

REINHOLD ENVIRONMENTAL Ltd.



**2013 NO_x-Combustion Round Table
& Expo Presentations**

February 18 & 19, 2013, in Salt Lake City, UT / Hosted by PacifiCorp

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2013 NOx Combustion/PCUG Conference

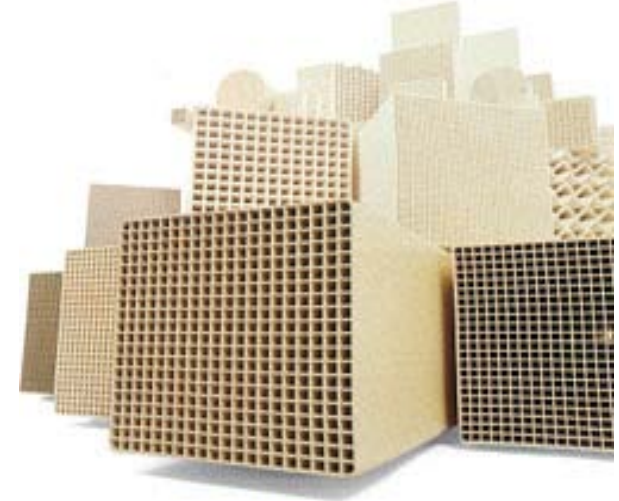
Boiler Performance Influence on SCR Efficiency and Longevity

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February 19 2013

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SCR Efficiency and Longevity Factors

- SCR Mechanisms
- Fuel
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Combustion Modifications

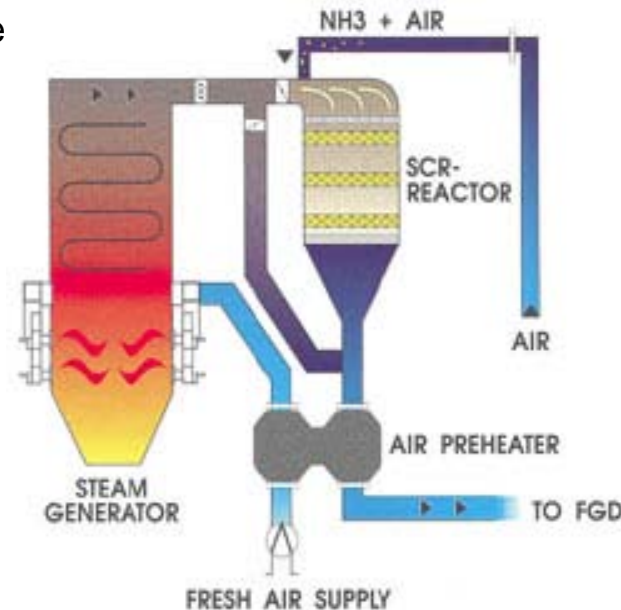
- Coal Combustion in Utility Boile
- Gases and Gas Pollutants
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Boiler Cleaning

- Applications: Mayo and Ashville

SCR Cleaning

- USR Retractable
- Sonic Horn



It is a common industry challenge to prioritize the impact and urgency of various factors for optimum SCR operation and catalyst life.

- **In-Furnace** - Combustion can play a definite role in improving SCR reactor inlet conditions and, therefore the efficiency and longevity of the catalyst. Key properties of the fuels have direct influence on the performance and life of the catalyst.
- **Boiler Cleaning** - Elevated flue gas temperatures reduce the catalyst life. The control of flue gas temperature within these high and low limits becomes an optimization problem and using combustion modifications and advanced cleaning and control practices is an effective method to ensure continuous and uninterrupted SCR operation.
- **SCR Reactor** - Cleaning techniques can help keep it from fouling and to extend the catalyst life.

This paper explains the elements mentioned for SCR operation in detail and illustrates the importance of each factor and provides evidence from recent case studies.



SCR Efficiency and Longevity Factors

SCR Efficiency and Longevity Factors



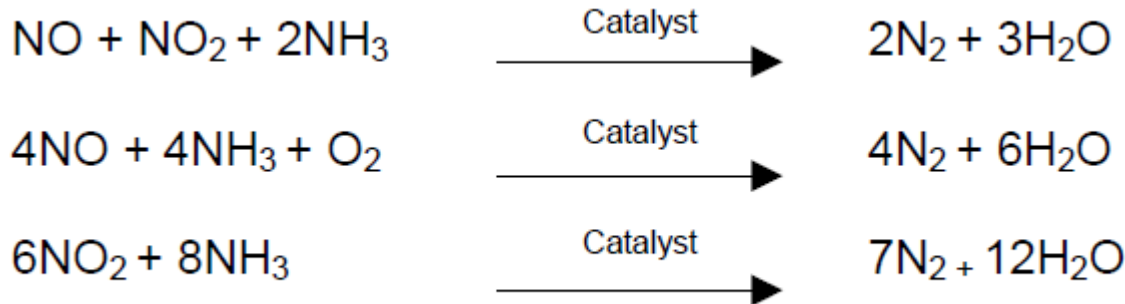
- Fuel
- Operating Conditions, Load
- Flue Gas Properties
- Fouling Potential



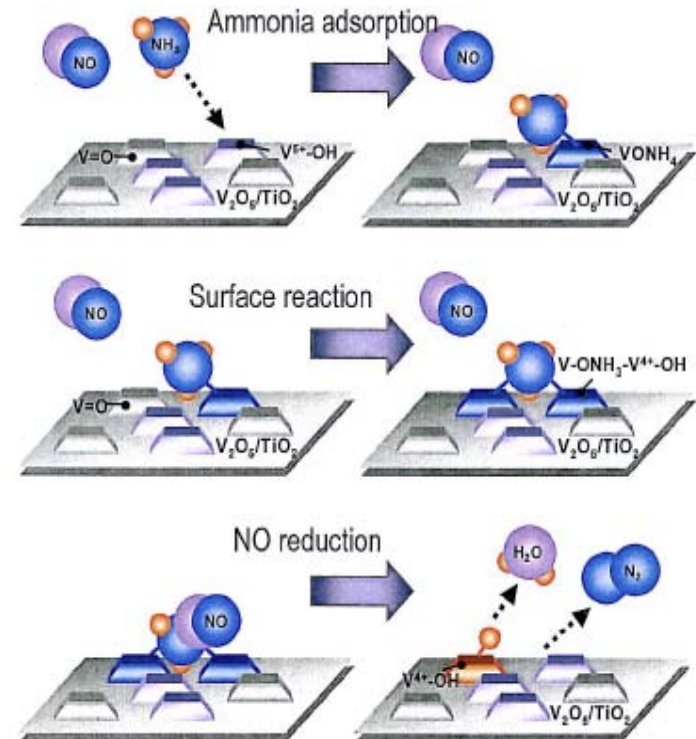
SCR Mechanisms

The catalytic reactions take place between 300°F- 1100°F. Typical applications for coal between 600°F- 800°F. Low operating temperatures are suitable to low sulfur cases (biomass).

Global reactions are:



Basic Mechanism:





Key properties of coal and biomass fuels that have shown to have a direct influence on the performance and life of the catalyst include:

- Ash loading and particle size
- Sulfur (S)
- Arsenic (As)
- Alkali metals (Na, K, Li, Rb and Cs) and phosphorous
- Alkaline earth metals (Ca, Mg)
- Other coal based trace metals: coke, tires, etc
- Other fuel based trace elements: halogens(Cl), Pb, Zn and V

Operating Temperature Window

- temperature window a function of the catalyst formulation but typically ranges between 600°F-800°F for sulfated fuels. Biomass window operates at lower temperatures 400 – 500 F.
- catalyst activity improve with temperature increasing, but operation above maximum limits (800°F) can cause catalyst sintering, resulting in permanent deactivation. So temperature control is critical for SCR technology
- precipitates can deposit on the catalyst at low temperatures(<600°F), leading to further reduced activity
- NO_x removal declines above the optimum operating temperature due to oxidation of ammonia

Flue Gas Pressure Drop

- dependent upon flue gas velocity, catalyst configuration, and quantity of catalyst required to achieve specified NO_x reduction
- site specific in nature, but generally on the order of 2-4" water column

Flue Gas Flow/ Temperature Distribution

In general, catalyst guarantees predicted upon the flowing limitations:

- $\pm 10\%$ variation in flow across the face of the catalyst
- $\pm 15\%$ variation in velocities across the face of the catalyst
- $\pm 20\%$ variation in temperature across the face of the catalyst
- use of flow straightening devices or static mixers can improve distribution
- good combustion and cleaning practices can significantly improve on these variations

Flue Gas Concentration Distribution

- $\pm 10\%$ NO_x profile

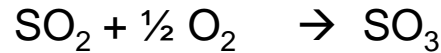
Ammonia Injection System

- needs to provide even distribution of ammonia in direct proportion to mass flow and NO_x levels for optimized performance
- $\pm 5\%$ NO/NH₃ ratio distribution
- An NH₃/NO_x mole ratio of 1.0 is typically used.

Flue Gas Contaminants

- Alkaline compounds, halogens, and heavy metals can cause permanent catalyst poisoning
- Sulfur-bearing fuels can foul or mask vanadium/titanium-based catalysts by the formation of sulfate compounds that block reactive sites

Oxidation of sulfur dioxide SO₂ to sulfur trioxide SO₃

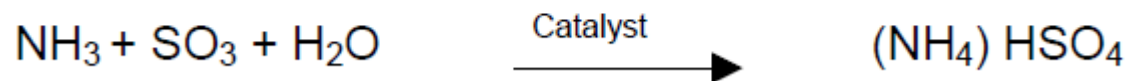
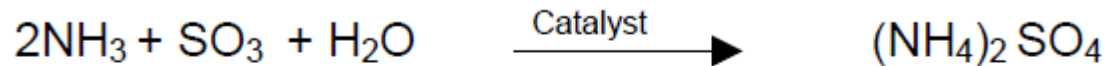


- The more SO₃ formed, the higher dew point required the higher exist gas temperatures translate directly into a loss of system efficiency, which imposes a significant heat rate penalty.
- An increase in SO₃ formation will lead to increase in sulfate particle formation, which is a known PM_{2.5} precursor.
- The formation of SO₃ can lead to problems in downstream equipment due to corrosion and/or plugging when combined with excess ammonia slip

Ammonium Compounds Formation



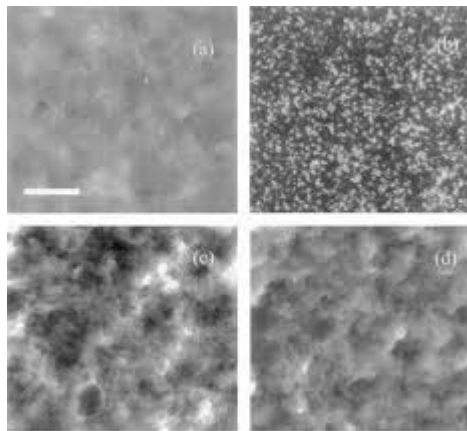
Reactions for ammonium sulfate and bisulfate:



- The formation of these slats is highly dependent upon the concentration of each constituent, therefore, each component is a key design parameter for the system. This processes are temperature dependent
- Ammonium bisulfate formation is of particular concern because it is extremely sticky, and is very difficult to remove from heat transfer surfaces.
- This formation has caused severe maintenance problems in some units resulting in forced outages, accelerated rates of corrosion and heat exchanger fouling.

Fouling Potential and Impact on Emissions

- reaction of excess ammonia with SO_3 generated from sulfur bearing fuels can lead to increased particulate emissions and potential fouling and corrosion of cold end heat transfer surfaces
- the catalyst can promote oxidation of SO_2 to SO_3 , which can react with ammonia to form ammonium bisulfate/ sulfate leading to corrosion of cold end heat surfaces and increased pressure drop across the air heater
- tradeoffs exist between catalyst SO_2 oxidation potential, NO_x reduction activity, and cost. A catalyst can be formulated to balance these properties for each specific application



SCR Operating Factors



	Flue Gas Temperature and Profiles	Fuel Use and type, Load	Flue Gas Flow	Flue Gas velocity and Profiles	Flue Gas NOx and Profiles	Ash composition	NOx
SCR	√	√	√	√	√	√	√

Catalyst Evaluation Parameters



- Fuel Analysis, including trace elements and firing duration
- Fuel Additives
- Flue Gas Analysis
- Ash analysis, including trace elements
- Ash Loading & Characteristics,
- SO₃ and SO₂ vs Load
- NO_x vs Load
- Temperature vs Load
- Removal Efficiency
- Ammonia Slip
- Boiler Firing Method
- Pressure loss
- Distribution Criteria
- Systems Operation (load swings, Capacity factor)
- Regulations (seasonal, Trading)
- Site Conditions (multiple boilers, back-end arrangement, foundation, electrical)

Potential Impacts on Catalyst and System Components



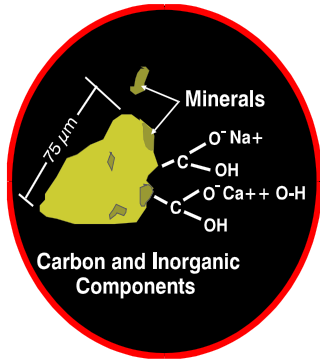
- Fan or Turbine Capacity
- Catalyst Reactor Design
- Boiler and/or ESP Reinforcement
- Reactor and Flue Gas Design
- Life Management plan
- Control logic
- Catalyst Management Systems Inspection
- NOx Reduction Requirements
- SCR Bypass (seasonal)
- Type of Reagent
- Reagent Vaporization Methods
- Catalyst Formulation
- Catalyst Volume
- Catalyst Management
- Monitoring Plan
- Catalyst pitch
- Ammonia Slip
- Downstream Equipment Design
- Sootblower Requirements
- Economizer Bypass
- Water or Stream Injection Rate
- AIG Ammonia Injection Grid
- Ash Handling
- NOx Content
- SO₃ Content
- Ash Loading & Characteristics



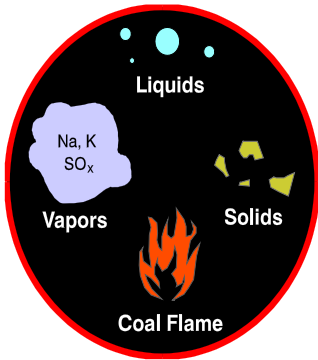
Combustion Modifications

Background: Coal Combustion in Utility Boilers

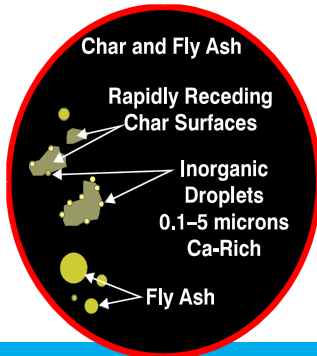
1. Initial Coal



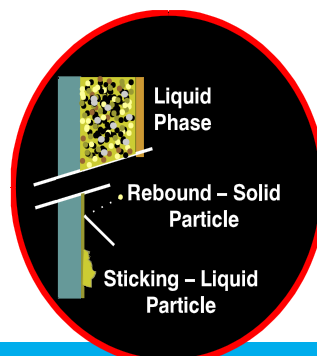
2. Combustion



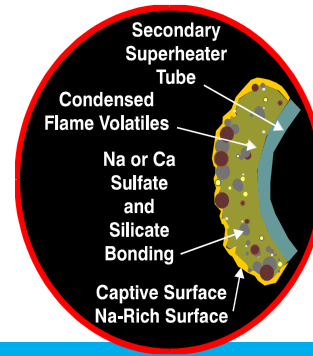
3. Early Combustion Products



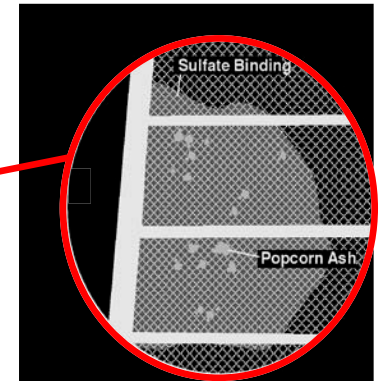
4. Slag Deposit Formation



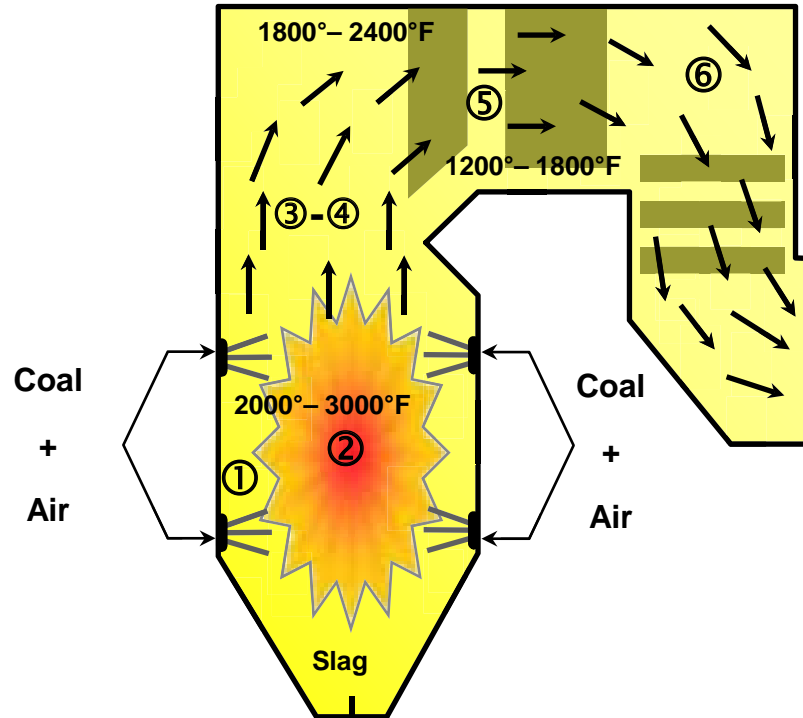
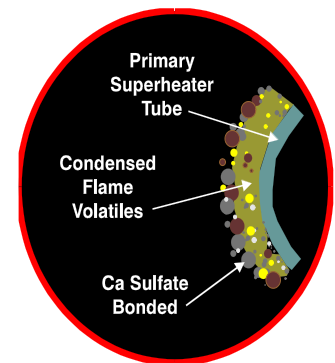
5. High-Temperature Fouling Deposit Formation



