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FIRST EVALUATION OF THE RETROFITTED SCR AT THE COAL FIRED SOMERSET GENERATING STATION

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Abstract:

The AES Somerset SCR system has operated through almost two (2) ozone seasons, eight (8) months, since retrofit installation of the selective catalytic reduction system in 1999. During a recent scheduled outage a thorough inspection of the units was conducted. Photographs taken are presented. Previous to this inspection, catalyst sample coupons were removed and returned to the catalyst supplier for evaluation. This evaluation included catalyst activity, SO_2 to SO_3 oxidation rates, physical properties and a quantitative analysis of the catalyst for accumulated materials. The results of these evaluations are presented and discussed.

Introduction:

The Somerset station is a single B&W radiant boiler with a GE G3 steam turbine. It is rated at 675 MWe firing essentially eastern bituminous coal, mostly Pittsburgh Seam. The coal contains about 2.5 – 3.0% sulfur. It is owned by AES Eastern Energy LP a subsidiary of AES Corporation of Arlington, Virginia, a power producer with about 120 plants worldwide capable of generating over 42 gigawatts.

The boiler is design to produce 4,855,000 pounds/hour of steam @ 1005 ^{0}F and 2650 psig. It is equipped with low NOx burners, an electric precipitator, and a wet scrubber to keep sulfur oxide emissions below 0.6 lb/MMBTU.

The SCR system is shown in Plate 1. The boiler is North (right) with the stack being South (left). The SCR reactor is split by one wall into a west (A) and an East (B) compartment, one train for each of the two (2) air preheaters.

Plate 1: SCR System Facing West

Construction of the Selective Catalytic Reduction (SCR) system began in October of 1998 and went into operation the following July. Thus total operation to date is about 1.6 ozone seasons or about 8 months. The SCR system is designed to reduce the NOx by 90%; from 0.55 lb/MMBTU to 0.055 lb/MMBTU with an ammonia slip that does not exceed 3 ppm for a minimum of 24,000 operating hours. In addition, it is required to keep the SCR catalyst production of SO_3 below 0.75% of the SO_2 that enters the reactor.

To meet these stringent requirements, the AES/B&W team selected the Babcock-Hitachi (BHK) SCR catalyst for this coal fired boiler's SCR. The design required three initial layers of BHK designed catalyst with a fourth empty or spare future layer.. A total of 897 m^3 of 6 mm plate type catalyst constituted the initial charge. This catalyst had impeccable experience in over 15 SCRs on coal fired boilers rated over 500 MWe.

Background:

The station first went on line 1984 and thus met New Source Performance Standards. The station, originally known as the Kintigh station when formerly owned by the New York State Electric & Gas (NYSEG) and was purchased by AES along with the other generating assets of NYSEG in August of 1999. The history of the SCR for this station is very interesting but it has been previously detailed and thus will not be discussed further herein. For those interested, the authors recommend "Update of Selective Catalytic Reduction Retrofit on a 675 MW Boiler at AES Somerset", by Nischt, W.; Hines, J.; and Robison, K.; presented to ASME International Joint Power Generation Conference, July 24-25, 2000, Miami, Florida .

Visual Inspection:

The care taken during the SCR design really paid off. This included use of both a 1/12 th scale physical model and computational fluid dynamic models to achieve the required flow uniformity and avoidance of ash accumulation pockets. In general, all areas were relatively very clean except for horizontal surfaces, such a beam flanges where dust was present. This dust, however, was loose and easily removed indicating that it had just recently came to rest during shutdown.

The SCR design had considerable number of plates in the flue gas stream. These plates served several purposes. They helped to straighten, turn and guide the flow. They also form the damper louvers of the SCR bypass flue design. SCR isolation has a damper with double louvers to seal the bypass and single louver isolation dampers at the inlet and outlet of the SCR reactor. The reactor inlet gas turning vanes are shown in Plate 2. Their appearance is that of clean surfaces with no ash on the surfaces or within the operating mechanism. All plates in the gas stream were observed to have a similar appearance.

