



## **LaCygne Unit 1 SCR Graduated Straightening Grid Project**

Scott Hiedeman, KCP&L  
Reid Thomas and Dale Pfaff, Fuel Tech, Inc.  
Diane Fischer, Black & Veatch

KCP&L's LaCygne Generating Station provides 1,532 MW of peak power to customers from the site south of Kansas City. LaCygne Unit 1 is an 815 MW B&W cyclone boiler with Over-Fire Air (OFA) and SCR NO<sub>x</sub> controls, and the second oldest WFGD installation in the country. LaCygne Unit 2 is a 717 MW B&W PC boiler with Low NO<sub>x</sub> Burners (LNB), OFA, and ESP particulate control. LaCygne1 burns a blend of 90% PRB and 10% local Missouri coal. Modifications are under way on both units to reduce emissions. LaCygne1 is installing a Fabric Filter, new WFGD, new ID Fans, and new DCS system. LaCygne2 is retiring the ESP and installing a fabric filter, WFGD, new ID Fans, and SCR systems.

The LaCygne Unit1 SCR was installed in 2007 with a 3+1 catalyst layer configuration. This SCR installation was plagued with excess flyash accumulations until fall 2012. During the period of SCR startup in spring 2007 through fall 2012, flyash pluggage caused eight catalyst layers to be replaced with new, regenerated, rejuvenated or cleaned catalyst. This paper discusses the solution to LaCygne1 flyash accumulation issues. These flyash problems are common to many industry PRB coal SCR installations as described by EPRI 2010 "Guidelines for New SCR Installations<sup>1</sup>."

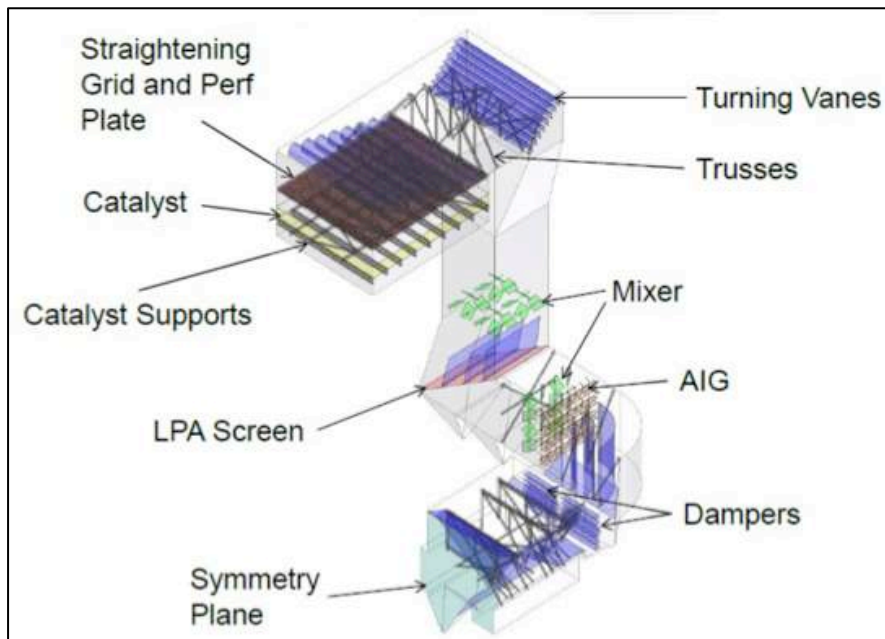
In the Fall 2012, LaCygne vacuumed 2,900,000 lbs. of flyash from the Unit1 SCR after a 17-month operating cycle. This was twice the typical amount of flyash removed due to an extended operating cycle with a low demand load factor. However, the catalyst pluggage of approximately 50% was typical of previous operating cycles. The LaCygne SCR consists of two reactor casings separated by a common division wall. Flue gas would enter the SCR North Side B and South Side A of the SCR Hood to flow down through these separated casings (refer to flow model arrangement shown in Figure 2). Flyash would pile 5-6 ft deep near the SCR North to South Reactor casing division wall. The flyash accumulation caused high ash removal costs, catalyst replacement costs, high catalyst pressure drop and fan power costs, high ammonia slip and ammonia reagent costs, and outage critical path time. The flyash accumulation also caused unit capacity derates in combination with other draft losses. Excess flyash accumulations are shown in Figures 1a and 1b.



