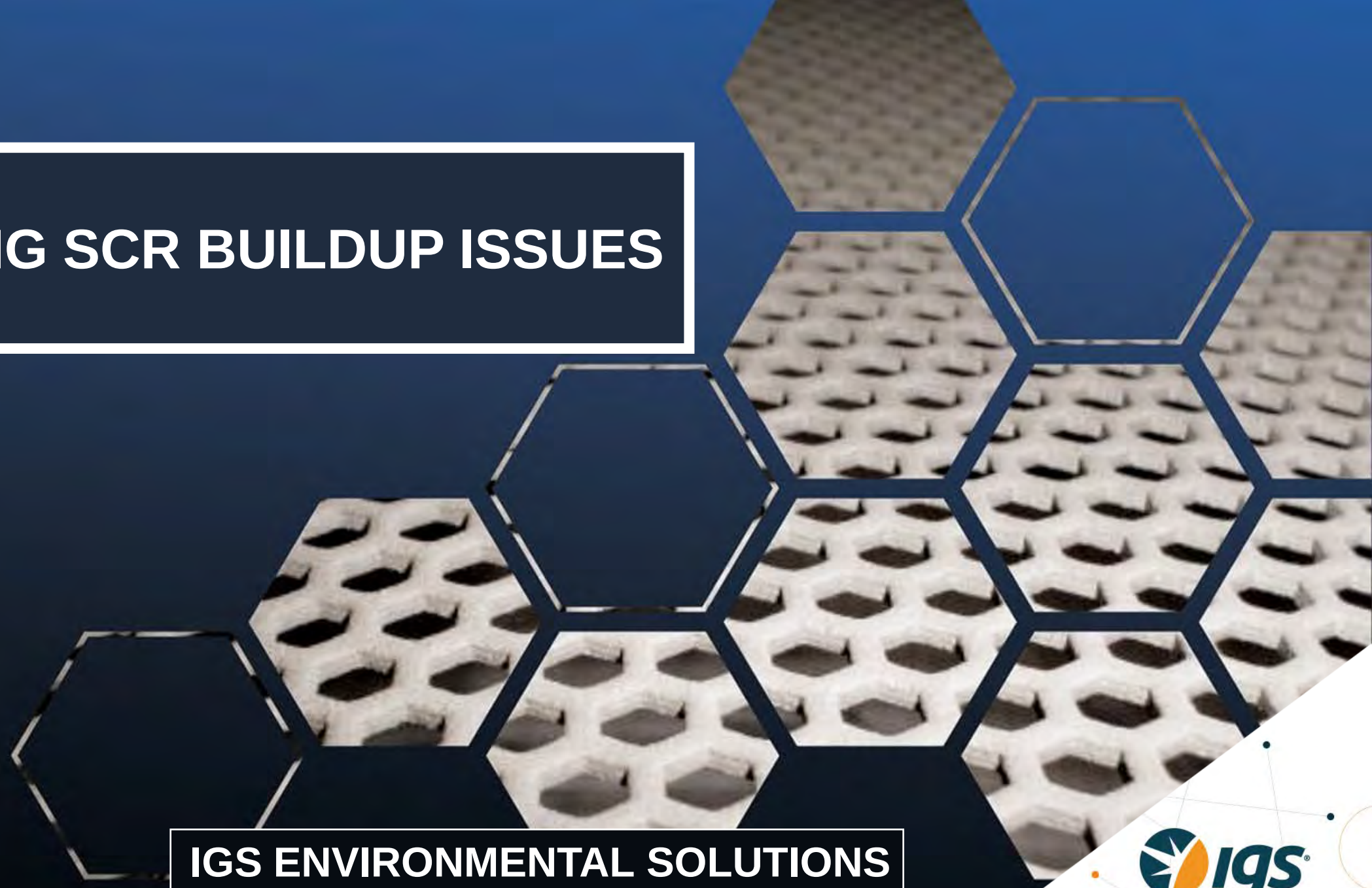
REINHOLD ENVIRONMENTAL Ltd.

