REINHOLD ENVIRONMENTAL Ltd.

2013 NOx-Combustion Round Table & Expo Presentations

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Reinhold Environmental LTD.
2013 NOx-Combustion / PCUG Conference

Keeping Your SCR Clean

February 19, 2013

Jake Shelton
SCR Tech
&
Jeff Shelton
Martin Engineering

Keeping Your SCR Clean

1st Half of the Presentation – Jake Shelton

- Traditional Online Catalyst Cleaning Systems

2nd Half of the Presentation – Jeff Shelton

- Emerging Online Catalyst Cleaning Systems

Traditional Online Catalyst Cleaning Systems

Rake Style Sootblowers

- Steam
- Compressed Air

Acoustic Cleaners

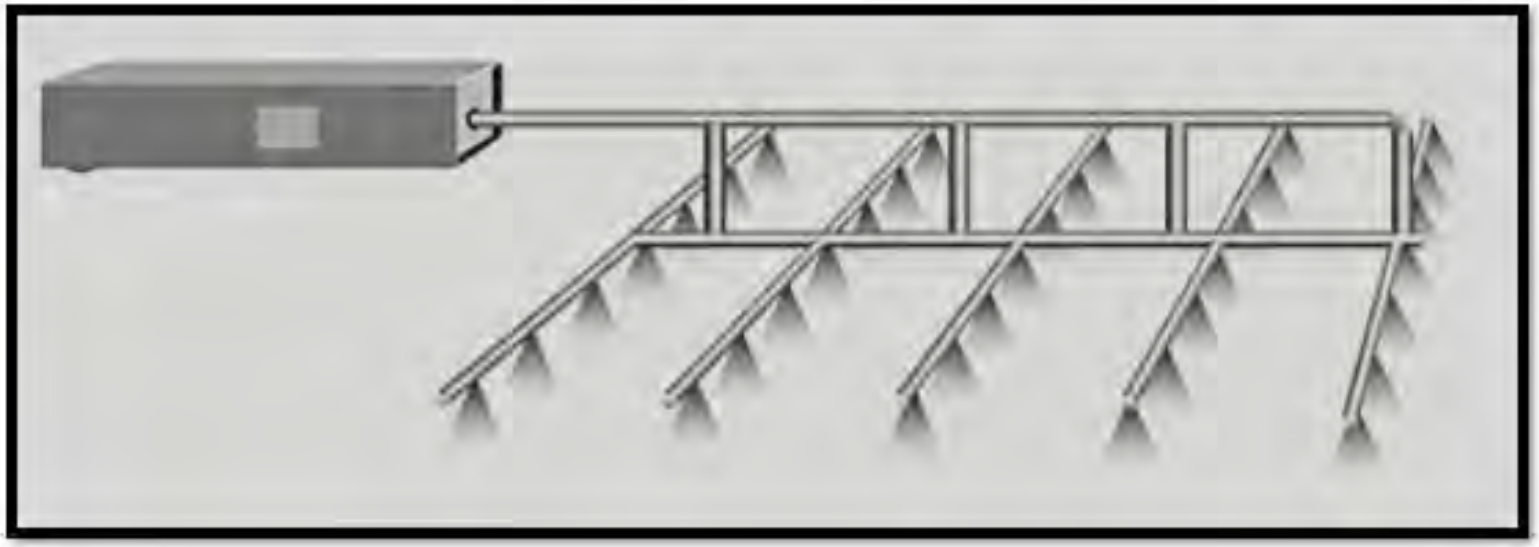
aka sonic horns

Rake Style Sootblowers

Prior to 2001, sootblowers were installed on the majority of the SCR reactors constructed in the United States. The use of sootblowers on SCR reactors came from the experience of the Germany utility industry.

Rake Style Sootblowers
Steam or Air

- Cleaning Effectiveness is equal.
- Steam is more available.
- The majority of the installations use steam.



Rake Style Sootblowers Steam/Air Consumption

Based on the following design features:

3/16" dia. nozzle
240 nozzle per rake
40 PSIG pressure at each nozzle
Steam temperature of 700 degrees F.
Air Temperature of 120 degrees F.
Average Travel of 84"
Travel Speed of 21" per minute

- Steam Flow Rate: 15,618 lbs. per hour
- Air Flow Rate: 4,433 SCFM

Sootblower Operation

➢ Operational Cycle

When the SCR reactor is started up, the sootblowers are operated once a day. This operational cycle is typically used because of the expense of operating the sootblowers. The sootblowing frequency may increase or decrease depending on the pressure drop across the catalyst layers. Over aggressive sootblowing can cause damage to the catalyst.

➢ Sootblowing Pressure

The pressure needs to be correct. If the pressure is too low, then the catalyst is not adequately cleaned. If the pressure is too high, it will cause erosion damage to the catalyst.

➢ No Moisture

The introduction of moisture will cause the ash particles to cake and become hard.

Catalyst Damaged by Over Aggressive Sootblowing

Acoustic Cleaner

Since 2001, acoustic cleaners have been used by as the sole online catalyst cleaning system on SCR reactors constructed in the US. At this time, more than 70% of the SCR reactors in service in the US are fitted with acoustic cleaners.

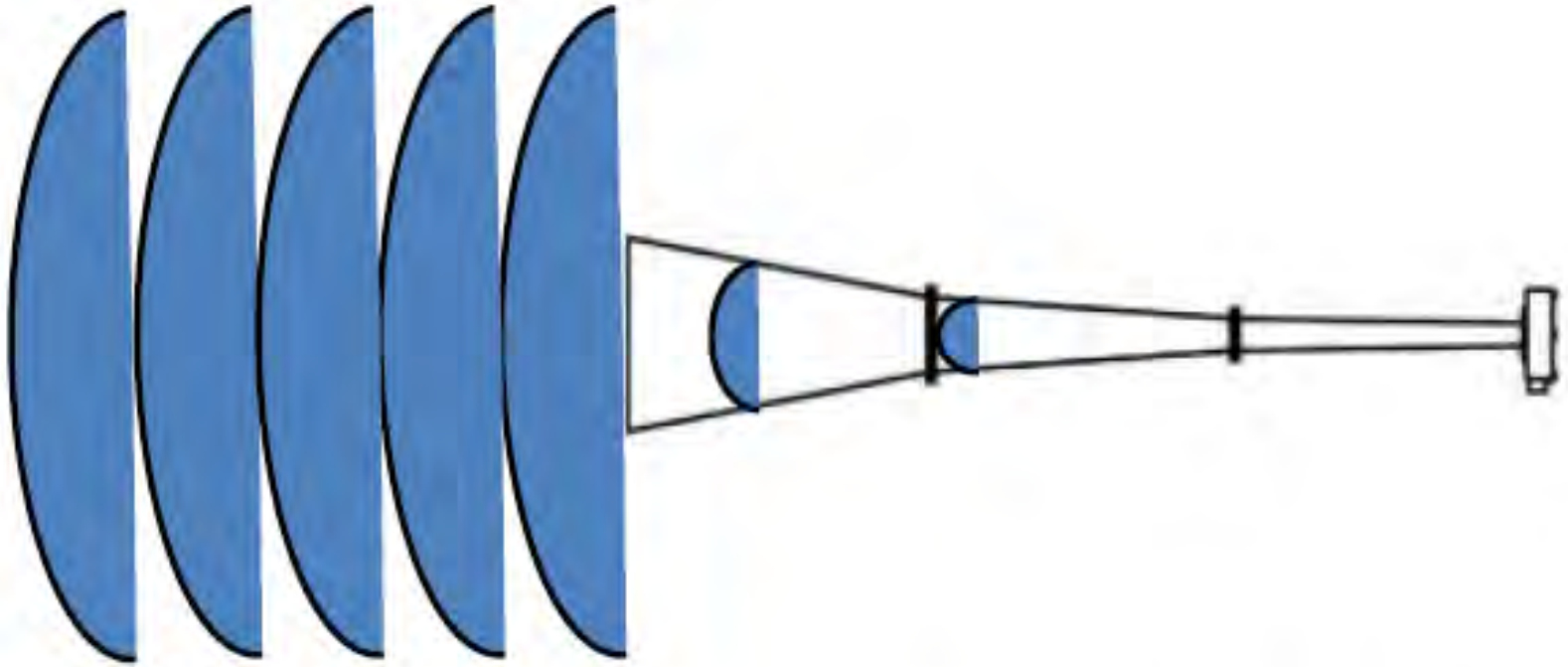
These pictures are of the same SCR reactor.

Sootblowers

Acoustic Cleaners

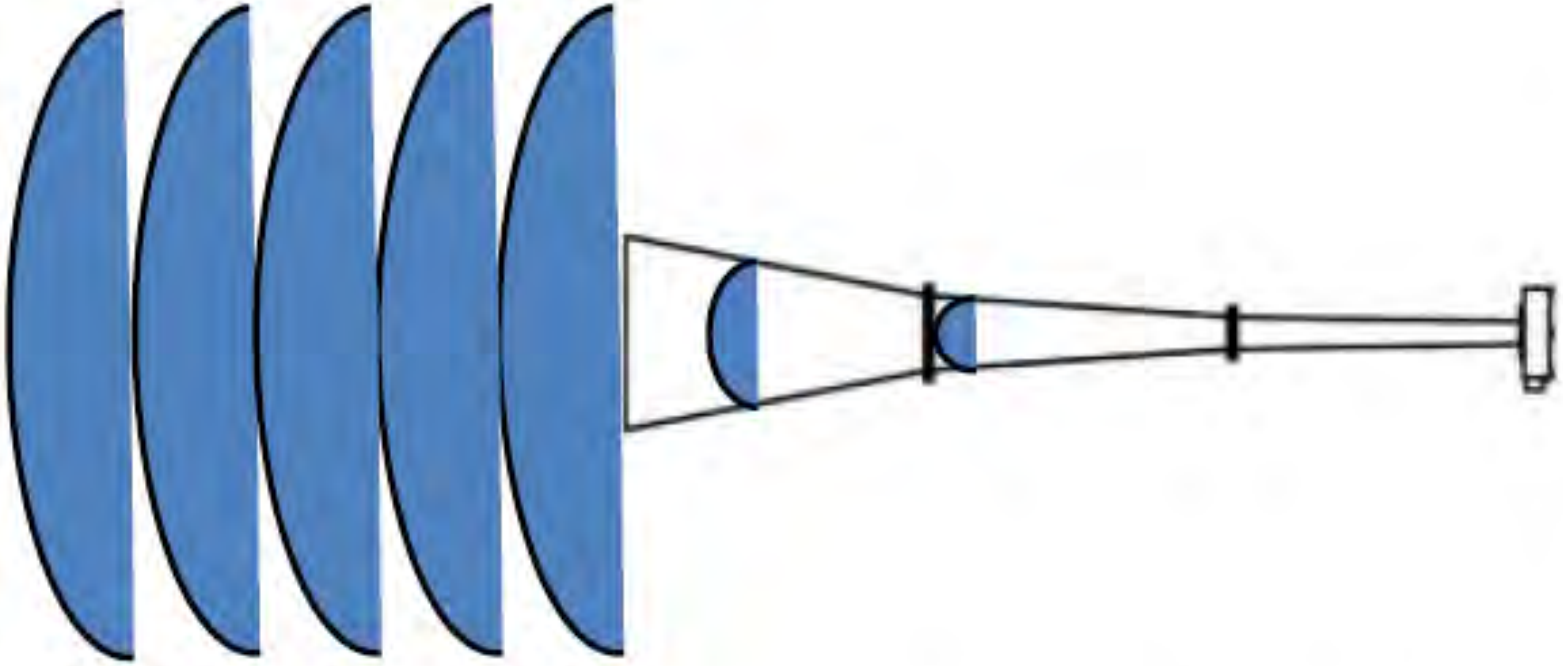
The acoustic cleaners became the cleaning system of choice by the SCR OEMs once it was proven that the acoustic cleaners were effective in cleaning the catalyst. The acoustic cleaners can be installed on a SCR Reactor for a faction of the cost of sootblowers.

Principle of Operation



Acoustic cleaners are air operated horns that produce low frequency/high energy sound waves

Principle of Operation



The sound waves cause particulate deposits to resonate and dislodge from structural and catalyst surfaces.

Air Requirements

Air Pressure: 70 to 90 psi
Air Consumption: 60 – 80 SCFM

The operating cycle for acoustic cleaners installed on SCR reactors is to sound each acoustic cleaner for 10 seconds every 10 minutes. The air consumption during the sounding cycle is 13 SCF of air. Each acoustic cleaner will average consuming 1.3 SCFM.