**Figure 1a:** Flyash on Turning Vanes



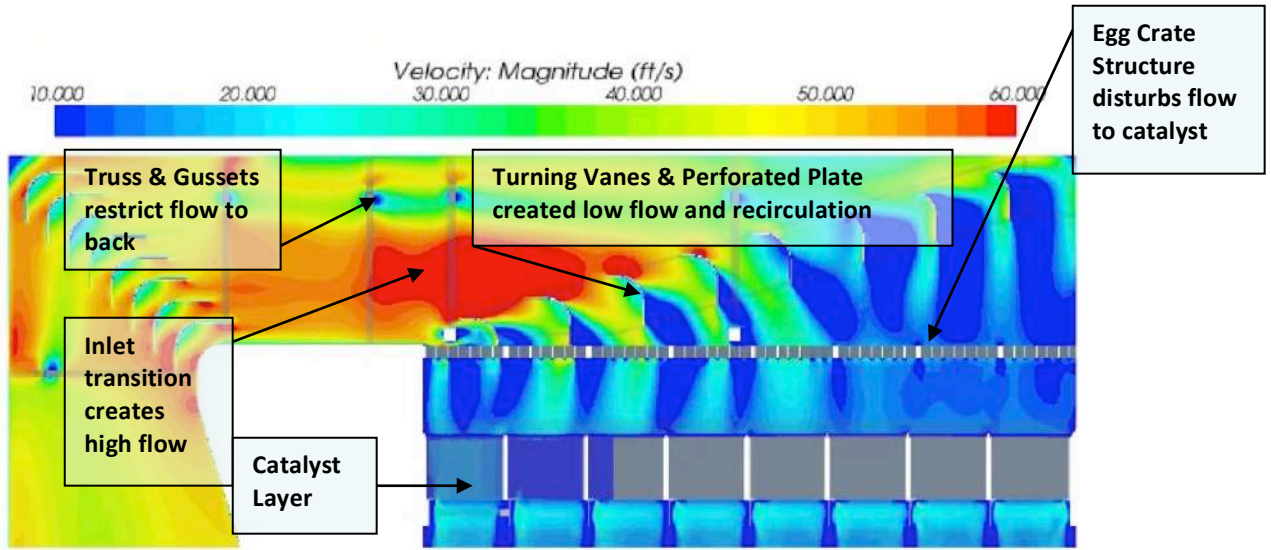
**Figure 1b:** South Side A SCR, Layer 2, 2<sup>nd</sup> Catalyst Module Seal Strip