7. Blinding and Plugging of SCR Catalysts



6. Low-Temperature Fouling Deposit Formation

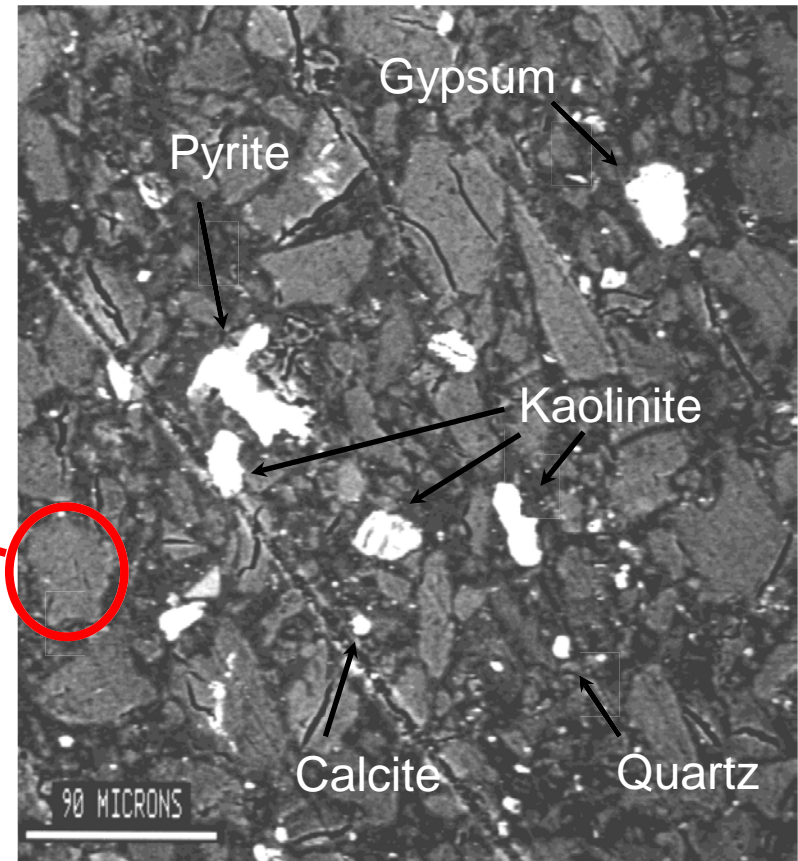


Source: EERC, University of North Dakota

Liberated Minerals

Organic Matrix: Locked Minerals

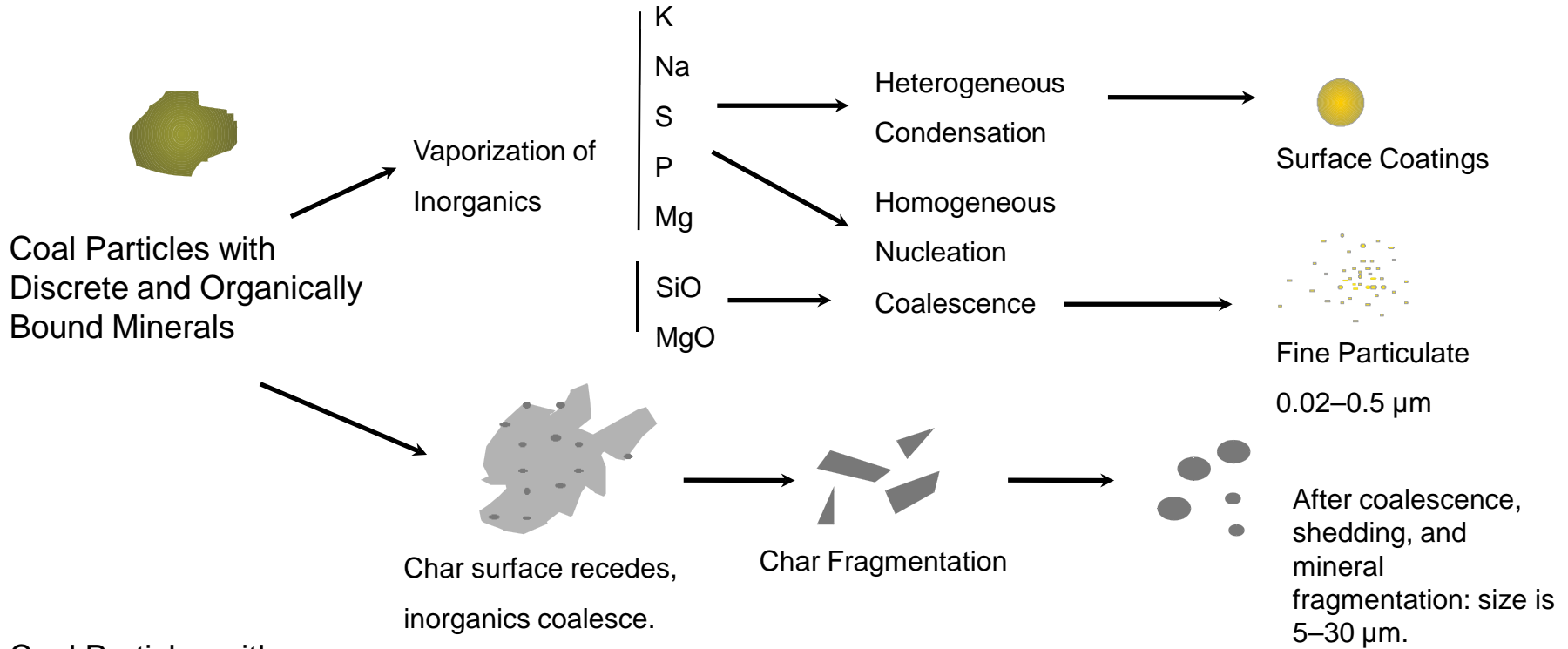
Na ₂ O	7.9
MgO	9.0
Al ₂ O ₃	18.1
SiO ₂	7.2
SO ₃	20.9
CaO	23.5
Fe ₂ O ₃	5.8



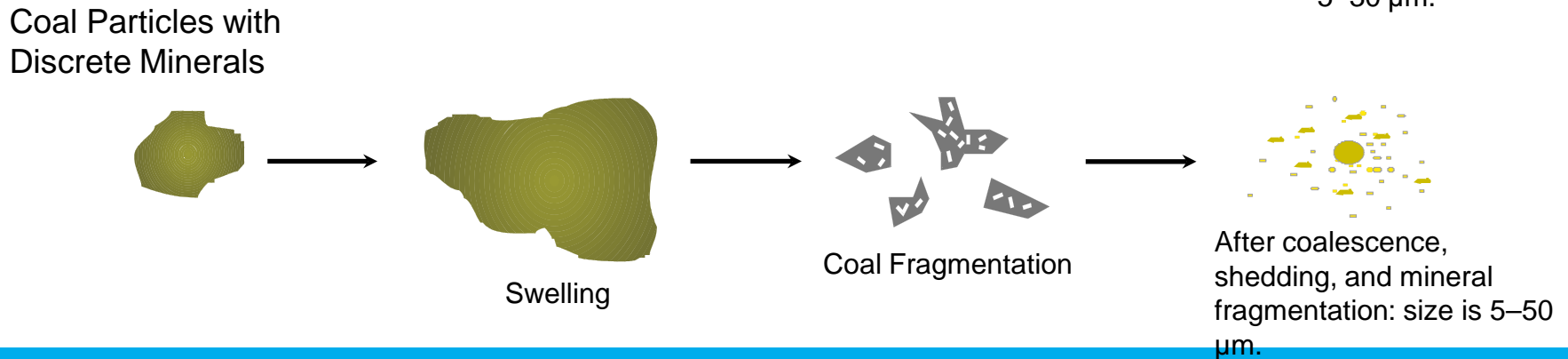
Source:
EERC, University of North Dakota

Coal Particles with Locked Minerals

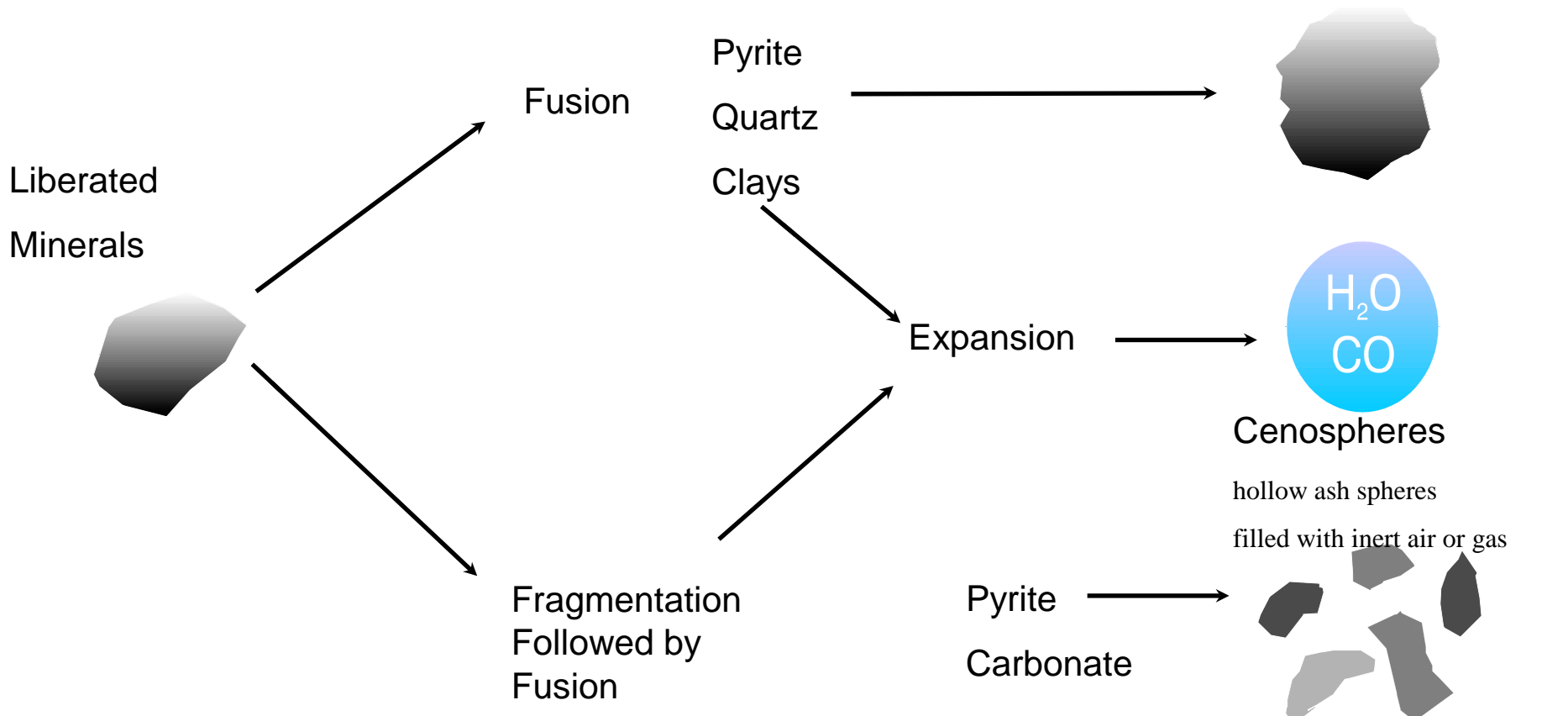
Low-Rank Coals



High-Rank Coals



Coal Particles with Liberated Minerals



Source:
EERC, University of North Dakota

- Combustion Products of standard fossil fuels in commercial and industrial boilers produce the following main gases:
 - carbon dioxide (CO_2)
 - nitrogen (N_2)
 - oxygen (O_2)
 - water (H_2O)
 - carbon monoxide (CO)
 - nitrogen oxides (NO and NO_2 called NO_x , N_2O)
 - sulfur oxides (SO_x : SO_2 , SO_3)
 - volatile organic compounds (VOC) and hydrocarbons (HC)
- CO , NO_x ($\text{NO}+\text{NO}_2$), N_2O , SO_x (SO_2 , SO_3) and VOC 's and HC 's are considered pollutants
- The primary greenhouse gases in the Earth's atmosphere are water vapor, CO_2 , methane, nitrous oxide and ozone.

Nitrogen Compounds (NO_x)



NO_x is primarily formed in three ways:

➤ Thermal NO_x

Thermal NO_x is formed when nitrogen and oxygen in the combustion air combine with one another at the high temperatures in a flame.

Thermal NO_x makes up the majority of NO_x formed during the combustion of gases and light oils, but only ~20% of solid fuels

➤ Fuel NO_x

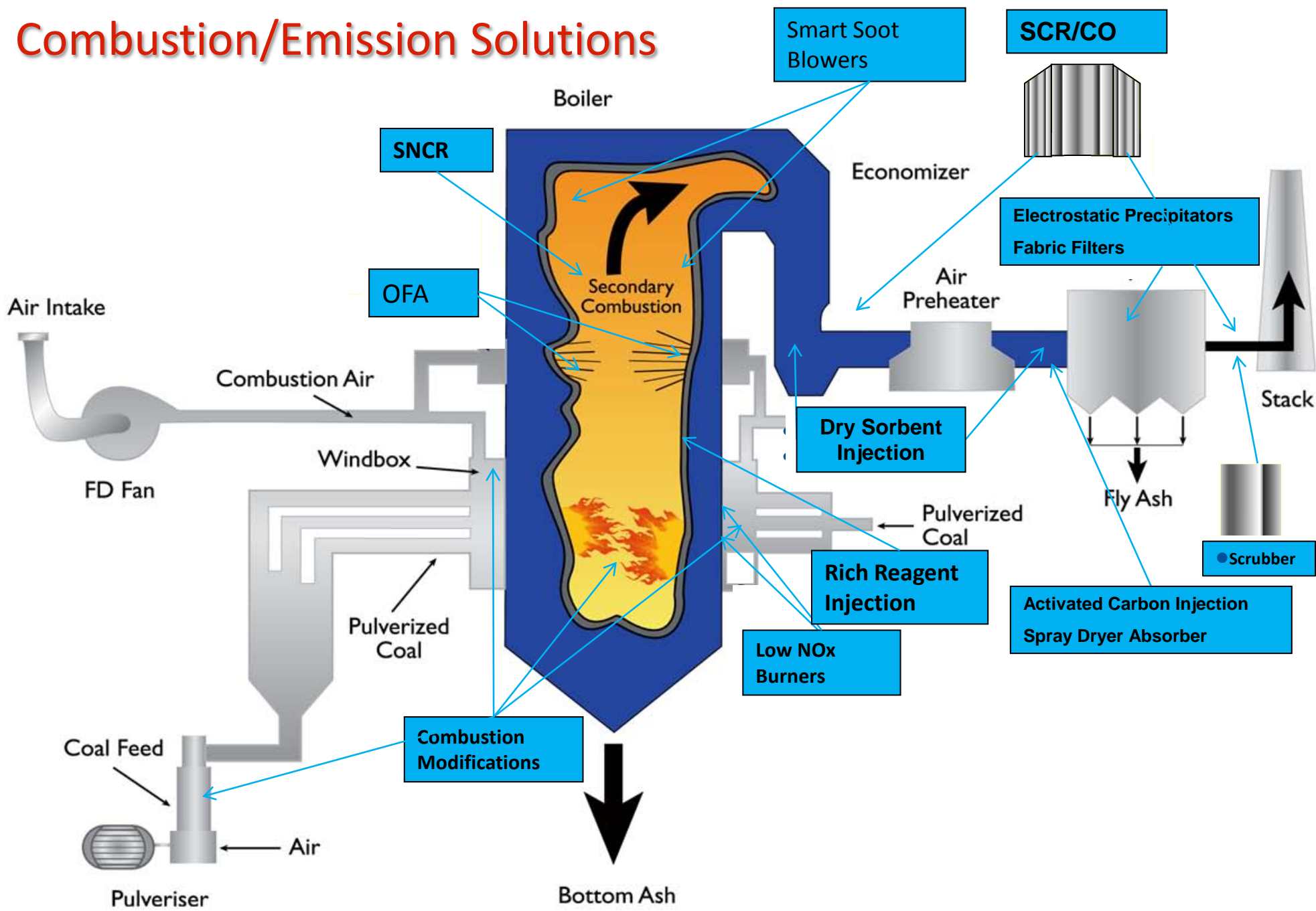
Fuel NO_x is formed by the reaction of nitrogen in the fuel with oxygen in the combustion air.