75 Hz Acoustic Cleaner - Straight Bell Design

75 Hz Acoustic Cleaner - Curved Bell Design

Maintenance Issue

The main maintenance issue experienced on the acoustic cleaners is the growth of a hard crusty deposit in the ID of the bell sections protruding through the lagging. The deposits in the bell sections interfere with the sound wave development.

Close up view of the ID of the acoustic cleaner's bell sections.

Properly Installed Acoustic Cleaners

In this type of installation arrangement, the bell sections are being keep warm by using the hot air trapped between the reactor wall & lagging. This keeps the flue gas that backs into the bell sections above the acid dew point.

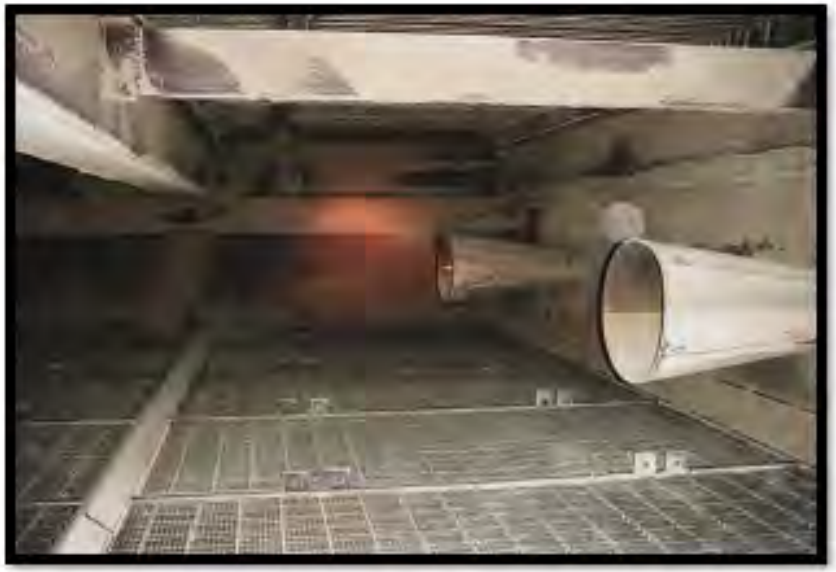

Conventional Horn at 20 Feet


MARTIN MEGA Horn at 20 Feet

Mega 75 Hz Acoustic Cleaner at a distance of 40’.

Rake Style Sootblowers

Acoustic Cleaners



- Both technologies have been installed on 200 plus SCR reactors.
- Both technologies have been installed on high dust and low dust reactors.
- Both technologies have been applied to reactors following boilers burning a variety of coals. Including PRB and high ash coals.
- Both technologies are being used to clean all the different types of catalyst: honeycomb, plate and corrugated.

Rake Style Sootblowers

Acoustic Cleaners

Unfortunately, both technologies have also proven to be ineffective with overcoming flow and ash distribution problems.

Keys to Keeping SCR Clean

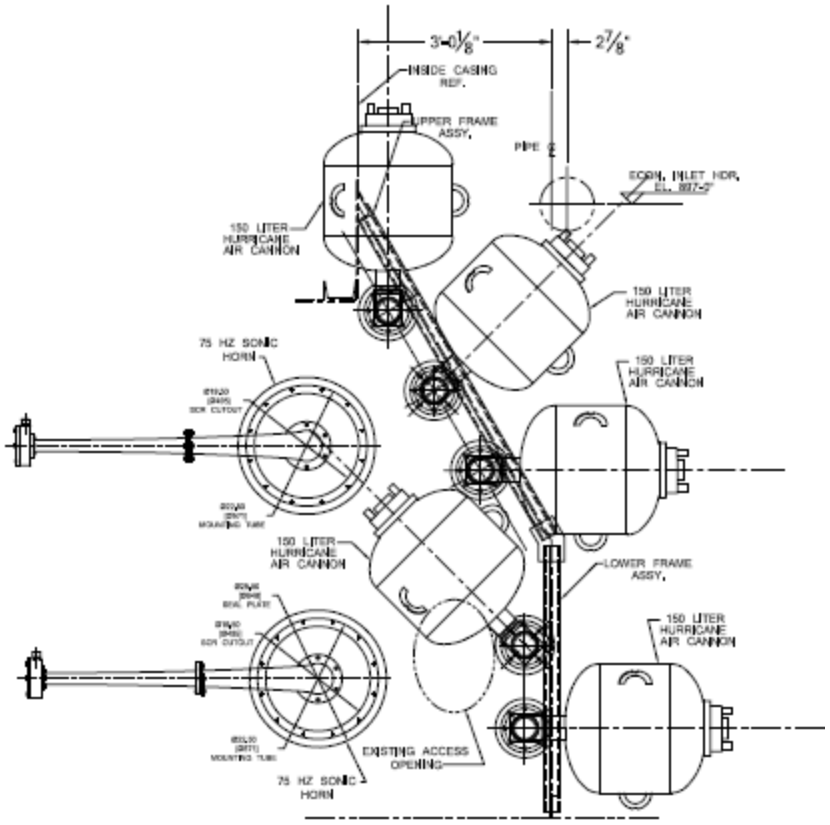
- Proper Air Flow and Ash Distribution
- Proper Catalyst pitch
- Elimination of Large Particle Ash
- Maintain proper load on boiler
- Maintenance of Cleaning System

Factors that affect Proper Air Flow Distribution and Velocity

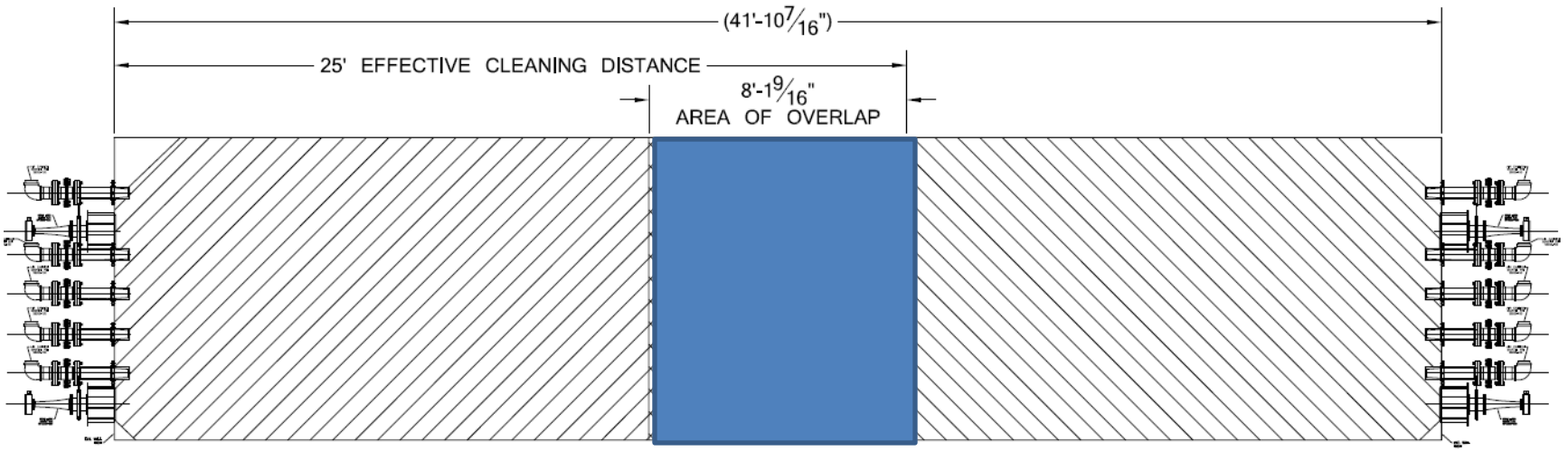
- Buildup in LPA screen
- Buildup in turning vanes or ductwork
- Buildup in SCR
- Boiler Load

Solution to LPS Screen Buildup

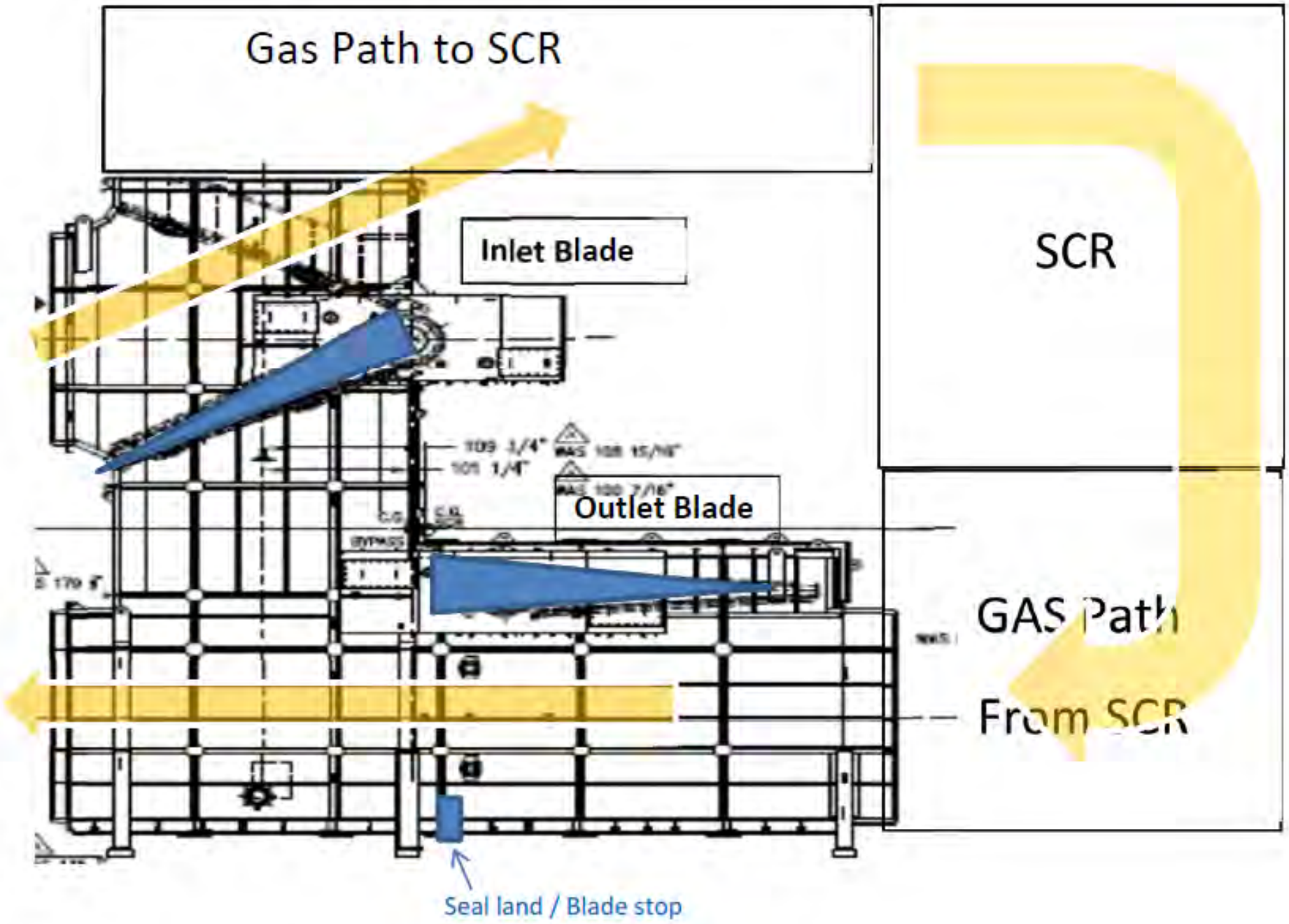
Combination Acoustic Cleaners and Ash Sweeper