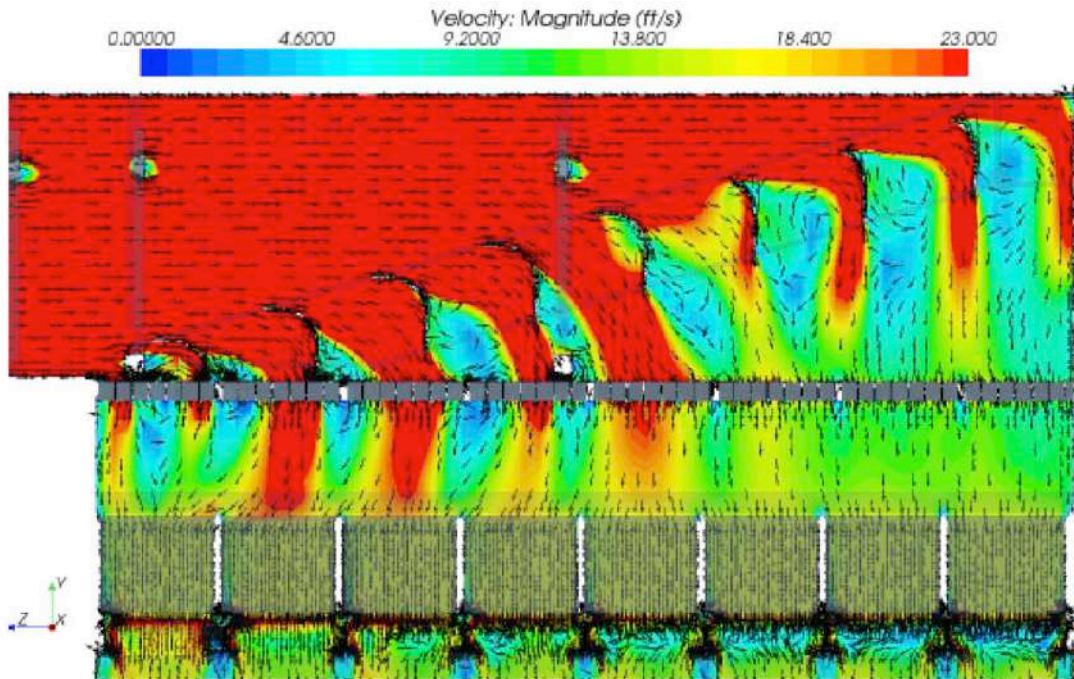
**Figure 2:** North Side B SCR Model Arrangement

Many minor repairs were attempted through the five years of LaCygne1 SCR operation prior to fall 2012. The original flow modeling was reviewed and missing flow control baffles were installed. The sonic horn's air supply dryer drain solenoid was corrected to drain off excess condensation. The sonic horns were heat traced and insulated. The flyash was vacuumed from the catalyst. Horizontal vane and beam surfaces were covered or removed in some areas to "pilot" corrective actions to prevent ash pile accumulations. The original catalyst was 7.1mm pitch honeycomb ceramic catalyst. Catalyst layer replacements were made with larger 8.2mm pitch honeycomb catalyst, and 9.2mm pitch catalyst was installed near the SCR reactor casing division wall. These minor repairs were not successful, because they were not addressing the root cause of poor flow distribution variance.

To move PRB flyash through the catalyst, flue gas flow to the catalyst must be of uniform velocity, vertical, and without recirculation. In 2010, KCP&L LaCygne initiated Computational Fluid Dynamics (CFD) flow modeling with Fuel Tech, Inc. (FTEK) to determine the cause of flyash accumulation, and design potential devices to correct flow variances to the catalyst. The CFD analysis shown in Figures 3 and 4, indicated problem areas in SCR design flow including 1) SCR Inlet duct North-South contraction pushed flow to the lower 4 SCR Hood turning vanes; 2) trusses and large gusset plates in SCR inlet duct and hood restricted flow to the upper four SCR Hood turning vanes; 3) the turning vanes and perforated plate on top of the original Egg Crate flow straightening grid created flow recirculation zones that cause flyash dropout. The turning vanes also collected ash on horizontal surfaces due to low flow, and these ash piles sloughed off on FD Fan startups; 4) The Egg Crate structural support steel created flow disturbance that could not be corrected in the short distance to the first catalyst layer.



**Figure 3:** Baseline Velocity Results  
*SCR Hood area baseline velocity profile showing uneven velocities.*



**Figure 4:** Baseline Velocity Vectors

The flow direction vectors show the flow recirculation zones behind the SCR Hood turning vanes. The flue gas recirculates behind these vanes, but the flyash does not follow this twisting route, and falls out on the catalyst layers.



Modification to the LaCygne1 SCR Hood was originally planned for fall 2013, when a longer duration outage was scheduled. However, low demand load factors on KCP&L and Westar systems in 2012, and the high price of continuing catalyst ash pluggage led to the decision for a 2012 installation. A short boiler inspection outage was extended to a 44 day to accommodate the work. Design of the new flow distribution devices for the LaCygne1 SCR Hood was kicked off in July 2012, with the outage scheduled for Oct 1, 2012. With the short timeframe for design and fabrication, the contracted services were secured for flow modeling, structural engineering, fabrication and construction installation.

