Does Size Really Matter?

And, should you be worried about PSD when using ACI?

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Abstract

Investigators have pondered whether or not ESP size has an impact on mercury capture by sorbent injection or deposition on fly ash. If important, ESP size would then have an impact on how effectively a power plant captures mercury and can comply with mercury control requirements. There are two possible elements to the impact of ESP size. First, does a larger ESP enable more mercury capture to occur within it? For example, does residence time or surface area within an ESP have an effect? Second, are there unwanted side effects for sorbent injection that will limit the ability to treat the flue gas? And, are these effects more significant for a "small" ESP than a large one? For example, will a "small" ESP be more likely to have increases in particle emissions, increases in ESP arc rate, or other adverse side effects? In this study we will examine published full-scale test results for answers to these questions and consider the implications for ESPs of practical design.

Introduction

The large majority of power plants are equipped with a cold-side ESP as the sole particle collection device. As companies begin to install carbon injection systems for the purpose of capturing mercury emissions from coal-fired power plants, many of the plants with cold-side ESPs subject to a stringent mercury control requirement that do not also scrub for SO2 are very likely to be considering the use of Sorbent Injection (SI) for capturing mercury. The ESP has a key role in mercury capture from SI because it is the ESP that captures the injected sorbent, and thereby the mercury. It is well known that ESP size – often measured in terms of specific collection area (SCA – normally in units of square feet of collection area times 1000 divided by

acfm of flue gas) or in terms of gas treatment time - is an important parameter in the particle collection efficiency of an ESP. So, it is worth considering if ESP size may impact mercury capture. Moreover, it is worth considering if the additional material being injected into the ESP actually has an adverse impact on ESP performance, which may put a limit to the amount of carbon that can be injected.

Will ESP Size Impact Mercury Capture?

It is widely acknowledged that mercury capture by SI will be impacted by:

- Sorbent injection concentration – typically measured in terms of lb of sorbent per million actual cubic feet of flue gas
- Coal characteristics, especially sulfur content, chlorine content, and unburned carbon in the fly ash
- Sorbent characteristics, including surface area and if the sorbent has been surface treated with a halogen or other compound to enhance oxidation

However, is it possible that larger ESPs will permit higher mercury removal rates through greater mercury capture within the ESP? Will the greater "treatment time" for sorbent-gas interaction in large ESPs provide the opportunity for more mercury capture? Will the greater surface area of the "large ESP" provide more capture surface for the mercury? This is examined in this paper by a review of theoretical studies and a comparison to actual test results.

Theoretical Study

Clack did examine this in a theoretical study.[1] In this study he examined potential mercury capture through mass transfer on the plates of the ESP through migration of the mercury to the sorbent deposited on the collection plate surface. He also examined capture by the sorbent within the ESP while in the entrained gas flow, and the subsequent capture of the sorbent by the ESP. The sorbent, of course could be injected sorbent or fly ash. In this study, some assumptions were made that are important to consider when evaluating the results.

- The sorbent particles had infinite capacity for capturing mercury

[1] Clack, H., "Mass Transfer Limitations to Mercury Capture within Electrostatic Precipitators", 9thAnnual EUEC Conference, January 22-26, 2006

- The mass transfer at the surface of the sorbent particle did not drop as the sorbent adsorbed mercury.

So in these respects the sorbents were "ideal" sorbents that offered potential performance well beyond what any real sorbent could provide. Therefore, the results of Clack's study should be considered "maximum" capture potential. Nevertheless, the results of his study provide useful insight to mercury capture mechanisms within an ESP.

Clack determined that capture of mercury by gaseous migration and capture on the sorbent that coats the collection plates for ESPs of any practical size should not exceed about 15%-20% or so. Since this is the most to expect for an ideal sorbent, for practical sorbents one would expect less capture.

However, Clack did determine that the potential capture of mercury by entrained sorbent particles that are subsequently captured by the ESP has far greater potential. Depending upon particle size characteristics (which affects surface mass transfer and migration velocity) and the energization level of the ESP (which affects migration velocity, or how quickly the sorbent is pulled out of the gas stream), the capture by this mechanism could be anywhere from a few percent to as much as about 80%. Figures 1a and 1b show the results of this analysis for 25 micron and 10 micron particles, respectively. Notably, in both cases virtually all of the mercury capture occurs within a treatment time of two seconds or less.

Figure 1. Maximum Mercury Capture within ESPs (by Clack)

Figure 1a. For 25 micron particles

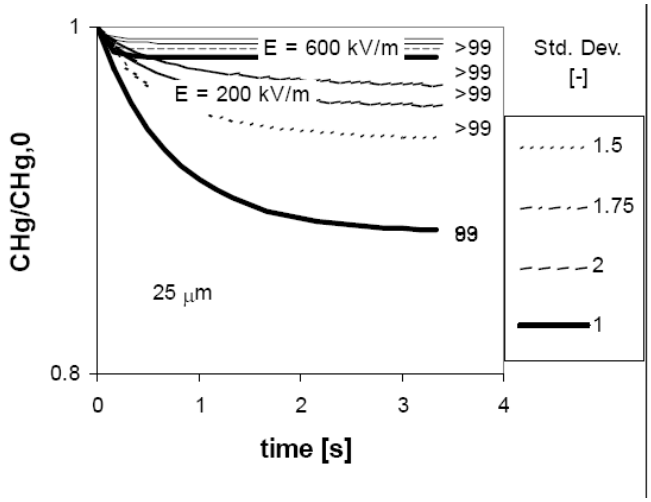


Figure 1b. For 10 micron particles

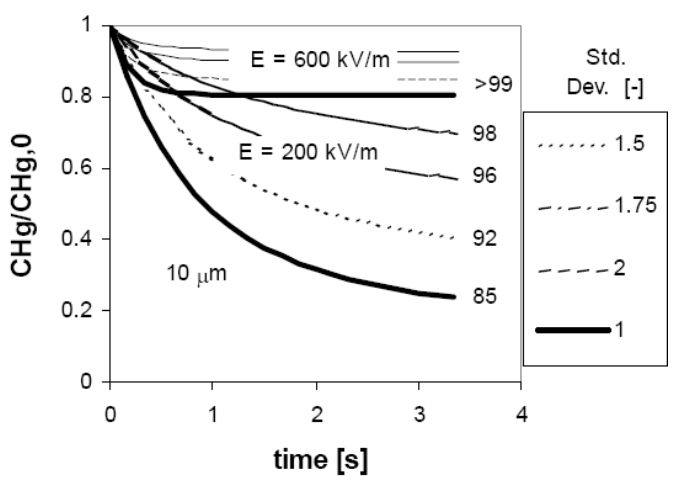


Table 1 is taken from a paper by Mastropietro. [2] As shown in Table 1, the smallest ESPs used in utility applications tend to have treatment times in the range of 2-4 seconds.

