Performance of Non-Halogenated Activated Carbon for Mercury Compliance

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ABSTRACT

With the introduction of the first national standards for mercury pollution from power plants in December of 2011, many facilities will turn to activated carbon injection to meet the EPA Mercury and Air Toxics Standards (MATS) requirements. Activated carbon injection is a mature technology that is widely available and proven for achieving mercury removal greater than 90%. In anticipation of the need, Carbonxt has developed powdered activated carbons for mercury removal from coal-fired power plant flue gas. The products stand apart from most available mercury control sorbents in that they are non-halogenated. The Carbonxt products have been tested extensively at the Mercury Research Center under various conditions. The testing includes a span of injection location/particulate control configurations, injection rates, and concentrations of SO_3 (inherent and injected for flue-gas conditioning). This presentation reviews the mercury control performance and operational impacts of these recent test events.

INTRODUCTION

The US Mercury and Air Toxics Standards (MATS) were finalized in December 2011 implementing new power plant emission standards for all coal-fired power plant boilers larger than 25-megawatts in size. The regulation limits mercury emissions based on fuel type as well as sets limits for additional hazardous air pollutants. The goal of the rule is to prevent 90% of mercury in coal burned from being emitted into the air. The EPA and prominent medical associations estimate this legislation will prevent 11,000 premature deaths, 4,700 heart attacks and 130,000 asthma attacks, 5,700 hospital and emergency room visits, and over 3 million restricted activity days saving between USD$37 and USD$90 billion annually[1].

The US EPA estimates this ruling could affect over 1,400 existing boilers at 600 power plants over the next three years and has noted that activated carbon is the best demonstrated mercury-specific control technology. To assist utilities in meeting mercury compliance, Carbonxt has developed and licensed technologies for the production and post-production treatment of activated carbon (AC) for mercury capture. Carbonxt ACs have a variety of unique benefits including: (1) non-halogenated, (2) performance compatibility with multiple utility configurations and conditions (3) lower injection rates to provide significant cost savings (4) can be tailored to individual utility environments, and (5) viable for co-location production through its ability to be manufactured from various coal feedstocks. This paper presents the highlights from extensive, independent testing at the Gulf Power Mercury Research Center (MRC). Through this testing, Carbonxt ACs have verifiable performance capable of achieving mercury capture rates that will help utilities be MATS compliant.

METHODS

Mercury Research Center

The MRC is a unique testing facility for the development of pollution control technologies and devices. Situated at Gulf Power's Plant Crist, the MRC is a 5-megawatt facility equipped with a complete system of flue gas pollution-control devices including:

1) Selective catalytic reduction unit
2) Multiple flue gas conditioning injection capabilities
3) Baghouse (GE MAX9 pulse-jet)
4) Electrostatic precipitator
5) Wet limestone scrubber

The MRC redirects up to 30,000 acfm of flue gas from Plant Crist, allowing its clients to test pollution-control technologies under actual flue gas conditions. Testing conditions such as product injection location, SOx concentrations, presence or absence of particulate control devices (i.e., electrostatic precipitators and baghouses), and NOx concentrations can be manipulated. The facility is completely instrumented with data acquisition systems and monitors to provide detailed results, allowing for a comprehensive understanding of test outcomes.

Figure 1: Image depicting the majority of the MRC System.

