to assist in converting Hg^0 to Hg^{2+} . This effect appears to be more likely to occur with bituminous coals, where 90+% Hg^{2+} is possible at the PCD inlet. The only PRB site tested did not show a high oxidation rate. However, additional data are necessary from other sites, especially the more representative PC-fired applications, before any conclusions can be developed for PRB applications.
- The three bituminous coal-fired power plants with wet FGD systems achieved mercury removals of 84%-92%. Comparable results without the SCR ranged from 43% to 51%. These increased removal efficiencies may be due to the combined effects of the SCR system to increase Hg^{2+} concentrations and reduce re-emissions of the Hg^0 from the FGD system.
- For bituminous coal applications operating at space velocities of $\sim 3800 \text{ hr}^{-1}$, the extent of mercury oxidation across the SCR may be slightly less than for the SCR catalysts operating at $\sim 2000 \text{ hr}^{-1}$. However for the three sites tested, the mercury at the PCD inlet was essentially all oxidized. This interpretation of the data needs more study given the high levels of Hg^{2+} in the flue gas even without the SCR system operating.

- It is not clear whether SCR oxidation is significantly affected by catalyst aging for bituminous coal applications. One site did measure lower mercury oxidation rate across the SCR between one and two ozone seasons; however, the mercury at the APCD inlet was essentially the same (all oxidized mercury) at both times.

Again, these conclusions are based on a relatively small sample and, thus, should be considered tentative and designed to focus future research activities rather than final conclusions that can be extrapolated to predict the results at all other similar units.

Although this project has indicated that there may be some significant co-benefit mercury reductions achievable with the installation of SCR systems on plants burning an Eastern bituminous coal, the understanding of this effect and, thus, the ability to capitalize on this effect with the design and operation of the combines SCR/FGD technology is still limited.

FUTURE TEST PLANS

Further data will be obtained to develop a more robust database to verify these observations. The top priorities are 1) PRB pulverized coal-fired applications and 2) more and better data for SCR/FGD combinations. Other data gaps include PRB/bituminous coal blends, other low-rank coals, and continued evaluation of the catalyst age and space velocity relationships. The mechanism for the Hg^0 oxidation to Hg^{2+} and the FGD re-emissions are not well understood, and additional studies are needed to confirm/support the sustainability of mercury removal rates.

REFERENCES

1. U.S. Environmental Protection Agency. *Mercury Study Report to Congress Volume I: Executive Summary*. Office of Air Quality Planning and Standards and Office of Research and Development, Dec 1997, EPA/452/R-97/003 (PB98-124738).
2. EPRI. *An Assessment of Mercury Emissions from U.S. Coal-Fired Power Plants*. EPRI Report No. 1000608, Oct 2000.
3. ICR Reports. <http://www.epa.gov/ttn/uatw/combust/utiltox/utoxpg.html> (accessed October 7, 2000).
4. EPRI, DOE, EPA. *Power Plant Evaluation of the Effect of Selective Catalytic Reduction on Mercury*. EPRI Report No. 1005400, December 2002.
5. EPRI. *Impacts of NO_x Controls on Mercury Controllability*. EPRI Report No. 1004000, March 2002.
6. EPRI, *Impacts of NO_x Controls on Mercury Controllability*. EPRI Update No. 1004268, March 2003.
7. EPRI, *Fate of Mercury in Combined Particulate and SO_2 Scrubbers*. EPRI Report No. 1004073, November 2001.

Figure 1 – Effect of SCRs on Mercury Speciation (Bituminous Coal-fired Sites)
Comparison of Mercury Speciation at SCR inlet and outlet