Table 1

ESP TREATMENT TIMES FOR UTILITY BOILERS

Date	Treatment Time Seconds
1940's	2-4
1950's	3-5
1960's	3-6
1970's	5-13
1980's-1990's	7-30

In another paper by Mastropietro, he offers an equation for estimating the treatment time in an ESP based on SCA.[3] For an ESP with 9 inch spacing, the treatment time is estimated to be equal to:

Treatment time (seconds) = SCA/44.4

For an ESP with an SCA of 100 square feet per 1000 acfm – roughly equal to the smallest ESPs in US coal-fired utility application – this equation predicts that the treatment time is about 2.25 seconds. ***Since theoretical analysis showed that nearly all of the mercury capture by the entrained sorbent particles in an ESP occurs within the first 2 seconds, this suggests that there is little or no advantage to having a larger ESP from the perspective of capturing mercury within the ESP. Moreover, even the smallest ESPs in the US should be capable of achieving high removal of mercury.***

[2] Mastropietro, R., "Achieving Low Particulate Emissions with Electrostatic Precipitators", ICAC Forum, March 22, 1994

[3] Mastropietro, R., "Use of Treatment Time and Emissions instead of SCA and Efficiency for Sizing Electrostatic Precipitators", Mega Symposium, August 29, 1997

Test Results

The most widely tested sorbent is powdered activated carbon (PAC), and this is the sorbent that is currently seeing commercial application. So, this paper will focus on this sorbent where there is ample data. This paper will also only examine injection upstream of a cold-side ESP, the most likely configuration. Configurations such as TOXECON II are not considered in this paper.

Brayton Point –

One of the first tests of carbon injection on US coal-fired power plants was at Brayton Point Unit 1, which was equipped with two ESPs in sequence – the first with an SCA of 156 and the second with an SCA of 403. In these tests the carbon was injected between the first and second ESPs, and continuous CEM measurements were made at four locations:

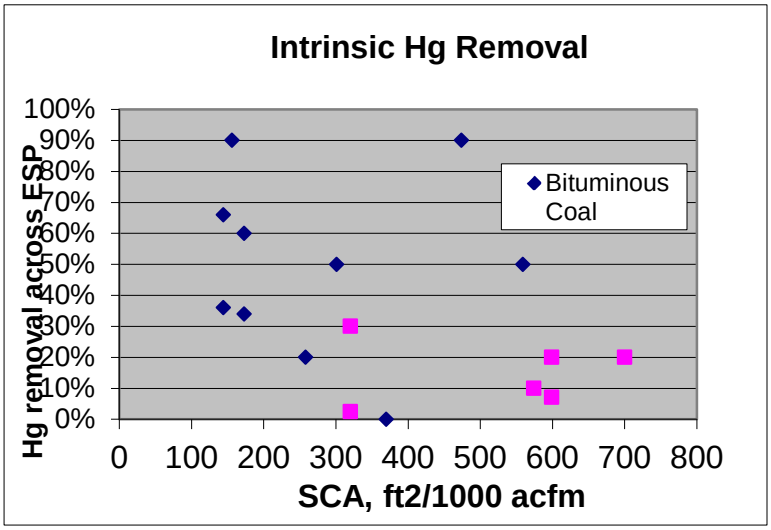
1. Upstream of the APH
2. Between the APH and the first ESP
3. Between the APH and the second ESP
4. After the second ESP

Baseline testing in June 2002 (before any carbon injection) showed 90.8% removal between points 1 and 4. There was no measured removal between points 3 and 4 without sorbent injection. In other words, at that time the first ESP, with an SCA of 156 was providing 90.8% removal based upon capture that was intrinsic to the fly ash. Intrinsic removal can be variable, depending upon boiler conditions and the coal being used. Previous tests showed lower baseline removals. Therefore, in this testing 90% removal was apparently achieved across an ESP that some would consider "small". No adverse impacts to the ESP were reported.[4]

[4] Travis Starns, Jean Bustard, Michael Durham Ph.D., Cam Martin, et. al, "Results of Activated Carbon Injection Upstream of Electrostatic Precipitators for Mercury Control, paper # 83, The Mega Symposium, 2003

Other test sites

Figure 2.



Data has been collected for intrinsic and total mercury capture from a number of tests. Intrinsic mercury capture is capture without any additional carbon injected. Total capture is the total capture across the ESP including both intrinsic capture and capture from additional carbon injection. The results plotted against the SCA of the ESP are shown in Figures 2 and 3 (data is shown in Tables at the end of the paper). As shown in Figure 2 there is no apparent trend in the intrinsic removal associated with ESP size except that the only real trend is that western coal units have less intrinsic removal than eastern coal units – not an unexpected trend.

Figure 3.