2017 NOx-Combustion-CCR Round Table Presentation

February 27 & 28, 2017, in Cleveland, OH / Hosted by FirstEnergy

SOLVING SCR BUILDUP ISSUES



IGS ENVIRONMENTAL SOLUTIONS

FEBRUARY, 2017

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WYGEN INTRODUCTION

IDENTIFICATION OF PROBLEM

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Integrated Global Services

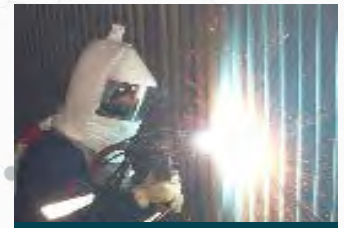
A BRIEF INTRODUCTION

IGS is the industry leader providing comprehensive solutions to erosion and corrosion problems in critical equipment throughout the Power, Oil and Gas, and Paper industries.

In the early 2000's IGS developed NoNOx™ LPA screens which quickly became the industry leading LPA filtration device.

The NoNOx™ product line evolved into IGS Environmental Solutions, specializing in complex systems enhancing emission control equipment efficiency and reliability.

IGS – Company History



Metalspray is established, serving the pulp and paper industry with thermal spray protective coatings

1980

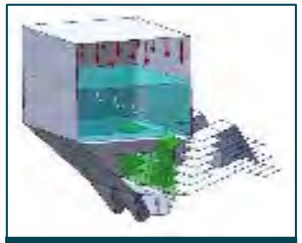
The Company acquires DOE high temperature erosion testing facility

1991

Acquisition of Thermal Coating Services from Westinghouse adds mechanical service capabilities and digester coatings

1994

1997



The Company leverages its thermal spray expertise to enter the LPA filtration market

2000

The Company adds weld overlay and later adds refractory capabilities

2003

2004

IGS supports its growth and moves into a new Virginia Headquarters and establishes two new regional operations centers (Texas, Canada)

2008

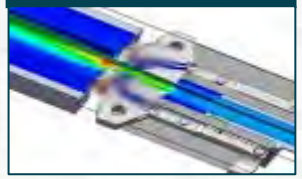
2011

2015

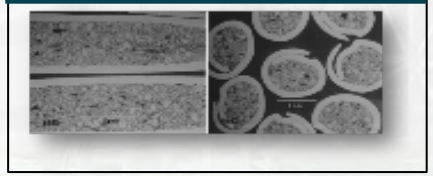
Completed numerous 5,000 - 20,000+ SF projects for Duke Energy, TEP, Basin Electric, AES, First Energy, and Southern Company

Significant Industry Milestones

In-house development of HVTS technology for low stress state, low oxide cladding.



Development of next generation of super alloys to prolong life extension by improving material performance and characteristics



Black Hills Energy, Corp.

Wygen 3

WYGEN GENERATING FACILITIES

Wygen 1 and Wygen 3

Location: Gillette, Wyoming

Capacity: 110 MW per unit

Type: PC Fired Boilers

Fuel: PRB, Wyodak Mine

Wygen 3 Unit 5 SCR Reactor

Wygen 3 U5 SCR reactor before secondary screens, LPA screen modifications and air cannons