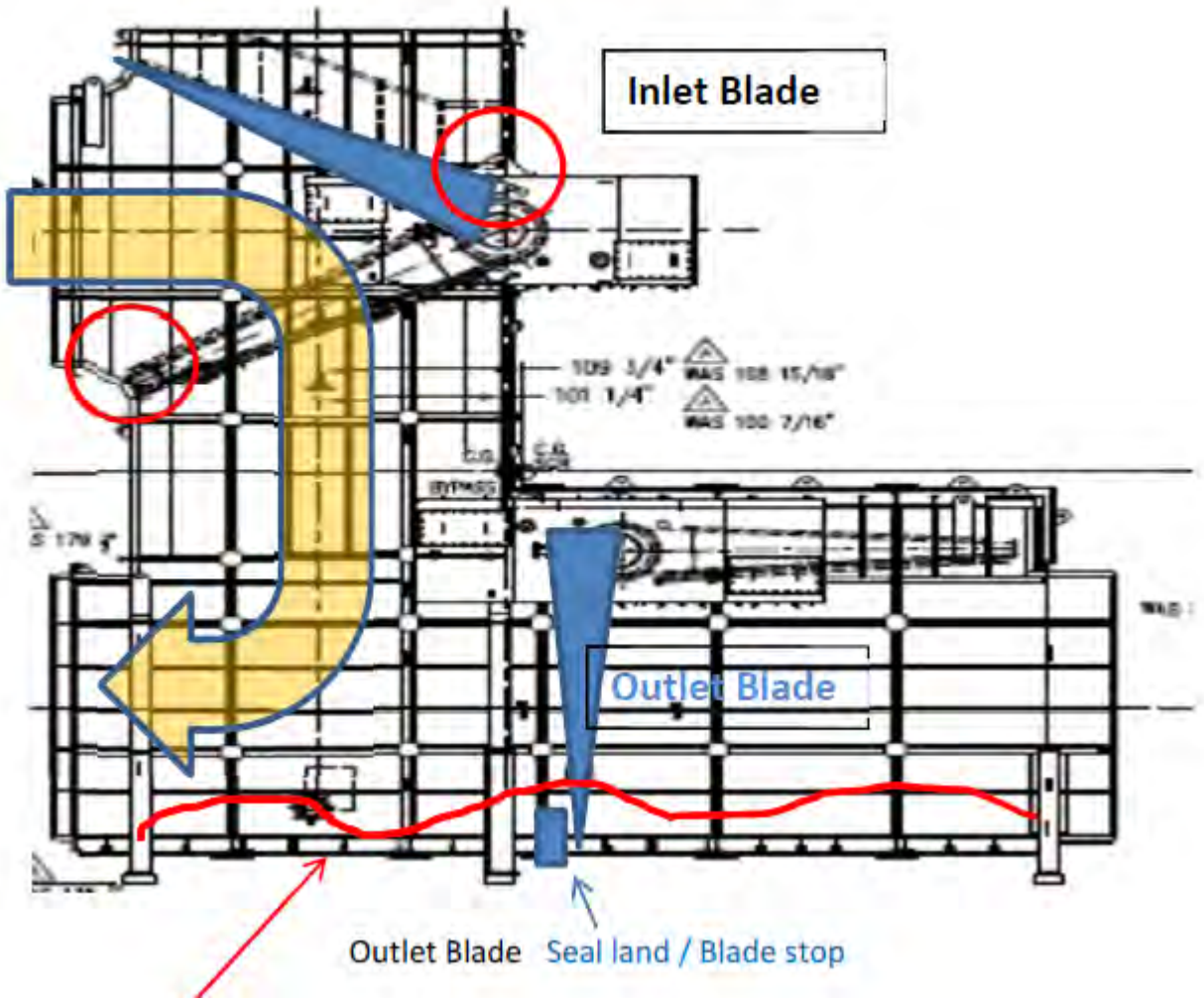
Cleaning Pattern



Ash Sweeper is designed with high velocity nozzles for cleaning long distance.

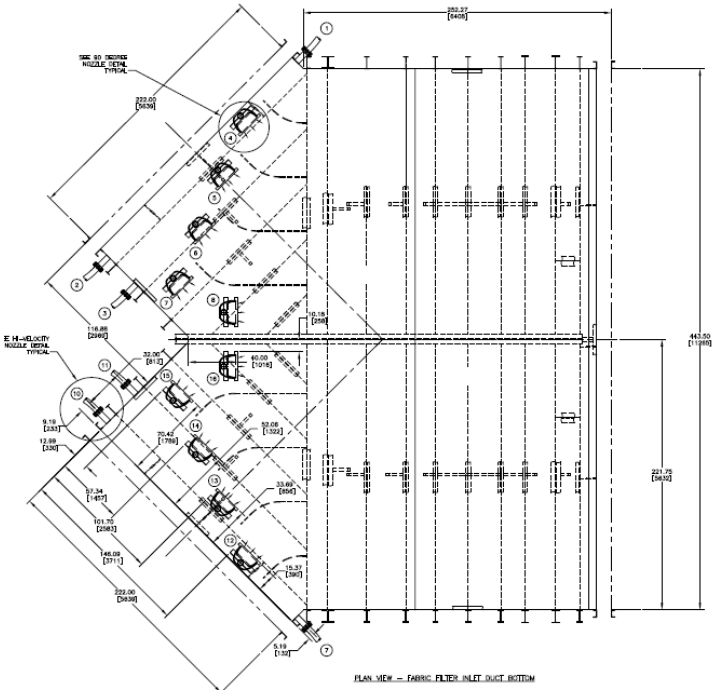

Gas Path to SCR
SCR
Inlet Blade
Outlet Blade
GAS Path
From SCR
Seal land / Blade stop

Flow shown in yellow arrow

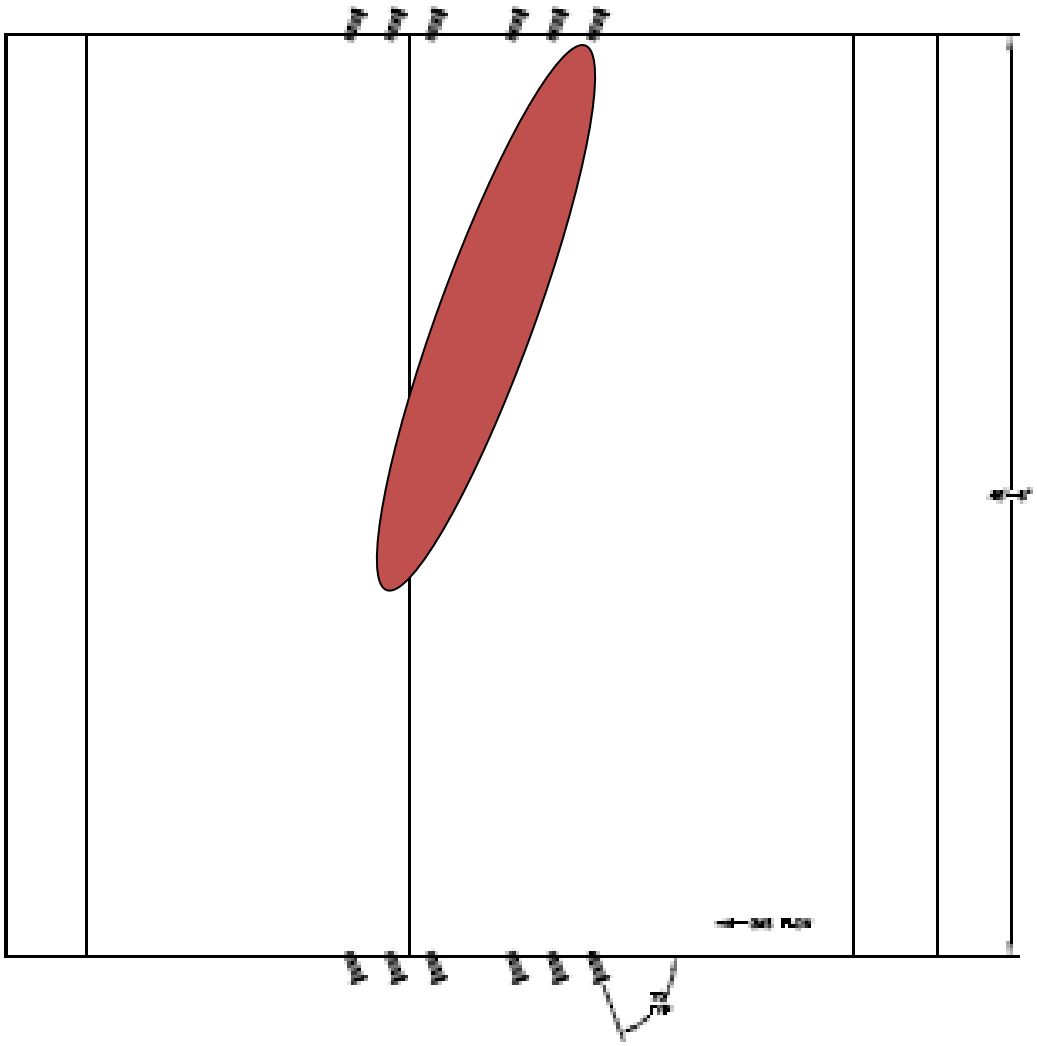


Cleaning ductwork

- Access is important. First approach is cleaning with 90 degree nozzles installed in floor of duct.

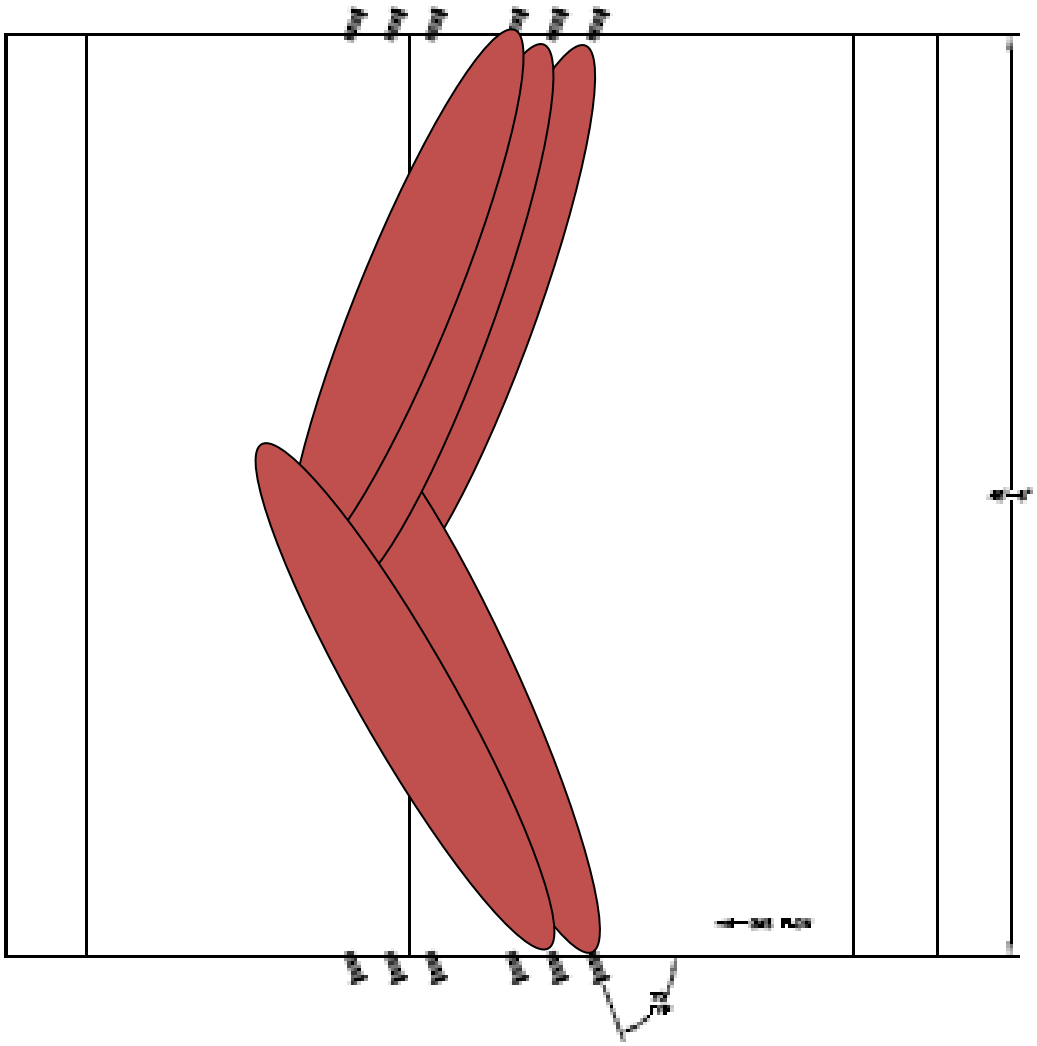


Second Option is the installation of high velocity nozzles from two sides.