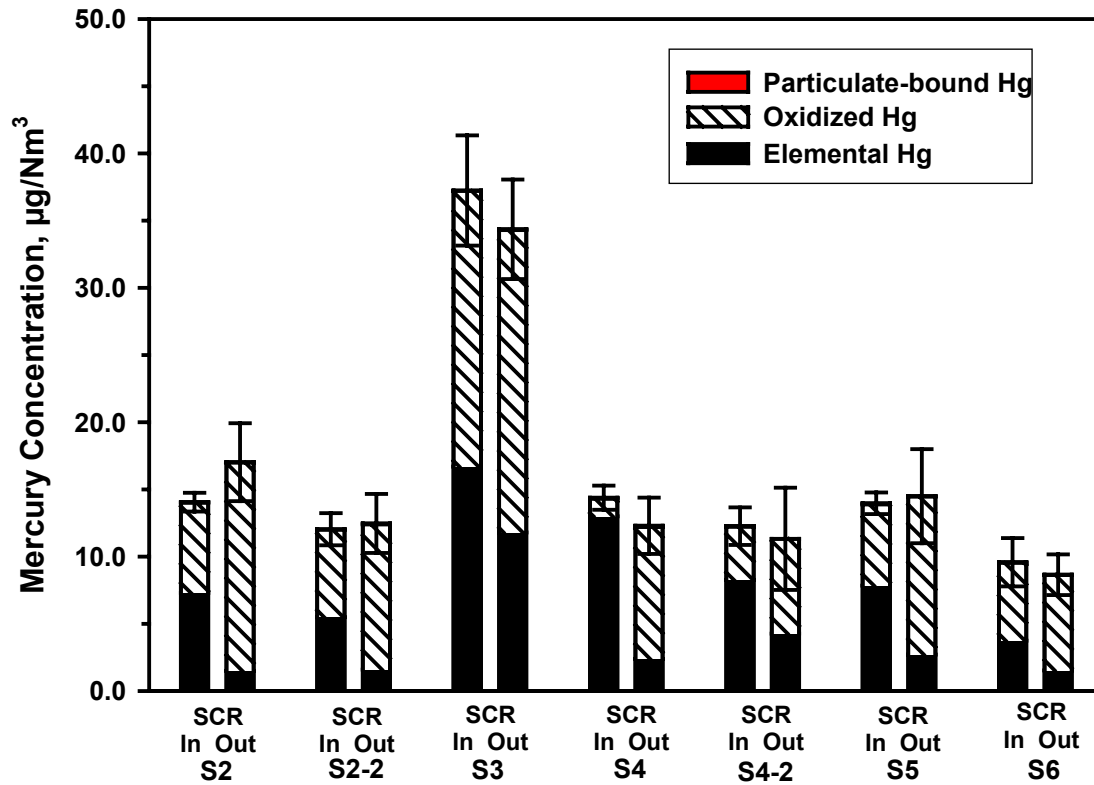


Figure 2 – Effect of SCRs on Mercury Speciation (Bituminous Coal-Fired Sites)
Comparison of Particulate Control Device (PCD) Inlet with SCR (left bar) and without SCR (right bar)