Plate 2: SCR Inlet Turning Vanes

Plate 3: Ammonia Injection Grid

Each flue gas train had a separate ammonia injection grid with 21 independently adjustable injection zones; seven zones horizontally and three vertically. Plate 3 shows a representative portion of the injection grid. The dust is of a powder consistency and principally on horizontal surfaces. Design layout in conventional boilers usually lends the AIG plane to be horizontal in up flue gas flow or vertically in horizontal gas flow. Placement of the AIG in a horizontal flow area protects it from falling dust that can accumulates in the nozzles. Some nozzle fouling was observed. There was some red substance near and below some of the nozzles. This can be observed in the plate. It was conjectured that this might be some ferric based residue although its exact composition and origin was not determined. This has been noticed in other installations.

The general condition of the catalyst cavity was good. Again, dust was observed only on horizontal surfaces and was very loose. Some small dust piles were noted on the catalyst but these were always just below beams or other obstructions that collected dust and it is concluded that these piles are nothing more than dust that fell from above at or after shutdown. The general condition of the reactor can be seen in Plate 4. Dust on the horizontal surfaces is

Plate 4: The SCR Reactor Cavity

easily observed. It was found to be very loose and dry and an individual could blow it off its perch. The remainder of the reactor is very clean. Rake type half track steam soot blowers are used on a periodic basis to keep the catalyst and reactor clean. The soot blowers can be seen in Plate 4.

Several photographs of the catalyst were taken. Plates 5, 6 and 7 being representative of what was generally found. Plate 5 shows the general clean condition of the catalyst. In the upper center of Plate 6 a small loose pile of dust can be observed. No pluggage was observed. Close visual examination uncovered no signs of erosion. The catalyst, in general, looked pristine. It retained it original yellow coloring except for a slight dusting of gray tinge. This is typical of the general catalyst conditions. Unfortunately the lighting for the photographs was not the best and colors are thus not true.

