REINHOLD ENVIRONMENTAL Ltd.

2019 REINHOLD Round Table Presentation

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Economic Advantages of Strategic SCR Catalyst Cleaning and Management

Presented by: Carl Wise
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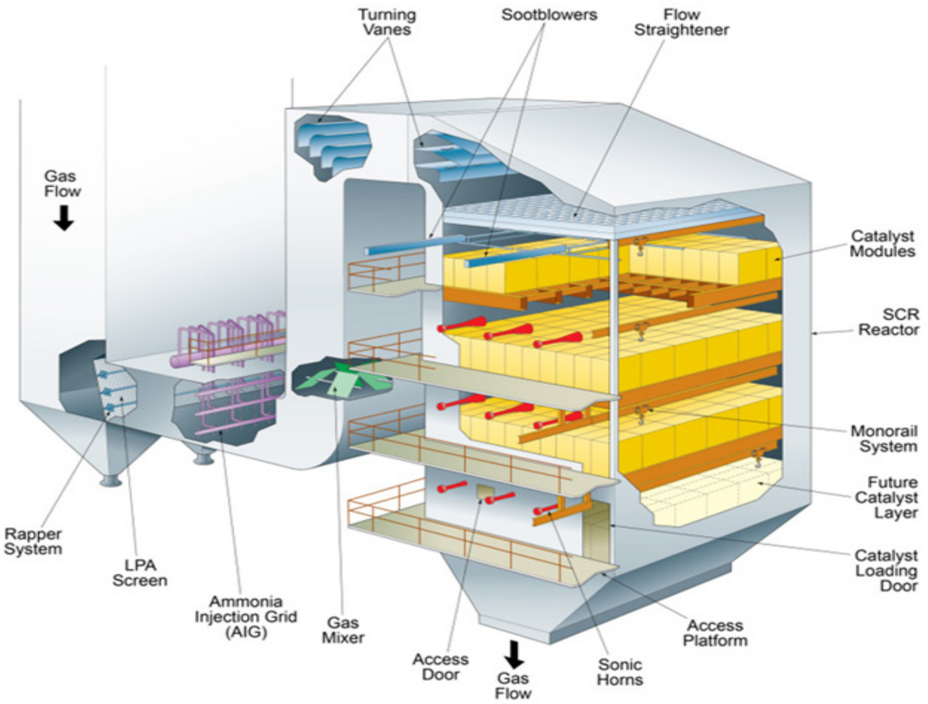
2019 NOX-COMBUSTION-CCR / PCUG CONFERENCE

Requirements for Optimal SCR Efficiency

- **Even Flow & Distribution**
- **Proper Ammonia-to-NOx Balance**
- **Maximum Catalyst Surface Area for NOx & Mercury Oxidation**