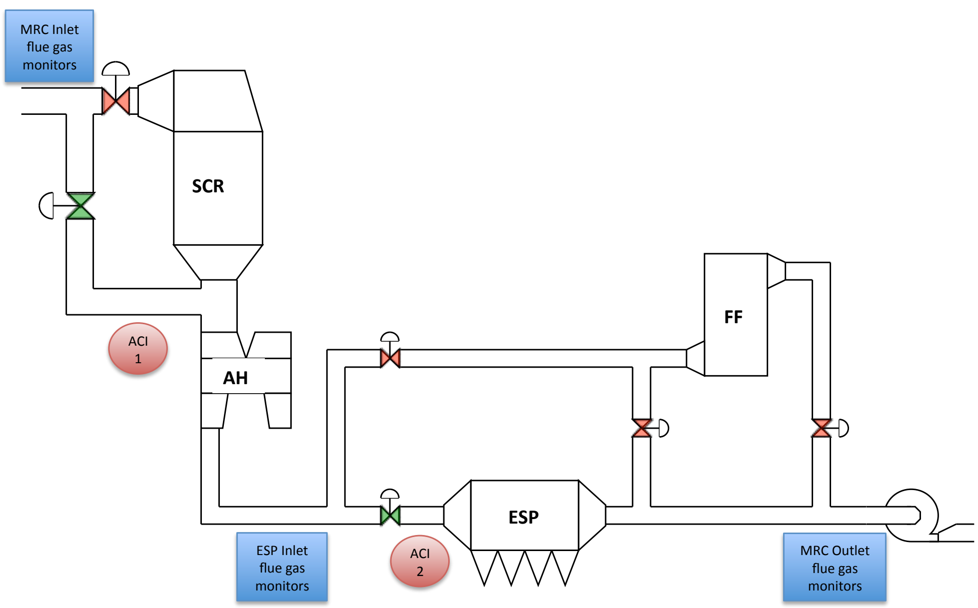

Figure 2: Layout of first configuration for the MRC with two different injection locations.

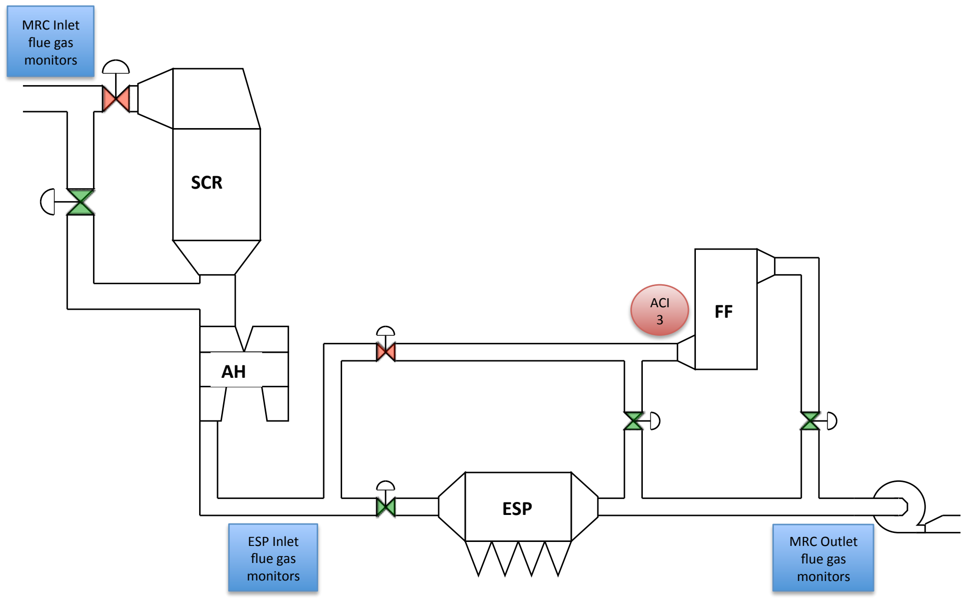

Figure 3: Layout of second configuration for the MRC.

Activated Carbon Injection Performance Evaluation

It is well known that coal-fired power plant flue gas chemistry is complex and variable. To account for this complexity, the MRC has two continuous emissions monitoring systems (CEMs) for CO_2, SO_2, and NO_x, and three CEMs for speciated mercury at different locations in the system. This high degree of analytical capability permits the observation and detailed understanding of flue gas characteristics and pollution control device performance during testing.