Black & Veatch was contracted to provide design drawings and specifications, review the flow modeling and proposed flow distribution devices, and evaluate constructability. The entire team participated in preliminary flow model result review meetings, to provide immediate input to flow modeling and direction to engineering. Conceptual SCR Hood structural truss supports were developed prior to flow modeling. Likely flow distribution devices were detailed by engineering to obtain construction installation bids. Catalyst installation was planned for Layers 2-3-4 to allow Layer 1 to be a work platform for the SCR Hood modifications. Flow device fabrication was performed off-site at fabrication shops to speed production. Fabrication was scheduled to continue through the start of the October 1<sup>st</sup> outage, as demolition would occur before new materials would be needed.

The CFD modeling reviewed removal of the SCR Hood turning vanes and replacement with Fuel Tech's patented GSG™ Graduated Straightening Grid. Previous CFD modeling had shown heavy flow recirculation behind the SCR Hood turning vanes. The FTEK GSG device consisted of parallel plates installed on the SCR Hood diagonal, to turn the flue gas and flyash vertically into the first catalyst layer. The CFD model results indicated the GSG corrected the large flow recirculation zones, and flow was vertical out of the GSG. However, the flow statistics were not within the projects recommended +/- 15% of arithmetic mean. The SCR Hood truss/gussets, and Egg Crate structural steel were creating large flow velocity variances before the first catalyst layer.

The CFD model was analyzed with removal of the two trusses, removal of the Egg Crate support steel, and removal of both truss and Egg Crate. Removal of all internal structure obviously had the best result. However removal of Egg Crate steel had a nearly identical result, without the expense of replacing the SCR Hood Truss system. The Egg Crate steel was too close to the first layer of catalyst for the flow distribution to recover. Yet the flow statistics were still not close enough to the recommended +/- 15% of mean. The SCR inlet flue contraction and truss/gussets were both working to push flow to the SCR inlet corner, and away from the back half of the SCR Reactor casings at the division wall. The next CFD model run added a perforated plate to the leading edge of the GSG blades. This showed improvement in the flow statistics. One more CFD model run was accomplished to tune a variable perforated plate across the leading edge of the GSG blades. The final perforated plate open area was varied 42-50-63-50% open. This variable perforated plate prevented excess flue gas from making the quick turn into the

front of the reactors, and also pushed more flow past the truss/gusset system to the back half of the reactors. The lower percentage open area at the back wall was needed to reduce flow being turned down to the catalyst by the back wall.