- It is rarely a problem with gaseous fuels.
- It is important in oils containing significant amounts of fuel-bound nitrogen.
- It can account for up to 80% of the total NO_x emissions in coals

➤ Prompt NO_x

Prompt NO_x is attributed to the reaction of atmospheric nitrogen N₂, with radicals such as C, CH, and CH₂ fragments derived from fuel. Occurring in the early stages of combustion species that are generated NH (nitrogen monohydride), HCN (hydrogen cyanide), H₂CN (di-hydrogen cyanide) and CN⁻ (cyano radical) can oxidize to NO

Combustion/Emission Solutions



- In- Furnace Combustion control
- Post Combustion control
- Multi-layered combinations

The Selective Catalytic Reduction (SCR) process is a highly effective method of post combustion NOx control which can reduce NOx up to 90% and higher

Depending on the application we observe:

- more complete combustion with better utilization of the fuel and potential fuel reductions and reduced ash loading
- reduced boiler exit flue gas temperature as the walls capture more heat. This can help lower the flue gas temperature into the SCR reactor
- boiler excess air can be better controlled and in many cases lowered to reduce sensible heat losses with a cooler flue gas
- strong mixing within the flue gas at the boiler exit produces flatter profiles for temperature, gas emissions including NO_x and particulates
- NO_x, CO, VOC's, HC's, unburned fractions reduced

In-Furnace NOx Control Techniques



- Reducing NOx emission formation in-furnace requires the proper burner/boiler design and a delicate balance of operating conditions
- NOx formation reduction at the source are more economical than post combustion methods in most cases. They are:

→ Burner:

- Design: Low NOx Modifications
- Operational: Burners Out of Service (BOOS)

→ Combustion Tempering:

- Water/Steam Injection
- Near burner zone water wall cleaning

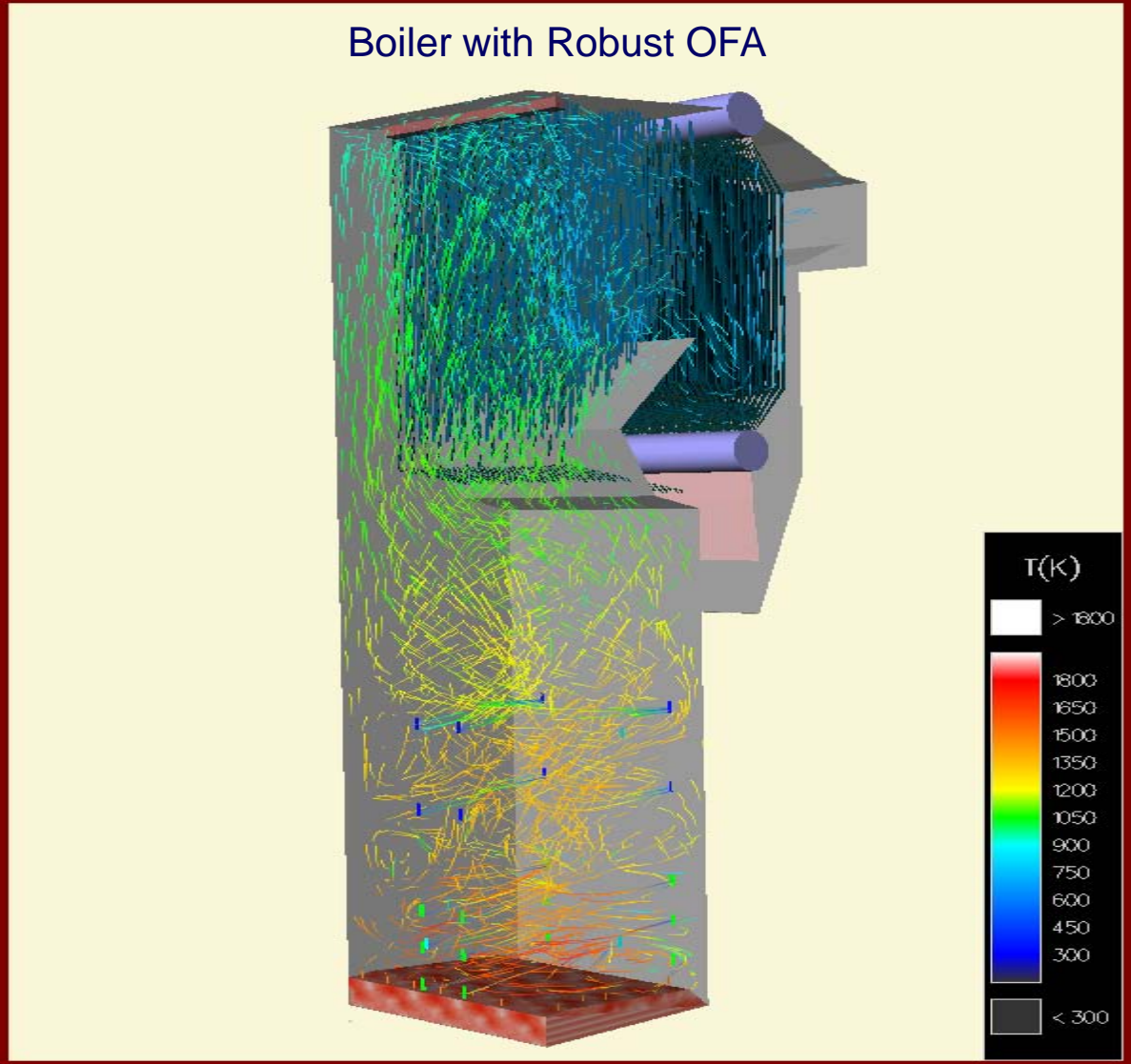
→ Flue Gas Recirculation

→ Air staging: Overfire Air

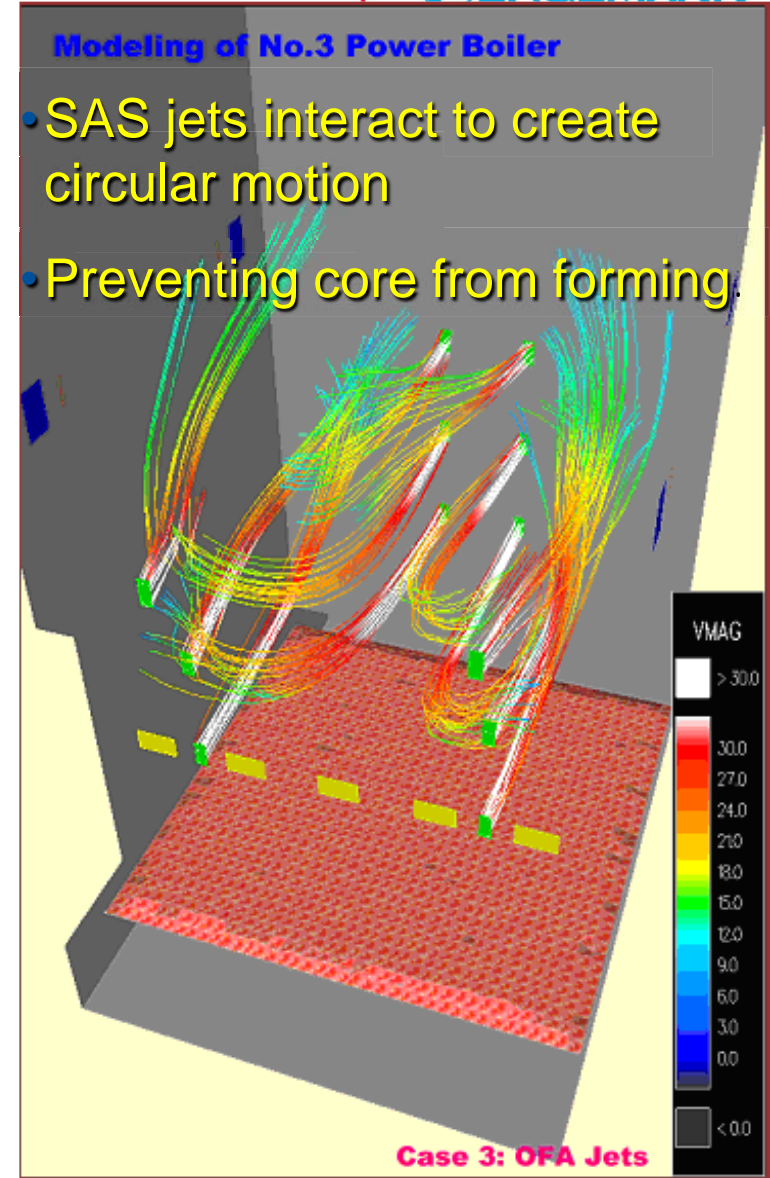
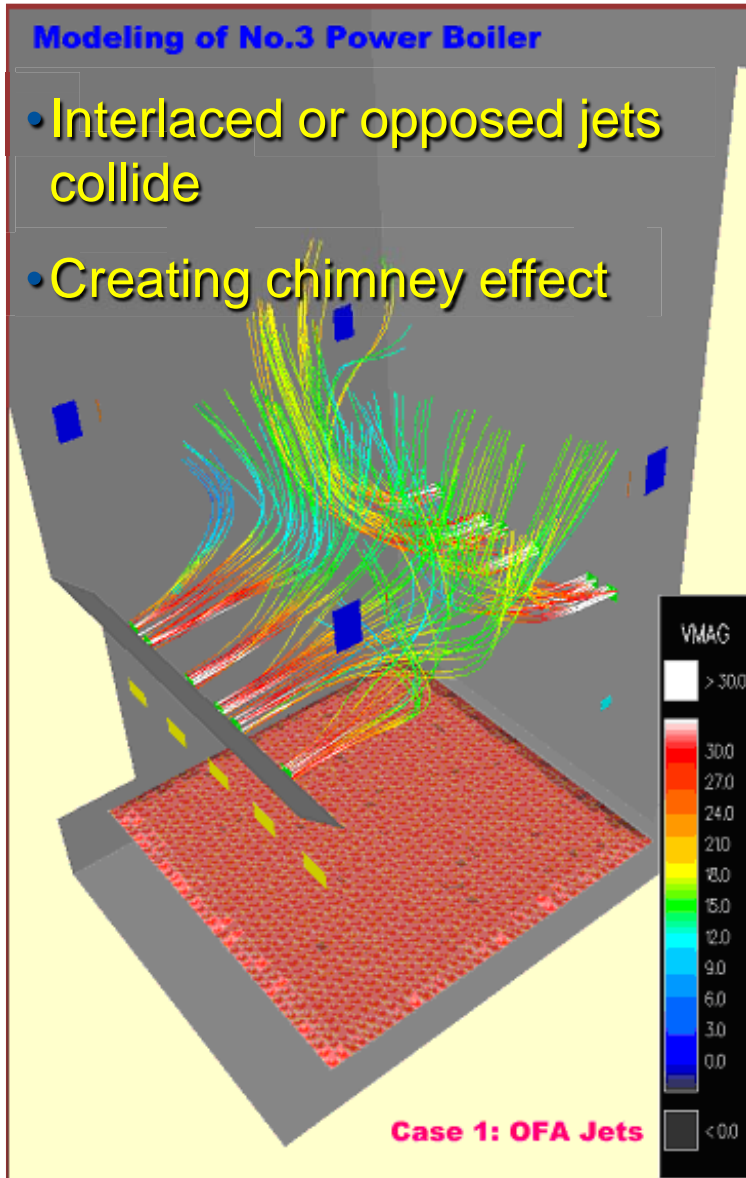
→ Fuel staging: Reburning