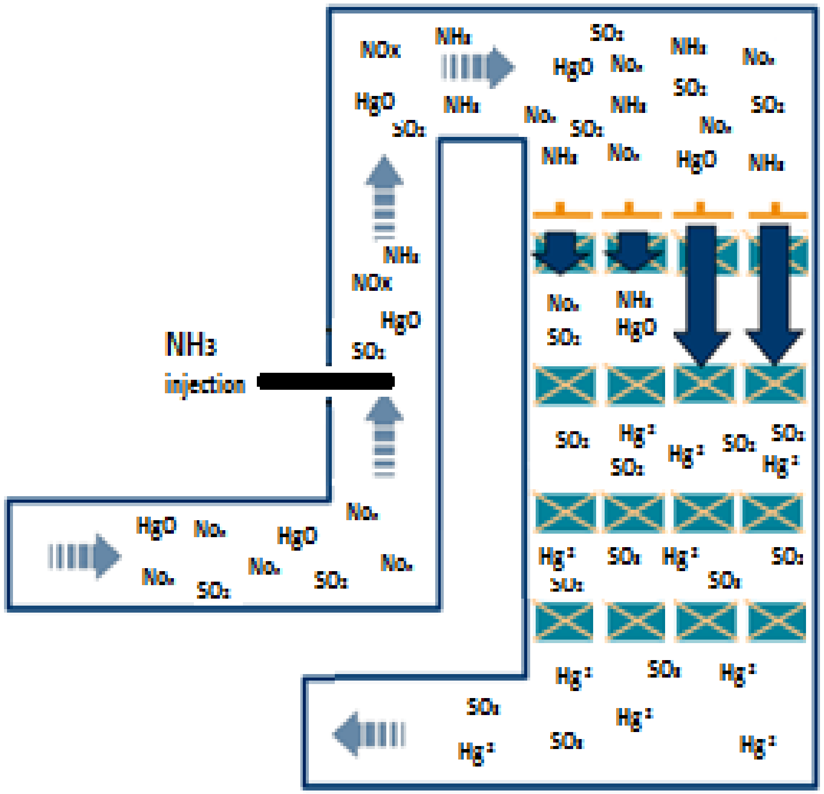


Need for Maximum Catalyst Surface Area

- **Flue Gas Stream Contains:**
  - **Nitrogen Oxides**
  - **Sulfur Dioxide**
  - **Mercury**

- **NOx competes for Oxygen and wins over both Sulfur Dioxide and Mercury.**

- **The presence of ammonia inhibits Mercury and Sulfur Dioxide conversion.**

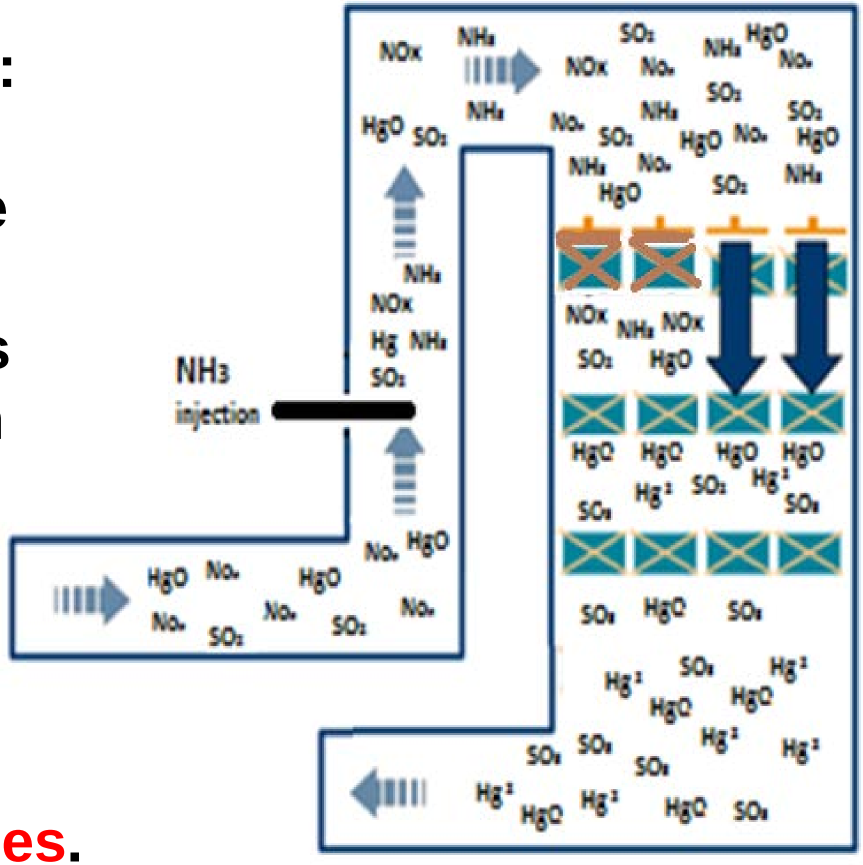


Catalyst Life

Catalyst deactivation is caused by:

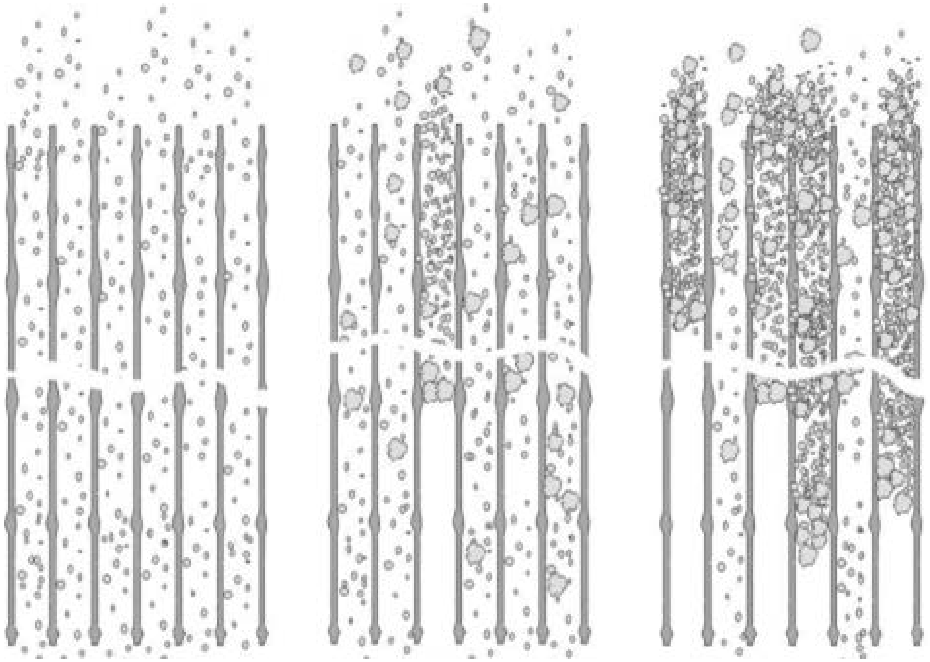
- **Poisoning of active sites by flue gas constituents**
- **Thermal sintering of active sites due to high temperatures within reactor**

- **Blinding/plugging/fouling of active sites by ammonia-sulfur salts and particulate matter**
- **Erosion due to high gas velocities.**



As the catalyst activity decreases, NOx removal decreases & ammonia slip increases.