**Figure 5:** Turning Vanes & Center Truss

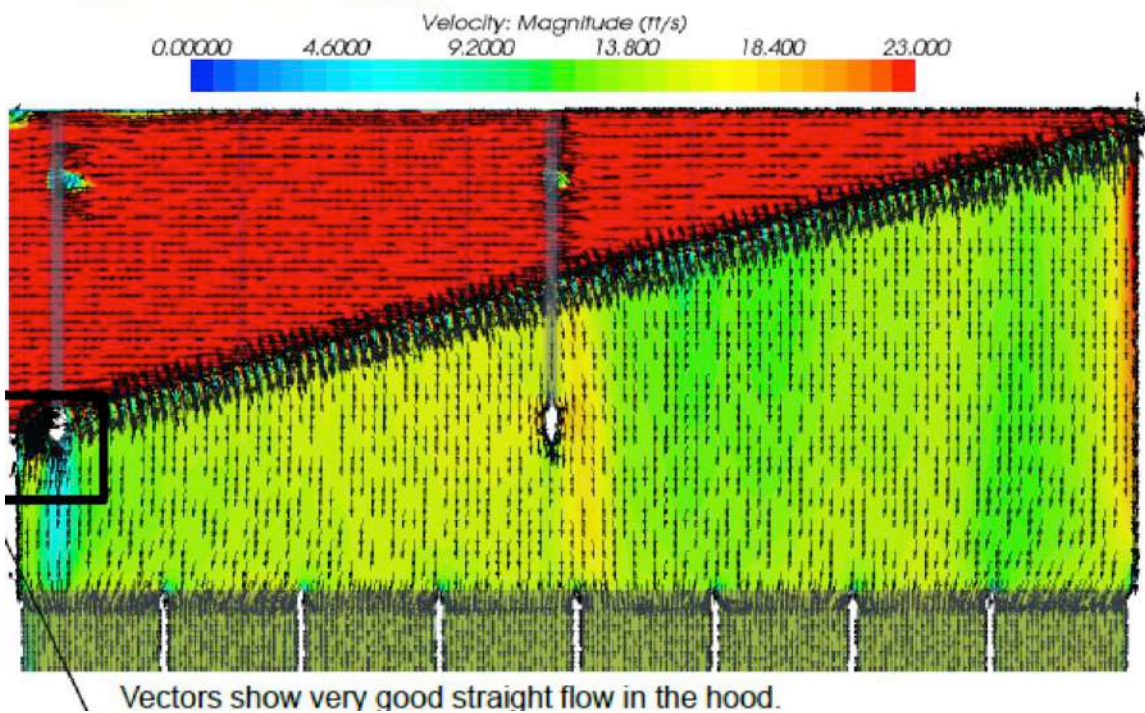


**Figure 6:** Egg Crate & Structure Demo

The final modification arrangement included demolition of the Turning Vanes in the hood of the SCR Reactors, and demolition of the original Egg Crate flow straightener, perforated plate and its support steel. Original equipment photos and Egg Crate demolition are shown in Figures 5 and 6.

B&V Engineering then picked up this design to detail the drawings for fabrication and installation. The GSG blade detail drawing was already complete. Engineering added the final perforated plate details, and turned these drawings over for fabrication. Engineering also began re-design of the support for the SCR pressure load where the Egg Crate support steel was removed. The Egg Crate steel not only supported the old flow straightener weight, but also restrained the pressure forces on this elevation. A buckstay arrangement was developed to resist these forces.

The selected arrangement installed the GSG device with perforated plate at the turning vane location. The GSG replaces the turning vane and Egg Crate functions by turning the flow 90-deg and aligning the flow up vertically to pass through the catalyst layers. A perforated plate was needed on the GSG blades leading edge to overcome the low flow at the SCR A & B division wall. The flow statistics did not quite reach the desired project goal of 100% of all flow velocities within +/- 15% of arithmetic mean. The final model showed flow distribution statistics with 91% of all analyzed flow velocities within +/- 15% (equal to 9.5% RMS). This was a significant improvement compared to the original, traditional turning vane design where 58% of flow velocities were within +/- 15% (17.5% RMS). The flue gas flow direction (velocity vectors) result was excellent, with the flow recirculation nearly eliminated, except at the two Truss systems, and the flow direction was vertical going into the catalyst.



**Figure 7:** GSG Vector Flow

Graduated Straightening Grid (GSG) with perforated plate installation, and Egg Crate support removal produces vertical, non-recirculating, uniform velocity to the catalyst.

The fabrication of the GSG modules was straightforward. These modules were completed and shipped to the site prior to the installation crews needs during the October 1<sup>st</sup> outage. The late addition of the variable perforated plate added a complication to the fabrication schedule. Fabrication time at six different shops was secured to laser or plasma cut all the perforated plate piece parts. The final GSG device with perforated plate was installed as shown in Figures 8 and 9.