Carbonxt's ACs have been regularly tested at the MRC to facilitate product optimization and validate performance. During each event, a baseline was established with flue gas flowing through the chosen pollution control configuration before exiting the MRC outlet. Two particulate control configurations with three AC injection locations (i.e., ACI 1, ACI 2, and ACI 3) have been used for testing (Figure 2 and 3), as follows:

- ACI 1: injection upstream of the air-heater (AH). This injection point is located 34 ft before the AH, into a 36" duct. The AH is 62 ft from the ESP; the average gas velocity was about 42 ft/s, allowing for a residence time of 1.5 s. The gas temperature before the AH was about 700 F.
- ACI 2: injection upstream of the ESP. The injection point is located 25 ft before the ESP, into a 30" duct. The average gas velocity was 57 ft/s, allowing for a residence time of 0.44 s. The gas temperature at the ESP was about 300 F.
- ACI 3: injection upstream of the fabric filter (FF), after fly ash had been removed by the ESP. The relative residence time was extended, due to a fixed bed formed by AC accumulation over the filter.

For each study, the AC was injected at a rate between 1 and 7 lb/MMacf for at least 45 minutes. The mercury CEMs rapidly registered changes in mercury concentrations, and a steady state was reached within 30 minutes.

The influence of SO_3 injection, often used to condition fly ash for improved ESP performance, was evaluated. The inherent SO_3 concentration at the MRC was generally less than 1 ppm, although this condition varied – increasing in some cases up to 3 ppm – depending on the coal blend burned at Plant Crist. Further, a higher concentration (12 ppm) of the conditioning agent was injected about 70 feet upstream of the pre-AH to challenge the AC product. SO_3 concentrations were measured both upstream and downstream of the ACI and ESP.

RESULTS AND DISCUSION

Role of Injection Location

Figure 4 presents the mercury capture data from the injection of Carbonxt AC at ACI 1 and 2 (pre-AH and pre-ESP). As shown, the product lowered the influent mercury concentration from about 11 ug/ Nm^3 to about 3 ug/Nm^3. The removal at both ACI 1 and ACI 2 were very similar demonstrating that the product is high temperature tolerant. While ACI generally performs better with lower injection temperatures, in some situations, the benefit of a longer residence time may outweigh the drawbacks of increased temperature. The Carbonxt product does have the flexibility to be injected at a wide range of temperatures. Each utility has a unique set of pollution control configurations and ducting that should be assessed to determine the optimal injection location.

