Mercury Emission Control Evaluation at Progress Energy's Lee Station

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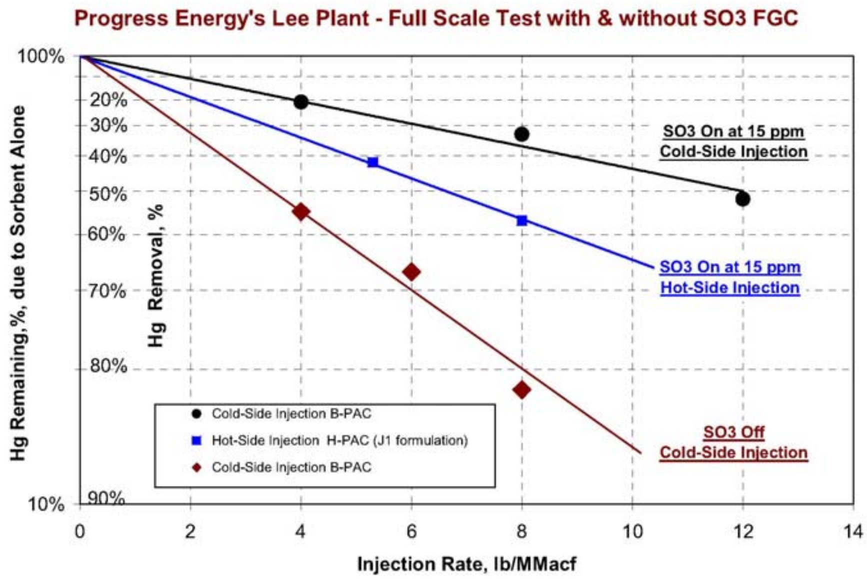
Progress Energy, headquartered in Raleigh, N.C., is a Fortune 250 diversified energy company with more than 23,000 megawatts of generation capacity. The company includes two electric utilities serving approximately 3.1 million customers in North Carolina, South Carolina and Florida. The company has a diverse mix of generation resources, including nuclear, coal and oil-fired, natural gas-fueled and hydroelectric plants.
The 23 coal-fired units range in size from under 50MW to over 700MW. Each of these units is an important contributor to the overall generation portfolio, but the wide range of boiler sizes and ages present unique challenges with regards to controlling Mercury (Hg) emissions and managing combustion products. While the large coal units are expected to achieve significant Hg reductions as a co-benefit from the installation of flue gas desulfurization (FGD) systems, the primary Hg control technology considered for the smaller units is sorbent injection prior to the electro static precipitator (ESP).
One possible sorbent, Toxecon (TM EPRI), requires significant capital costs and O&M costs from the installation and operation of a bag-house particulate collection device. Therefore it was not considered economically practical for use on smaller, older units. Sorbent Technologies Corporation (STC) is the developer and manufacturer of a family of brominated activated carbon mercury sorbents that do not require additional particulate collection devices aside from the ESP. Therefore, these sorbents were selected for the testing at the Lee plant.

Lee Unit 1:

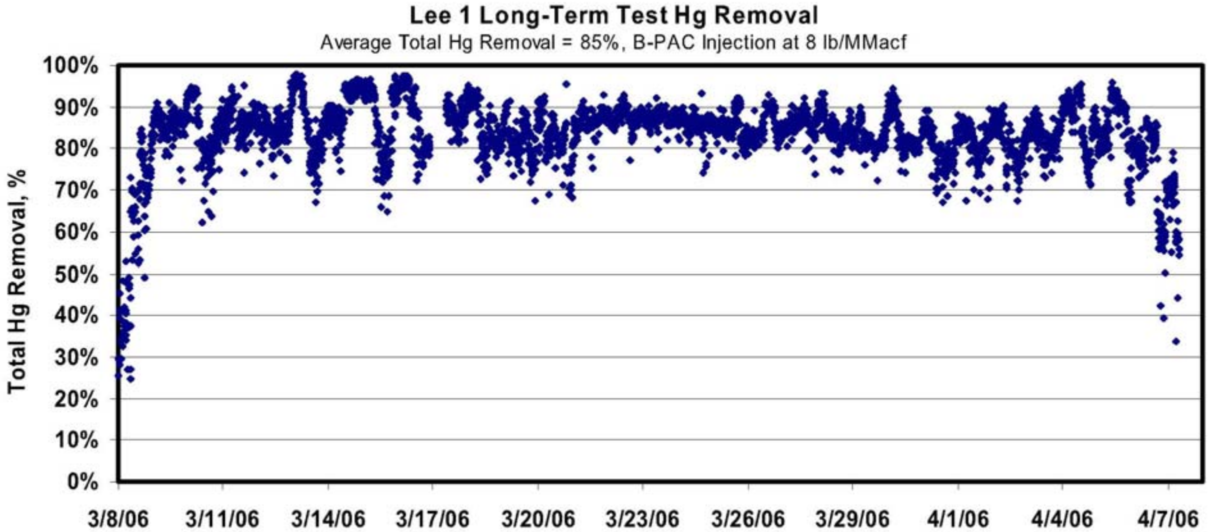
Unit #1 was built in the early 1950's and has a gross capacity of approximately 84 MW. The boiler is tangentially fired and primarily uses low sulfur (0.8% as received) bituminous coal from the Eastern United States. The unit is equipped with a cold-side ESP for particulate control. SO3 injection is used to condition the fly ash to modify its resistivity and improve ESP performance.

During the initial, short-duration testing on Unit #1, sorbent was injected at two locations. The first location is referred to as the cold-side and is in the ductwork after the air preheater and before the ESP (note that "cold-side" here refers to the injection point, not the ESP location). The second injection location is referred to as hot-side and is upstream of the air preheater and the location at which the SO3 is injected. The tests were performed both with and without SO3 injection in order to determine the impact on the mercury sorbent performance. There is some evidence that the sorbent may unintentionally capture SO3 and be rendered less effective for mercury capture. For the cold-side injection, the sorbent injection provided the expected high mercury removal when the SO3 injection was turned off. However, operation with the SO3 injection turned on, greatly reduced the mercury sorbent performance.

Sorbent injected on the hot-side of the air preheater appeared to be independent of the SO3 injection and provided better mercury removal than with injecting on the cold-side with SO3 injection (although not nearly as good as on the cold-side without SO3 injection).



Following the initial short-duration testing, a long-term test was conducted on Unit #1 without SO3 injection and with the sorbent injected on the cold-side of the air preheater. The total mercury removal for the 30-day long-term test, excluding the first day (during which SO3 was injected), averaged 85%.



Lee Unit 2:

Unit #2, like Unit #1, was built in the early 1950's. It has a gross capacity of approximately 80 MW and uses low sulfur (0.8% as received) bituminous coal from the Eastern United States. The unit is equipped with a hot-side ESP for particulate control. High temperature sorbent was injected in the ductwork before the ESP. The testing was performed in February of 2007 with multiple sorbent injection rates at both high and low load conditions. Since the mercury capture rate in hot-side ESP's is typically less than that in cold-side ESP's, the target Hg capture rate was between 50% and 70%. Additional data will be presented at the conference on this matter.

Deleterious Effects (and how to avoid them) of Sorbent use on fly ash utilization

Outside the scope of the DOE study, Progress Materials, Inc. (PMI) evaluated the impact of the activated carbon sorbent and captured mercury on the ash.

PMI obtained several samples of ash recovered from the Lee Plant while injecting activated carbon sorbents into the flue gas stream. Samples were taken from both the hot side and cold side electrostatic precipitators (ESP). Cold-side samples were taken from the Unit #1 ESP and hot-side samples taken from the Unit #2 ESP. All of the samples were tested for sorbent effects on fly ash usability and then processed using the Carbon Burn-Out (CBO) beneficiation technology at the pilot plant in Crystal River, Florida.