Each High Velocity Nozzle has a cleaning range of 30-35 feet. Cleaning pattern is long an narrow.

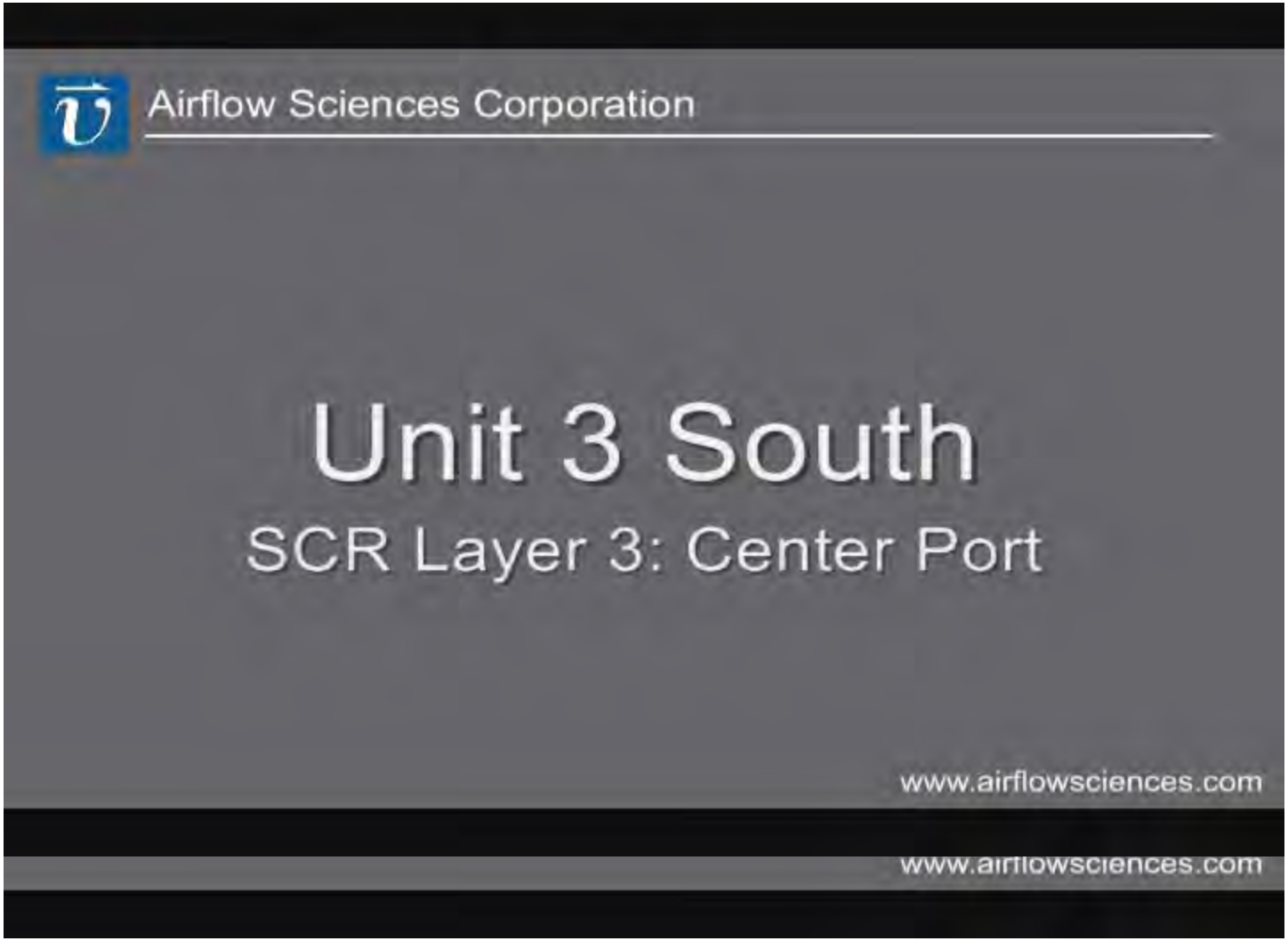
System designed to provide overlapping cleaning



Each High Velocity Nozzle has a cleaning range of 30-35 feet. System is designed to over lap each nozzles cleaning area.

What Is Large Particle Ash?

Is it material that falls on beams, wall or



Large Particle Ash ---pop corn ash?

Catalyst pitch

- The pitch of the catalysts is often blamed for ash piles. Industry has moved to larger pitch. From 6.9 to 7.1 to 8.2 to plate catalyst. Results have been mixed. Moving to larger pitch has provide benefits but

TECO Big Bend Power Station

SCRs added, beginning in 2007

Output **3 units @ 446 MW** (1972. 1973, 1976) **Unit 4 @ 485 MW** (1985)

Fuel **High Sulfur Eastern Bituminous** with up to 20% pet coke

SCR OEM **Sargent & Lundy**

Size: 60 ft x 44 ft by 48 ft high

Catalyst **Cormetech** Honeycomb

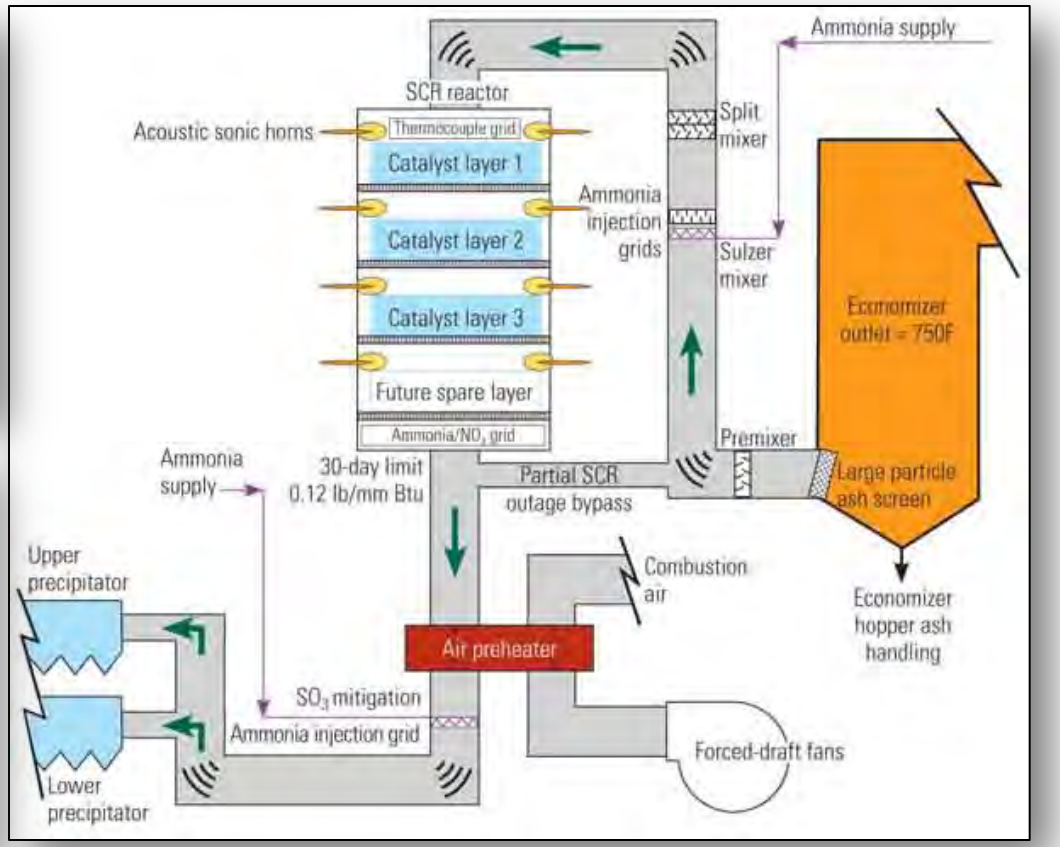
Pitch 6.9

Weight ~1 Million Pounds per SCR

SCR layout at Big Bend

Due to plant configuration and space issues, no two SCR "back halves" are the same; Less than ideal gas flow path allows ash buildup

Sonic horns installed on SCR at Big Bend



Ash buildup in Unit 3 SCR

Potential Solutions

- Flow Model
- Sootblowers
- Larger pitch catalyst
- Ash Sweeper

So what's an Ash Sweeper?

Uses eruption of compressed air to move material

- Reservoir of compressed air discharges as an eruption into a storage or process vessel to promote flow and prevent material buildup
- Introduced ~1975, accepted across industry, around the world
- Common in power plants on coal bunkers and chutes
- Available as individual units *(one outlet per tank)*
- Or as multi-port system *one tank serves several outlets)*

The Ash Sweeper Solution

Systems solves piling with a sweeping cleaning action.

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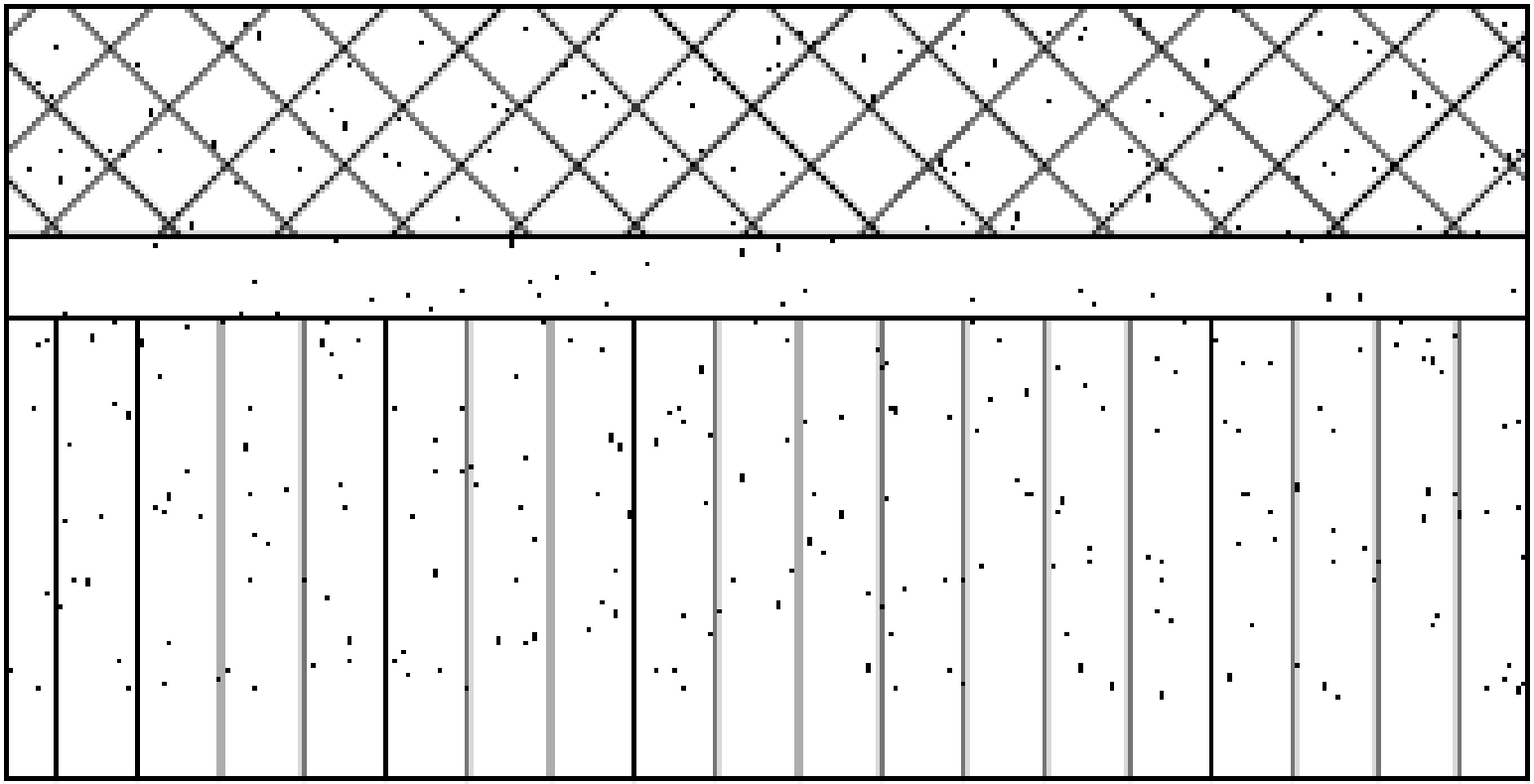
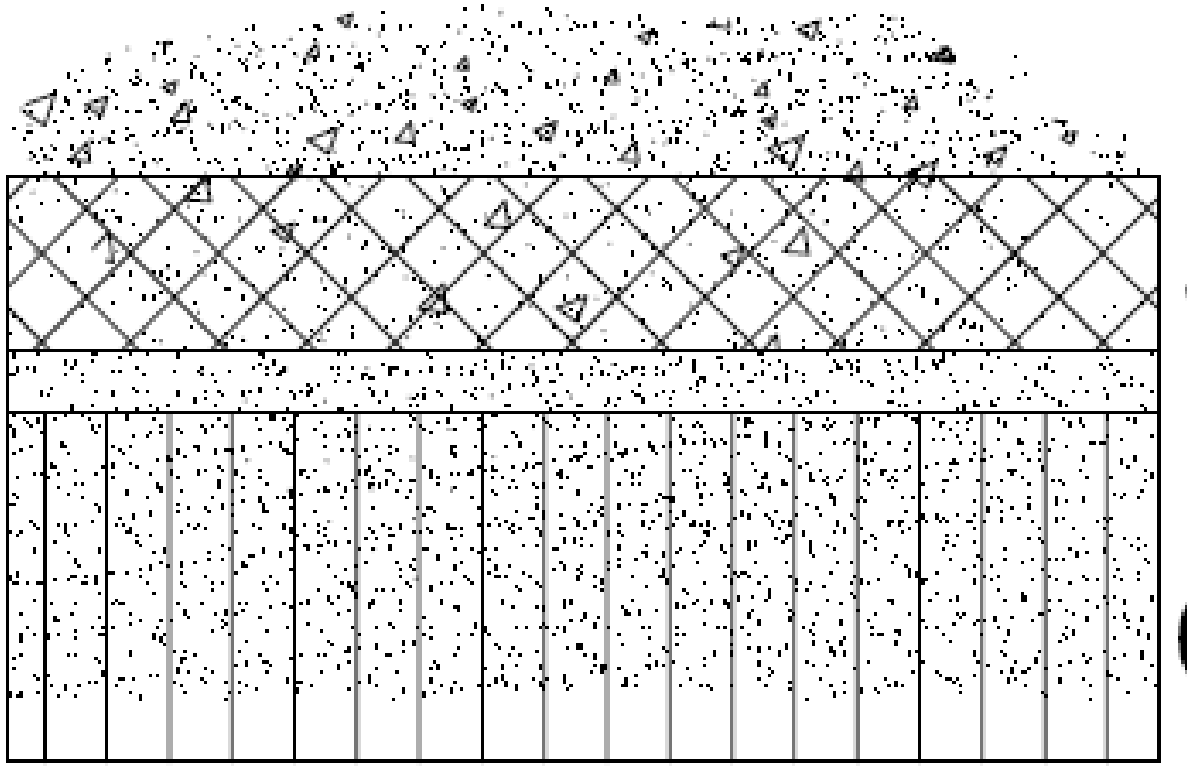
Ash Sweeper System installed on SCR