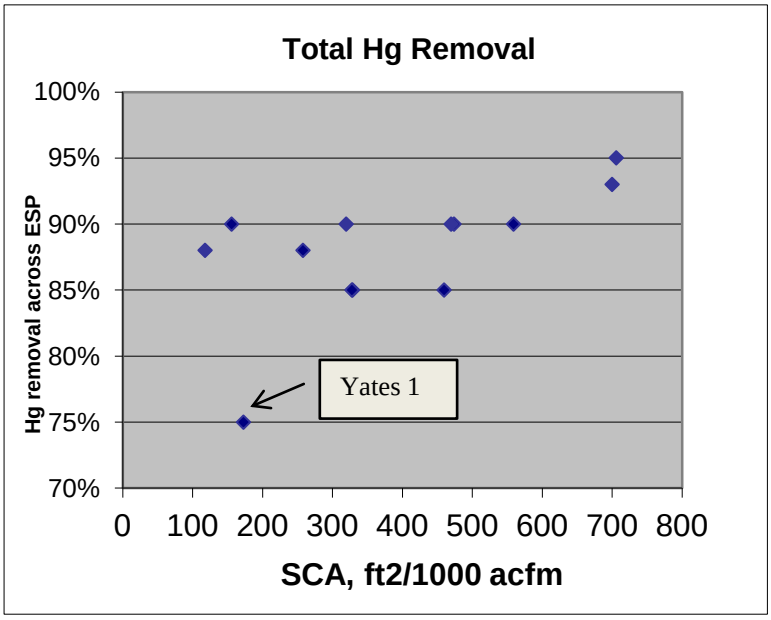
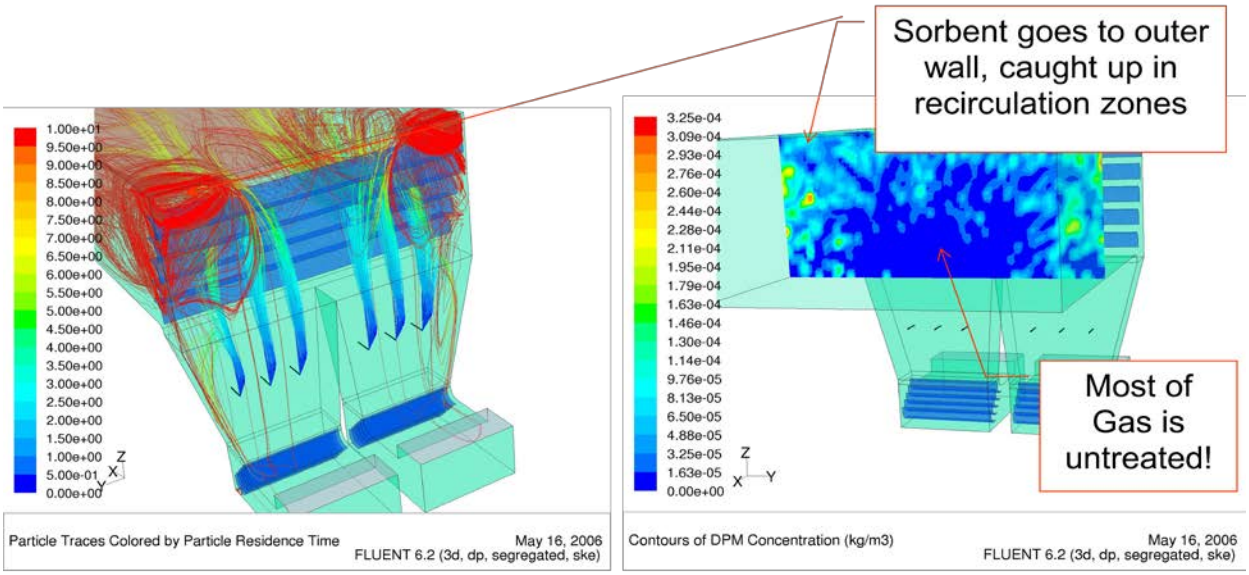


Figure 3 shows the total mercury capture at a number of test sites versus ESP size in SCA. Except for one program, all of the programs resulted in mercury capture of 85% or more. One program achieved 95% capture. However, this was a project on a low sulfur coal boiler with treated sorbent – an application where it is known that mercury capture can be high. The tests where about 85% removal was achieved were bituminous units – known to be somewhat more challenging than western coal units due to sulfur content of bituminous coal. The farthest left data point was with a "concrete friendly" carbon on PRB coal that was not expected to provide quite the reductions of a fully treated carbon One application showed only 75% total capture (on average – some tests had

slightly higher removal and some lower). This happened to be testing at Yates unit 1. Excluding for the moment the Yates 1 results, there is not a strong apparent trend in the relationship between total mercury capture and ESP size measured in SCA.

Yates 1 testing showed maximum capture rates attributed to the sorbent (not including intrinsic capture) of 55-60%. The poor removal at Yates 1 can be explained by poor sorbent distribution, as shown in Figure 4. Figure 4 is the result of modeling of the gas flow at the Yates 1 ESP inlet and the sorbent injection system. Yates 1's ESP has inlet ductwork with several turns. As shown in Figure 4, the flow field tends to force the sorbent to the outer edges of the duct, leaving much of the gas poorly treated. ***Hence, recognizing that the low capture at Yates 1 was a result of uneven sorbent distribution, Figure 3 shows no real trends in total capture as a function of ESP size. This is consistent with the theoretical analysis discussed earlier that suggested that ESP size should not affect mercury capture.***

Figure 4. Flow modeling results of injection at Yates 1[5]



- Maximum capture rates achieved during field tests: 55…60%
  - Removal plateaus at high feed rates
  - Similar results with three different sorbents (Darco-Hg, HOK, NH Carbon)
  - Yates burns Eastern bituminous coals (Cl-insufficiency not an explanation)

[5] Figure provided by Fluent, Inc.

Will Sorbent Injection Have an Adverse Impact on the ESP, Particularly a "Small" ESP?

Having determined that small ESPs should be capable of high removals, it is worth considering if a small ESP has potentially adverse impacts. Adverse impacts potentially unique to a "small" ESP could be in the form of:

- Equipment failure
- Increased arc rate (and reduction of ESP power levels)
- Increased ESP exit particle emissions or opacity
- Carbon carryover to downstream equipment

As noted earlier, in this paper we are focusing solely on injection upstream of a cold-side ESP. Other configurations – notably TOXECON II, where sorbent is injected between fields of an ESP – have been tested and have shown some impacts to the ESP performance. However, TOXECON II has some unique challenges that will not be examined here.

But, the concern is that small ESPs may be more challenged to provide good particle removal performance when additional material is injected into the ESP. Therefore, small ESPs might be more susceptible to some of the adverse impacts noted above. We will examine the test program where these problems were alleged to have occurred.