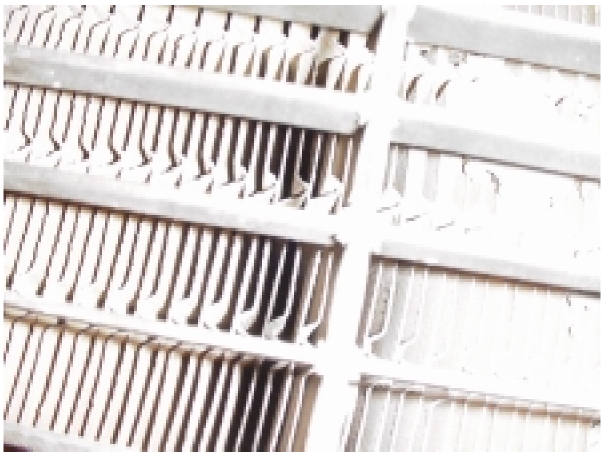

Plate 5: SCR Catalyst

Plate 6: SCR Catalyst

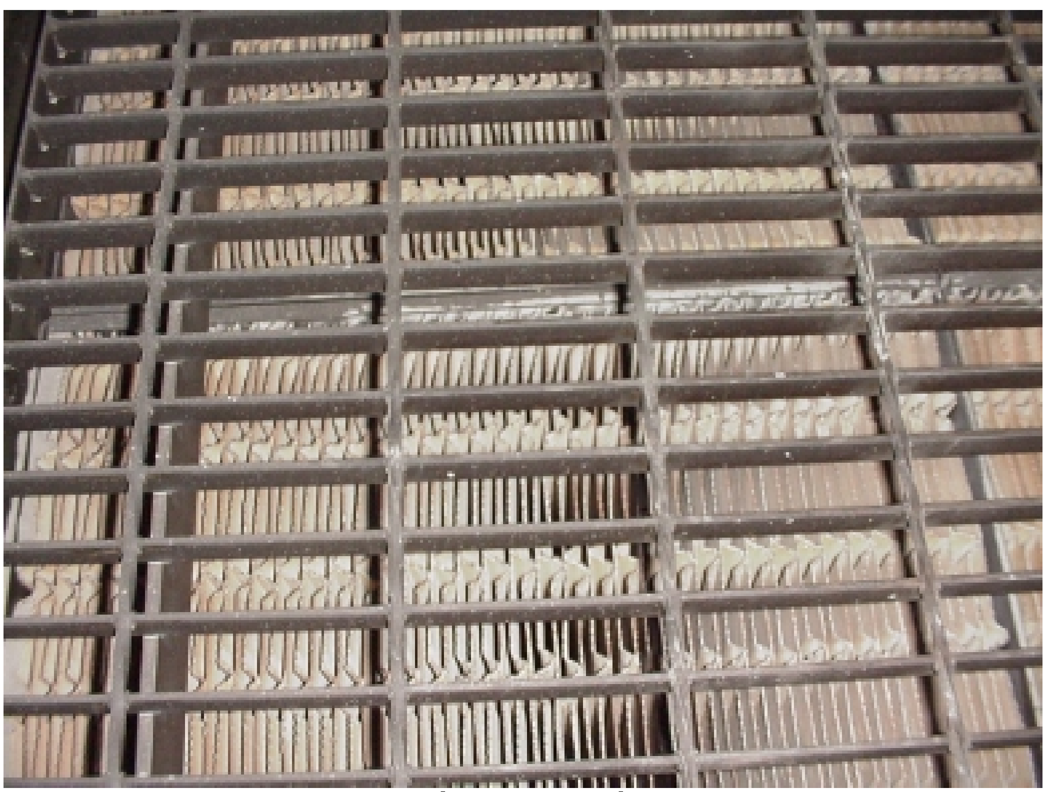

Plate 7: SCR Catalyst

Catalyst Examination:

Four (4) catalyst cassettes each containing about 60 catalyst sample coupons, as that shown in Plate 8, were installed into the reactor. One cassette was installed at each reactor train inlet and each reactor train outlet. At the end of the first 8 months of operation two coupons were taken from each cassette and sent to BHK for testing and examination. It was noted that the outlet coupons showed signs of erosion. It was determined that the outlet cassettes were installed in a somewhat higher velocity region in the outlet flue where the flow was not perpendicular to the cassettes causing erosive impingement of the ash upon the coupons. Normally, on the actual (full size) plates this impingement would affect a minor surface area but for the very short coupons the loose of catalyst made activity testing for these unreliable.

Plate 8: Catalyst Test Coupons in Cassette

Past experience indicates that the results for the sample coupons are conservative. That is, the turbulent flow through the coupons causes accelerated catalyst activity deterioration compared to the actual catalyst plates' flow which is almost entirely laminar over the length.

Testing:

The inlet coupons were tested using conventionally standard techniques. A synthetic standard flue gas was passed over the coupons. It contained known constituents, including NO and SO_2, plus it was saturated with ammonia, an NH_3/NOx mole ratio 1.2. The NOx reduction thus obtained is a measure of the NOx reduction activity. The results are given in Figure 1

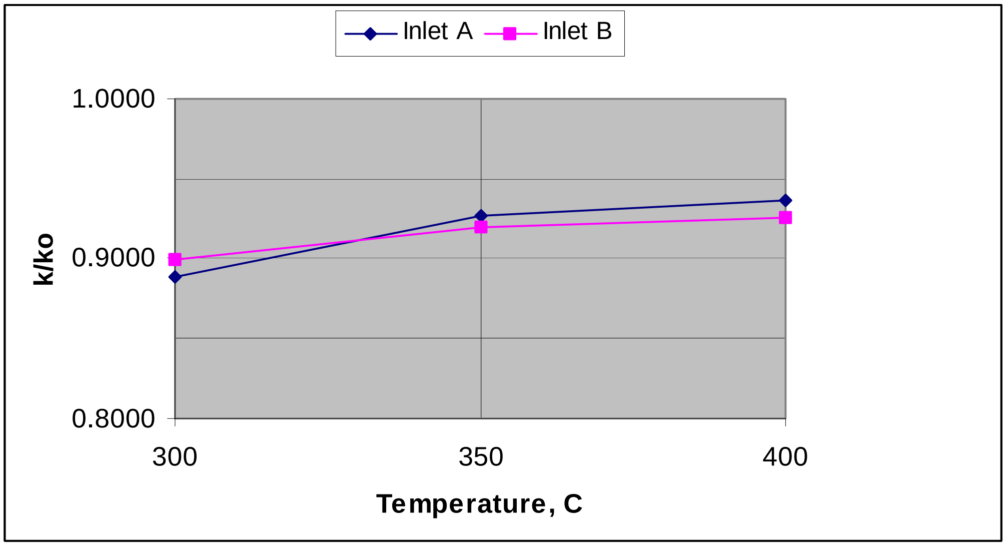

Figure 1: Activity verses Temperature – 8 Months operation

These results are well within the expected range and well above the design values for the operating exposure as shown in Figure 2.