→ Oxygen use: Oxy Fuel

Combustion Modifications: Overfire Air Systems

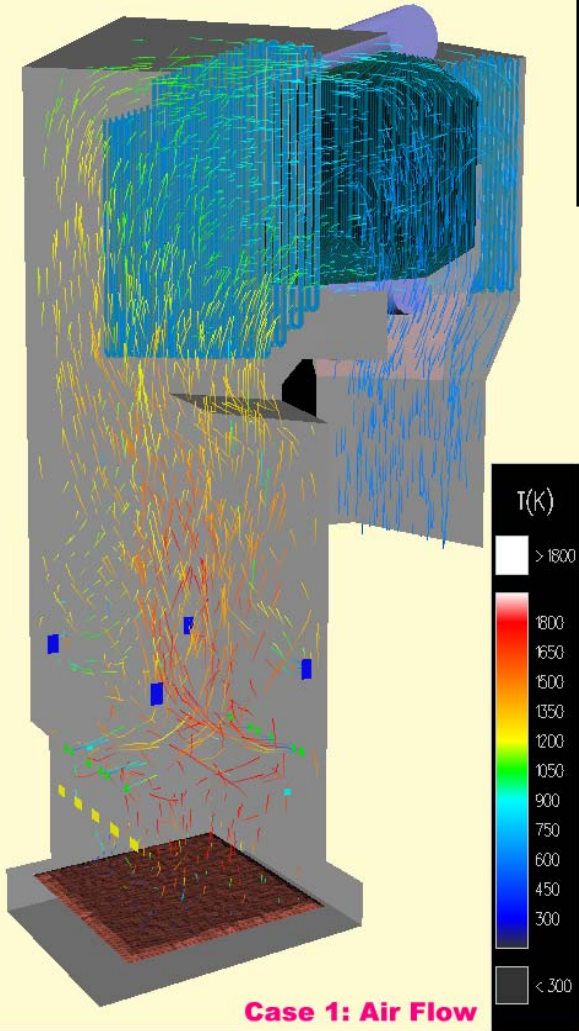


Case Study- Interlaced vs SAS Air Jets Comparison



Case Study- Original and SAS Air Flows

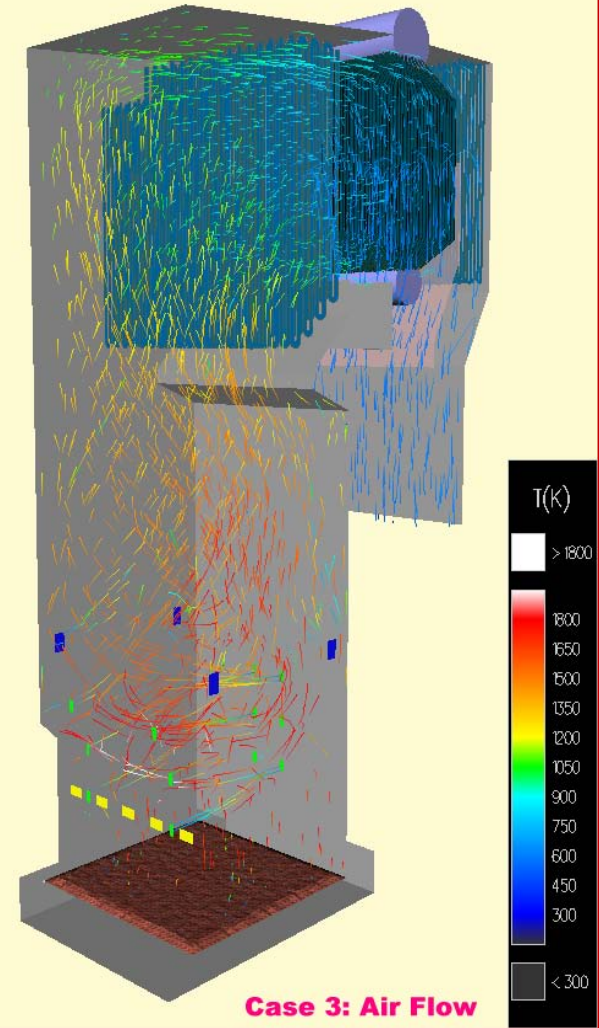
Modeling of No.3 Power Boiler



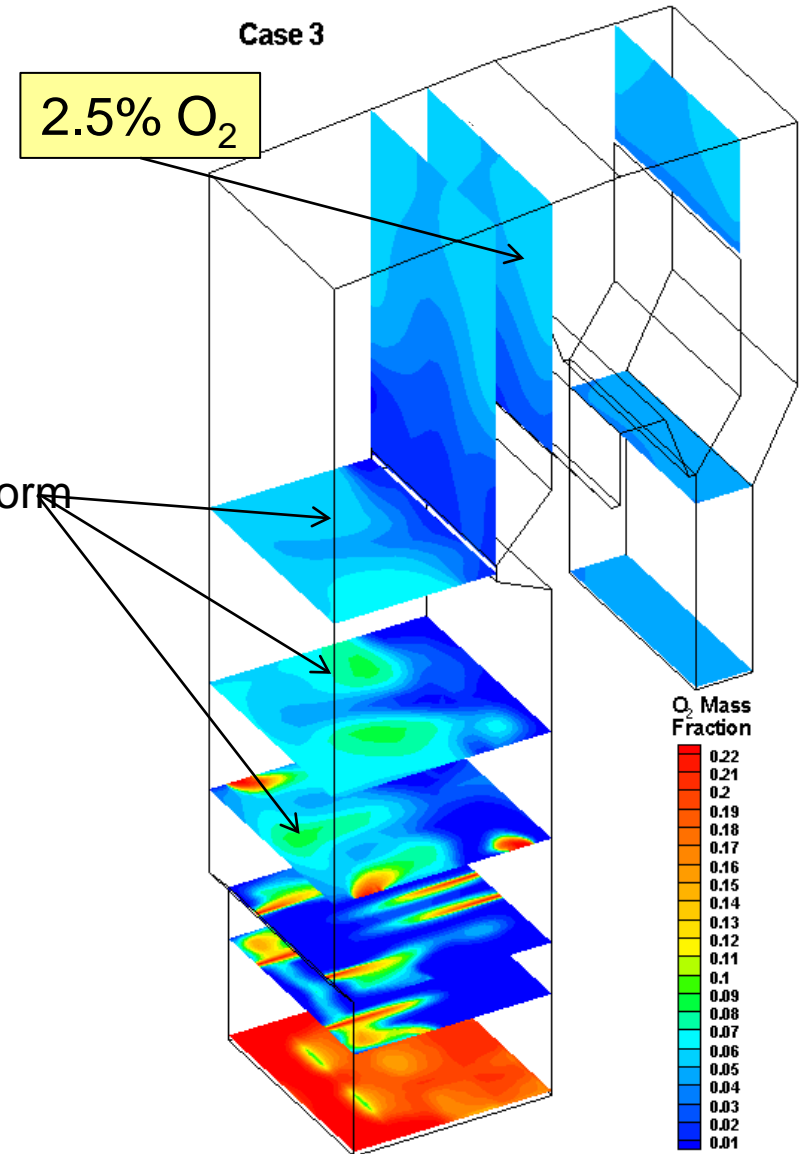
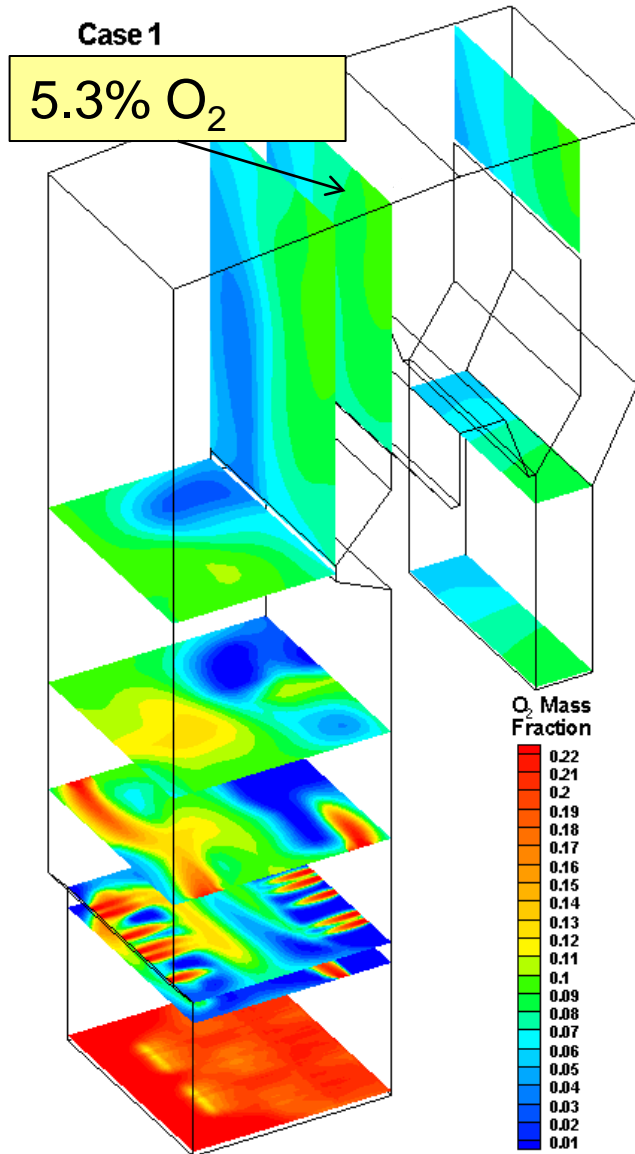
- Air goes straight up central chimney
- Rapidly carried up and out of the combustion zone

- Air swirls around, utilizing all of furnace volume
- Longer residence time in the furnace

Modeling of No.3 Power Boiler



SAS improvement – O₂ Balance

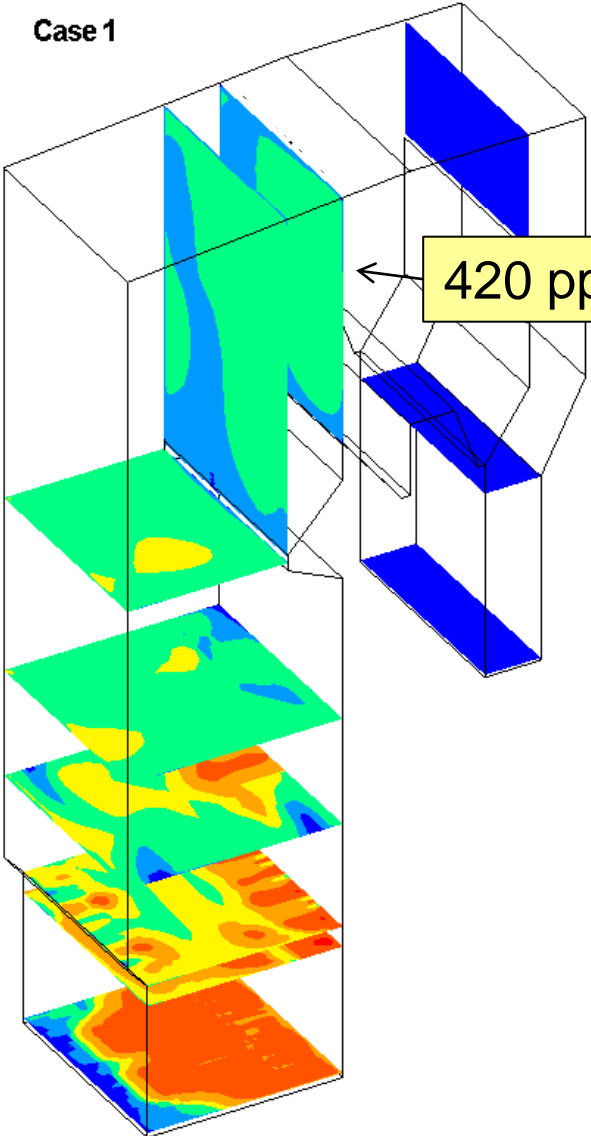


- O₂ is lower at each level, also more uniform

SAS improvement - CO



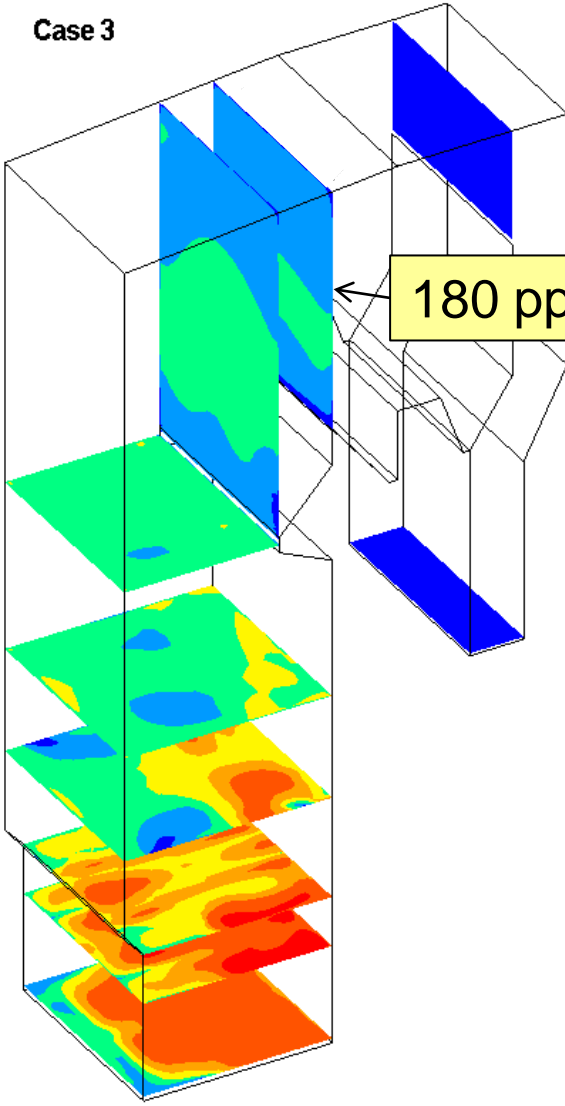
Case 1



420 ppm

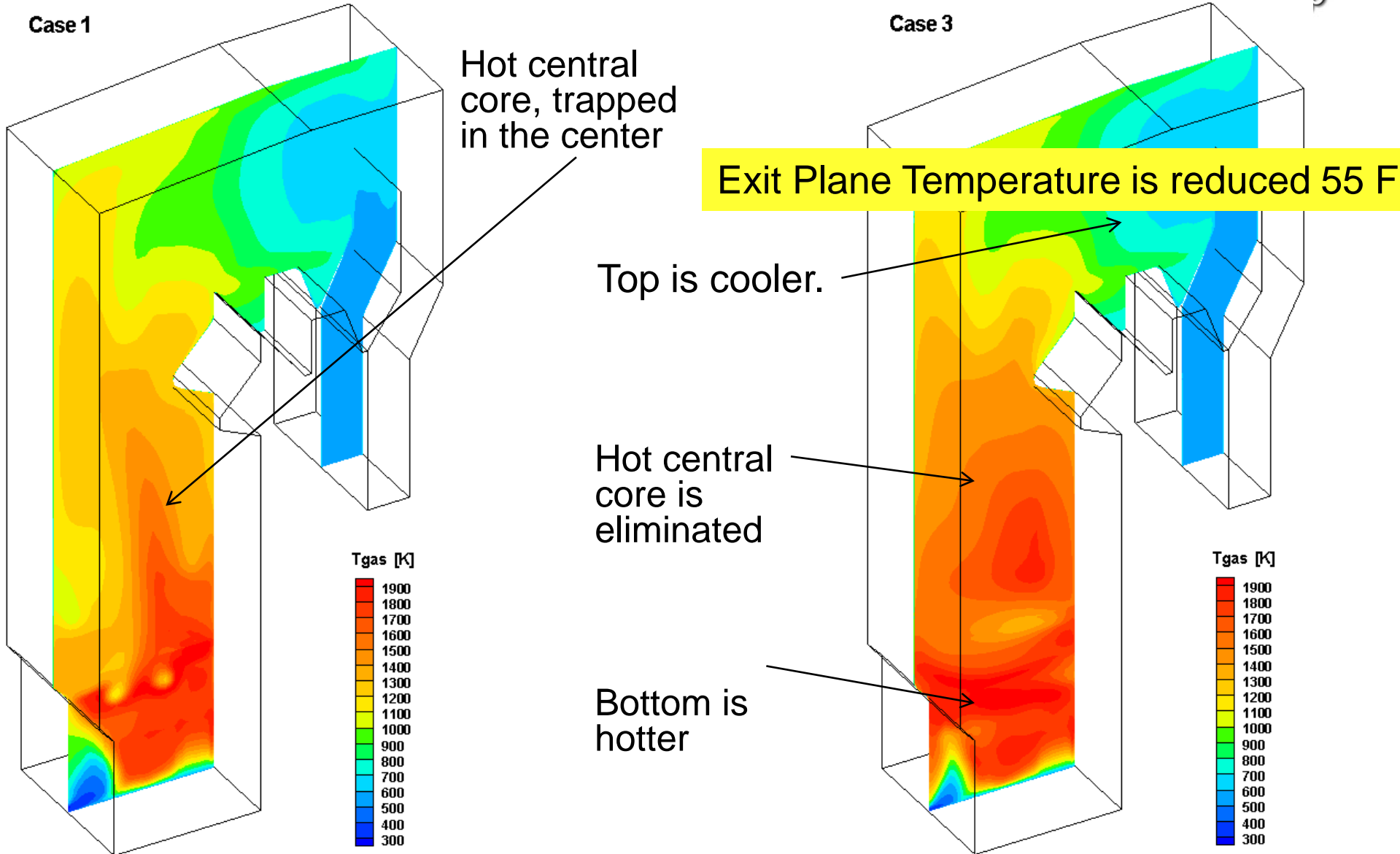
● CO reduced by half despite O₂ reduction

Case 3

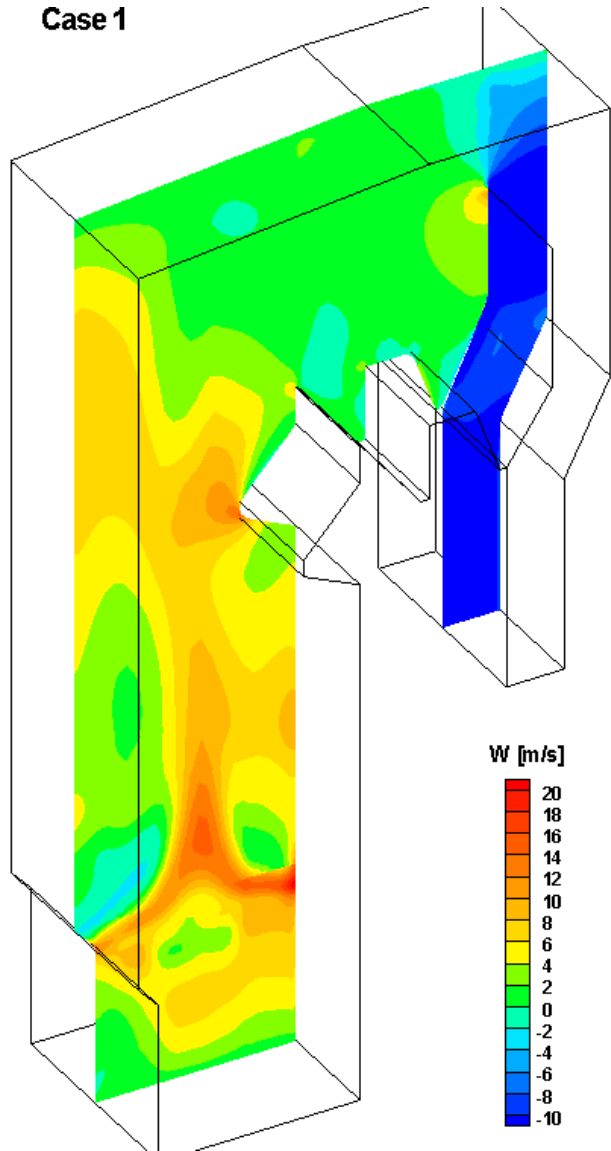


180 ppm

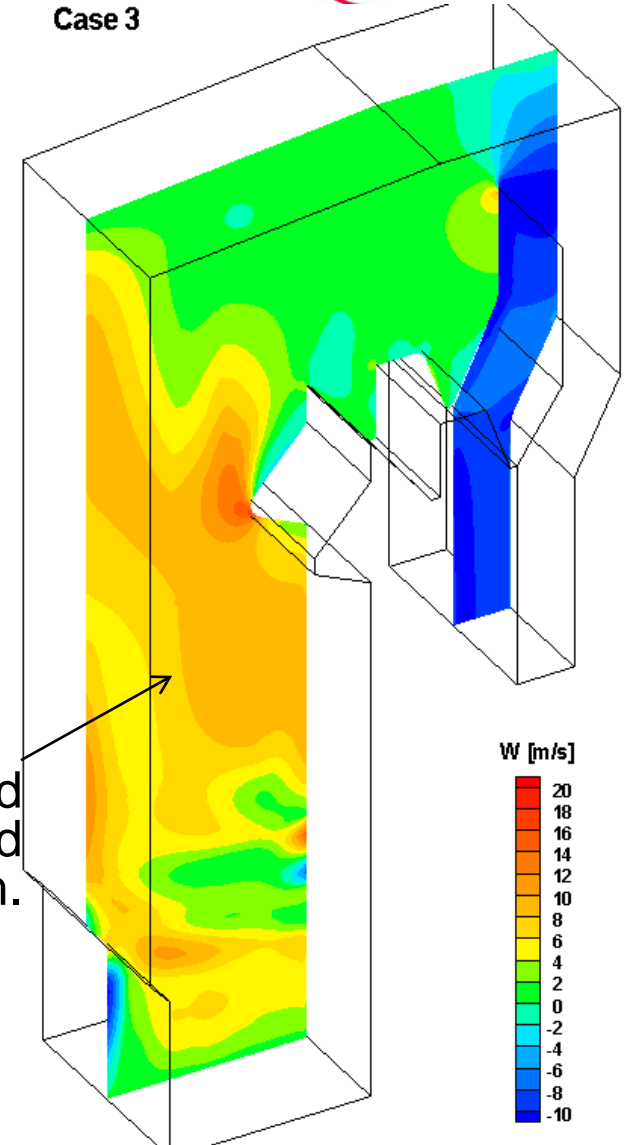
Temperature profile



Vertical velocity at centerline



Notice velocity and temperature profiles patterns match



Chimney eliminated in the modified system.