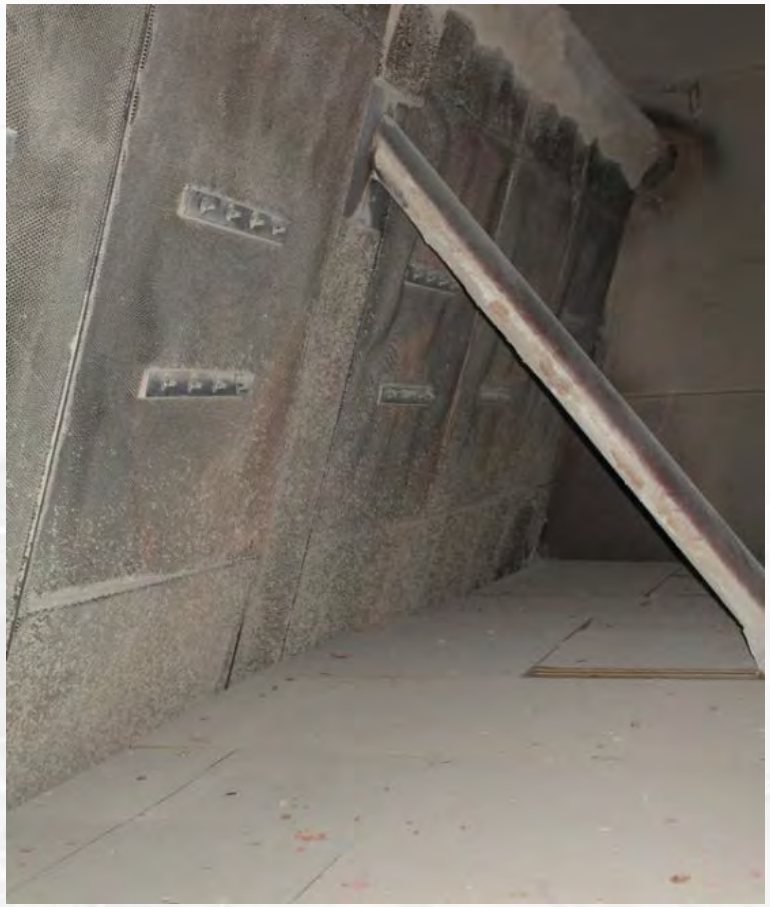
ASH BUILDUP AND ASSOCIATED COSTS

The Unit 5 SCR reactor suffered from excessive ash pluggage and accumulation.

Costly accumulation occurred rapidly causing extreme pressure differential across the catalyst, often forcing unplanned outages in 6 months or less.

Similar buildup problems have been documented to cost facilities up to $5,000,000 annually.

Wygen 3 Unit 5 LPA Screen



Wygen 3 U5 LPA screen prior to air cannon installation

ASH BUILDUP AND ASSOCIATED COSTS

The LPA screen in the unit 5 economizer outlet was an OEM's design utilizing NoNOx™ material. IGS did not design this system.

This system suffered from a poor gas flow profile, which led to excessive pressure drop and ash buildup across the screen.

Sections of the screen were removed to relieve the pressure drop, allowing LPA to reach the SCR reactor and plug the catalyst.

Wygen 3 Unit 5 SCR Reactor

Wygen 3 U5 SCR with air cannons and secondary LPA screens

CORRECTIVE ACTIONS

NoNOx™ secondary LPA screens and an air cannon cleaning system were installed on the top layer of unit 5.

Secondary LPA screens are specifically engineered to repel buildup, increase the effectiveness of the SCR cleaning devices, improve gas flow through the catalyst, and protect the catalyst from LPA pluggage and air cannon blasts.

Air cannons address improper ash flow distribution by redistributing the ash throughout the reactor. By re-entraining ash particles into the gas stream, air cannons do not allow ash to settle on the catalyst.

Wygen 3 Unit 5 LPA Screen

Wygen 3 U5 LPA screen air cannon cleaning system during installation

CORRECTIVE ACTIONS

IGS was contracted to supply NoNOx™ LPA screen panels to replaced those that had been cut and damaged.

An IGS LPA screen air cannon cleaning system was designed and installed on the unit 5 LPA screen.

Wygen 3 Unit 5 RESULTS

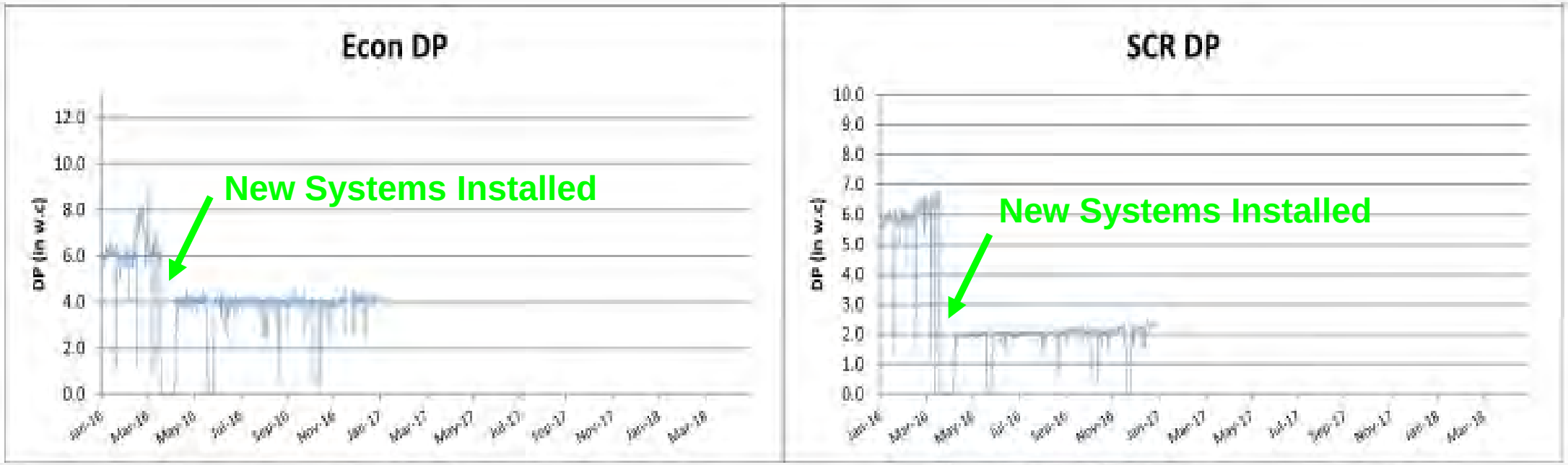
Wygen 3 U5 LPA screen after LPA screen air cannon installation