Testing at Yates Unit 1

One of the most widely publicized test programs, and one some have pointed at as an example of the adverse impact of carbon on "small" ESPs was the program at Yates Unit 1. All of the above adverse effects – equipment failure, increased arc rate, increased ESP emissions, and carbon carryover - were alleged to potentially be the result of carbon injection. Yates Unit 1 fires bituminous coal, has an ESP with an SCA of 175 square feet per kacf, and the ESP is followed by a Chiyoda Jet Bubbling Reactor for SO_2 capture. Baseline LOI at Yates was in the range of about 10%. The quarterly report published in July 2005 provides a fairly comprehensive compilation of data on this test program.[6] While the data speaks for itself,

[6] Richardson, C., "Sorbent Injection for Small ESP Mercury Control in Low Sulfur Eastern Bituminous Coal Flue Gas" Quarterly Technical Progress Report, April 1– June 30, 2005, July 2005

different conclusions might be drawn from analysis of the data. We will examine each of the alleged failure modes at Yates Unit 1 and provide independent analysis.

Equipment Failure – After short-term testing of carbon injection in spring 2004, an inspection of the ESP found a damaged insulator. Since the ESP was not inspected immediately prior to short term testing, it was unclear if the carbon injection contributed to the failure or if the failure even occurred during carbon injection. However, during subsequent long-term testing – late 2004 to early 2005, no insulator failures were found (inspections were performed before and after the tests). If short-term testing of carbon contributed to failure of ESP insulators, then one would naturally expect carbon injection to cause failures during long-term testing. Since long-term carbon testing did not cause insulator failure, it is safe to say that the failure during the short-term test was not likely due to carbon injection. Insulators do occasionally fail, and the largest source of carbon in the Yates 1 ESP was actually the carbon in the fly ash. This author is not aware of any other alleged ESP failures due to carbon injection at any other test sites.

Increased Arc Rate – It is not unusual for arc rate of an ESP to increase as load, and the particle mass to the ESP, increases. Arc rate can be affected by other things as well – alignment of equipment, particle loading, etc. Testing at Yates showed that as load increased, arc rate increased. Figures 5 and 6 are taken from the July 2005 quarterly report, and these figures in the report differ from what was presented in meetings on Yates 1 in that the load is shown here.[7] As shown in Figures 5 and 6 (which include annotations that I have added), which are figures that show load, opacity, arc rate and carbon injection rate, arc rate and opacity increases with load (this is reported in the quarterly report), even during periods when carbon is not injected. This is an expected trend – as both the mass of material the ESP sees per unit time is increased while the gas treatment time in the ESP is reduced as load increases. The relationship between load and arc rate (and opacity) is quite clear. But, in light of the clear relationship between load and arc rate, it is hard to discern any additional relationship between carbon injection rate and arc rate.

The July 2003 test report also indicated that arcing was erratic, and in fact the arcing in field A stopped altogether in January despite carbon injection, as is apparent in Figure 6. Clearly, something besides activated carbon injection was contributing to arc rate.

[7] Dombrowski, K., Richardson, C., "Sorbent Injection for Small ESP Mercury Control in Bituminous Coal Flue Gas", DOE/NETL's Mercury Control Technology R&D Program Review, Pittsburgh, PA, July 12-13, 2005

Figure 5. Load, A field Arc Rate (APM), Carbon Injection Rate and Opacity at Yates 1 (from July 2005 Report with annotation)

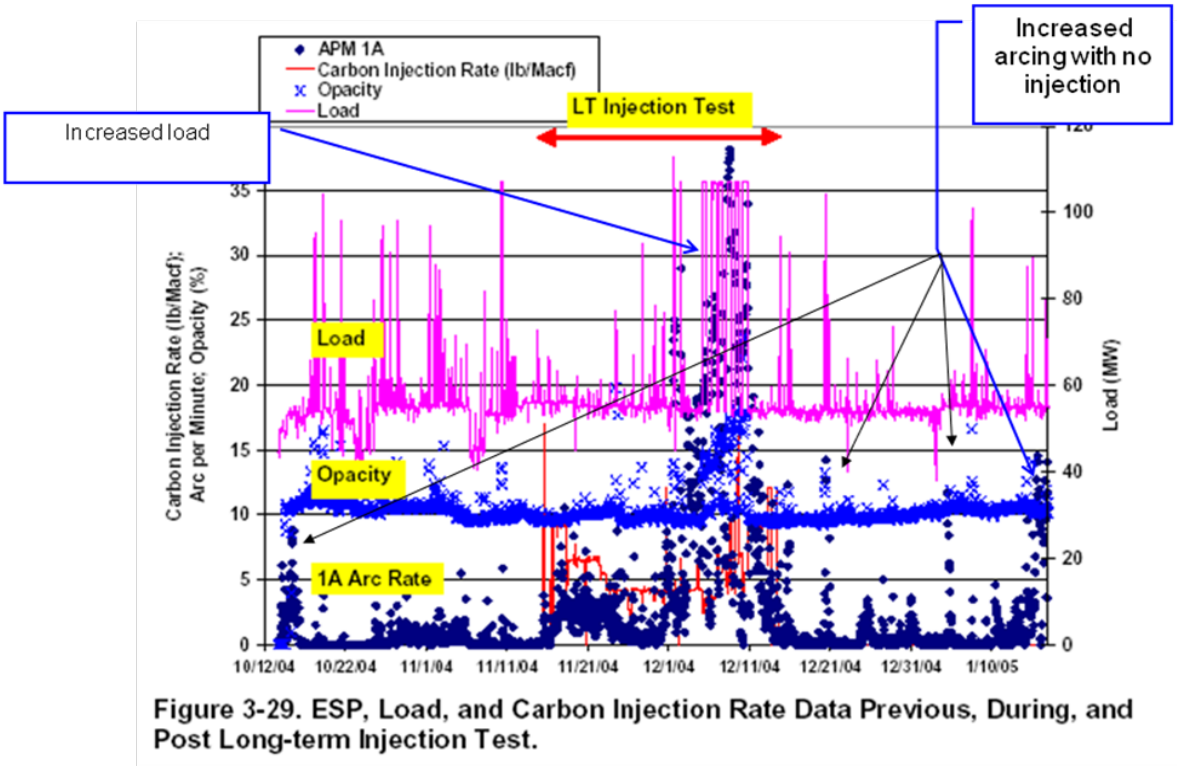
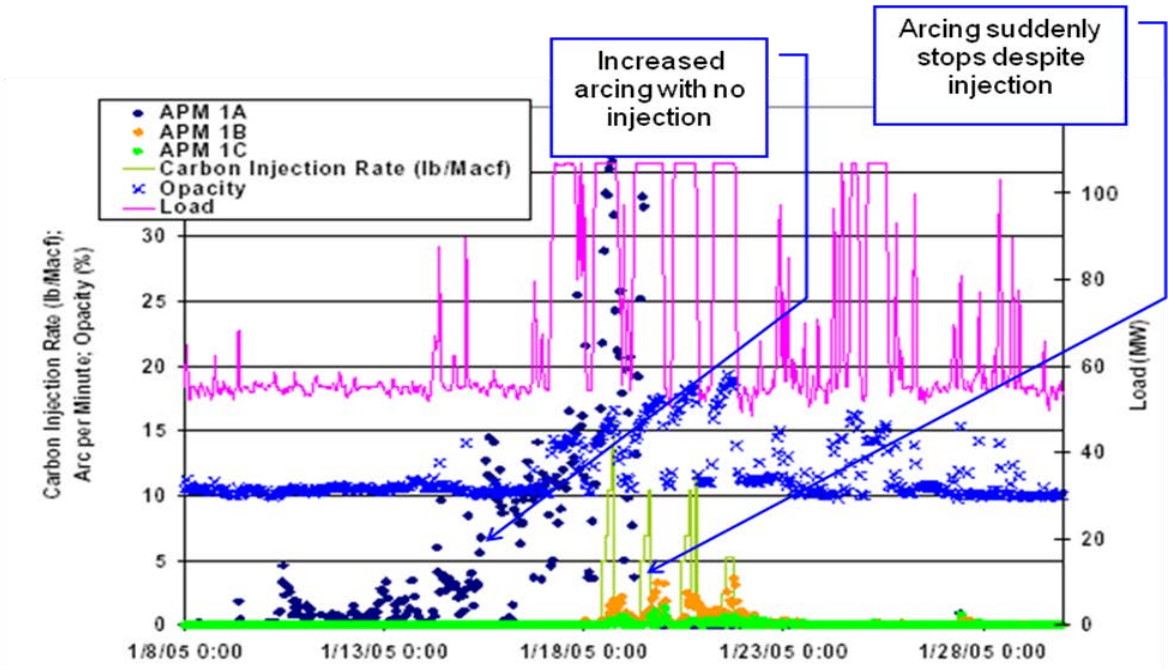