Discharge nozzle installed across front wall.

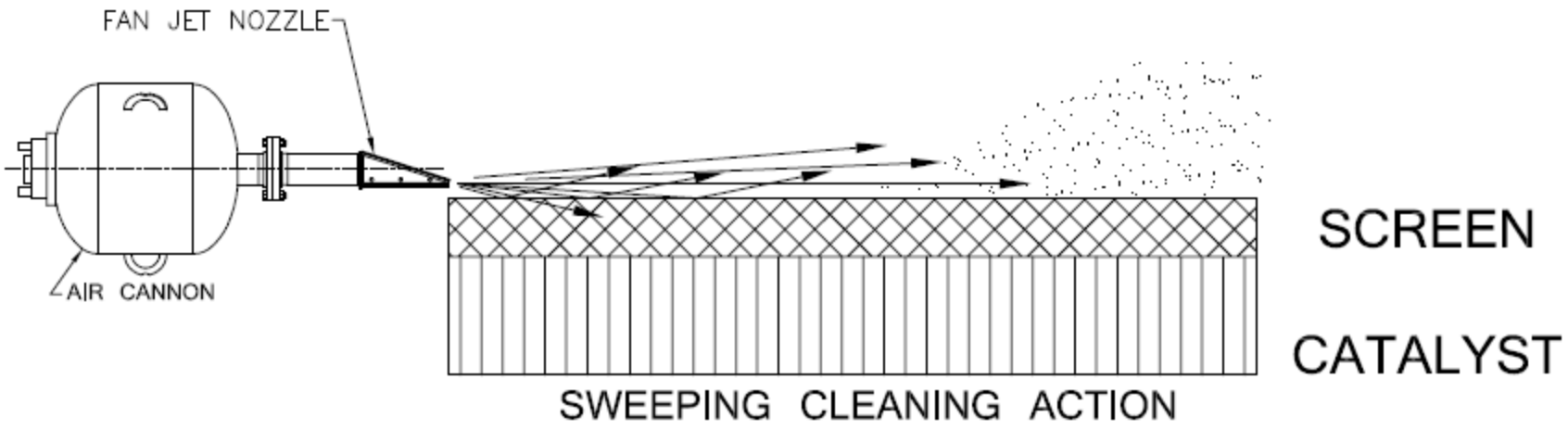
Normal operation. Concentration of ash is at it lowest point and the risk of buildup is low.



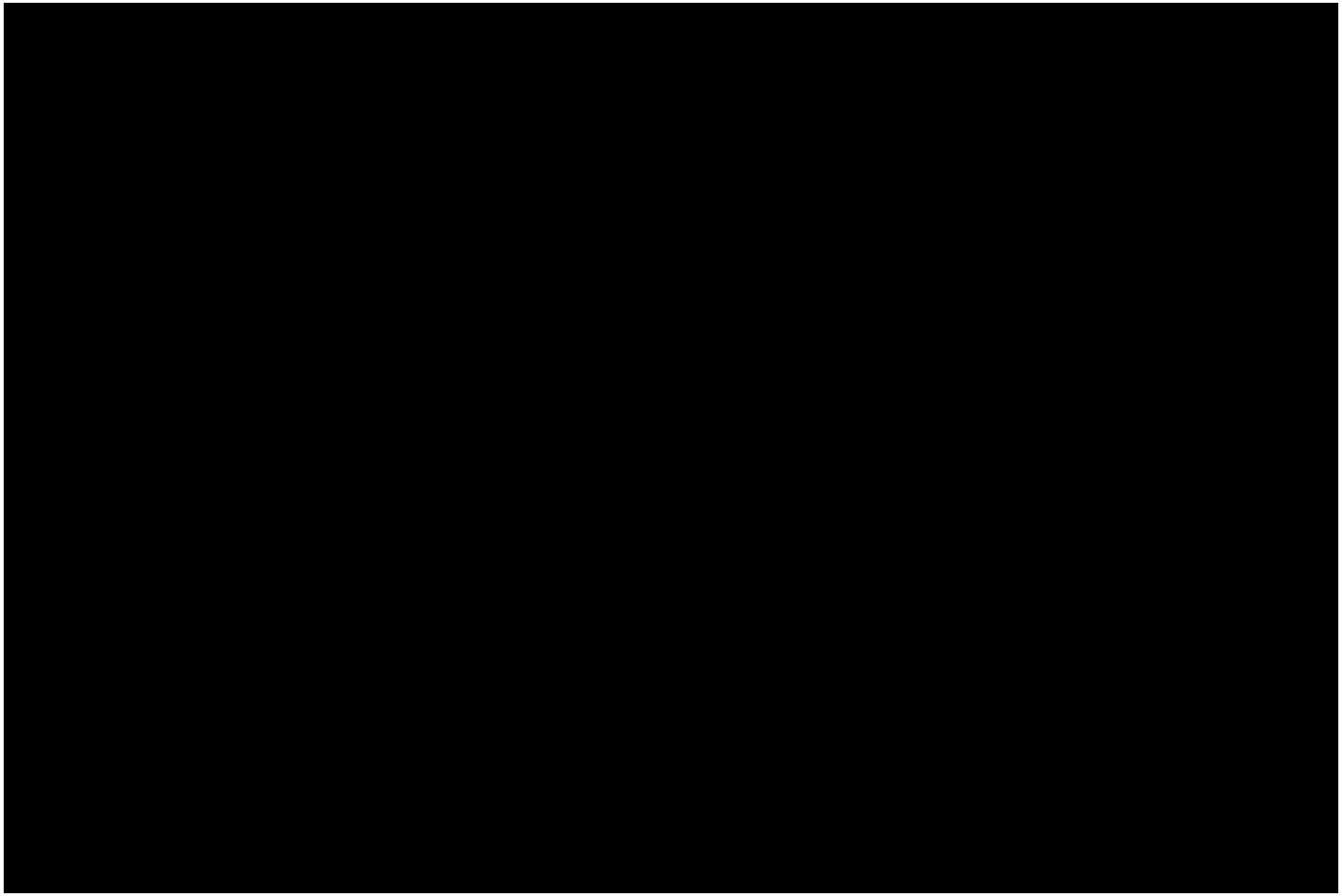
Sootblower blast dislodges ash from 12 hours of buildup. Ash concentration is at its highest level and you have a swirling cleaning action. The risk for buildup in the catalyst is now at its greatest point!



Ash Sweeper is designed to clean the screen. The cleaning action is sweeping across the screen and not blasting directly upon the screen.

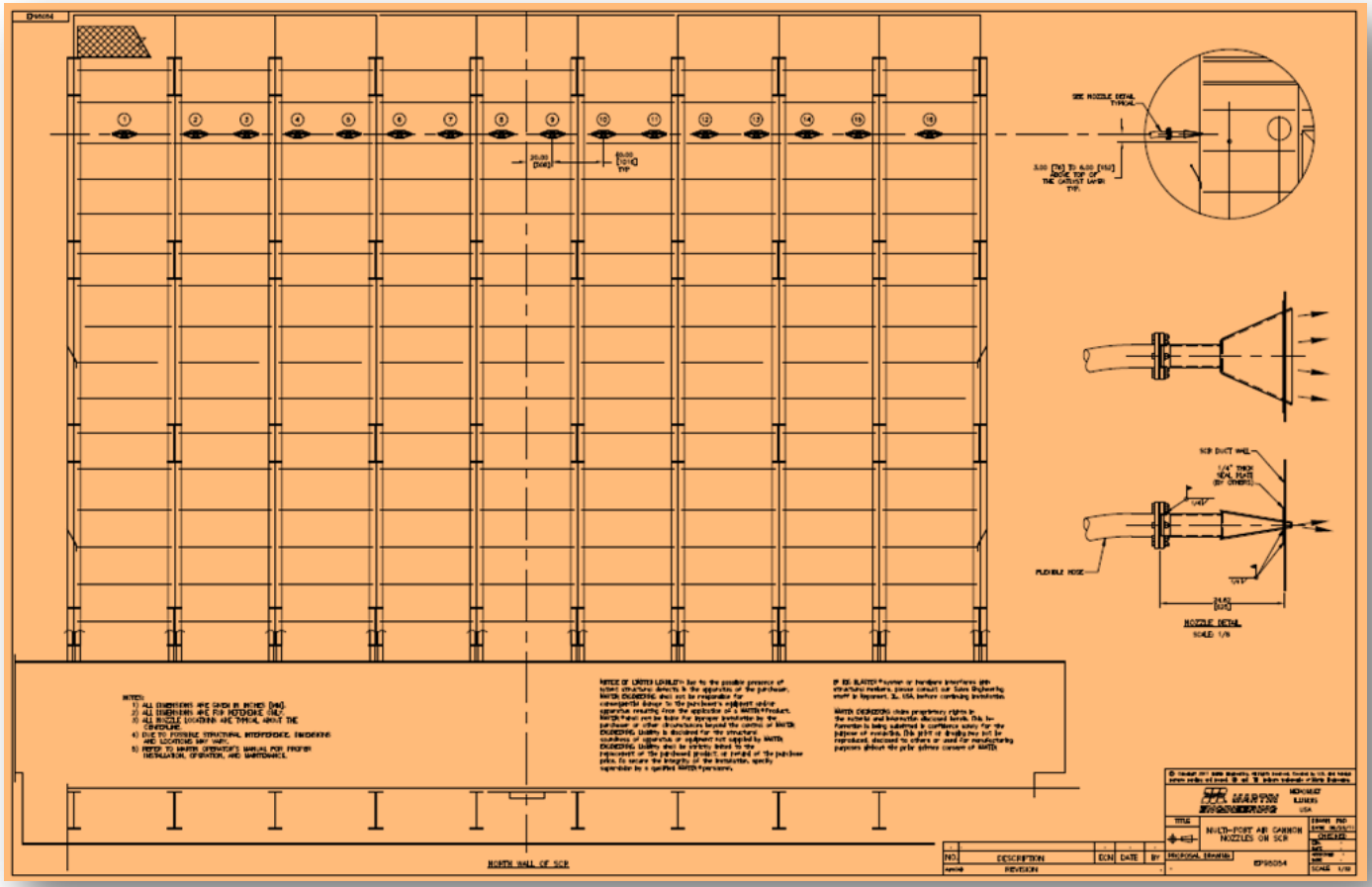


Ash Sweeper Blast



Multiport systems installed

Two 8-outlet multiport air cannons, with 16 fan jet nozzles spaced across the Level 1 of Unit 3 SCR