**Figure 8: GSG Installed**



**Figure 9: GSG shown below center truss with ash guard on lower truss beam**

Beam ash guard with teepees



**Figure 10:** SCR crane and hood openings for material transport

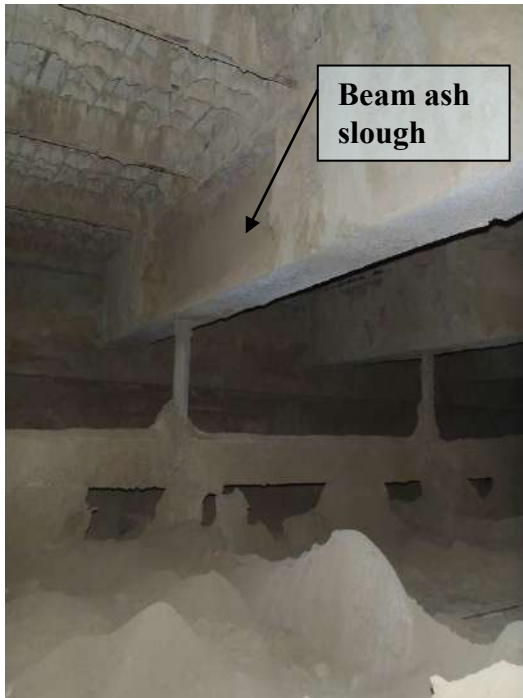
The Egg Crate steel above Layer1 catalyst that was removed, also provided the catalyst removal cart wheel tracks. An alternate catalyst installation method needed to be developed. A grating floor was installed in catalyst Layer1. Future Layer1 catalyst installation will be by pallet carts. Catalyst was installed in Layers 2-3-4 during the 2012 outage to aid GSG construction sequence. Catalyst support beam teepee ash guards were installed on the grating floor to prevent PRB flyash stalagmites from growing up from the beams.



**Figure 11:** Grating Floor

Additional PRB flyash accumulation prevention measures were taken by installing ash guards on all horizontal surfaces inside the SCR. The EPRI 2010 “Guidelines for New SCR Installations<sup>1</sup>” notes several zones where flyash can accumulate. Zone 2, 4 and 5 on the EPRI diagram show flyash accumulation on horizontal surfaces, where unstable flyash piles can fall off onto the catalyst. Flow recirculation Zones 1, 3 or 5 (under turning vanes or structure at LaCygne) can cause flyash to drop out of the flue gas flow eddies.

LaCygne catalyst seals were sloped similar to the beam guards shown in Figure 11. Catalyst support beam and loading monorail beam pockets were covered to prevent ash buildup. SCR Hood Truss beam pockets were covered, beam tops sloped to eliminate ash buildup, and beam bottoms fabricated into air foils to avoid recirculation zones. Refer to examples shown in Figure 12a and 12b.



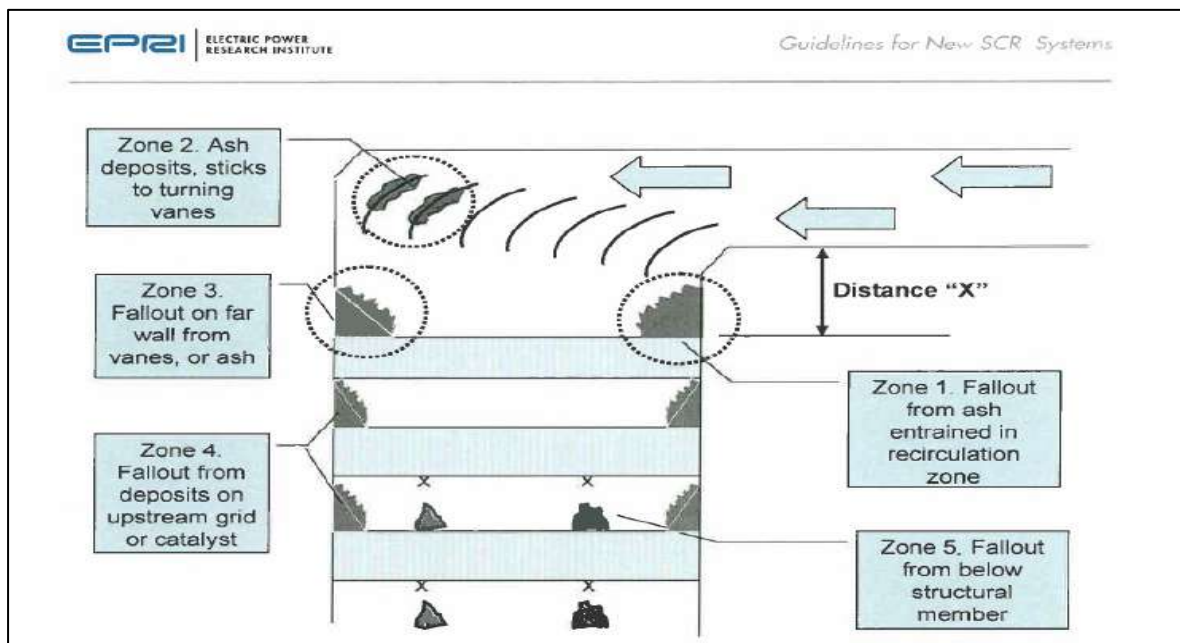
**Figure 12a:** Beam ash slough (left)