Figure 3-29. ESP, Load, and Carbon Injection Rate Data Previous, During, and Post Long-term Injection Test.

Figure 6. Load, Arc Rate (APM) for A, B, C fields, Carbon Injection Rate and Opacity at Yates 1 (January 2005 testing), from July 2005 Report with annotation



Increased ESP exit particle emissions or opacity – Increases in PM emissions were not experienced during the short-term testing in early 2004. But, subsequent testing in late 2004 found a wider scatter of measured Method 17 emissions, as shown in Figure 7. Counting the points on this figure, 6 points are below the "baseline" measurements, 6 points are above the "baseline" measurements, and 8 points are within the "baseline" measurements – no apparent trend. Analysis of this representation of data with regression to determine the strength of the relationship between outlet concentration and treatment rate shows an R-squared of only 0.07 – no apparent relationship. A log plot of the same data in Figure 8 shows an even lower correlation – about 0.01. The wide scatter with no apparent trend and very low R-squared shows that activated carbon is not a significant contributor to increased PM concentrations. The wide scatter about the "baseline" is possibly the result of the baseline being taken several months prior – under somewhat different firing conditions with a somewhat different coal. But the "high" particulate concentrations are most likely the result of something other than carbon injection.

Figure 7. Yates 1 Method 17 PM Measurements versus Carbon Injection Rate (from July 2005 Report)