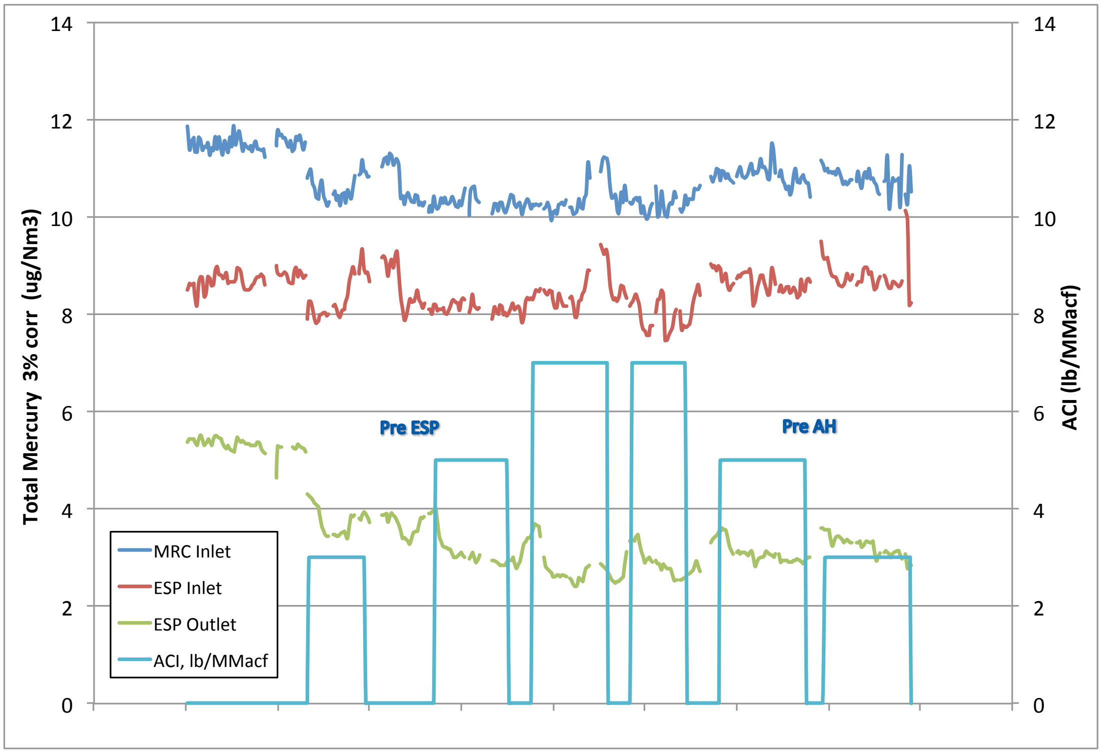

Figure 4: The impact of injection location (pre-ESP versus pre-AH) over mercury capture.

Role of Injection Rate

Figure 5 presents the influence of injection rate at ACI 2 over mercury capture. In this test event, the SO_3 concentration was less than 1 ppm. As expected, mercury removal increased with increasing injection rate with a strong linear trend. Total mercury removal at typical injection rates in the industry (5 lb/MMacf) was nearly 90%. Further increases in injection rate would continue to achieve higher mercury removal. The injection rate can be optimized to meet appropriate Hg concentrations for MATS compliance while minimizing AC costs.

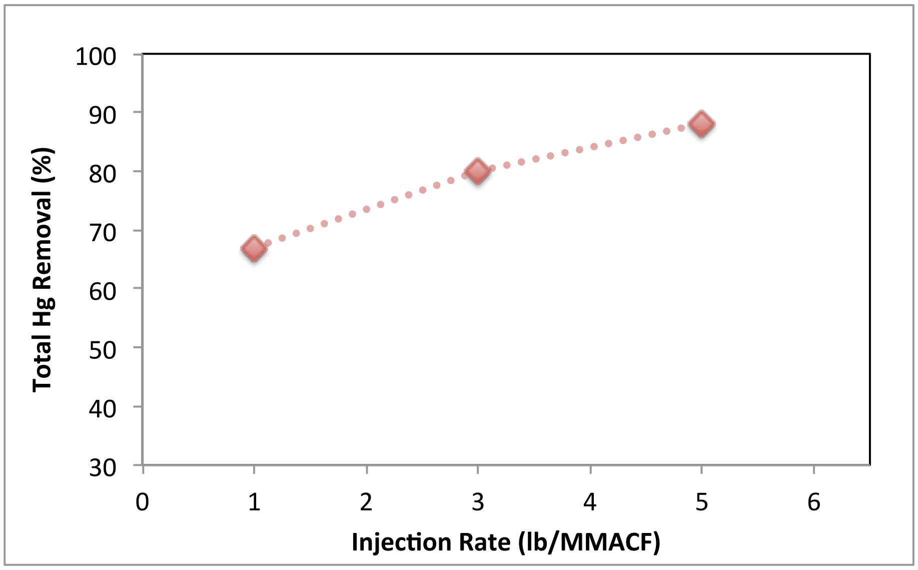

Figure 5: The influence of injection rate over mercury capture at ACI 2 (pre-ESP).

Impact of SO_3

Although the mechanism is still debated, the negative impact of SO_3 over mercury capture by ACs is well established[2]; concentrations as low as 3 ppm can dramatically hinder performance. Because inherent SO_3 concentrations can be as high as 50 ppm, and some plants burning very low sulfur coals inject up to 10 ppm for fly ash conditioning, understanding the influence of SO_3 over AC performance is beneficial.