Ash Sweeper Installation


03.05.2012 10:39


03.05.2012 10:37

Results from installation

Virtually no ash on catalyst layer 1

Savings in catalyst cleaning

Before and After comparison
("apples to apples" based on similar run length)

	"Run Time" (Days)	Labor Cost	Vacuum Truck Cost	Total Savings
Comparison A				
Before Installation October 2011	50	$21,849	$27,789	
After Installation March 2012	47	$9,931	$9,463	
$ Saved		$11,918	$18,326	$30,244
% Reduction in Cleaning Cost		**55%**	**66%**	
Comparison B				
Before Installation March 2011	9	$17,053	$18,426	
After Installation June 2012	10	$5,439	$5,560	
$ Saved		$11,614	$12,866	$24,470
% Reduction in Cleaning Cost		**68%**	**70%**	
Total Savings (two outages)				**$54,714**
(Four outages per year) **Estimated Annual Savings**				**$120,000**

Savings in ammonia usage

Improved SCR performance means
less ammonia slip, and less ammonia purchased.

	Ammonia Used (Pounds per MW/hour)
November/December 2011 **Before Installation**	**2.00**
January/February 2012 **After Installation**	**1.80**
Reduction in Ammonia Consumed per MW/hour	**0.20**
Yearly Reduction in ammonia consumption (lbs)	418,600
Converted to tons	209.3
Ammonia price (delivered)/ton	$472
Savings in ammonia consumed	$98,789.60

Reduced Power Consumption

From reductions in pressure drop to ID fan

Improved air flow reduces pressure drop through SCR by
2.5 inches water column

At unit load of 380 MW,
this reduces power consumption
of plant ID fan by
1.93 MW/hour

At 85% operating factor,
this creates
annual savings of $356,418.10

Less electricity
consumed in plant,
means more electricity to sell.

Prompt payback

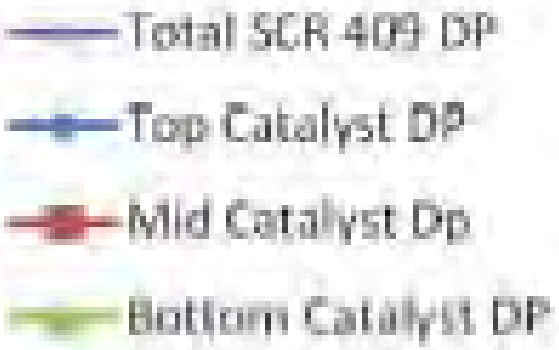
Air cannon installation pays for itself in 3 months

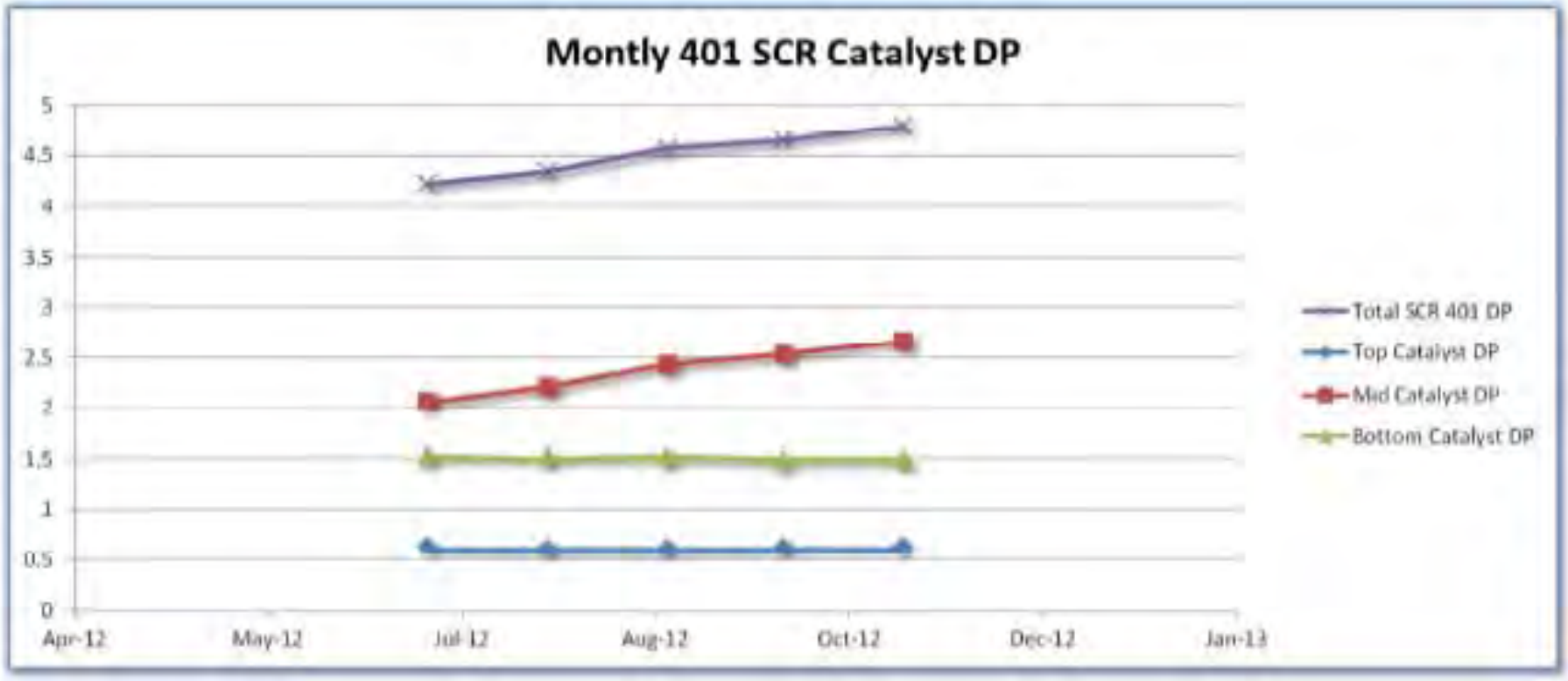
Reduction in Cleaning Costs	$120,000
Reduction in Ammonia Costs	$ 98,000
Reduction in ID Fan Energy Consumption	$356,000
Total Annual Savings	**$574,000**

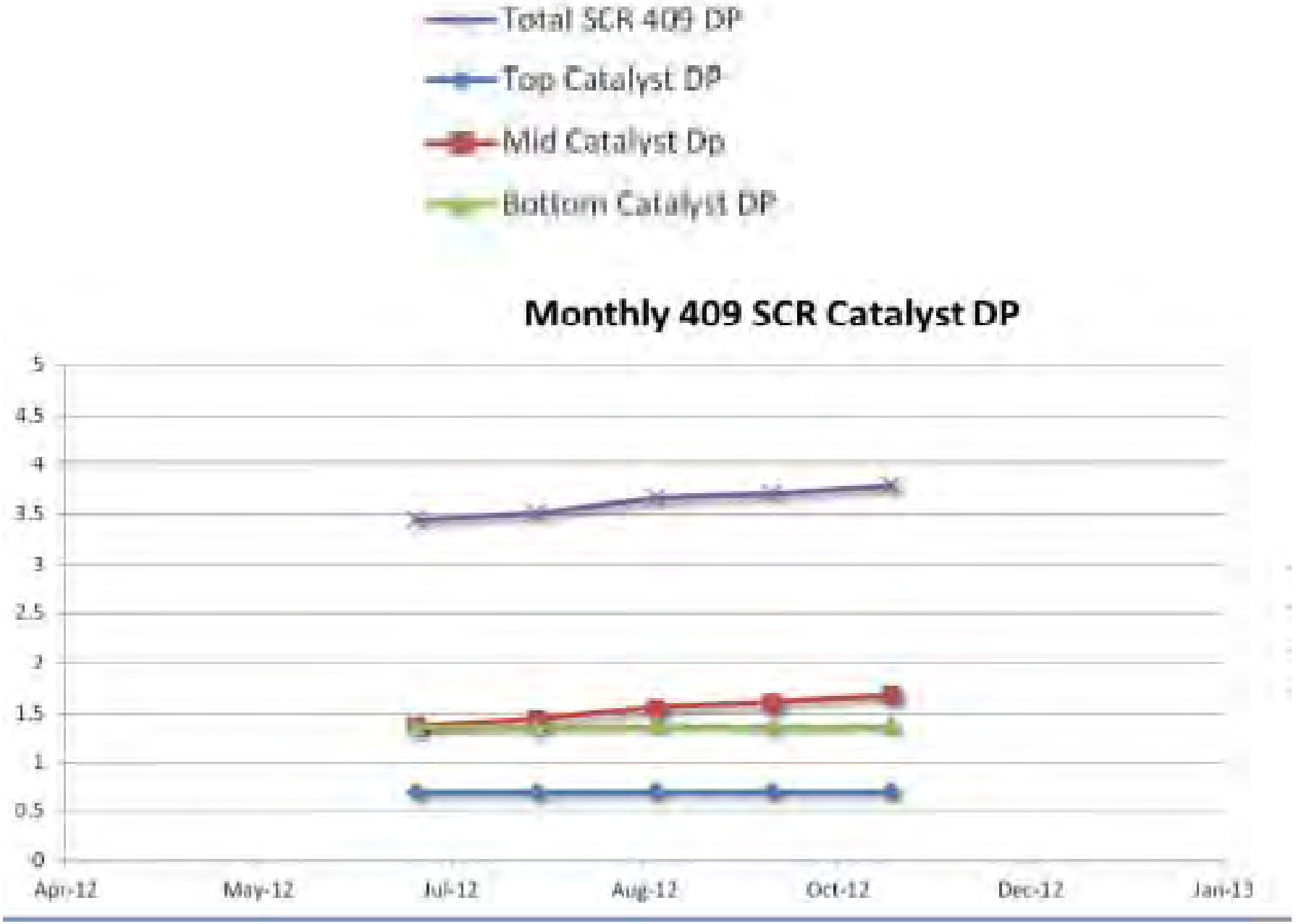
Annual savings = four times the cost of installed air cannon system

(Not counting improved performance and extended life for catalyst)


DANGER


Total SCR 409 DP
Top Catalyst DP
Mid Catalyst Dp
Bottom Catalyst DP


Montly 401 SCR Catalyst DP
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Apr-12
May-12
Jul-12
Aug-12
Oct-12
Dec-12
Jan-13
Total SCR 401 DP
Top Catalyst DP
Mid Catalyst DP
Bottom Catalyst DP


Total SCR 409 DP
Top Catalyst DP
Mid Catalyst Dp
Bottom Catalyst DP
Monthly 409 SCR Catalyst DP
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Apr-12
May-12
Jul-12
Aug-12
Oct-12
Dec-12
Jan-13

As a general guideline for the cost of a single layer of new catalyst for a 800 MW Coal Fired Boiler is $3,000,000. Extending Catalyst life has a significant impact on the operational budget for a SCR