Vacuuming

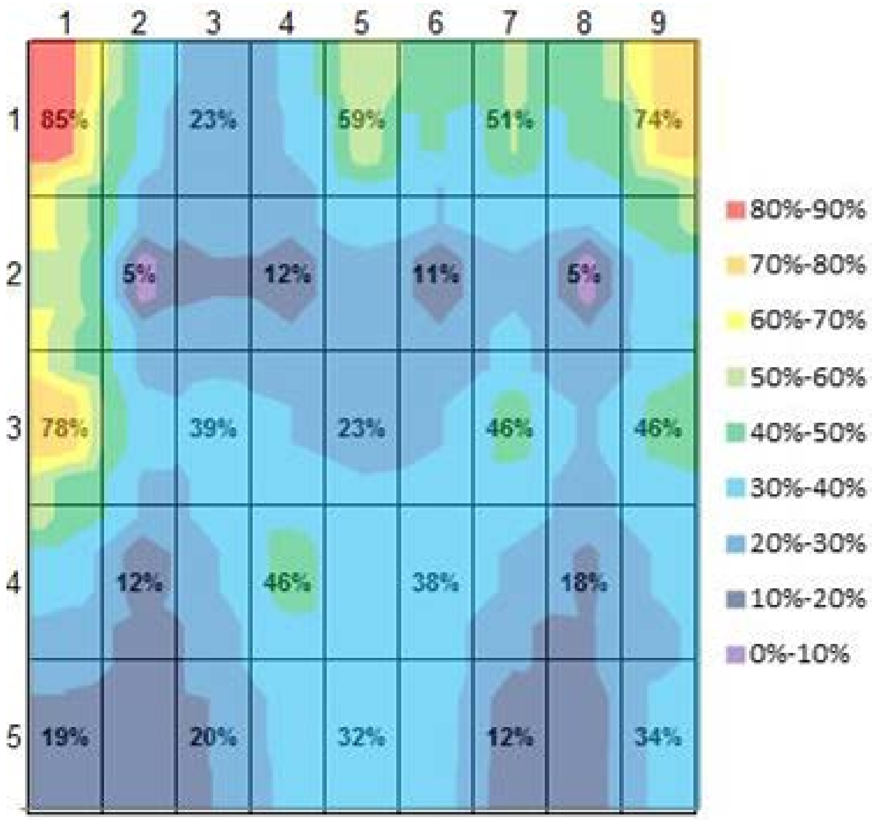


Simply vacuuming the fly ash off the top of the catalyst screens and catalyst surface *<u>does not</u>* effectively clear the inner catalyst surface or pores from physical or chemical poisoning substances.

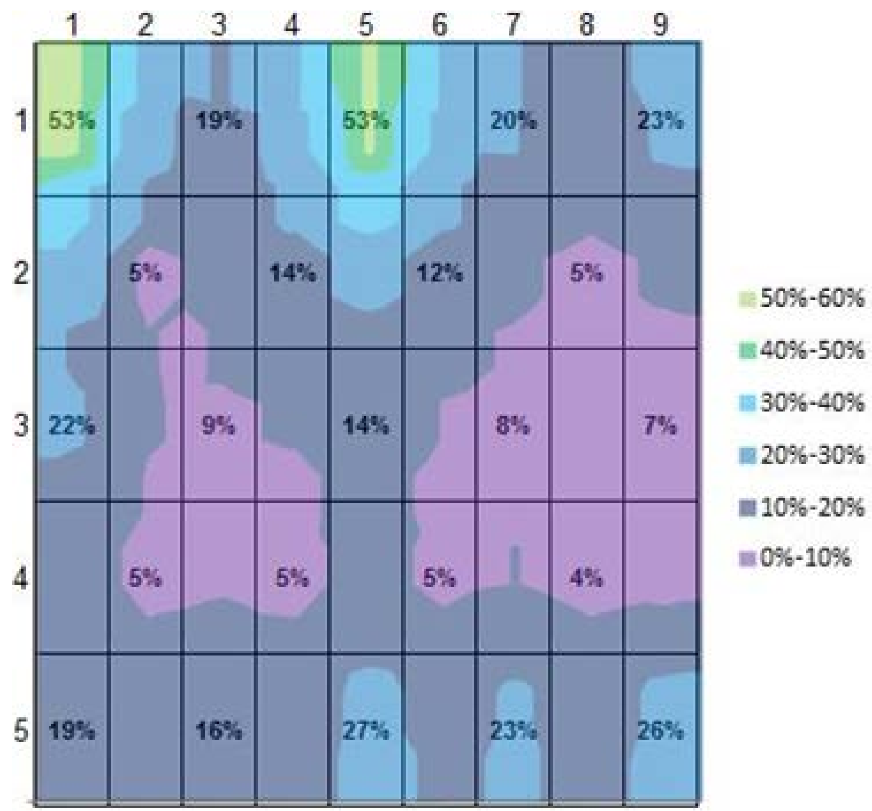
Vibration Cleaning in Action

Traditional vs. Vibration Technology

Traditional Cleaning



Vibration Cleaning Results



Removal of Hardened Ash

Sponge Blasting Process **utilizes polyurethane foam media to Safely Remove Hardened Ash from the Surface and Within the Catalyst without Damage.**