Wygen 3 U5 SCR reactor after secondary screens, LPA screen modifications and air cannons

Approximately 3 months after these systems were installed, Unit 5 was brought offline, unrelated to the SCR.

This allowed an opportunity to inspect the upgrades.

Wygen 3 Unit 5 RESULTS



Since installation, with almost a year of operating time, the pressure drop values have remained constant, indicating the system is operating properly without buildup.

Wygen 1 Unit 3

Wygen 1 and Wygen 3 both visible

INITIAL SITUATION

Wygen 1 Unit 3 is a “sister” unit to Wygen 3 Unit 5. The ash buildup problems of Wygen 1 Unit 3 were not as severe as Unit 5, however the buildup related costs were significant enough to warrant similar improvements.

The existing LPA screen was a simple wire mesh design that allowed screen failures and did not improve the gas flow through the system.

The catalyst modules were covered with flimsy wire mesh screens that did not provide adequate protection to the catalyst and tend to allow fly ash to accumulate.

Wygen 1 Unit 3 Upgrades

Wygen 1 U3 Upgraded LPA Screen

IGS NONOX™ LPA SCREENS

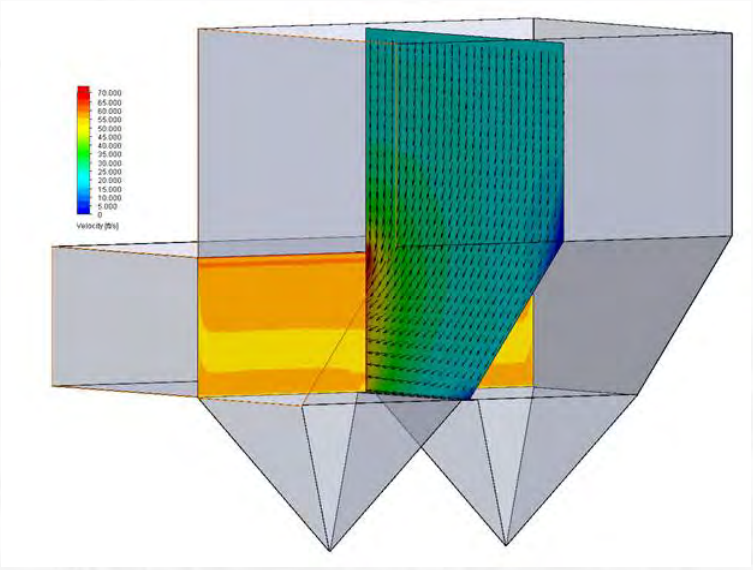
In May 2016, IGS designed and installed an engineered NoNOx™ LPA screen and air cannon cleaning system in Wygen 1 Unit 3.

The pressure drop across this system has remained approximately an inch water column less than the pressure drop of the system in Unit 5.