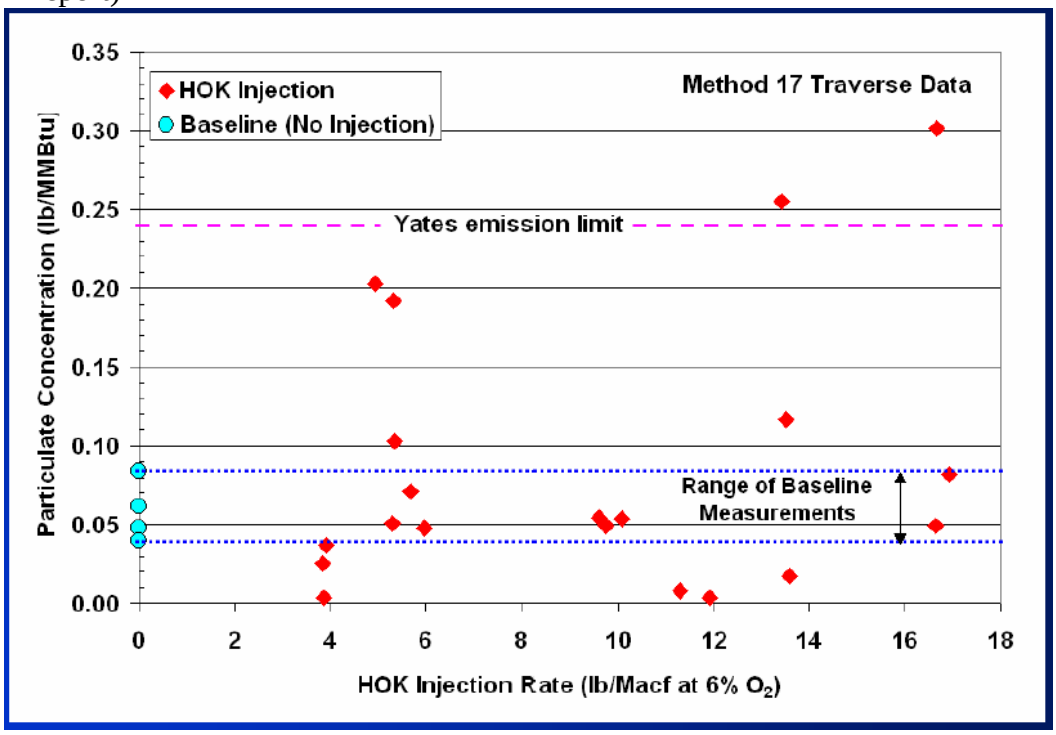
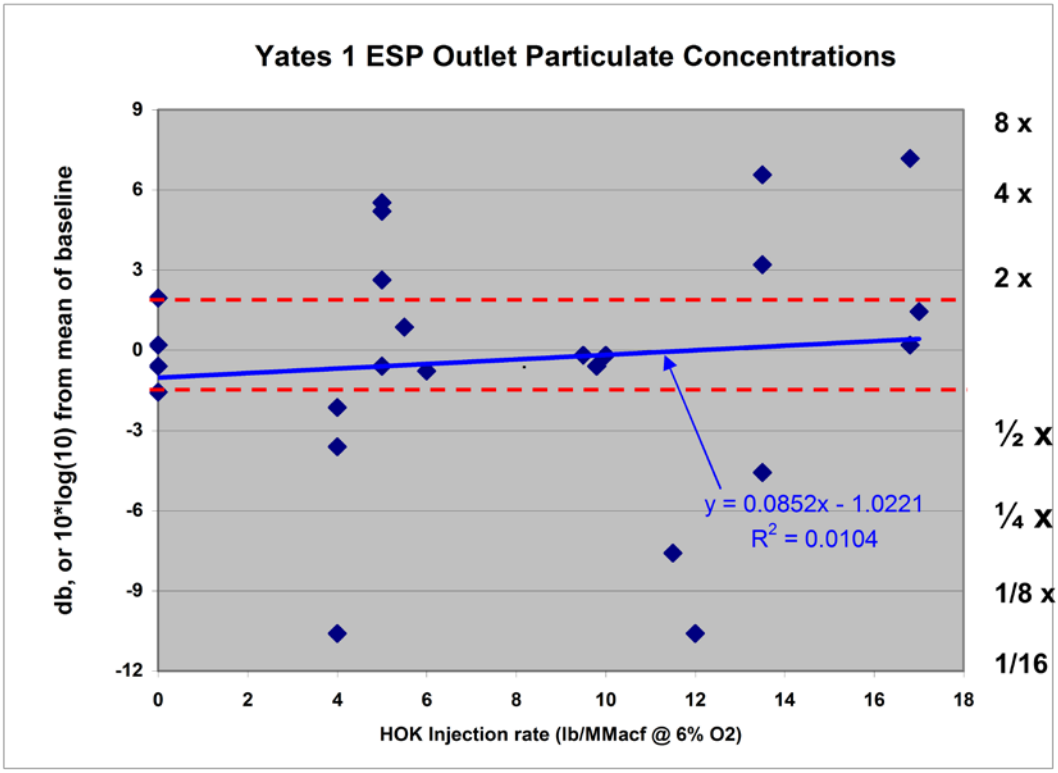
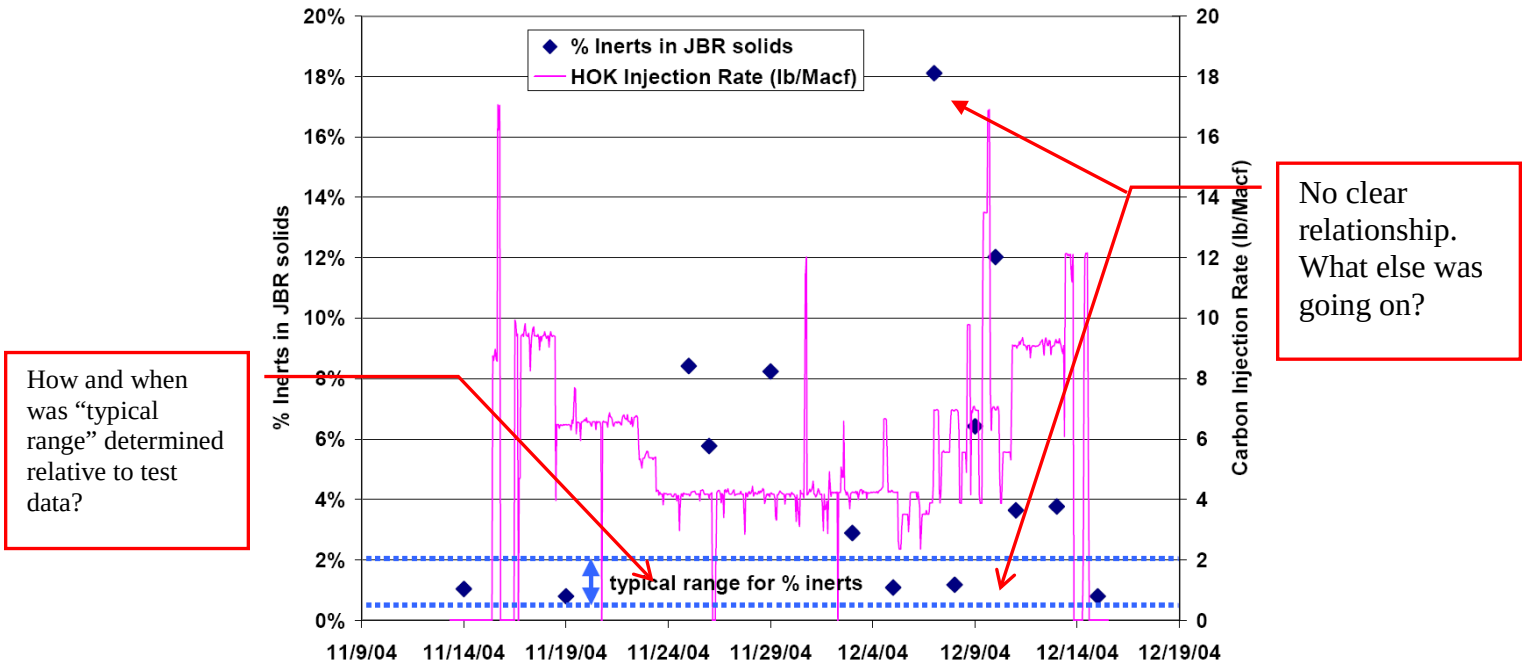


Figure 8. Yates 1 Method 17 PM Measurements versus Carbon Injection Rate plotted in Log Scale



Carbon carryover to downstream equipment – Carbon carryover to downstream equipment, particularly the JBL scrubber, was also observed at Yates 1. This was apparently manifested as darkness in JBL solids and as measured inerts in the JBL solids. The investigators attributed the carbon carryover to the activated carbon. Such an opinion is puzzling in light of the fact that Yates 1 had about 10% LOI and the activated carbon was therefore never more than a small fraction of the total carbon in the gas flow. Figure 9 shows a comparison of measured inerts in JBL solids versus activated carbon injection rate. I have added annotations. There is no apparent trend between injection rate and measured inerts. If activated carbon did contribute to inerts in JBL solids, some relationship other than the scattered relationship would exist. Moreover, it is unclear how and when the "typical range" was determined. It may have been determined from design specifications rather than testing. If it was determined by testing, it may have been determined months before during the "baseline" testing. In any event, there is no apparent trend other than a wide scatter of values that appears to be independent of carbon injection rate.