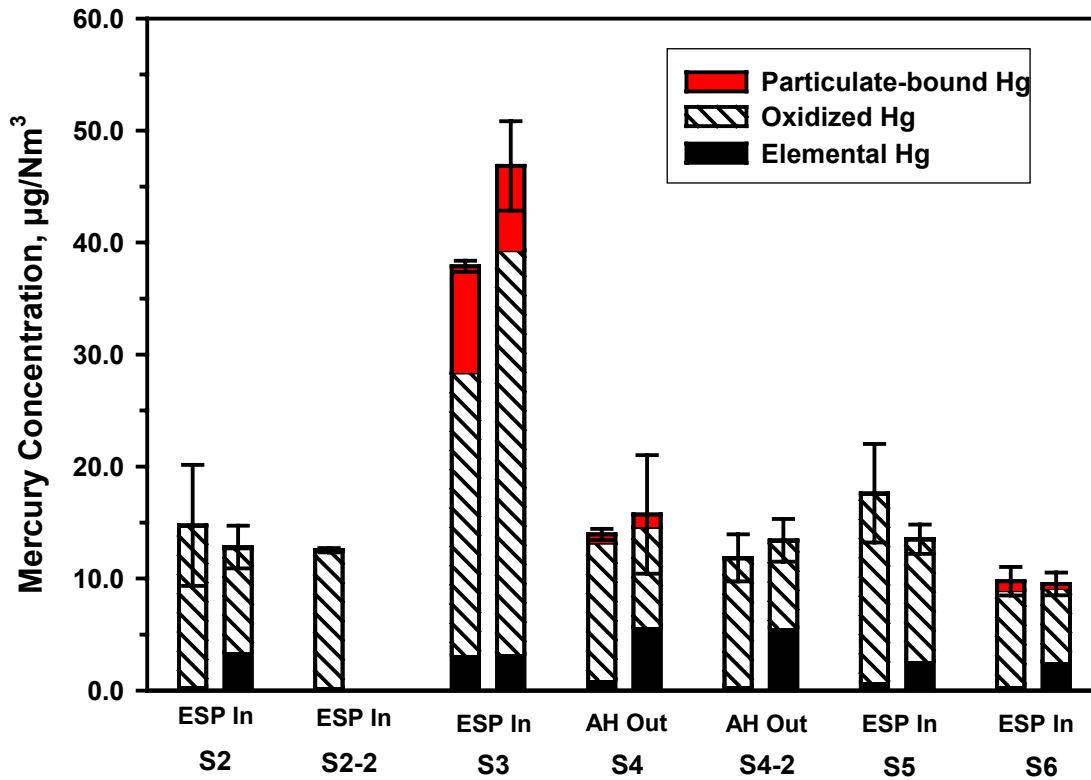


Figure 3 – Co-benefits of SCRs and FGDs on Mercury Emissions
 Comparison of Mercury Concentrations at PCD