What you should know about Combustion Modifications:



Combustion modifications can play a definite role in improving SCR reactor inlet conditions and, therefore efficiency and longevity of the catalyst.

- Potential Particulate matter carryover reduction
- Loss on Ignition (LOI) reductions due to increased particle residence time within the boiler
- Excess O₂ reductions
- Complementary NO_x reductions
- Furnace Exit Gas Temperature reductions in excess of 50°F
- Other: D/F reductions up to 90%, CO reductions up to 60%

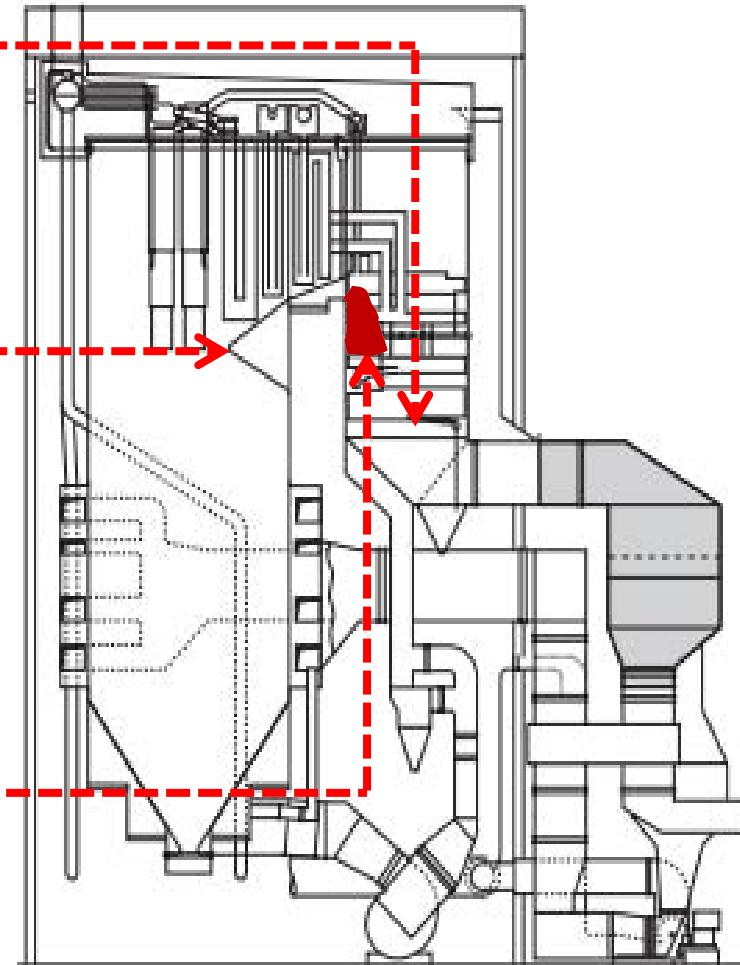
	Flue Gas Temp. and Profiles	Flue Gas Flow	Flue Gas velocity and Profiles	Flue Gas NO _x and Profiles	Total Comb Air	Ash Mass Loading	NO _x	Fuel Use/ Load
Combustion Modifications	√	√	√	√	√	√	√	√



BOILER CLEANING

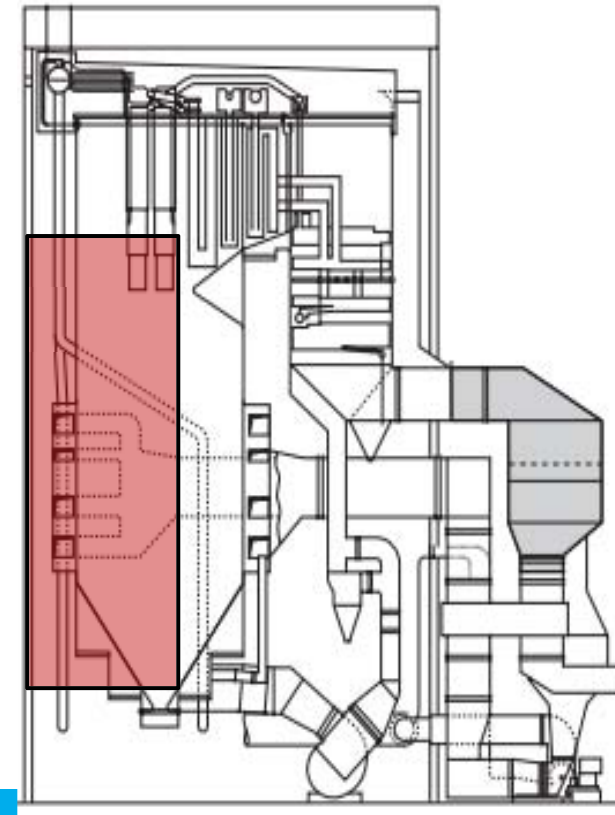
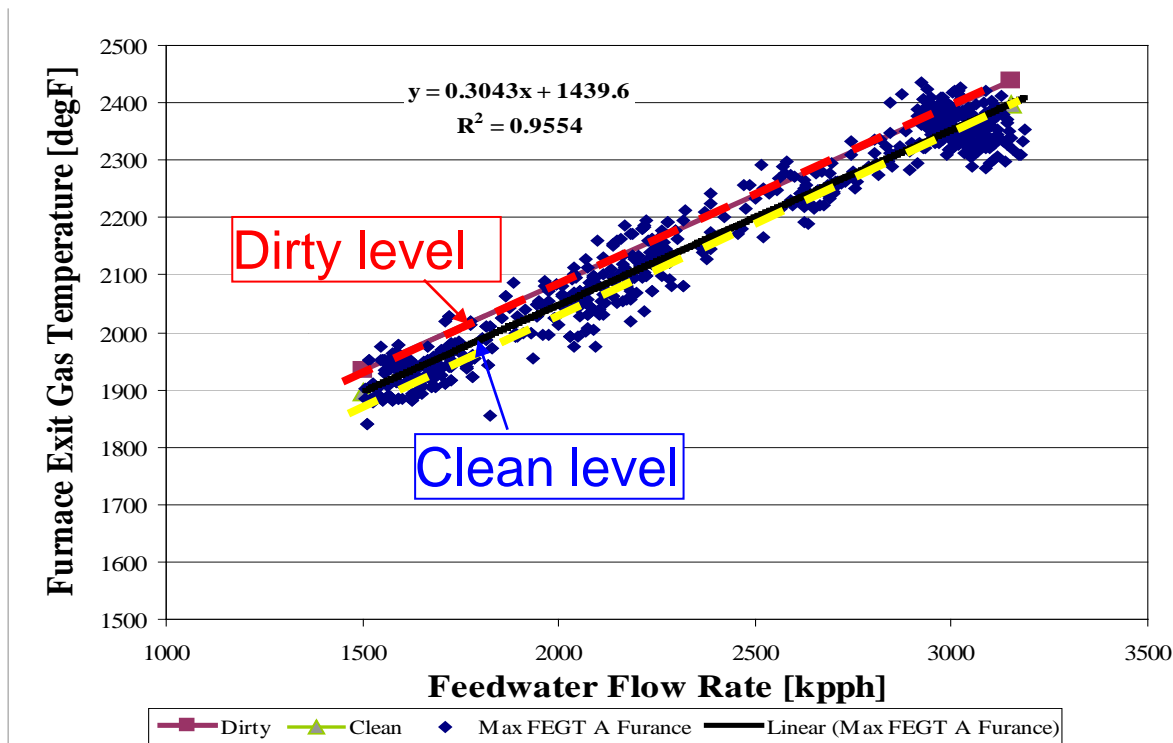
Boiler Cleaning Goals for proper SCR Operation:

- ➔ **Keep back pass temperature under control:** Effective and optimized boiler cleaning is important to ensure that the flue gas temperature entering the SCR is kept within the operating range (**typically 600 – 800°F for coal**).
- ➔ **Keep Furnace Exit Gas Temperature (FEGT) under control:** Poor furnace cleanliness can cause elevated Furnace Exit Gas Temperature (**>2200°F**) resulting in increased thermal NO_x formation and shift of stick area into the back pass region
- ➔ **Prevent pluggage in the back pass:** Results in flue gas flow imbalances and causes SCR to handle non uniform NO_x concentrations.



Keep the flue gas SCR inlet temperature under control (600 – 800°F):

- **Fact:** Furnace is the biggest heat transfer engine in the boiler
 - ➔ Typically 30-40% of the total boiler heat absorption is handled by the furnace
- **Method:** Keep the cleanliness variation in the furnace to a minimum



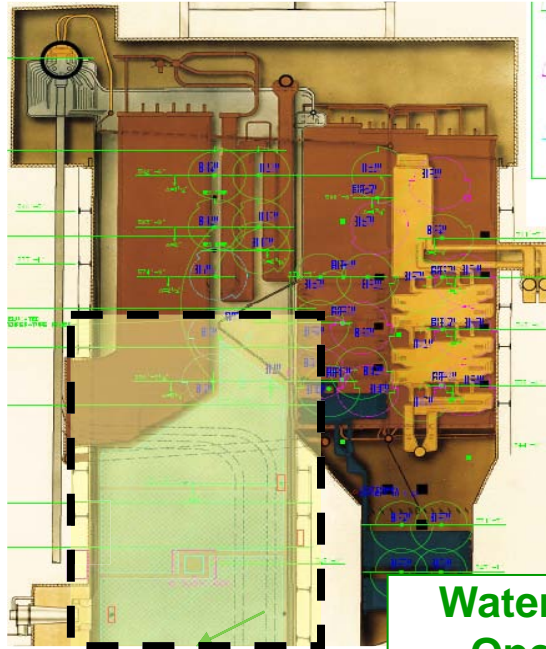
Keep the flue gas SCR inlet temperature under control (600 – 800°F):

- **Fact:** Once the large furnace cleanliness variation is taken out of the equation the rest of the problem is a convective heat transfer equation
 - ➔ Each sootblower is capable of improving heat transfer absorption to a certain btu/hr value
 - ➔ Heat Transfer Improvement $\sim d(m_{fg}) / d(t) \times C_{pfg} \times (T_{fg\text{before_cleaned}} - T_{fg\text{after_cleaned}})$
 - ➔ We need to optimize the sequence in a way to find the right sootblowers and get the correct cooling affect at all times
- **Method:**
 - ➔ Prioritize sootblowers based on their effectiveness on SCR inlet flue gas temperature
 - ➔ Do not run the effective sootblowers when the EEGT temperature is below the low limit for ammonia injection

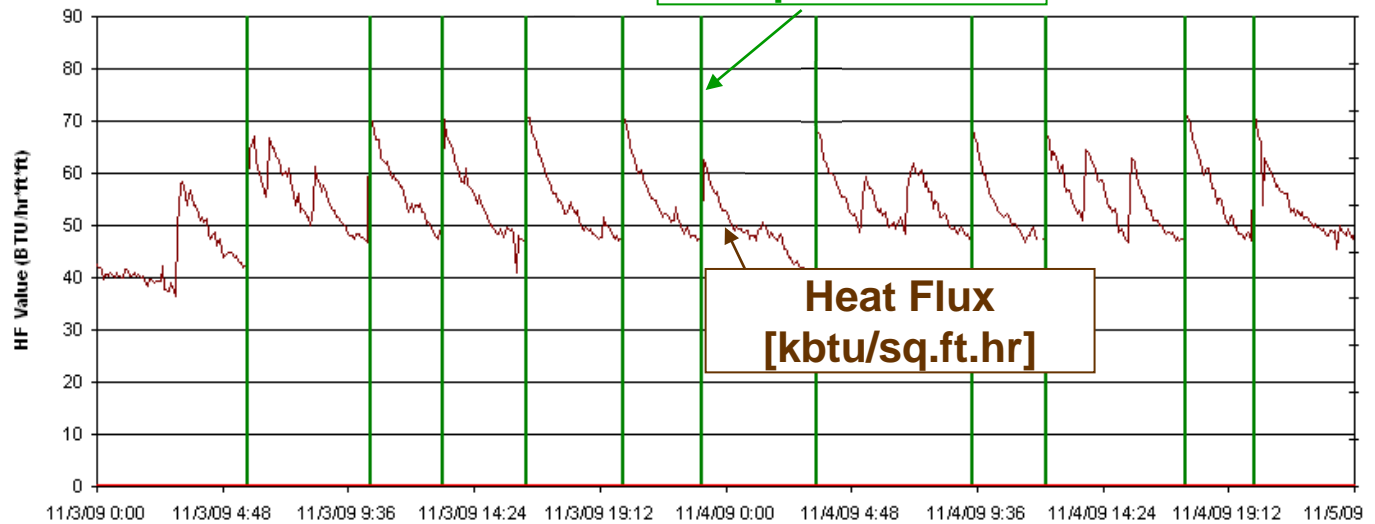
Challenges:

- Fuel Switch
 - Changes the fouling pattern in the entire boiler
 - Variable blends makes the cleaning optimization a dynamic problem
- Adding New Wallblowers or Water Cannons
 - New cleaning sequences need to be devised
 - The cleaning effect on Economizer Exit Gas Temperature (EEGT) and FEGT is unknown
- Other Performance Targets
 - Performance targets such as Main Steam Temperature and HRH Temp to be realized while making the SCR Temperature Goal