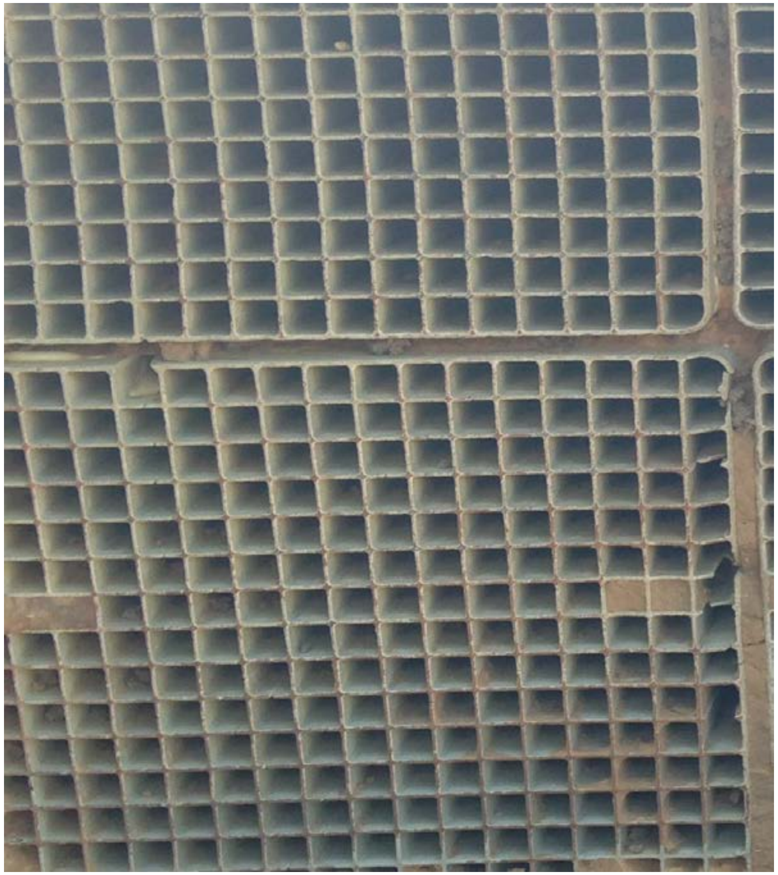
Sponge Blasting in Action

Sponge Blasting for Unplugging & Removal of Hardened Ash

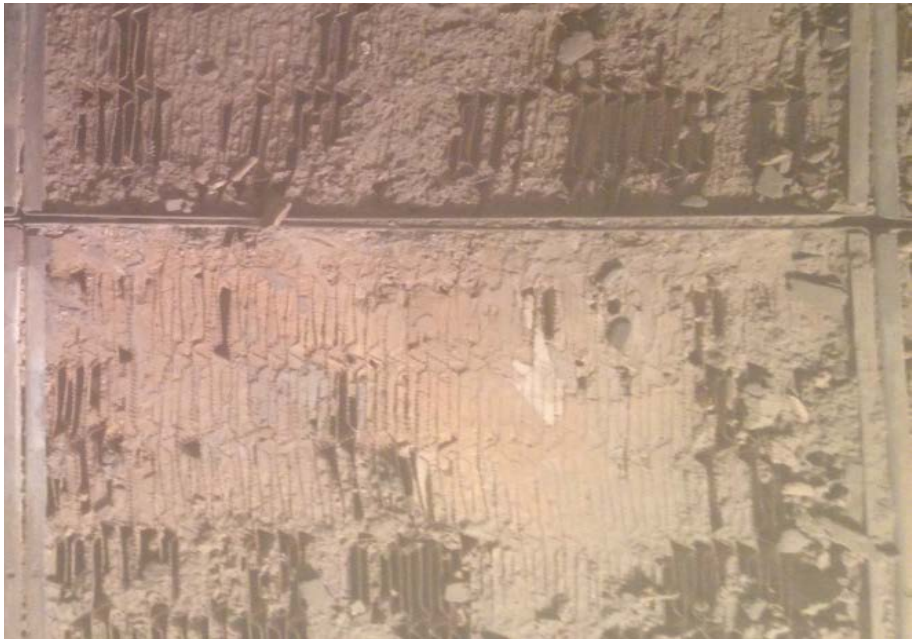
Results

BEFORE

AFTER



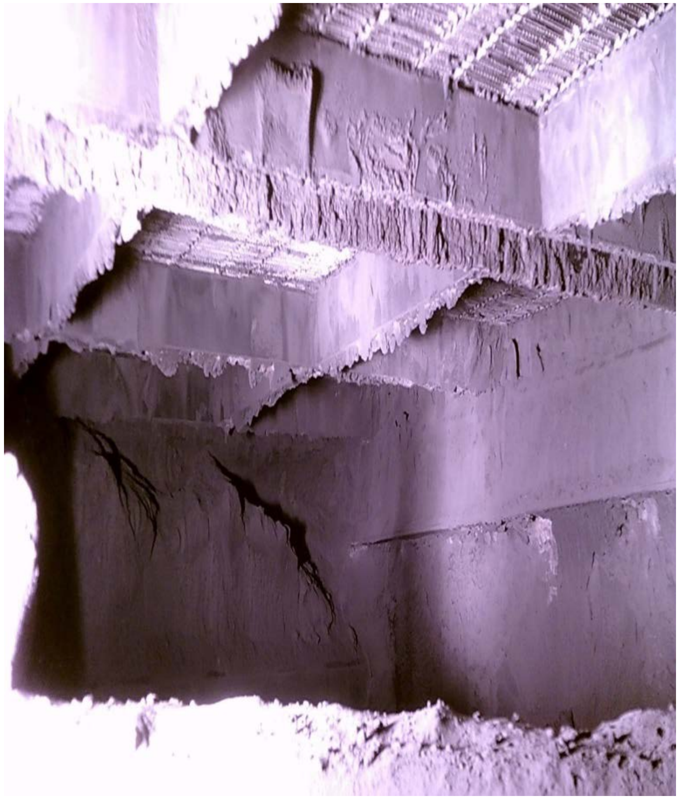
Results



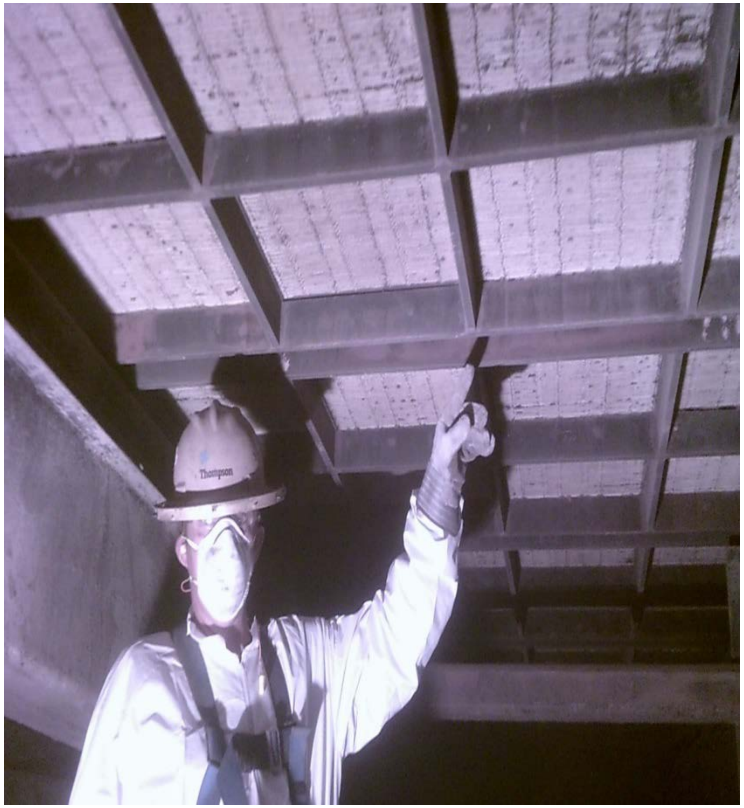
This combination of methods **Safely Clears both honeycomb and plate Catalyst of Potentially Harmful Contaminates that cannot be achieved by traditional methods.**

Bottom of Catalyst Layer

Before In-situ Cleaning Process



After In-situ Cleaning Process



Cost of Reduction in Catalyst Activity

LAYER	INVESTMENT	LOSS AT 25%	REMAINING VALUE
1	$1,000,000	$250,000	$750,000
2	$1,000,000	$250,000	$750,000
3	$1,000,000	$250,000	$750,000
Total	**$3,000,000**	**$750,000**	**$2,250,000**