Figure 6 shows the influence of 3 and 12 ppm SO_3 over mercury removal by a Carbonxt AC. While removal slightly decreases as SO_3 concentration increases, removal was nearly 70% at only 3 lb/MMacf. Carbonxt continues to engineer products to further establish SO_3 resistance.

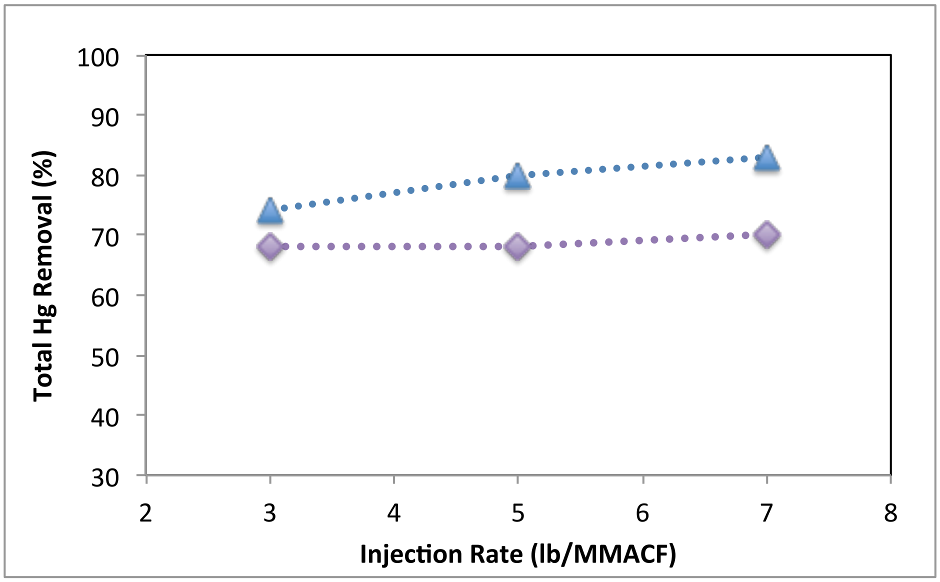

Figure 6: Comparison of Hg removal by ACI upstream of the ESP in the presence of about 3 ppm SO_3 (blue) and 12 ppm SO_3 (purple)

Injection Upstream of a Fabric Filter

For many facilities, installation of a secondary particulate control unit such as a fabric filter baghouse, is advantageous to reach both particulate and mercury compliance. Table 1 presents the total mercury removal of select Carbonxt ACs through the MRC fabric filter (ACI 3; Figure 2). As shown, the Carbonxt products can achieve greater than the regulated Hg removal at injection rates typically used in the industry. Further, product performance has improved steadily and significantly over the development.

Table 1: Hg-removal capacity of select Carbonxt products across a fabric filter.

	% Removal, Fabric Filter	
	1 lb PAC/ MMACF	**2 lb PAC/ MMACF**
Test 1	72	93
Test 2	83	94
Test 3	86	96

Plant Balance

Activated carbon has been criticized for negatively impacting plant balance. Through the MRC trials, ESP performance was monitored. No increases in opacity or significant changes in the ESP operating performance was observed. Fly ash samples were collected during typical injection rates of 5 lb/MMacf. The samples passed TCLP for mercury and were comparable to industry standard products for concrete compatibility as tested with the foam index and acid blue 80 index.

SUMMARY

Activated carbon injection is a proven technology for mercury control at coal fired power plants. Carbonxt activated carbons offer utilities flexibility in complying with the EPA MATs by providing an analysis of the plant's operating configuration to identify the optimal injection location. Further, Carbonxt offers the option to tailor product according to the needs of the utility. Extensive testing at the MRC has verified that Carbonxt's products perform well in a variety of pollution control configurations. Most importantly, the mercury capture is accomplished without the use of harsh corrosive chemicals such as bromine and chlorine.

REFERENCES

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KEY WORDS mercury removal, ACI, performance evaluation, coal-fired power