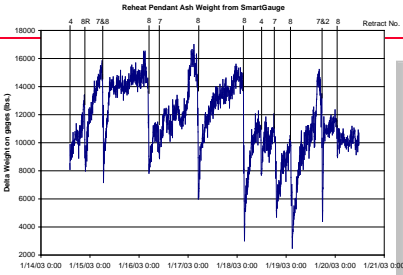
Measurement Strategies - Furnace



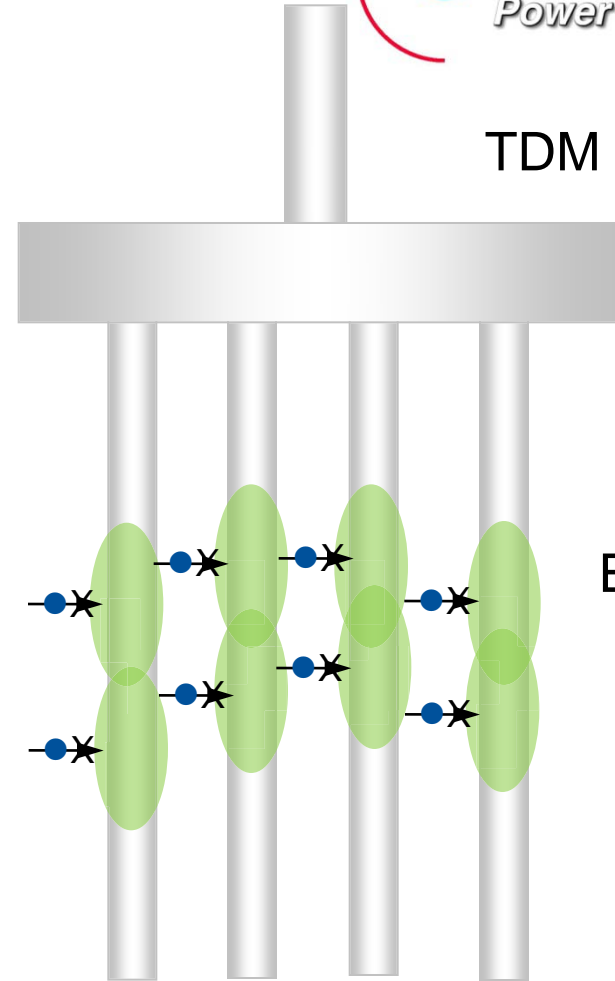
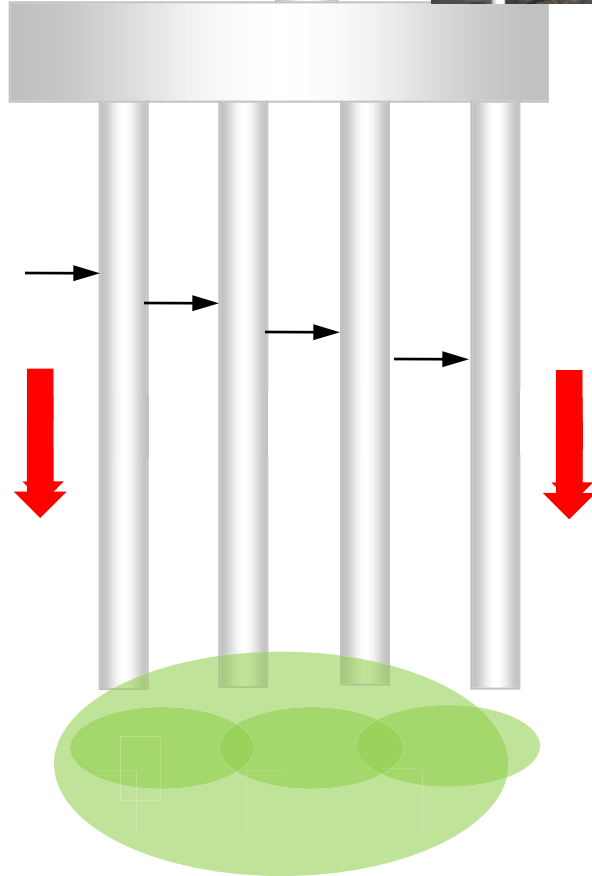
Water Cannon Operations



Measurement Strategies - Convective Pass



SMART Gauge

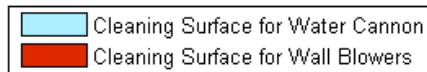


TDM Efficiency

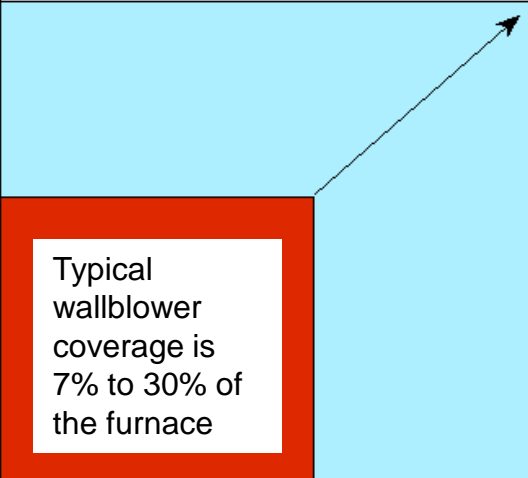
System	Clinker Formation	Loss in Heat Transfer	Ash Removal
SMART Gauge	Yes	No	Yes
TDM	No	Yes	Yes

SMART Furnace

- Closed Loop Total Furnace Cleaning
 - ➔ SMART Cannons
 - ➔ SMART Flux Sensors
- Reduce FEGT up to 100°F

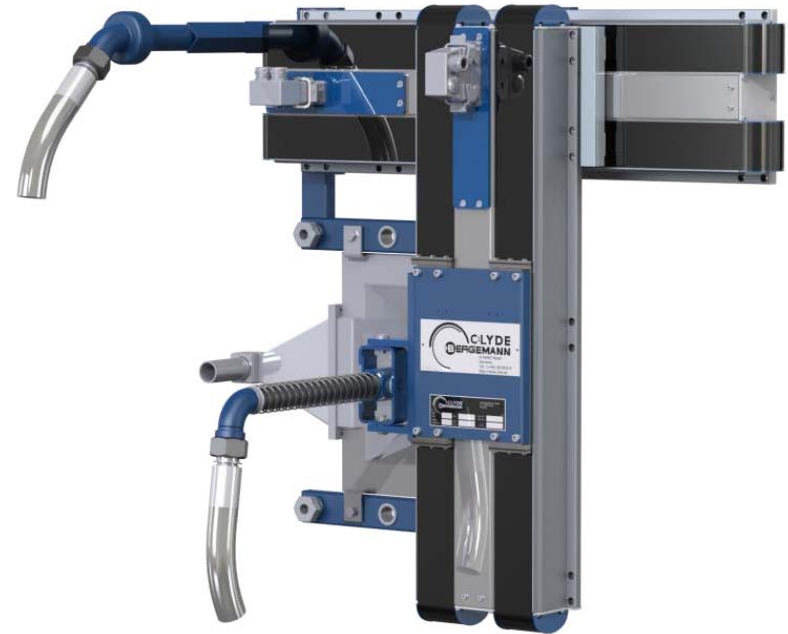


Typically Water Cannon cleaning coverage is 80% of the total furnace area



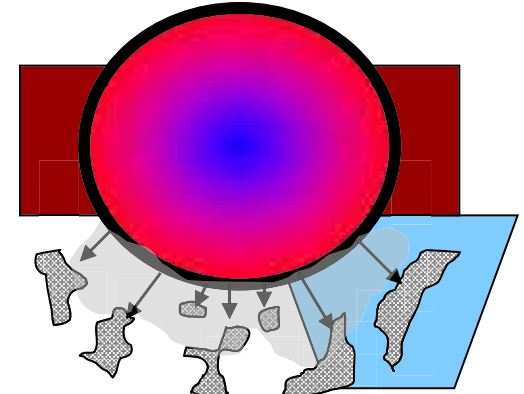
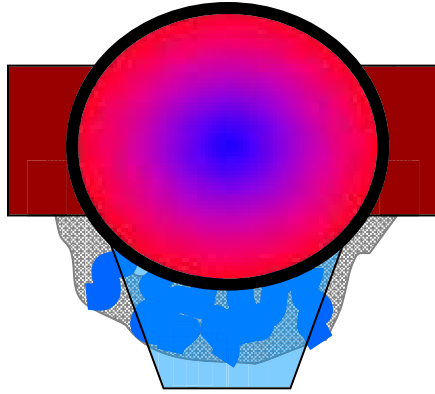
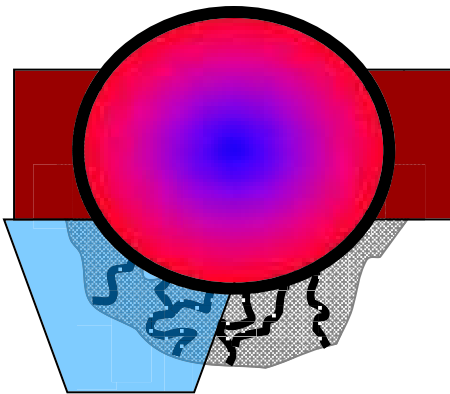
Typical wallblower coverage is 7% to 30% of the furnace

The diagram shows a square representing a furnace area. A large light blue rectangle covers approximately 80% of the area, representing water cannon coverage. A smaller red rectangle covers the bottom-left corner, representing wallblower coverage. An arrow points from the text box to the red rectangle.

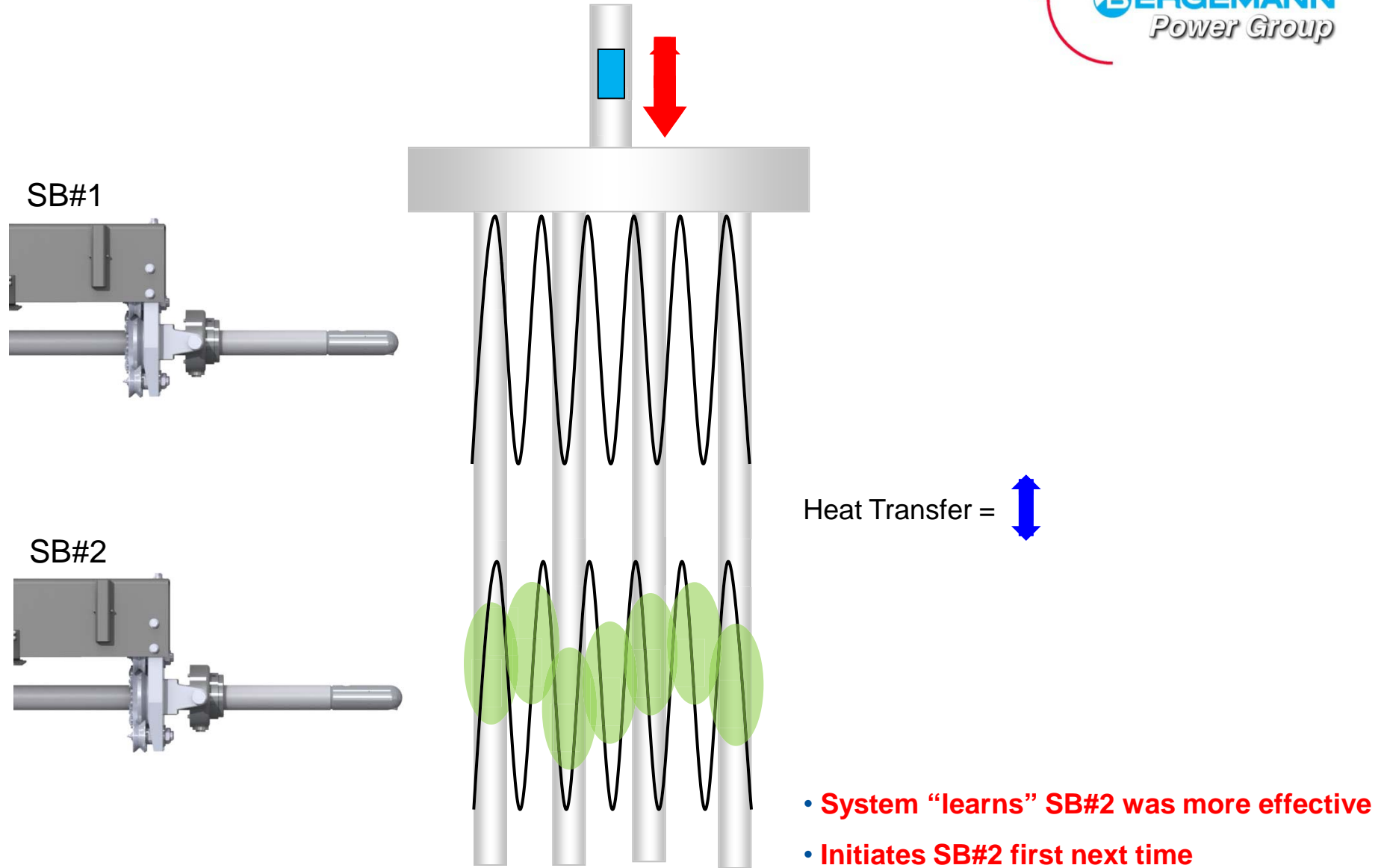


- Cleaning Philosophy

- Water spray impinges on deposit, forming fissures
- Water spray fills fissures, then flashes to steam
- Volumetric expansion safely removes deposit from tube



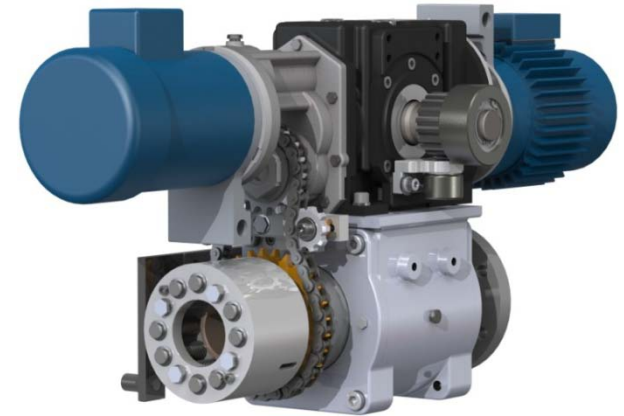
SMART Sootblowing



Dealing with Pluggage and Clinkers SMART Retract

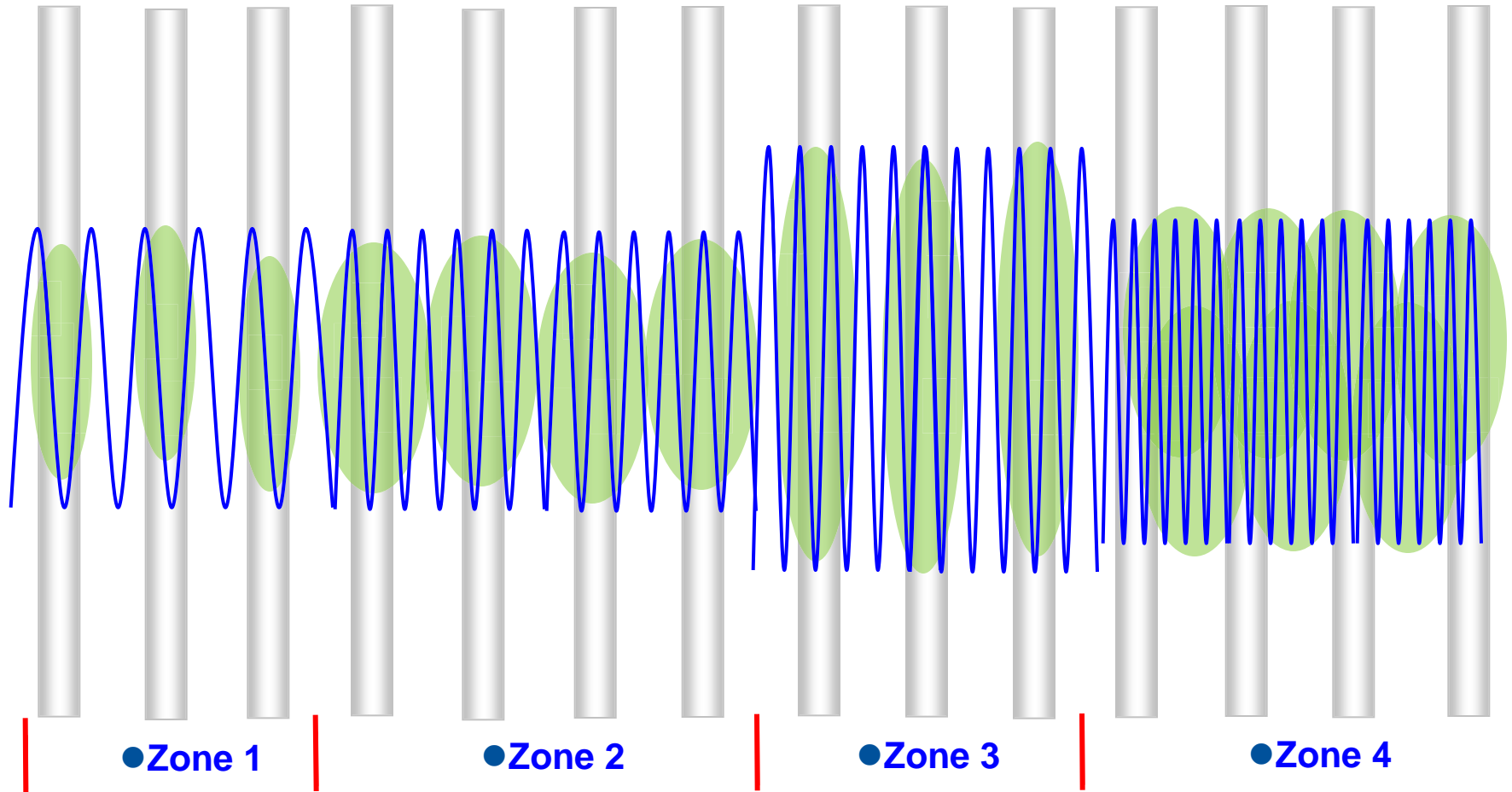


- Targeted Sootblowing
- Variable Intensities:
 - Variable Helix
 - Stop & Go
 - Variable Pressure