This series of tests was performed to determine the effect of Activated Carbon in coal ash, when injected into the duct work before the hot-side or cold-side of the ESP.

Several different types of activated carbon were injected during both the hot and cold side testing periods. Activated Carbon is generally very reactive, and even in very low concentrations is known to cause adverse results in the air entrainment characteristics of concrete made with such fly ash. These results can be measured by the Air-Entrainment of Mortar test ASTM C-311 and the foam index test (a less precise, but quicker and simpler test). This testing was run to determine the following:

- the fate of the captured Mercury.
- the impact of the Activated Carbon upon the product fly ash quality and
- the difference, if any, in the fate of the captured Mercury and the impact of the activated carbon when injecting several different types of Activated Carbon for Mercury absorption.

For purposes of this analysis, the first goal of any beneficiation unit is to quantify the impact on existing mercury emissions. This questioning attitude was suggested by EPA and Florida DEP at the 1/30/07 ACAA Conference in Florida. PMI's CBO has and continues to demonstrate to regulators, host facilities and on a stand alone basis that its emissions can decrease mercury emissions if coal is being offset since most of the mercury adheres to the fly ash. This fact is re-confirmed in the Lee Plant study.

Mercury testing was performed on Lee plant samples processed in a CBO pilot module. Several cold side and hot side samples were taken for analysis. For a given amount of feed ash, there is a certain percentage of captured mercury. When processed through a CBO unit the carbon content is significantly reduced. The total ash weight decreases resulting in what then appears as an increase in the remaining percentage of ash minerals, including the mercury. This increase in percentage is merely due to the reduction of the final processed sample weight. The result for a cold side sample shows that the amount of mercury present in the feed sample was .488 ppm compared to the product sample at .522 ppm. This increase indicates a complete return of all the mercury, which is consistent with the weight percent of the final sample weight. Thus, as presented in earlier papers, from a mass balance perspective, respective air emissions from the CBO's flue gas are decreased normally.

Now having documented the contributions of air emissions of mercury from the CBO beneficiation unit, it is worth determining how CBO fits into a utility's mercury strategic plan. Therefore, we used the Lee DOE tests to determine if a utility using CBO could use any kind of activated carbon to produce saleable ash regardless of the sorbent. The data below clearly demonstrates that CBO allows the utility flexibility to use any kind of sorbent and produce high quality saleable fly ash after CBO treatment.

Whether the CBO pilot unit is targeting a commercially desirable 2.5% LOI or allowed to run until burn-out, CBO selectively burns the activated, most reactive, carbon first. For example, the foam index results for the feed samples ranged from 9-11 drops on the cold side samples, while the hot side ranged from 20-24 drops for ash with one type of activated carbon and 33-34 drops for ash with the other type of activated carbon. Note the large drop in the foam index results for the burn-out samples, which were consistently noted at 1 drop, and can be seen in the following graph below.