Figure 9. Yates 1 FGD Inerts Analysis (from July 2005 Report)



The July 2005 report also states that:

"As mentioned in the previous section, activated carbon broke through the ESP during the long-term test period. This carbon was observed in samples of the JBR scrubber slurry. During the period of 25 November through 10 December the scrubber slurry was observed to be either black or dark in color. During this time period, the carbon injection rate typically ranged from 4 - 6 lb/Macf (with a few, brief periods at higher rates). Prior to and subsequent to this time period, the scrubber slurry did not show any visual evidence of carbon contamination. ***After December 10, the carbon injection rate was as high as 12 lb/Macf, yet no further darkening was observed****." (emphasis added)*

This paragraph begs the following questions:

- If activated carbon was the source of the darkened JBR scrubber slurry, why would there be no darkening at high carbon injection rates (12 lb/mmacf) but there was darkening at lower carbon injection rates (4-6 lb/mmacf)?
- What, besides activated carbon, might contribute to the darkening?

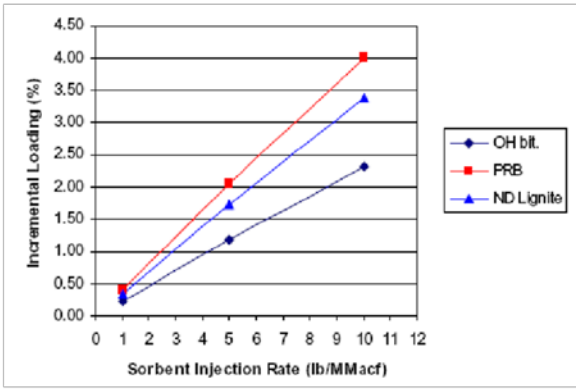
The answer to the first question is that there is likely another cause of the darkening. To answer the second question, one should consider that activated carbon was only a small fraction of the total carbon entering the Yates 1 ESP. Figure 10 shows LOI measurements for Yates 1 (from the July 2005 Report) and Figure 10 also shows a graph by US EPA of total percent

contribution to carbon for typical coals.[8] With LOI of about 10%, activated carbon (see table in Figure 10) at 5 lb/MMacf the activated carbon contributes to only about 1/10th of the total carbon (about 1% versus 10%). And at injection rates of 12 lb/MMacf it contributes only about 1/5th to 1/4th of the total carbon. Calculations using Yates 1 ESP gas flows and fuel analysis data show similar results. In other words, the carbon intrinsic to the ash was far greater than what was being added by the activated carbon.

Figure 10. Table showing LOI during Yates 1 (July 2005 report) testing and a figure from Refercnce 8 showing the typical incremental loading to fly ash of sorbent injection.

Table 3-8. Unit 1 – Bottom Ash and ESP Fly Ash Analyses for Baseline Characterization and Sorbent Injection (SI) Tests

Date	Time	Sample Type	Test Condition	Injection Rate (lb/MMacf)	Mercury (µg/g)	LOI (%)
2/24	13:15	ESP ash	Baseline	0	0.31	11.8
2/25	9:46	ESP ash	Baseline	0	0.26	9.9
2/25	13:10	ESP ash	Baseline	0	0.28	10.2
2/26	10:00	ESP ash	Baseline	0	0.33	12.8
2/26	13:00	Bottom Ash	Baseline	0	0.003	0.44
3/1	11:00	ESP ash	Darco FGD™ SI	6.3	0.32	12.8
3/2	13:30	ESP ash	Darco FGD™ SI	12.7	0.25	7.2
3/3	13:35	ESP ash	Darco FGD™ SI	4.2	0.27	8.5
3/4	13:30	ESP ash	Darco FGD™ SI	7.3	0.25	6.8
3/29	13:20	ESP ash	NH Carbon SI	4.2	0.182	7.97
3/30	13:20	ESP ash	NH Carbon SI	12.5	0.337	9.46
4/6	13:30	ESP ash	Super HOK SI	12.9	0.510	13.71
4/7	13:20	ESP ash	Super HOK SI	3.3	0.353	11.41



If activated carbon was not the culprit, what was? The only explanation for the behavior of the carbon in the scrubber slurry, and inerts in the JBL solids is that the carbon is from the inherent LOI in the fly ash. It is the biggest source of carbon – by far. According to the July 2003 report, "*There was no apparent increase in the carbon content of the ESP fly ash, as measured by percent LOI, for the activated carbon injection tests compared to the baseline tests.*" This, of course, is because there is much more carbon from the inherent LOI than from the additional activated carbon. And, depending upon the specific combustion conditions in the furnace and the specific conditions of the coal, LOI will vary somewhat (see Fig. 10). Even a

[8] U.S. Environmental Protection Agency, 2005, Air Pollution Prevention and Control Division, National Risk Management Research Laboratory, Office of Research and Develoment, "Control of Mercury Emissions from Coal Fired Electric Utility Boilers: An Update", Research Triangle Park, NC, February 18, 2005.

relatively small variation in LOI will exceed the contribution by activated carbon injection. LOI may very well have also been a contributor to the variability in PM at the exit of the ESP.