***Cost averaged between New Catalyst at $1,200,000 and Regenerated Catalyst at $800,000* (based on 192 Modules Per-Layer with 25% Loss Over 18-Month Outage Cycle). Does Not Include Cost of Installation.**

Traditional Cleaning vs Advanced Cleaning Technologies

Layer	Cost	Cost of 25% Pluggage	Traditional Cleaning	Total	5 % Recovered	Loss Per-Outage Cycle
1 2 3	1 Mill. 1 Mill. 1 Mill.	250k 250k 250k	20k 20k 20k	270k 270k 270k	50k 50k 50k	220k 220k 220k
Total	**3 Mill.**	**750k**	**60k**	**810k**	**150k**	**660k**
Layer	**Cost**	**Cost of 25% Pluggage**	**Advanced Technologies**	**Total**	**15 % Recovered**	**Loss Per-Outage Cycle**
1 2 3	1 Mill. 1 Mill. 1 Mill.	250k 250k 250k	40k 40k 40k	290k 290k 290k	150k 150k 150k	140k 140k 140k
Total	**3 Mill.**	**750k**	**120k**	**870k**	**450k**	**420K**
					NET GAIN	**$240,000.00**

As pluggage percentage continues to compound, (80% vs 90%), erosion will increase more rapidly.

Value of Extending Catalyst Life

Layer	Cost	Installation	Traditional	Invested
1	1 Mill.	400k	60k	1,460,000.00
2	1 Mill.	400k	60k	1,460,000.00
3	1 Mill.	400k	60k	1,460,000.00
Total	3 Mill.	1.2 Mill.	180k	4,380,000.00
			18 Mo. x3	54 Months
			Per Month	$81,111.11

Layer	Cost	Installation	Advanced	Invested
1	1 Mill.	400k	120k	1,520,000.00
2	1 Mill.	400k	120k	1,520,000.00
3	1 Mill.	400k	120k	1,520,000.00
Total	3 Mill.	1.2 Mill.	360k	4,560,000.00
			24 Mo. x3	72 Months
			Per Month	$63,333.33

Costly Effects of Pluggage

- Reduction in Catalyst Life
- Decreased Catalyst Efficiency
- More Frequent Catalyst Replacement
- Increased Pressure Drop Across the SCR
- Increased Fan Power Consumption
- Reduced Efficiency of Mercury Removal

Costly Effects of Pluggage

- **Poor Ammonia Distribution**
- **Ammonia Slip**
- **Increase Regent Usage**
- **Formation of Ammonium Bisulfate (ABS) in the Air Preheater.**

    Increased air preheater fouling.

    Increased back end corrosion

- **Interrupted Power Production & Revenues**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SCR Management Options

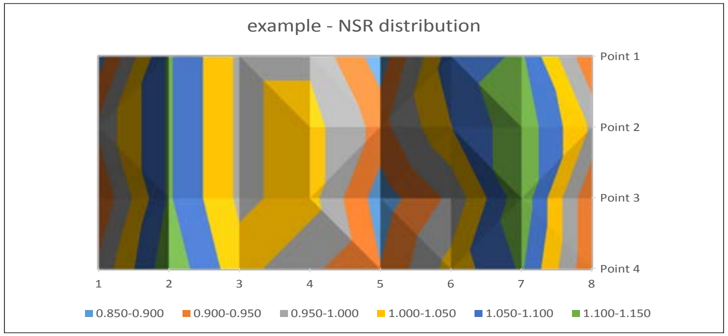
- **Catalyst cleaning alone cannot solve all SCR related issues.**
- **Other tools to troubleshoot SCR issues and optimize system operation**
  - Boiler tuning
  - SCR tuning
  - Bench-scale SCR catalyst testing