Inlet and FGD Outlet, with SCR (left bar) and without SCR (right bar)

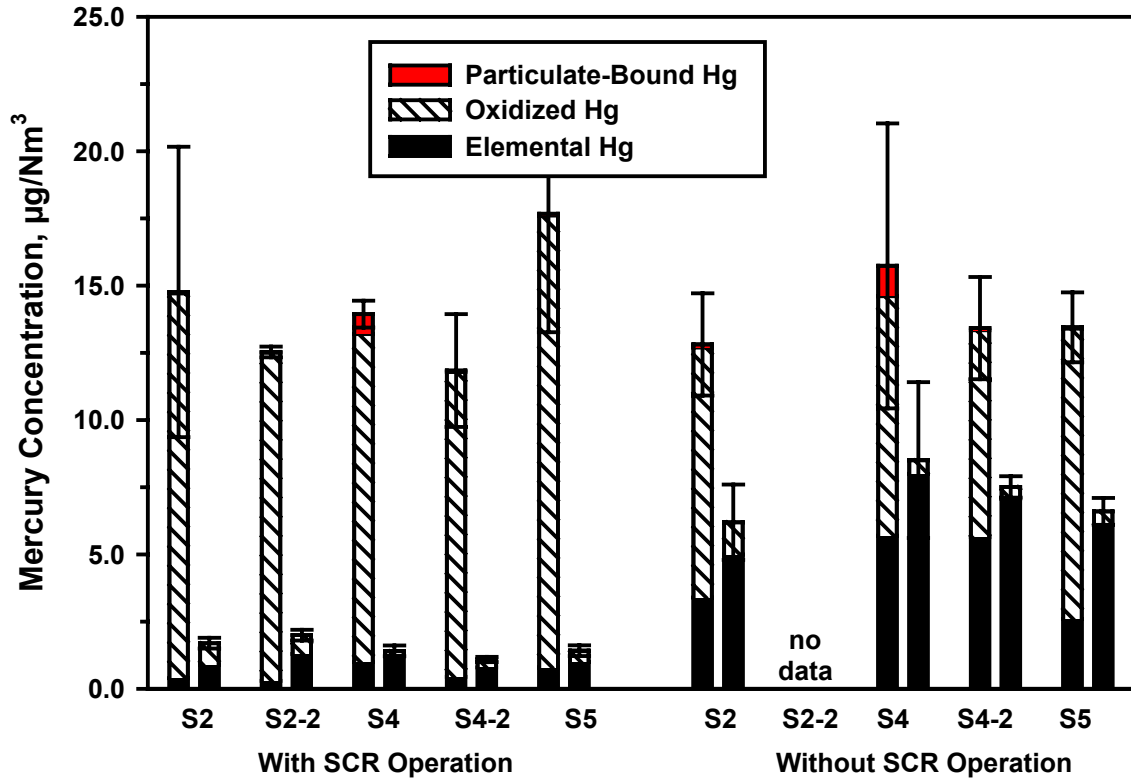
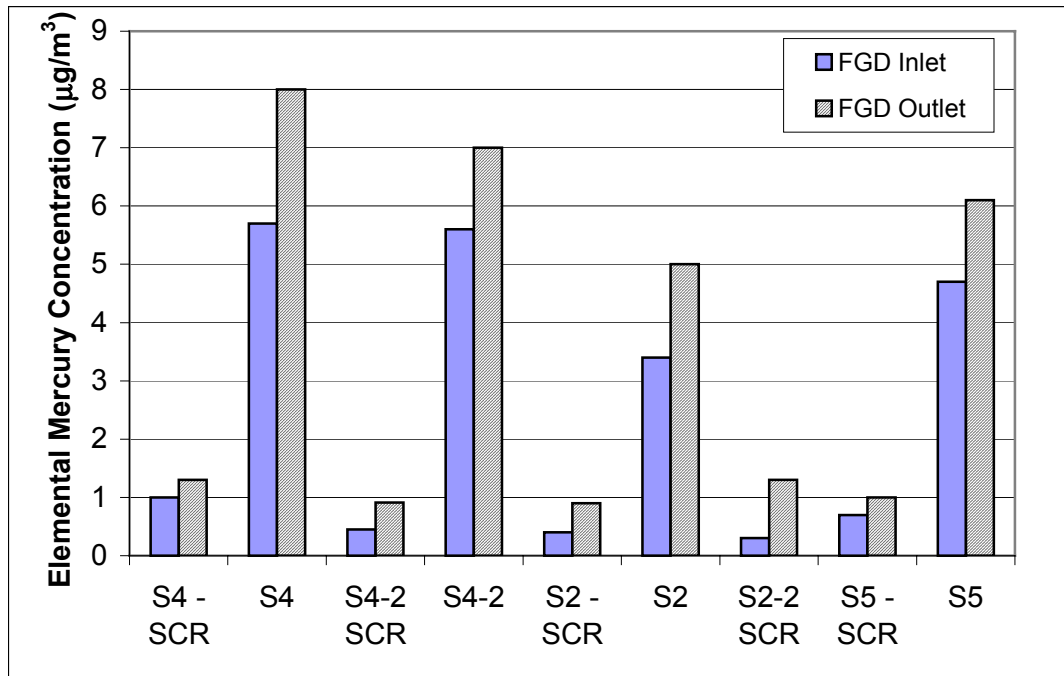