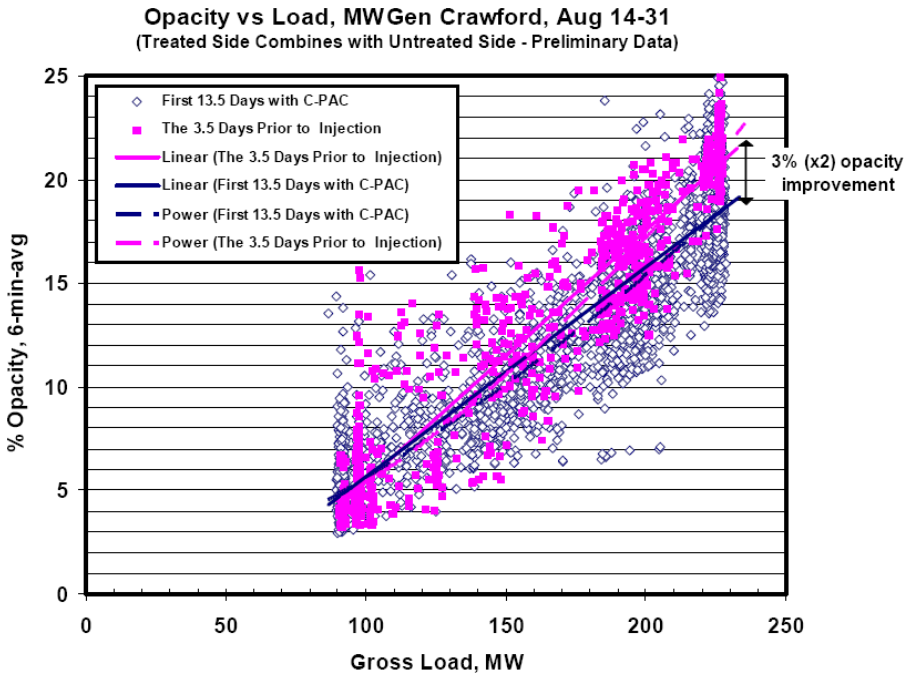
Summary of Yates 1 Results

The Yates 1 test results, carefully scrutinized, do not show adverse side effects attributable to activated carbon injection. For each of the issues alledged by some to be attributed to activated carbon – insulator failure, increased ESP arcing, PM emissions, and carbon carryover to the downstream equipment – there are other, more plausible explanations than activated carbon injection. In this author's opinion, each of these would very likely have happened regardless of any activated carbon injection. However, they might not have been observed were it not for the increased attention given to the plant during activated carbon testing. In fact, at the same plant – Yates Unit 6, a unit with a smaller ESP (SCA = 140) - showed no adverse impact from short-term activated carbon injection (see Reference 7).

Testing at Crawford

With an SCA of 118, Midwest Generating's Crawford Unit 7 is one of the smallest ESPs in the United States on coal-fired boilers, based on SCA as an indicator of size. Testing of brominated activated carbon at Crawford 7 (**DOE NETL Project DE-FC26-05NT42308)** showed high levels of mercury removal (75% to nearly 90%) with 3-5 lb/MMacf injection and no adverse impact to opacity. Figure 11 compares opacity versus load

Figure 11. Opacity Versus Load at Crawford Unit 7



for the 3.5 days prior to injection to the opacity versus load for the 13.5 days of carbon injection. There is certainly no adverse impact on opacity for this small ESP and, arguably, perhaps even a slight improvement.[9]

Therefore, a high removal rate with no adverse side effects was achieved at one of the smallest ESPs on coal-fired boilers in the United States.

And, with regard to the issue of PSD, I am very skeptical that PSD will be a problem for anyone using ACI. First, industry has been understandably concerned about this for years. After all of those DOE tests there isn't any data to show a problem of increased outlet emissions for ACI upstream of an ESP (Toxecon II is another issue). Much of the concern over PSD is due to the fact that many people mistakenly think of ESPs as constant percent removal devices. That is, a % increase in inlet loading results in an equivalent % increase in outlet emissions. However, the outlet emissions of ESPs are relatively insensitive to modest variations in inlet loading. This is because the outlet emissions of an ESP are mostly from reentrainment losses rather than from particles that pass through the device without ever being collected on a plate.

[9] This "slight" improvement has been speculated to be related to the possible "conditioning" effect of this type of brominated activated carbon that may improve resistivity characteristics of the fly ash.

Conclusions

This paper examined two important questions relating to ESP size and mercury capture from power plants equipped with cold-side ESPs. The answers to these questions impact whether or not ESP size has an impact on how effectively a power plant captures mercury and can comply with mercury control requirements.

- First, does a larger ESP enable more mercury capture to occur within it? For example, does residence time or surface area within an ESP have an effect?
- Second, are there unwanted side effects for sorbent injection that will limit the ability to treat the flue gas? And, are these effects more significant for a "small" ESP than a large one? For example, will a "small" ESP be more likely to have increases in particle emissions, increases in ESP arc rate, or other adverse side effects?

To the first question, both a theoretical analysis and analysis of the data from test programs shows that for ESPs of practical design there is no advantage to having a "large" versus a "small" ESP. For ESPs of practical design, the removal of mercury is completed within the treatment time of even the smallest ESPs.

With regard to the second question, performance of small ESPs do not appear to be adversely impacted for the treatment rates anticipated in practical activated carbon injection applications. ESPs, even "small" ones, are designed to handle far larger quantities of material than is added from activated carbon injection for the purpose of mercury control. In fact, for many ESPs there is significantly more carbon already in the fly ash than would be added by injection of activated carbon for the purpose of mercury capture. During any test of a new power plant technology, sensitivity to adverse impacts to equipment is naturally heightened. And, it is important during these tests to make an effort to distinguish adverse impacts directly related to the application of the technology from events that would result during normal operation.

Acknowledgments

Most of the analysis performed in support of this paper was performed in 2006 while the author was assisting the Illinois EPA with their power plant mercury control rule. The opinions expressed in this paper are those of the author.

Data used in Figures 2 and 3

Intrinsic Removal

Plant	SCA	Removal
Salem	474	0.9
Brayton June '02	156	0.9
Brayton previous	559	0.5
Yates 1 avg	173	0.34
Yates 1 hi	173	0.6
Yates 2 avg	144	0.36
Yates 2 hi	144	0.66
Monroe	258	0.2
Lausche	370	0
Conesville	301	0.5

Total Removal

Plant	SCA	Removal
Allen	460	0.85
Salem	474	0.9
Yates 1 avg	173	0.75
Monroe	258	0.88
Brayton previous	559	0.9
Lee	329	0.85
Yates 6	328	0.85
Brayton baseline	156	0.9
Dave Johnson	706	0.95
St Clair	700	0.93
Stanton	470	0.9
Leland Olds	320	0.9
Crawford	118	0.88