SMART FEATURE	CUSTOMER BENEFIT
Dual Motor Drive	✓ Infinite cleaning patterns ✓ Independent rotation and traversing speeds
Variable Helix	✓ Targeted cleaning for fouling conditions specific to that tube bank
Variable Cleaning Pressure	✓ Remove difficult slag by increasing blowing pressure, or eliminate tube erosion by reducing blowing pressure in real-time
Variable Intensity	✓ Stop the nozzles at specific tube banks that need additional cleaning, or speed through tube banks that are already clean

Cleaning Intensities



Optimized and Effective Boiler Cleaning

Increase Boiler Efficiency

Increased heat transfer

Reduce FEGT, EEGT

Eliminate fouling issues



Increased SCR Reliability

Optimize flue gas temperatures

Lower ammonia consumption

Control pressure drop



Increase Fuel Variability

Intelligent, closed loop boiler cleaning based on real-time boiler fouling



Reduced Cleaning Frequencies

Initiates cleaning events only when and where needed





SCR CLEANING

- Particulates in the flue gas are important not only in the mass loading amount, but also in composition, size and distribution in front of the catalyst layer. Key properties of the fuels have direct influence on the performance and life of the catalyst. Reactor cleaning techniques can help keep it from fouling and to extend the catalyst life.
- Sootblowing of the catalyst layers is one of the most effective techniques used to clean the catalyst surface from the accumulation of fly ash. Other techniques such as dry air cleaning and sound horns can be used

SCR Performance Improvement Solutions



- SCR Cleaning
 - ➔ USR Retractable
 - ➔ Sonic Horn



High Flue Gas Temperatures

- Catalyst life diminished
- SO₂ to SO₃ conversion increased

Catalyst Plugging

- Reduced catalytic efficiency
- Increased system pressure drop

Reduced Catalytic Efficiency

- Increased NH₃ usage to meet NO_x removal requirements
- Ammonia slip through SCR increases

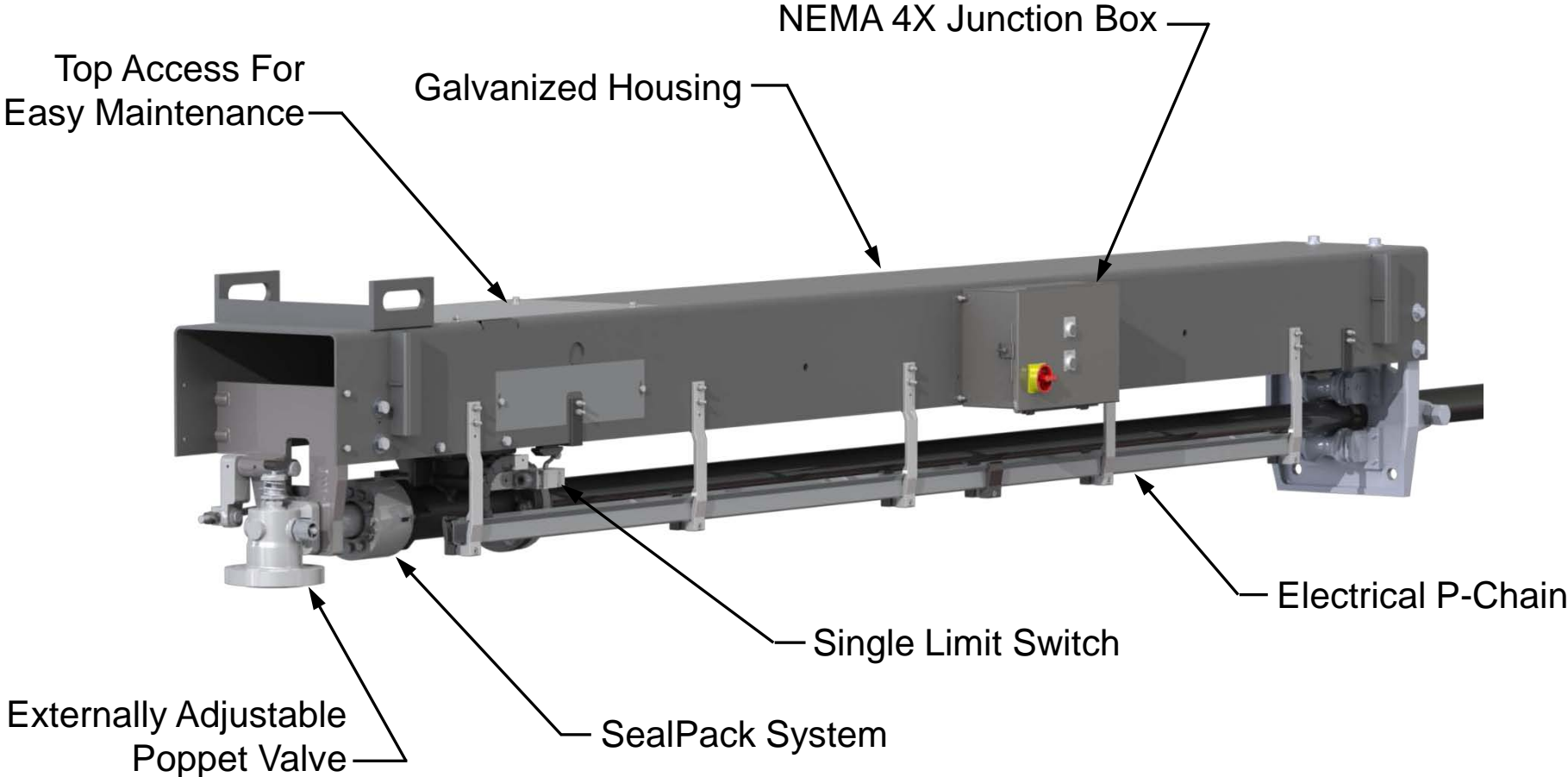
SCR Cleaning Experience



- US Market
 - 47 Boilers
 - 80% of the total SCR Rake Cleaners
- Industries
 - Utility, Refinery, Industrial
- Fuels
 - Coal (all types), Oil, Petcoke, Biomass
- Boilers
 - Subcritical, Supercritical



USR Retract



USR Retract Features

Heavy Duty Design

Developed for recovery boilers



Lower Cost of Ownership

Less Maintenance
Less expensive spare parts / Lower consumption



Superior Cleaning Performance

Pressure adjustment per catalyst recommendation



Balances Increased Reliability with Ease of Maintenance

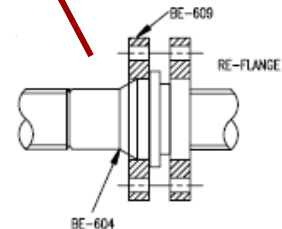
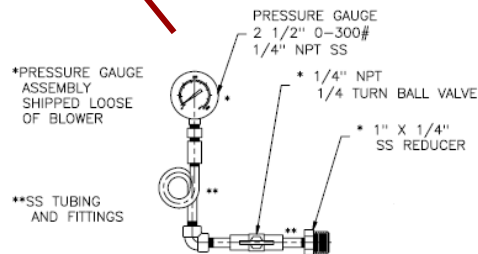
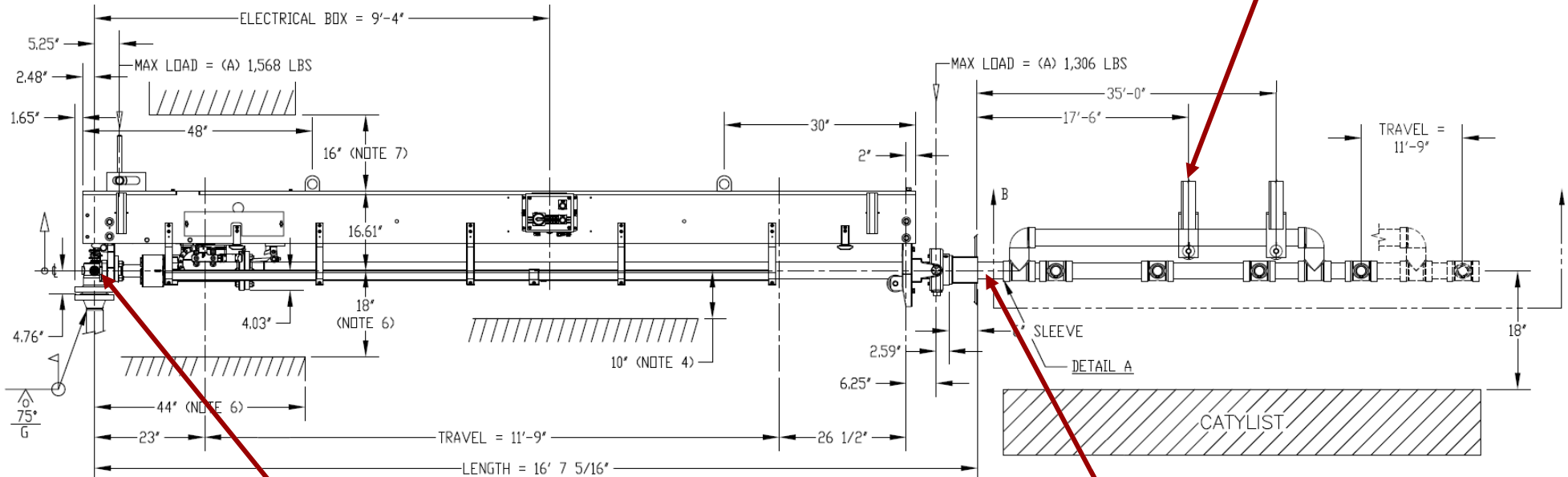
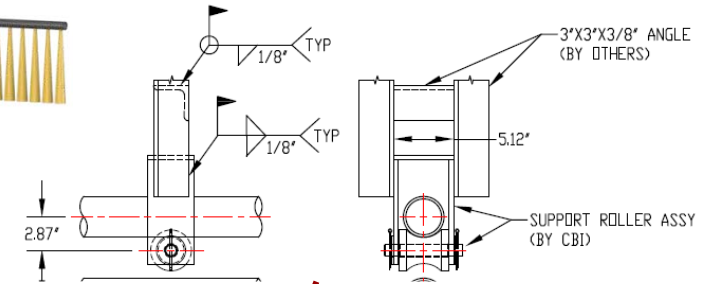


USR Specifications



Travel	8'-11' (standard)
Blowing Pressure	40-50 psig
Lance & PreHeat Tube	3"-Sch.40-CS
Rake Arms	2"-Sch.80-CS
Nozzles	3/16" (standard)
Motor	3/4 HP

General Arrangement – USR Cleaner

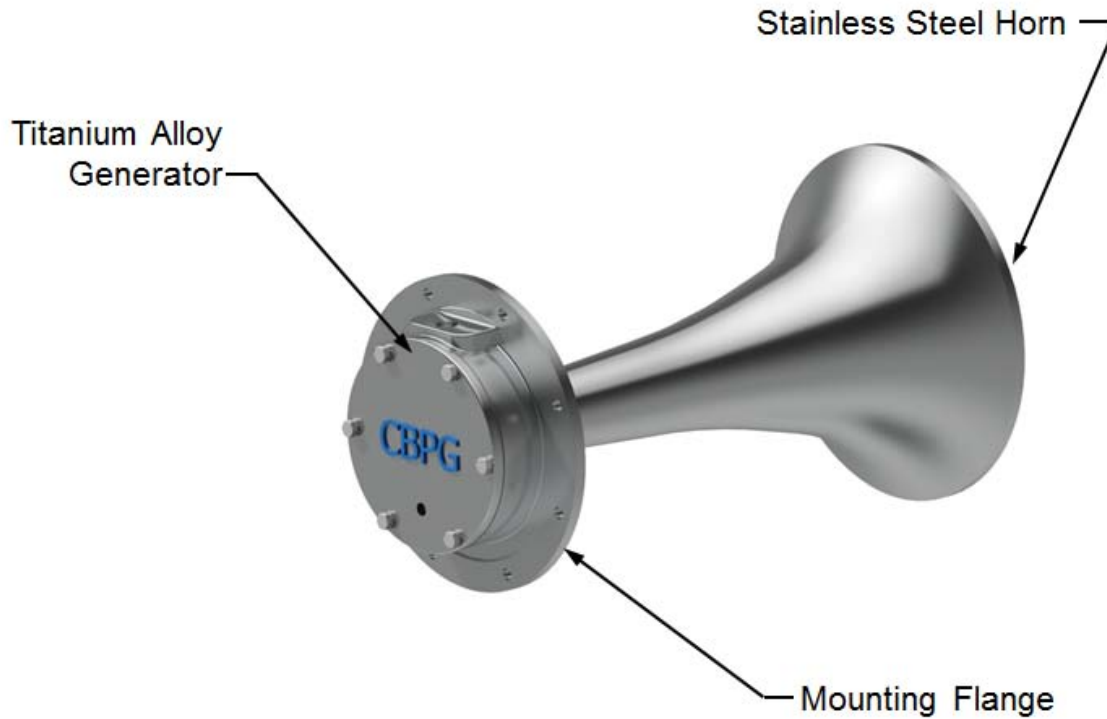


USR Benefits Summary



STANDARD FEATURE	CUSTOMER BENEFIT
Balanced Drive Carriage	<ul style="list-style-type: none"> ✓ Eliminates oil leaks and pinion failures in “handed” carriages ✓ Eliminates excessive rack wear due to uneven load distribution ✓ Reduces number of spare parts needed
Modular Drive Carriage	<ul style="list-style-type: none"> ✓ Shortens gearbox removal from 4 hours to less than 1 hour ✓ Extends service life due to reduction of heat transfer to gears
SealPack™ System	<ul style="list-style-type: none"> ✓ Extends packing life ✓ Reduces packing replacement time
Externally Adjustable Poppet Valve	<ul style="list-style-type: none"> ✓ Allows for easy On-line pressure adjustment ✓ Eliminates safety issues and lock-out/tag-out requirements
Hot-Dipped Galvanized Housing	<ul style="list-style-type: none"> ✓ Superior corrosion resistance ✓ Lifetime warranty
Single Limit Switch	<ul style="list-style-type: none"> ✓ Eliminates failure prone fixed limit switches

Sonic Horn



Frequency

75 to 250 Hz

Sonic Pressure

≥ 150 dB

Compressed Air

100 psig @ 30-40 SCFM



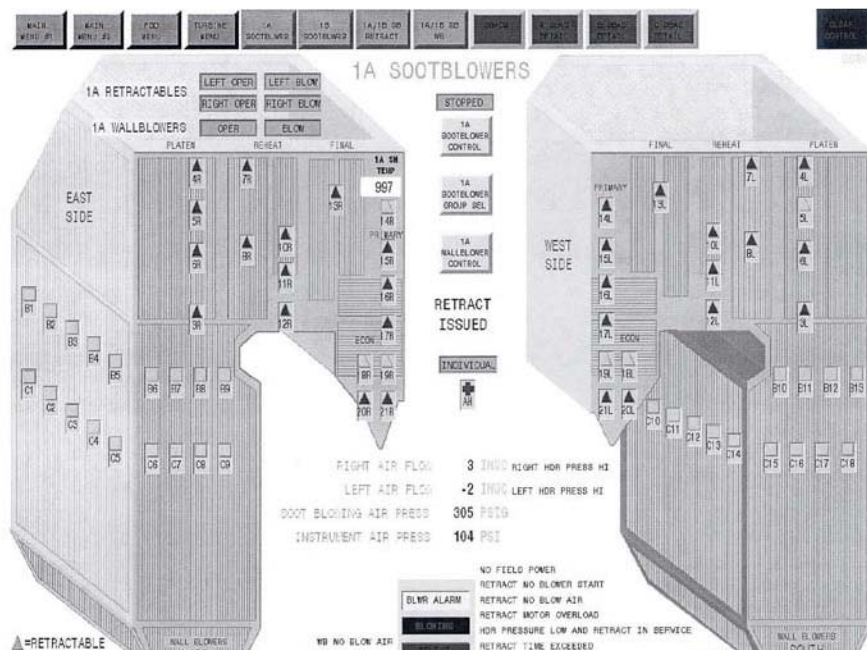
Case Study-SMART Clean

SCR Temperature Control With the Integration of the SMART Clean Technology in Duke Energy Mayo and Asheville Stations

Objective:

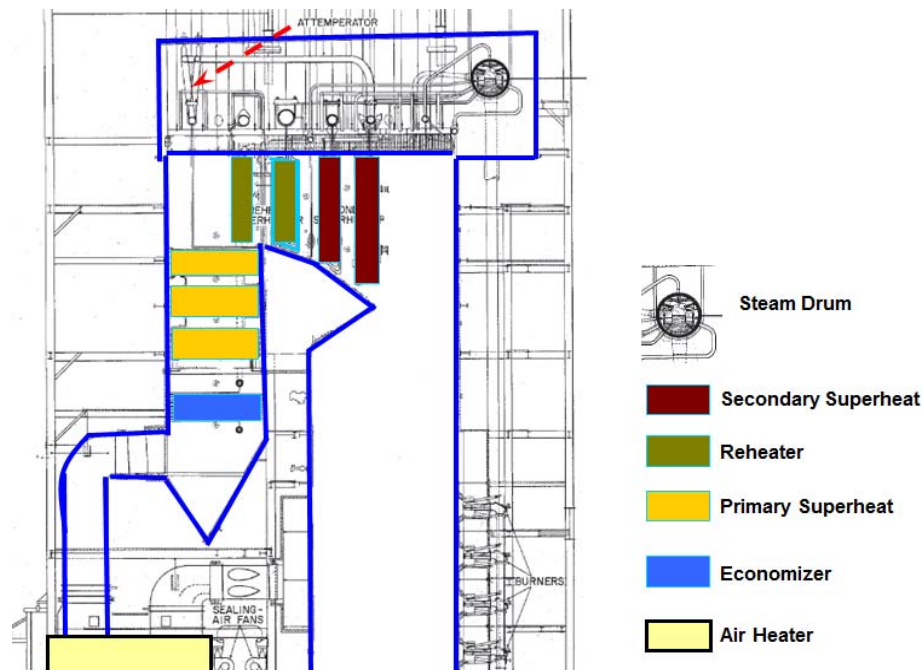
- As a result of the Fuel Flexibility initiative in former Progress (Current Duke) Energy MAYO and Asheville plants integrated Clyde Bergemann's SMART Clean technology to deal with the changes in the coal quality and ensure a stable flue gas temperature going into the SCR.
- The new SMART Clean technology optimized the cleaning to control the Economizer Exit Gas Temperature (EEGT) at a desired set temperature. The results of the performance tests showed that the EEGT control was successful and the temperature profile stabilized after implementing the new SMART Clean technology.
- The new technology derives decisions and changes the cleaning strategy based on the effect of the sootblowers on the heat transfer performance rather than the traditional approach of targeting a static cleanliness level in the boiler. The performance data of the closed loop tests are presented as well as the economical justification of the project.