**Figure 12b:** Stalagmite from flat catalyst module seals (right)

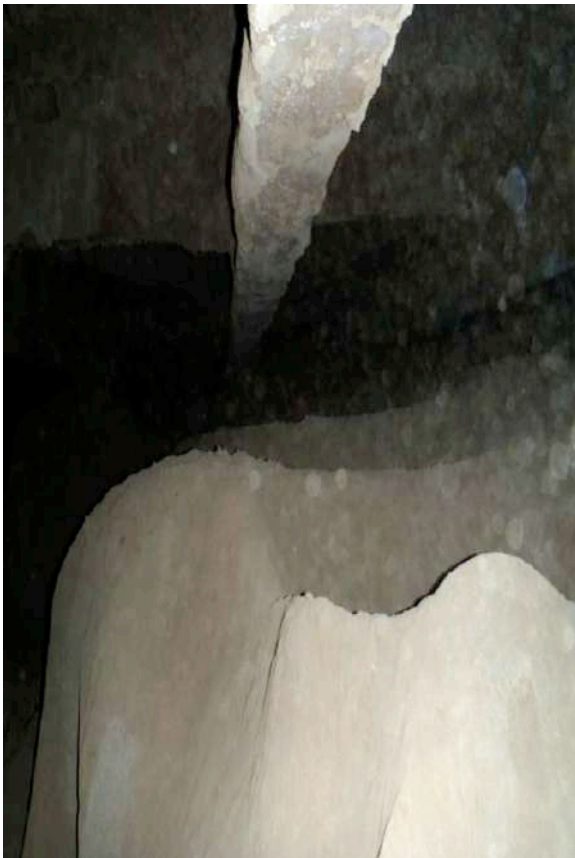


**Figure 13a:** Beam ash guard (left)  
**Figure 13b:** Beam ash guard (above)

PRB coal ash collects inside the SCR catalyst structural beam pockets. The ash in the deep beam pockets can slough off in large sections to cause bigger piles on the catalyst. Beam ash guards were installed to prevent ash accumulation.



An SCR internal inspection after four months of operation showed excellent results at the SCR division wall. Figures 14a and 14b show the before and after success of GSG in providing uniform, vertical, and non-recirculating flow in the SCR Hood to prevent flyash accumulation.



**Figure 14a:** Photo taken on 10/01/2012 near division wall



**Figure 14b:** Photo taken on 03/30/2013 near division wall.

Reduced flyash accumulation in LaCygne1 SCR will reduce catalyst replacement costs, reduce flyash vacuum removal costs, reduce catalyst pressure drop and fan power costs, reduce ammonia slip and ammonia costs, and reduce complexity of outages. The next catalyst layer replacement is not budgeted until after 2019. This would result in one layer being replaced after seven years operation, compared to previous replacement of eight layers in five years. Flow modeling for root cause correction of flyash pluggage has led to this SCR performance turn-around.

**Footnotes:**

1- Fig. 11-1 of "Operation and Maintenance Guidelines for Selective Catalytic Reduction Systems" Report 1022067.