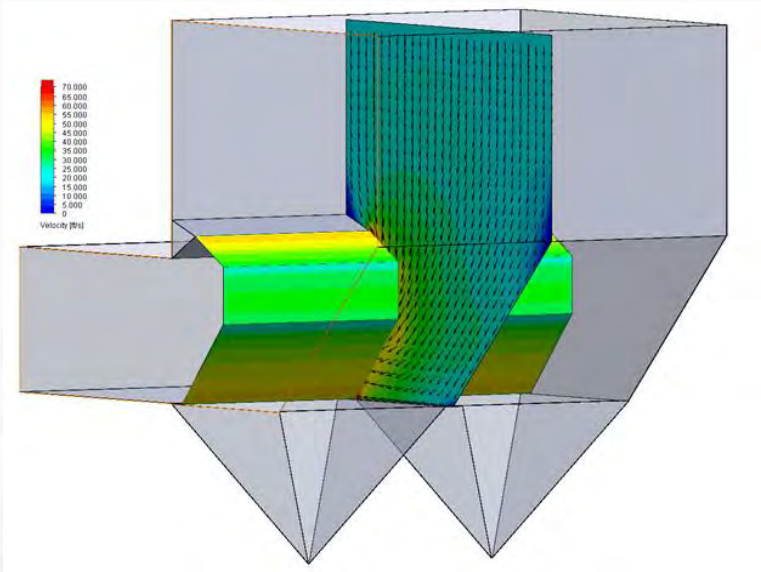
Secondary LPA screens were installed on the top layer of catalyst as well.

No buildup or pressure drop issues have been noted on the LPA screen or in the SCR since the time of installation.

Wygen 1 Unit 3 Upgrades



Standard LPA Screen



NoNOx™ LPA Screen

FLOW MODELING

A standard screen configuration shows an average velocity across the screen of 66 f/s with a pressure drop of 3.15 inWC.

The IGS designed system shows an average velocity of 35 f/s and the pressure drop to .4 inWC.

Wygen 3 Unit 5 SCR LAYER COMPARISON

Wygen 3 U5 Top Layer with IGS Secondary LPA Screens

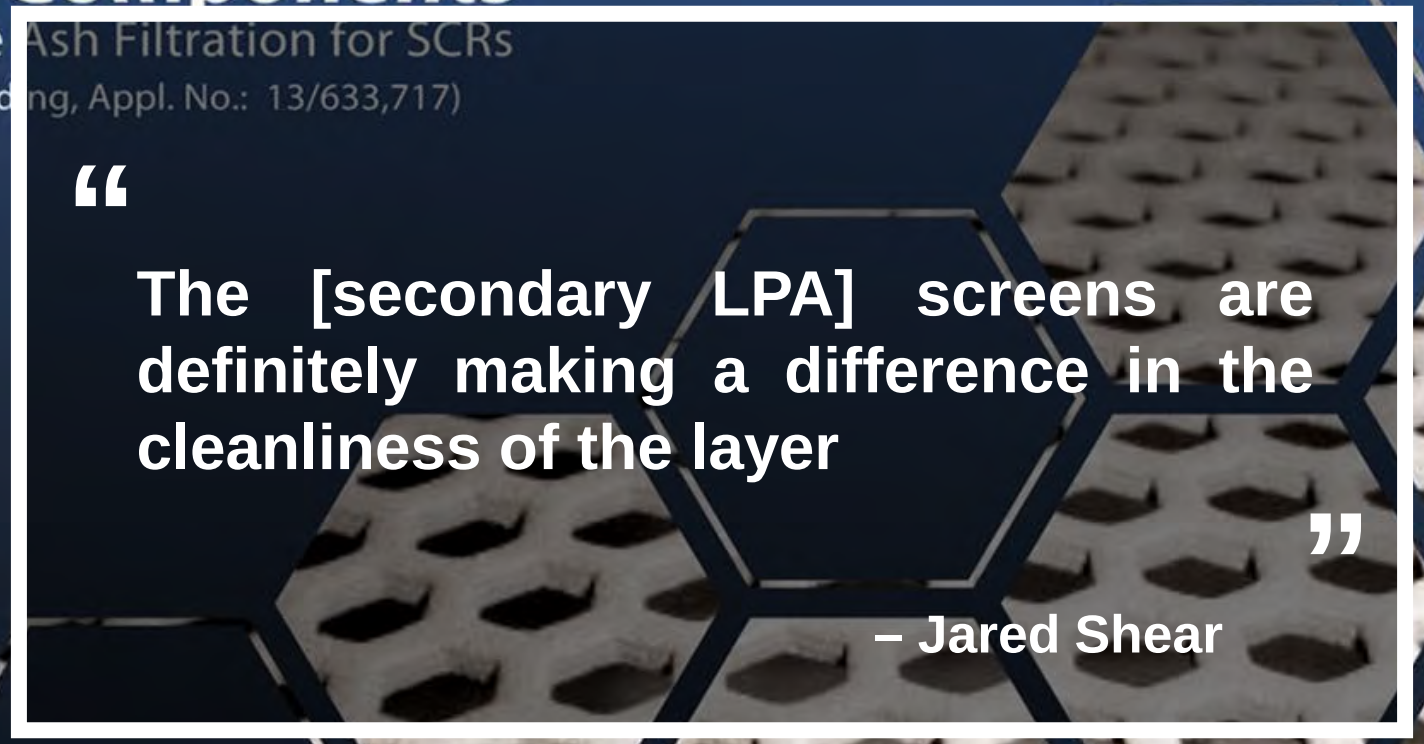
Wygen 3 U5 Bottom Layer with Wire Mesh Catalyst Screens