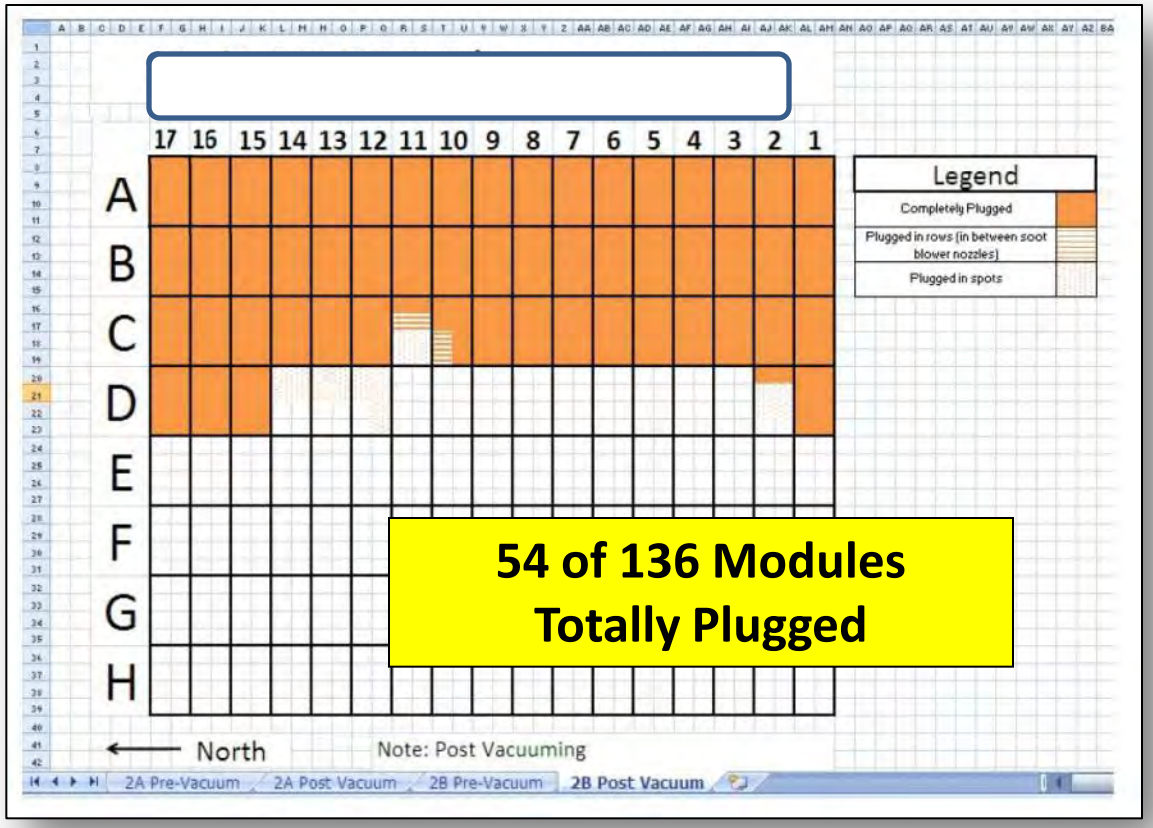
The cost of "lost" catalyst

Cost of Catalyst: $3 Million per Installed Layer

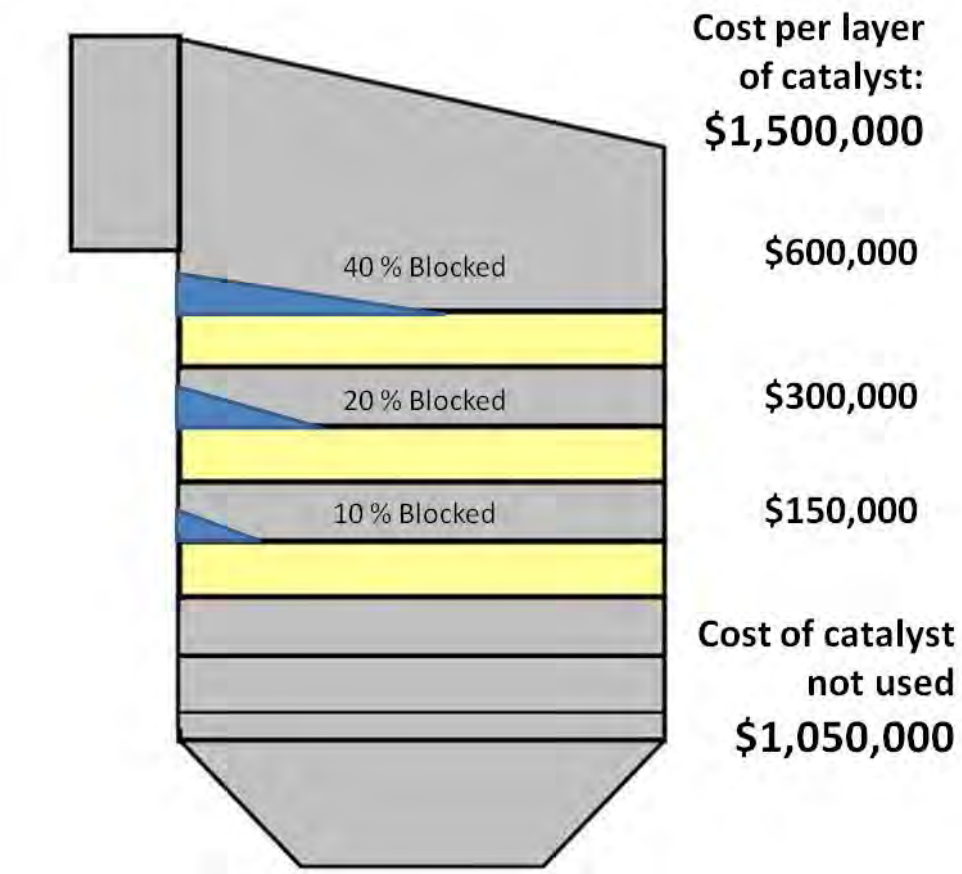
If 40 % Blocked as shown…

Cost of Non-Working Catalyst

$1,200,000

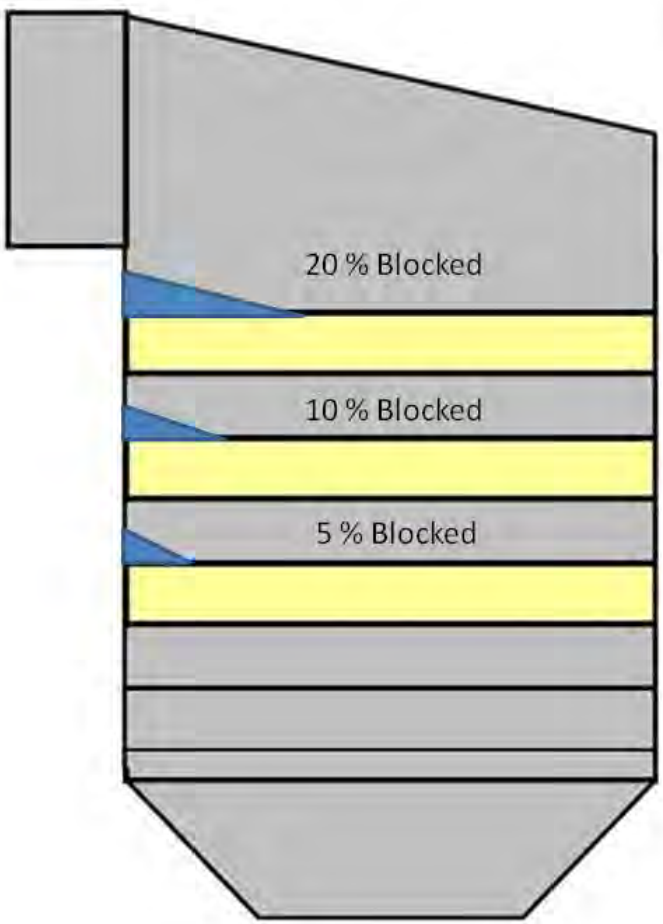


High Cost of covered catalyst!



Cost of covered catalyst for a single layer based on $3 million per layer is $2,100,00!

High Cost of covered catalyst!



Cost per layer of catalyst:
$1,500,000

$300,000

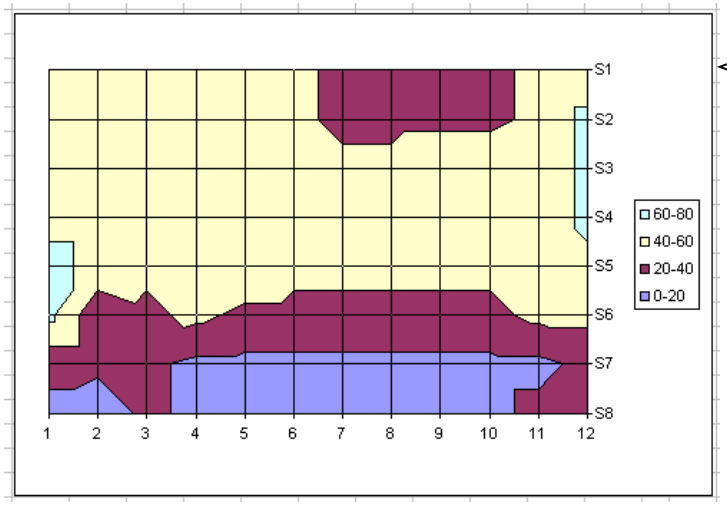
$150,000

$75,000

Cost of catalyst not used
$525,000

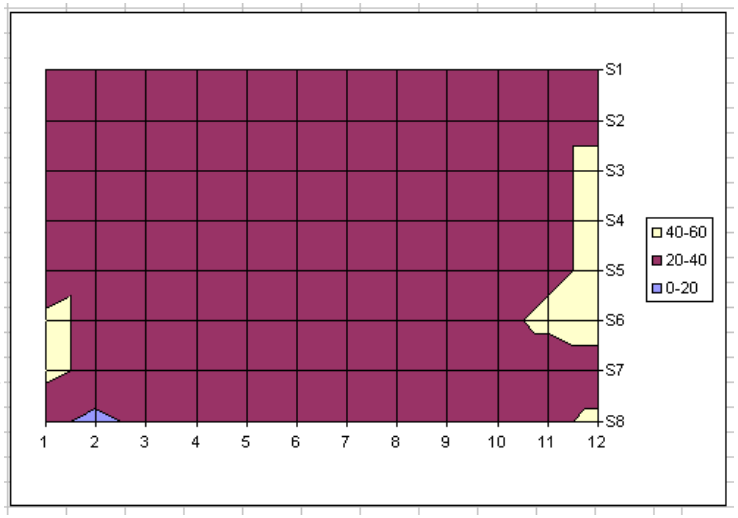
Cost of covered catalyst based on $3 million for a single layer is $1,050,00!

Manual Cleaning not 100% successful.



Estimated pluggage as found 39%, operating dp ~ 4”

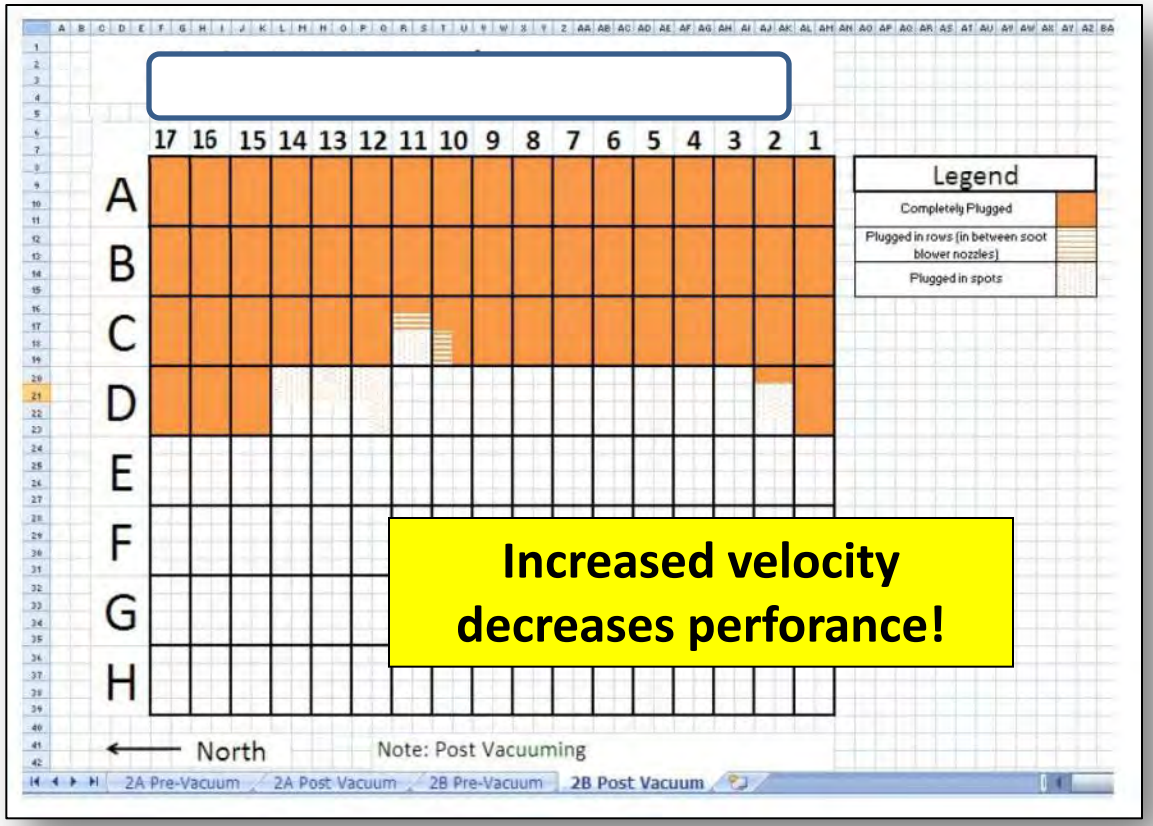
Estimated pluggage as left 32%, operating dp ~ 2”