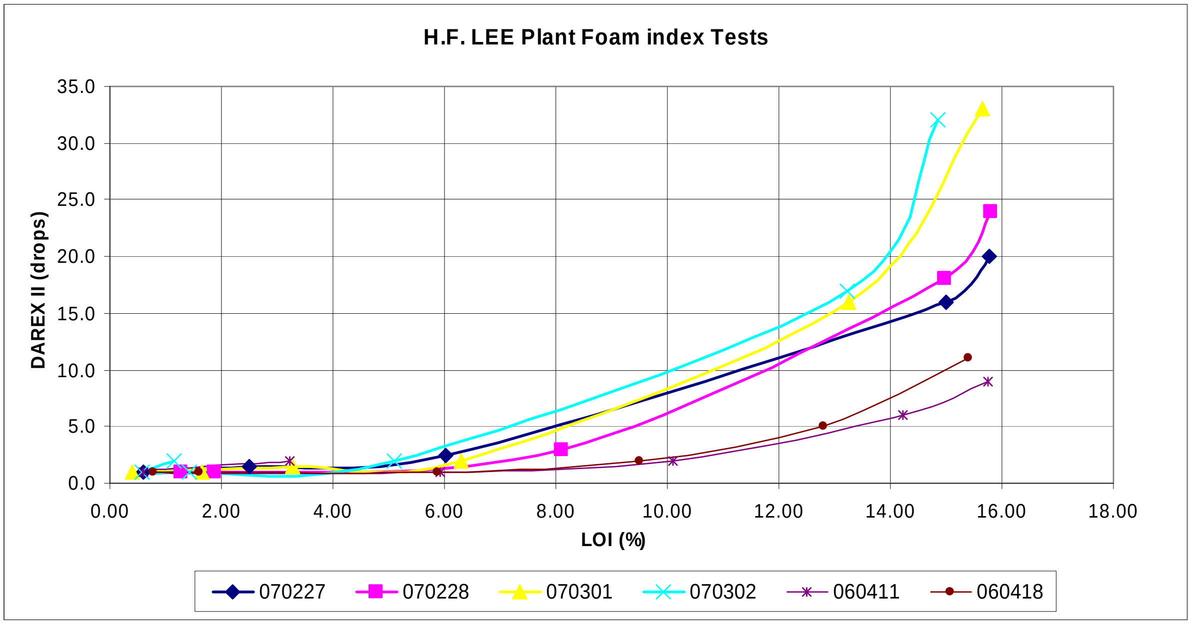


Table 1. Foam Index test results.

The foam index test is a relatively quick and simple test to characterize air entrainment. The foam index test is a quality control test used to determine the amount of air-entraining agent, darex II, required to achieve a stable foam. However, it is not an approved ASTM standard. Therefore, feed and product samples from three of the tests also were analyzed for air entrainment of mortar using ASTM C311. The air entrainment of mortar test is a quality control test which uses an amount of dry vinsol resin, expressed as weight percent of the cementitious material (cement and Fly ash), required to produce an air content of 18% in the mortar. In either test, foam index or Air entrainment of Mortar, using less admixture is better. The amount of Vinsol air entrainment admixture required to obtain 18% air entrainment in the three samples was reduced by about 85-89%. Note the consistent air entrainment results of the CBO product ash, where each sample contained a different type of activated carbon. Also note the high feed and low product sample similarities between the foam index graph and the ASTM C311 results. The results can be seen below in Table 2.

HF LEE Plant			ASTM C311
Sample ID	Description	LOI	Air Entrainment
		(%)	(WT %)
Hot side #1			
070228.1	Feed	15.52	0.280
070228.8	product	1.69	0.031
Hot side #2			
070302.1	Feed	15.21	0.240
070302.7	product	0.87	0.030
Cold side			
060411.1	Feed	15.86	0.193
060418.8	product	2.01	0.029

Table 2. ASTM C311 Air entrainment of mortar results.

PMI has also performed some additional activated carbon testing using varying levels of activated carbon. These tests used several different types of activated carbon with several different types of ash. All test runs appear to selectively burn the activated carbon, which is the most reactive carbon first. The foam index results for the feed samples ranged from 4-5 drops for ash without activated carbon to 13-85 drops for ash with activated carbon, while the foam index results for the burn-out samples were consistently noted at 1 drop.

Therefore, PMI can conclude the following based upon the follow-on work performed at the Lee Plant:

- For the CBO beneficiation unit, the fate of the mercury can be readily demonstrated for all media based on this and other mercury analysis. Mercury remains with the processed fly ash which allows for reductions in air emission normally.
- The impact of the activated carbon upon the product fly ash is quickly and significantly reduced as seen in the air entrainment results and foam index testing.
- CBO can accommodate all activated carbon sorbents used for mercury. There were no differences noted in the fate of the captured mercury or the impact of the activated carbon when injecting several different types of activated carbon giving utilities great flexibility.
- Injecting several different types of activated carbon for mercury capture did not have any effect on the CBO’s ability to contain the captured mercury and process the activated carbon to produce a high-quality premium fly ash.
- CBO is an effective long term flexible asset in any utility’s environmental control strategy.