After almost a year, Unit 5 was recently brought offline in February 2017 for reasons unrelated to the SCR reactor, which allowed for the IGS SCR cleaning systems to be inspected.

NoNOx Components

Large Particle Ash Filtration for SCRs

(US Patent Pending, Appl. No.: 13/633,717)



“The [secondary LPA] screens are definitely making a difference in the cleanliness of the layer”

– Jared Shear

Wygen 3 Unit 5 SCR LAYER COMPARISON

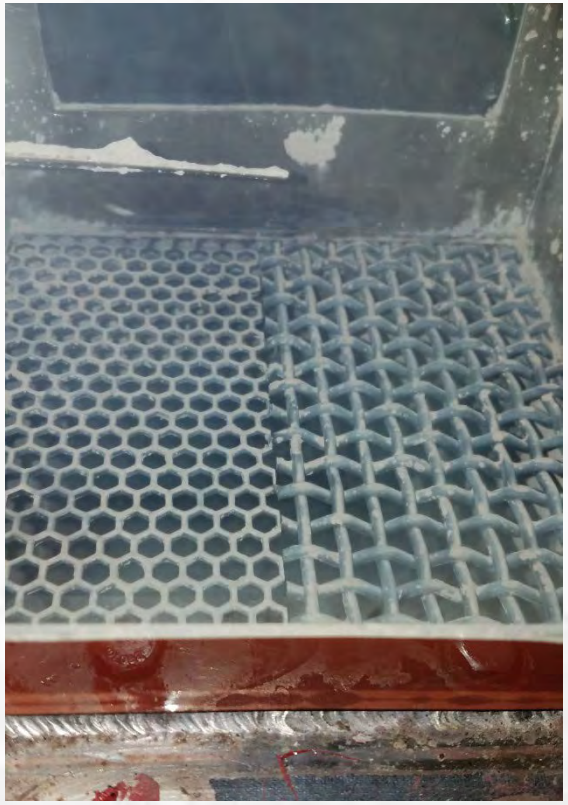
Wygen 3 U5 Top Layer with IGS Secondary LPA Screens

Wygen 3 U5 Bottom Layer with Wire Mesh Catalyst Screens

After almost a year, Unit 5 was recently brought offline in February 2017 for reasons unrelated to the SCR reactor, which allowed for the IGS SCR cleaning systems to be inspected.

Due to this inspection, plant management plans to install the IGS screens on each of their catalyst layers of each Wygen facility in the near future.

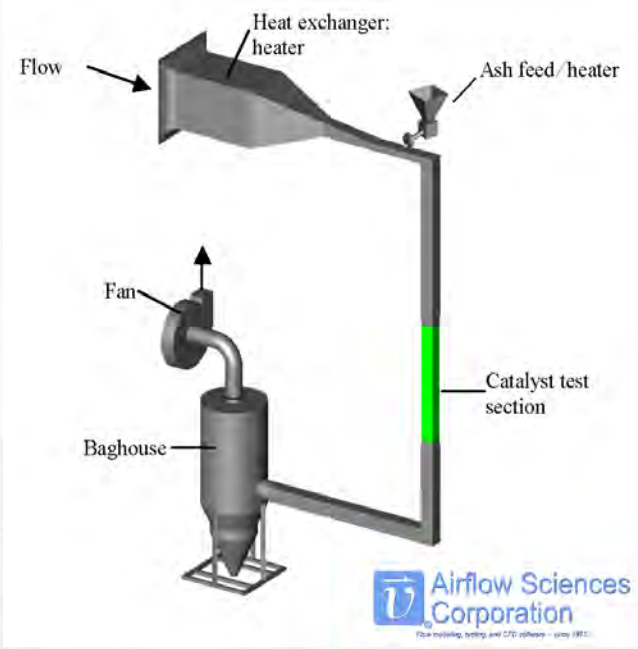
Researching the Effectiveness of the Secondary LPA Screens