Figure 4 – Effect of SCRs on Mercury Re-emissions
Comparison of Elemental Mercury Concentrations at the FGD Inlet and Outlet, with and without SCR



Site S2 and S4 – FGD may not have reached steady-state for non-SCR tests
 Site S2 – ESP inlet was used since ESP outlet data appeared to be an outlier.
 Site S2-2, S4-2 – represents the retests in 2002.

Figure 5 – Effect of Catalyst Space Velocity on SCR Mercury Oxidation
 Comparison of Non-Elemental Mercury Concentrations at the SCR Inlet, SCR Outlet, and
 PCD Inlet (S2 and S4 space velocity $\sim 2000 \text{ hr}^{-1}$; S3, S5, and S6 space velocity $\sim 3800 \text{ hr}^{-1}$)

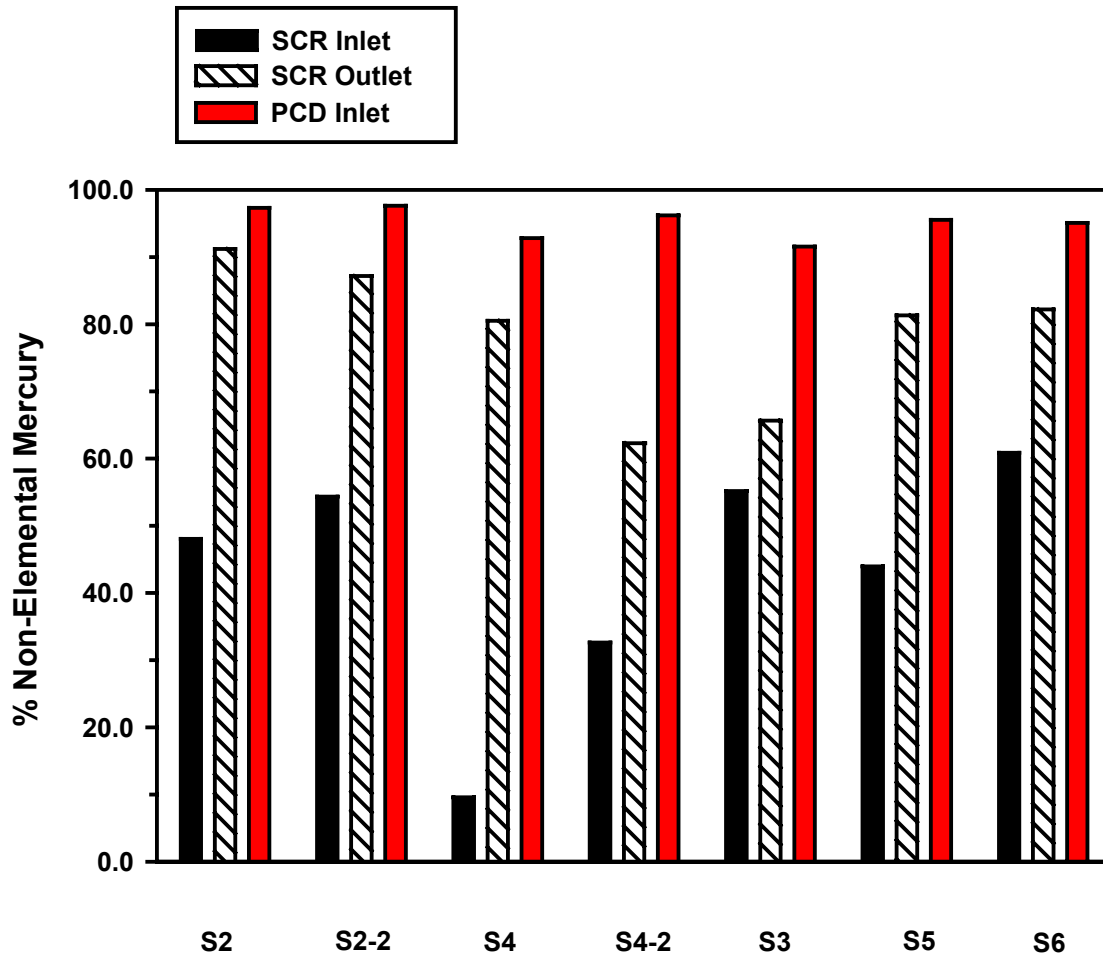


Figure 6 – Effect of Catalyst Operating Time on SCR Mercury Oxidation
Comparison of Non-Elemental Mercury Concentrations at the SCR Inlet, SCR Outlet, and
PCD Inlet