The cost of plugged Catalyst

Cost of Catalyst: $3 Million per Installed Layer

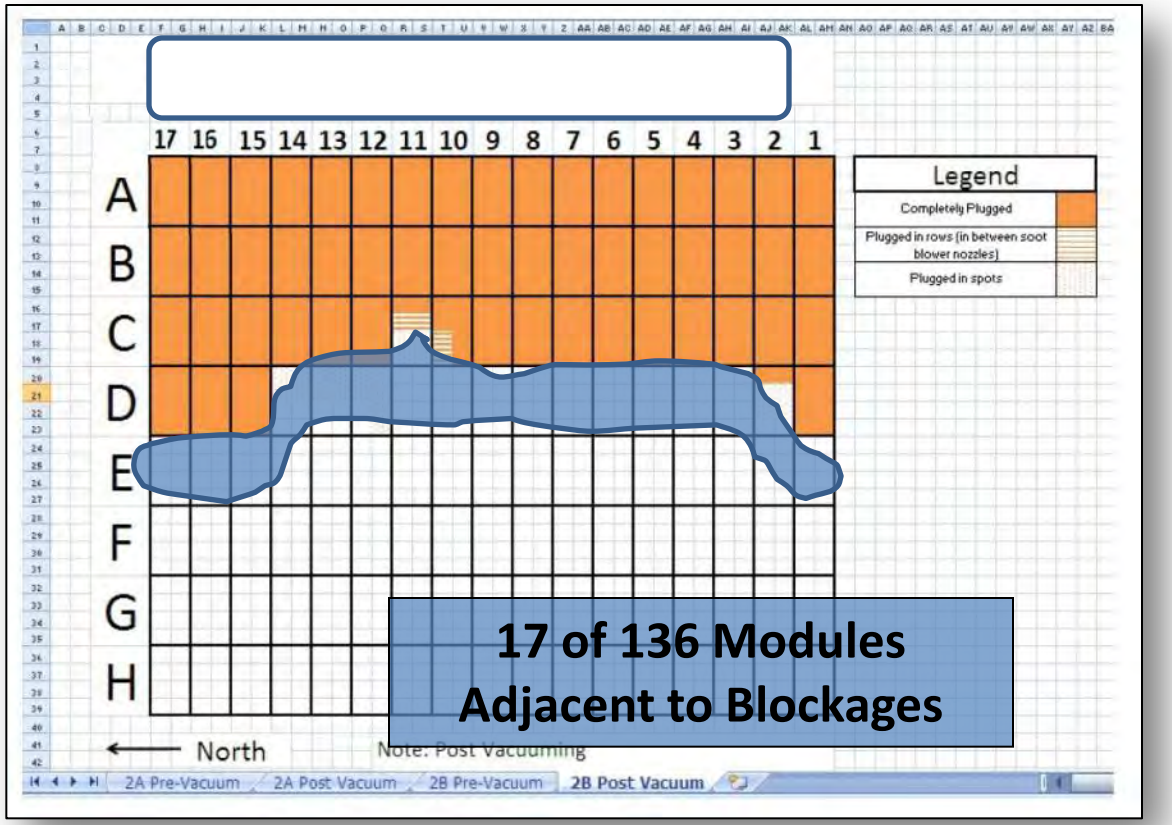
Plugged Catalyst equals increased velocity. Velocity determines resident time therefore performance.



Problems from deflected flow

Modules adjacent to blocked catalyst wear 3 times faster!

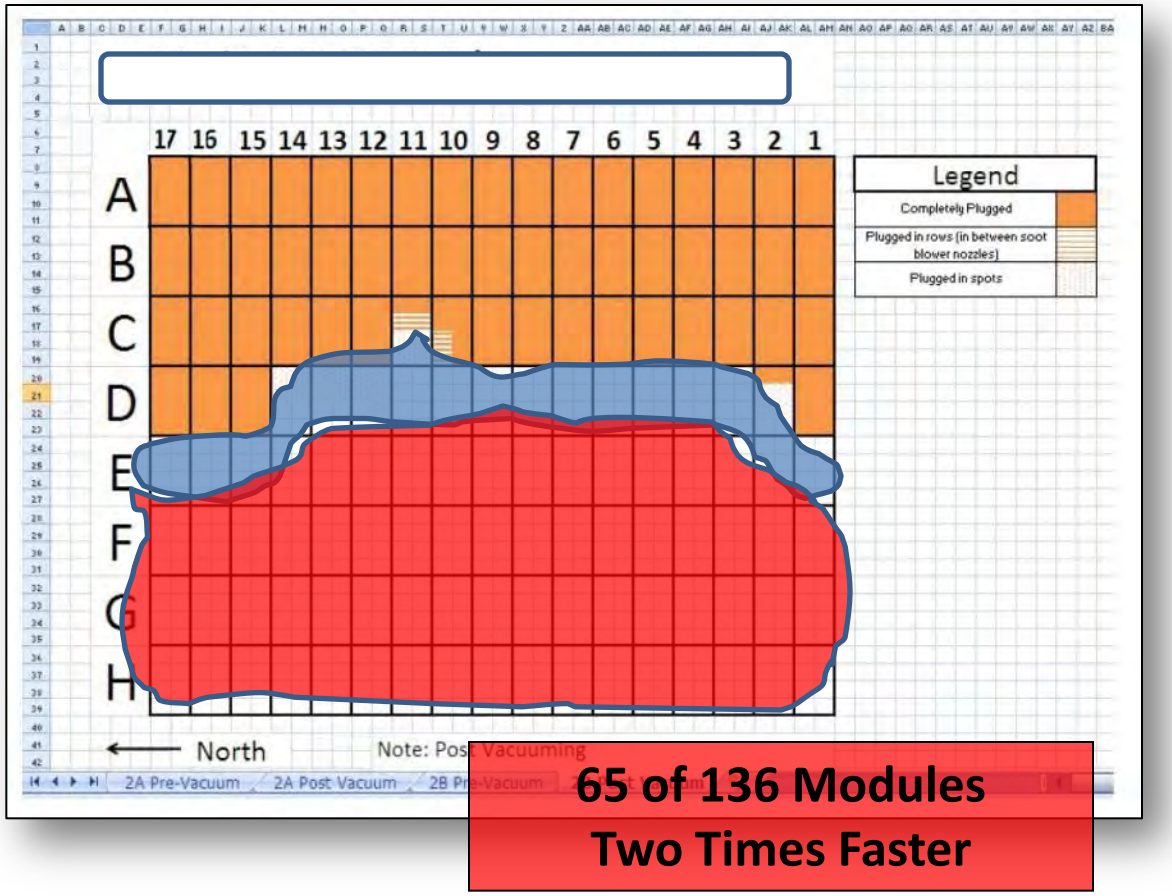
- **17 of 136 modules (Cost $187,500) experience erosion 3 times faster**



Problems from deflected flow

Remaining modules also wear 2 times faster

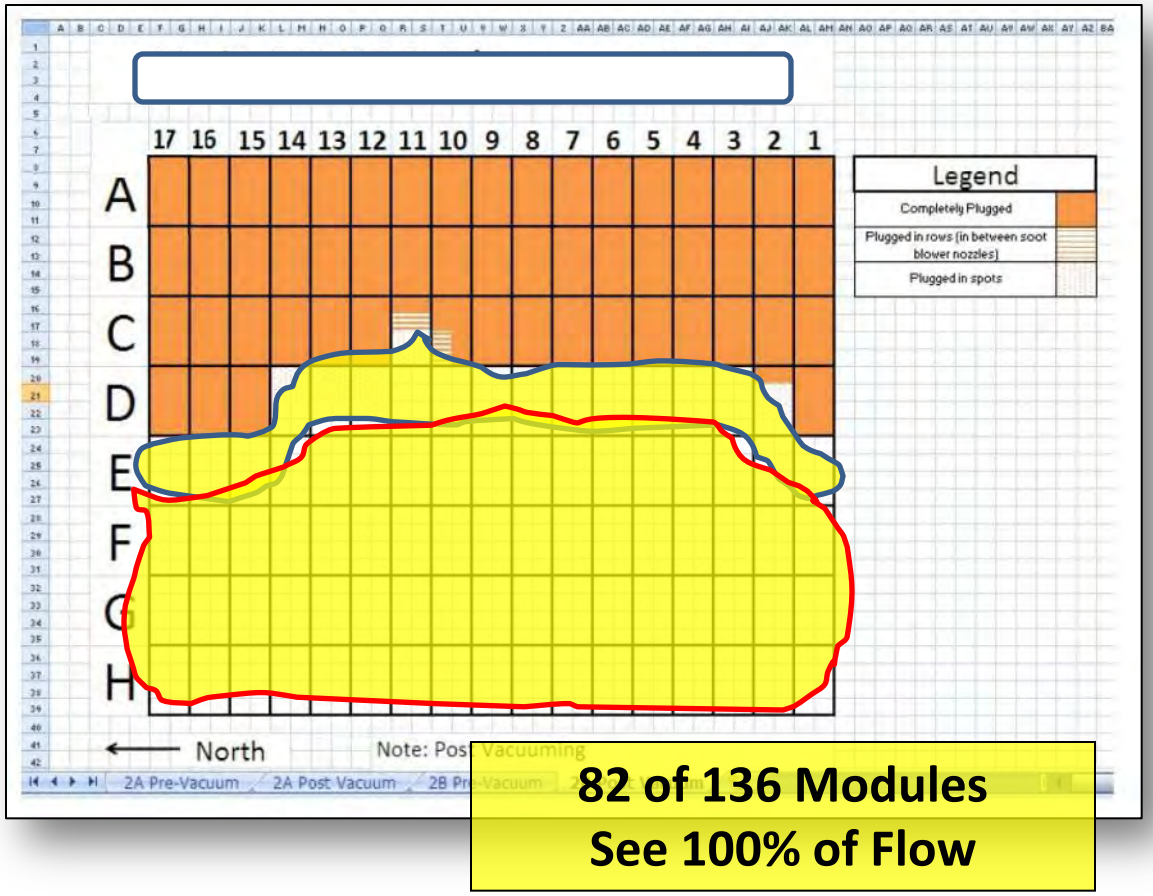
- **65 remaining modules of 136 (Cost $717,000) experience erosion 2 times faster**



Problems from deflected flow

100 percent of gas flow through 60% of modules

- **82 modules of 136 see 100% of gas flow**
- **This increases catalyst deactivation and poisoning**



Ash Sweeper and Sonic Horn used in new SCR reactors in the Refinery Industry!

Ash Sweepers used to clean new SCR reactors in the Glass Industry.

Review and summary

- ***Accumulations of ash can severely affect the performance of SCRs and has been an Industry problem. Principal reason for accumulations is poor gas flow distribution.***
- ***Sonic horns and Sootblowers are sometimes not enough to prevent ash buildups.***
- ***Improved Sonic Horn will reduce accumulations of ash because of greater material movement.***
- ***Combination Cleaning System of the Ash Sweeper and Sonic Horns to the SCR provides a total cleaning system that improves catalyst performance and life with a return on investment in less than 6 month****s.*

Who has the first question?