View into the Testing Chamber

AIRFLOW SCIENCES TESTING

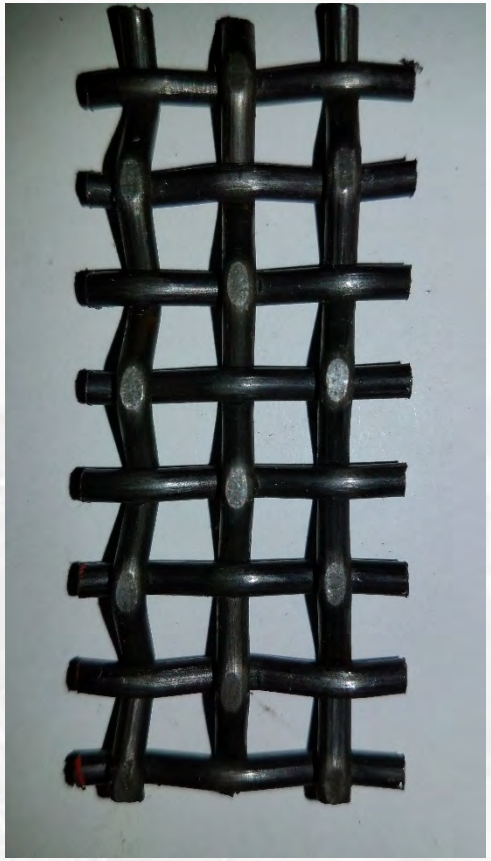
Airflow Sciences designed and performed a test of the buildup repelling properties of the NoNOx™ Secondary LPA Screens, compared to standard mesh wire catalyst screens.



Testing Unit Parameters:

- PRB Ash
- 15 f/s gas velocity
- 600 °F
- Ash loading of 100 g/nm3 (roughly 5x that of typical US SCR)

Researching the Effectiveness of the Secondary LPA Screens



AIRFLOW SCIENCES TESTING

Materials:

NoNOx™ Material (Right)

- Filtration capability: .22 in

Wire Mesh (Left)

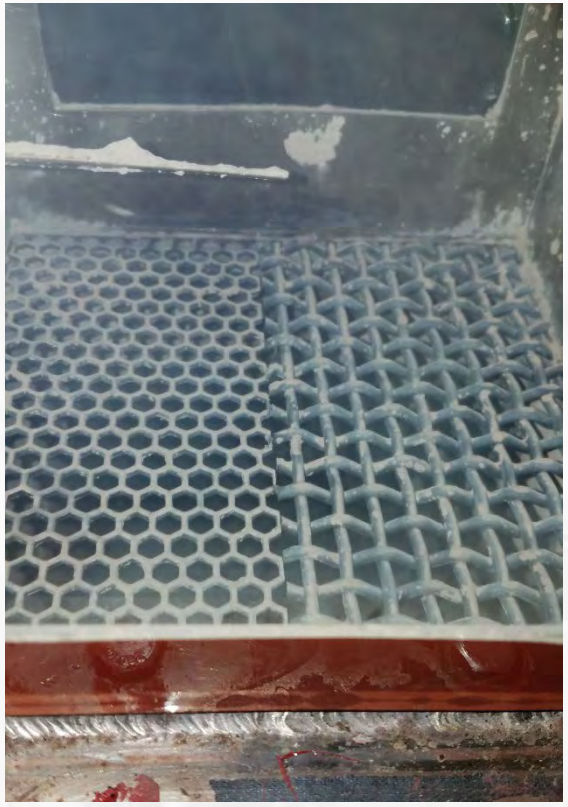
- Filtration capability: .315 in

Researching the Effectiveness of the Secondary LPA Screens

AIRFLOW SCIENCES TESTING

Condition 1

Condition 2



Condition 3

Researching the Effectiveness of the Secondary LPA Screens

AIRFLOW SCIENCES TESTING – RESULTS

Condition 1

Condition 2

Condition 3

DISCUSSION

Thank You