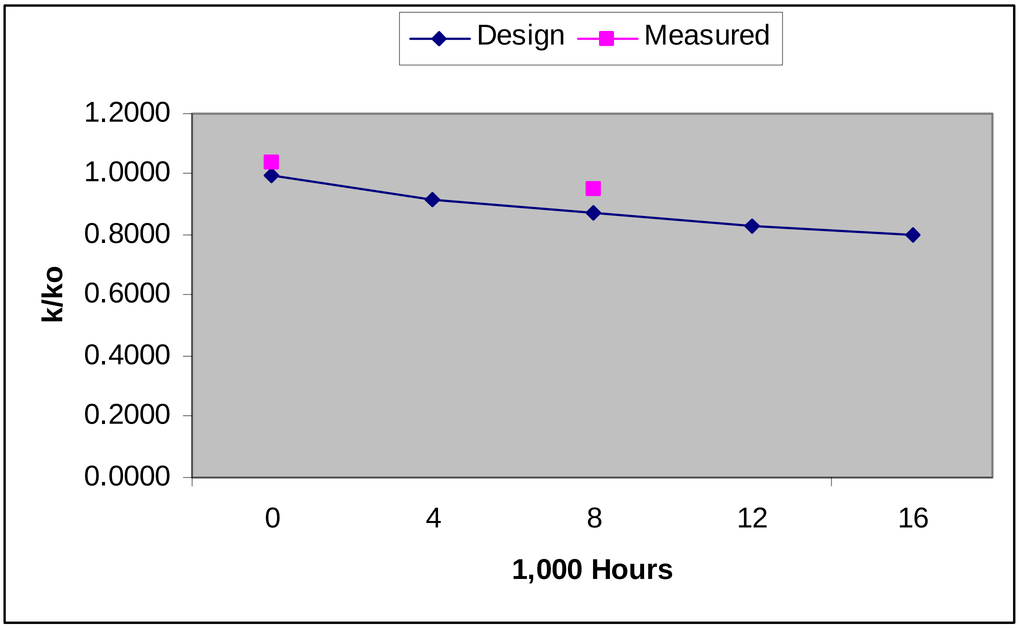

Figure 2: Activity Verses Operating Time

The standard BHK SO_2 to SO_3 oxidation rate test is performed at 350 ^{o}C with a standard gas containing a known quantity of SO_2. There was no change measured from the unused state of catalyst to that after the 8 months of operation. All results showed less than a 0.70% oxidation rate.

Changes in pore volume and specific surface area were also determined. This information is normally considered confidential by catalyst suppliers and BHK is no exception. All values were well within the acceptable range.

The final determination was the accumulation of material upon the catalyst. A semi-quantitative analysis was performed and based upon this analysis specific materials were selected for a quantitative analysis. Most of the materials accumulated were those found in the fly ash. Arsenic and iron were found to increase more than other elements. Although these, in sufficient quantities, are catalyst poisons, the quantities found posed no threat to the catalyst performance. It is particularly important to note that U.S. coals do have significant arsenic levels. Some eastern bituminous coals have sufficient arsenic concentration to pose a significant problem. The author is aware of early and catastrophic poisoning of honeycomb catalyst at the Seward station and a similar event happening at the Stanton unit 2. Remedial measures can, however, be taken.

Conclusions:

The results obtained from the visual inspections and catalyst investigations performed for the SCR at the AES Somerset station exceeded expectations. After almost 2 ozone seasons, about 8 months of operation the catalyst activity remained higher than expected even though some arsenic accumulation was observed. Other important SCR catalyst parameters were well within the acceptable limits and there are no future operating problems anticipated. BHK does, however, recommend that periodic catalyst sample coupon testing to confirm and track the catalyst performance. This should ensure continued successful SCR performance.

Special Thanks:

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