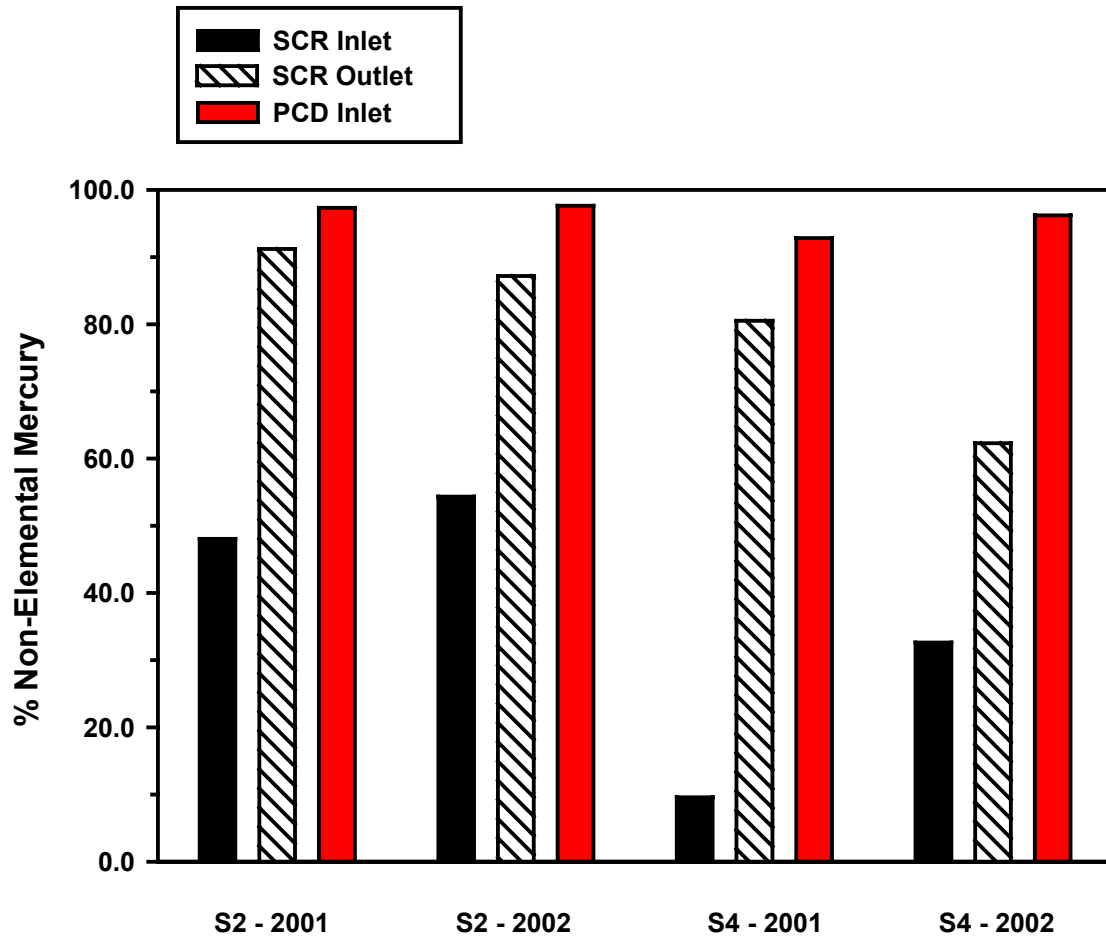
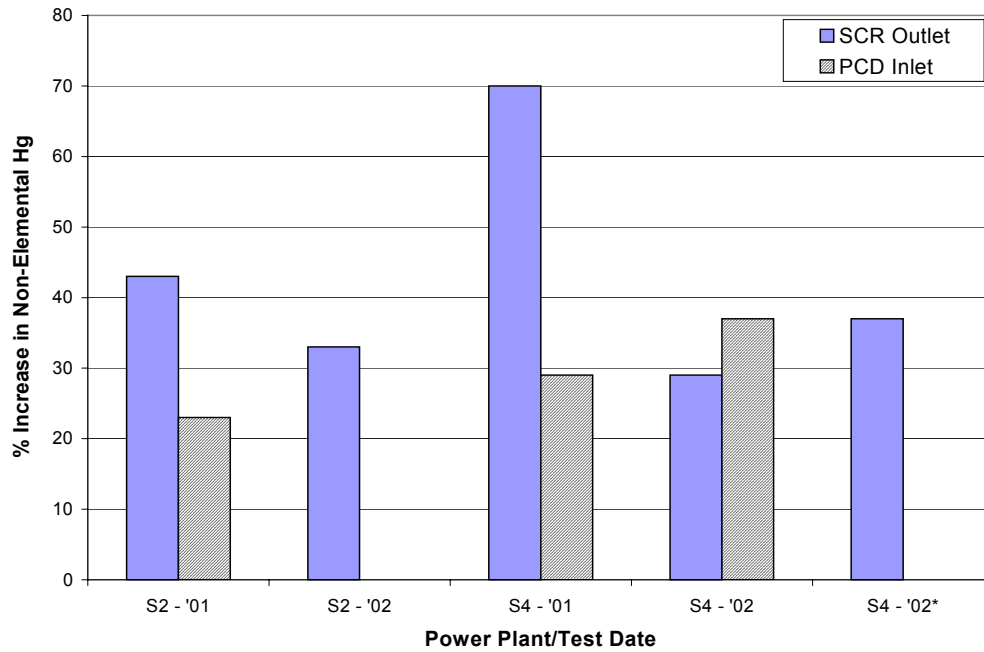


Figure 7 – Effect of Catalyst Operating Time on SCR Mercury Oxidation



* If one possible “outlier” data point at the SCR outlet is not included

SCR Outlet = Comparison of Non-Elemental Hg at SCR Outlet with and without SCR

PCD Inlet = Comparison of Non-Elemental Hg at Particulate Control Device Inlet with and without SCR