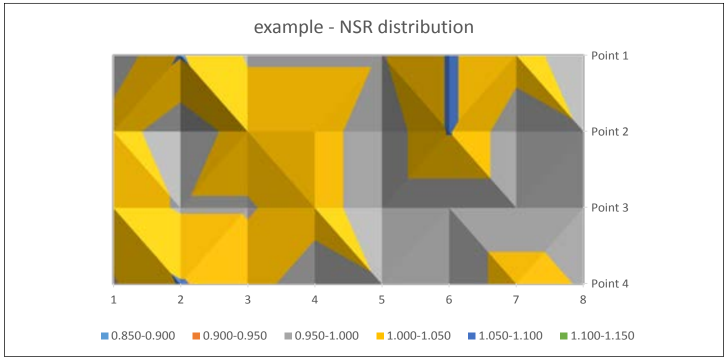
Boiler Tuning

- **Visual inspection of burners, air and gas systems, and pulverizers**
- **Controls evaluation during unit swing/ramp**
- **Validation of airflow indications**
- **Baseline testing from to evaluate**
  - NO_x/CO/O_2 distribution within furnace
  - Fuel fineness/distribution and air-to-fuel ratio
  - Air in-leakage
- **Tuning operating parameters to optimize unit efficiency and minimize emissions**
  - Reduced furnace exit NO_x and LOI
  - Improved heat rate

SCR Tuning

1. Inspect ammonia injection nozzles, if possible
2. Document inlet NO_x distribution/AIG injection valve position
3. Tune NH_3 injection to meet NO_x distribution
4. Retest SCR inlet/outlet NO_x until desired result achieved





SCR/Boiler Tuning: Economics

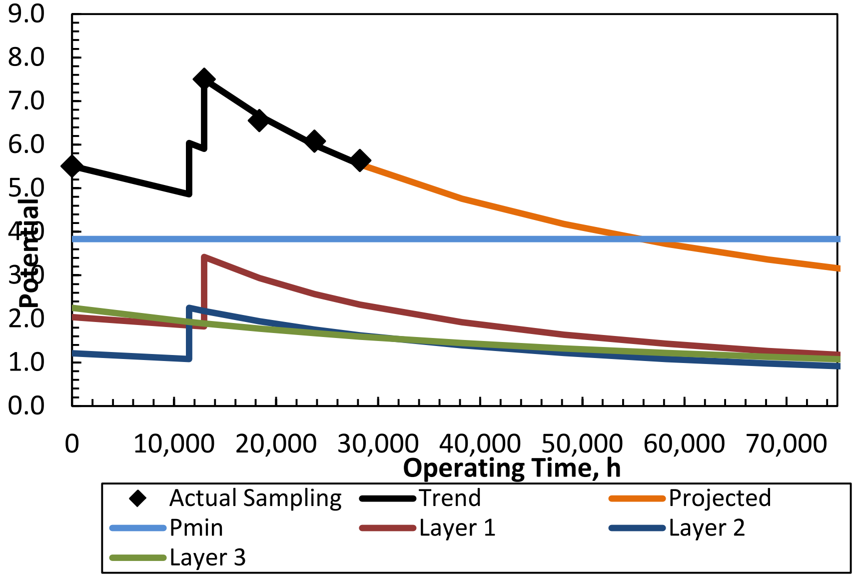
- Reduction in boiler exit NO_x can pay for cost of tuning program in one year
  - Reduced NH_3 consumption
- Additional benefits
  - Improved heat rate
  - Reduced slagging potential
  - Fewer forced outages
- Tuning NH_3 injection leads to optimal reagent consumption
  - Less NH_3 slip
  - Balanced distribution

Annual NH_3 Savings for Given Boiler Exit NO_x Reduction/NH_3:NO_x Distribution Improvement (600 MW Unit)

	2%	5%	10%
PRB	$19,800	$49,400	$98,800
Illinois Basin	$25,400	$63,500	$127,000
Bituminous	$32,500	$81,100	$162,300

SCR Catalyst Testing

- Track catalyst deactivation trends
- Determine primary catalyst deactivation mechanisms
- Project catalyst lifetime
- Optimize catalyst replacement schedules
- Evaluate impact of changing fuel type



Questions?

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