MAYO U4A & 4B



- Located near Roxboro, N.C.
- 1983 dual-boiler (Foster Wheeler) unit fired with Bituminous Coal. 800MW Gross.
- Clyde Bergemann SMART Clean Intelligent Sootblowing System was installed and commissioned in June 2010 along with 84 Clyde Bergemann VS sootblowers.

Asheville U1



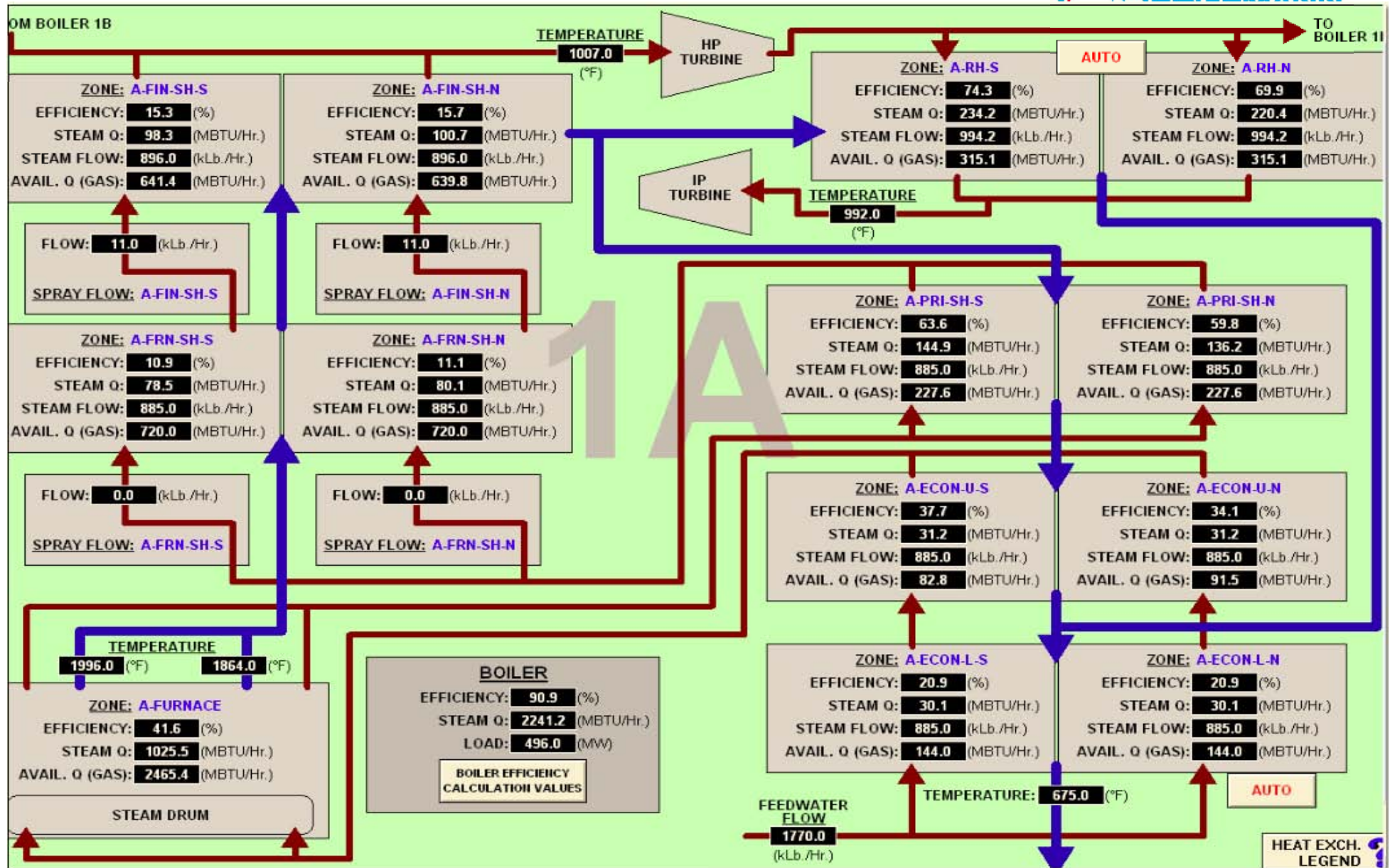
- Located near Asheville, N.C.
- 1964 dual-boiler (Riley) unit fired with Bituminous Coal. 207MW Gross.
- Clyde Bergemann SMART Clean Intelligent Sootblowing System was installed and commissioned in June 2011.

The SMART Clean algorithm calculates the heat transfer targets dynamically to determine the optimum heat transfer distribution in each boiler based on the following key performance targets:

- Main steam temperature = 1005 °F
- Hot reheater temperature = 1005 °F
- Economizer exit (SCR Inlet) gas temperature < 760 °F
- Economizer exit (SCR Inlet) gas temperature > 600 °F
- Furnace exit gas temperature < 2400 °F at maximum firing rate

A heat transfer efficiency (HTE) is calculated for each of the heat exchangers including the furnace, superheater and reheater sections. Heat transfer efficiency is used as the main process variable to derive the heat absorption target for each zone.

System HMI for the Thermodynamic Model Process Variables

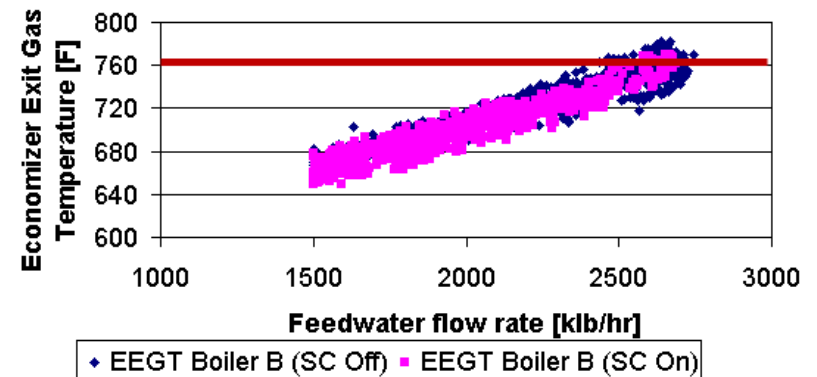
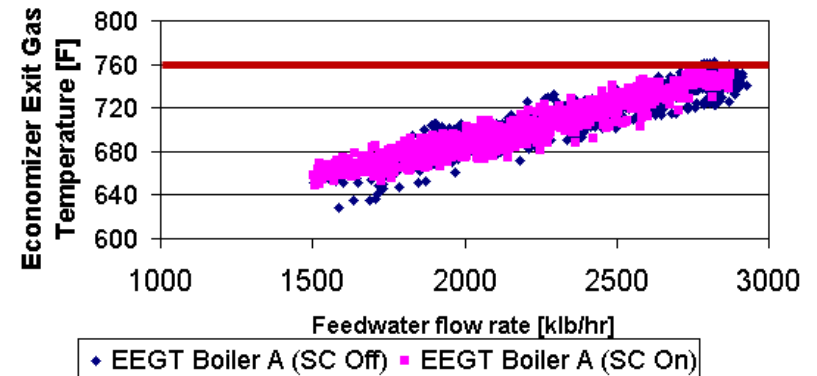
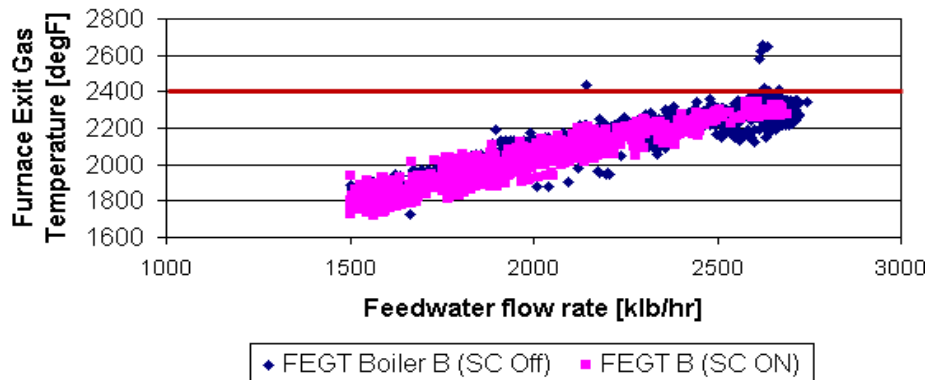
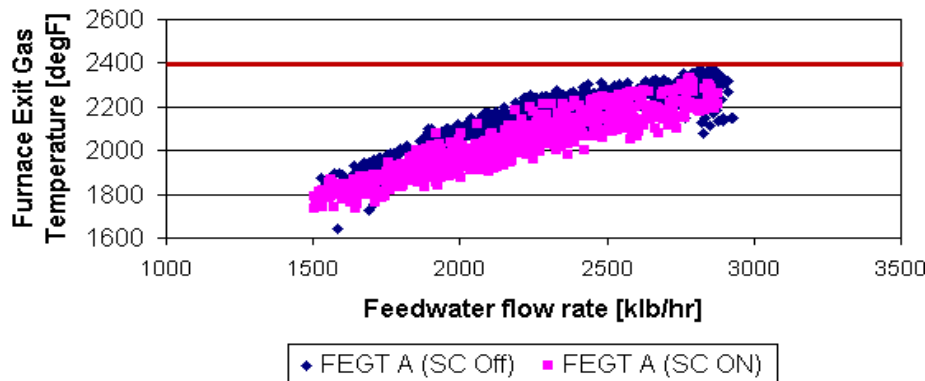


Flue Gas Temperature Control MAYO



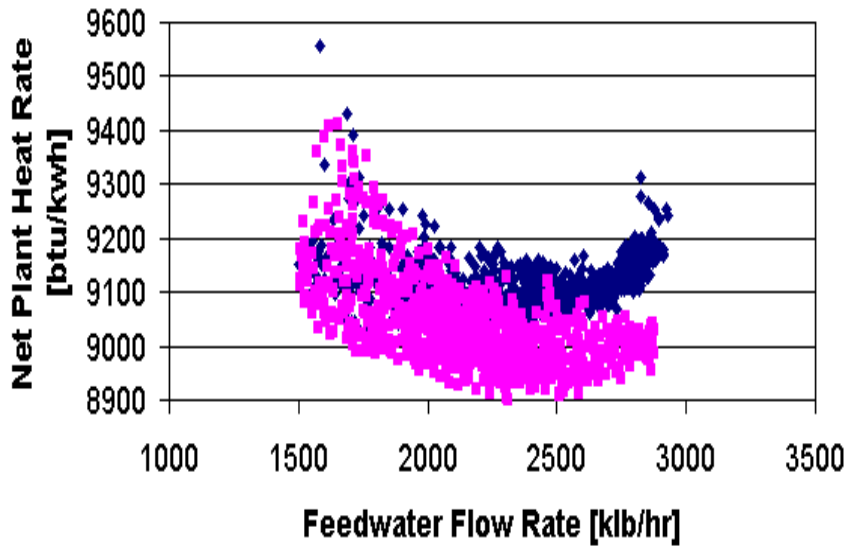
- Furnace Exit Gas Temperature has been controlled below the 2400°F at full firing rate condition during the SMART Clean period.
- Boiler A shows a reduction of 20°F to 40°F in the FEGT as a result of the SMART Clean operations.

- The SMART Clean operations successfully controlled the flue gas temperature below the required 760°F.



Plant Heat Rate Comparison

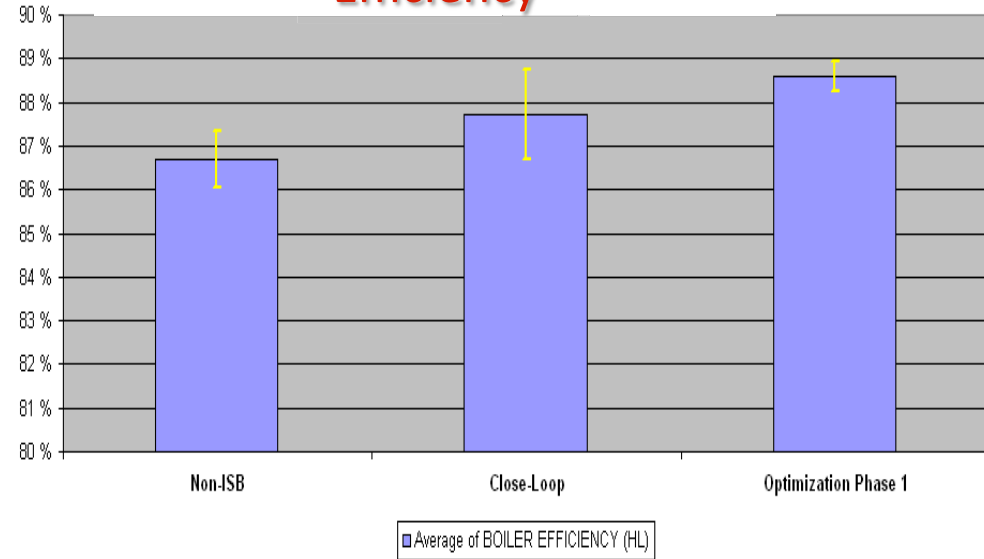
MAYO PHR



◆ Net Heat Rate (SC OFF) ■ Net Heat Rate (SC ON)

- The plant heat rate during the SMART Clean period was maintained 170 btu/kwh lower than the Sequential period at full load.
- The ambient temperature during the Sequential operations was 40°F lower than the SMART Clean time frame. The effect of the ambient temperature has been calculated as 80 btu/kwh. If the ambient influence is considered, the new improvement in plant heat rate can be calculated as **90 btu/kwh**.

ASHEVILLE U1 – Boiler Efficiency



- Based on the historian data, Unit #1 efficiency has been increased on average by 2%.
- The heat rate has improved on average by **220 btu/kWh**



Concluding Remarks

For optimal SCR Operation



- Combustion process need to be optimized and all critical elements influencing the SCR operation need to be monitored on a periodic basis
- Combustion modifications may be necessary to improve SCR inlet conditions of the flue gas mass flow and NOx concentration
- Fuel Source chemistry is an important factor and require consistent quality to provide best operational success.
- SCR Flue gas inlet conditions should be controlled within the operable range of 600 and 800 F. Biomass firing 400 to 500 F.
- SCR Flue Gas Inlet temperature can be controlled with optimized combustion and intelligent cleaning techniques specifically developed for SCR operation.
- Effective SCR Cleaning can be handled with few options. The direct cleaning of the reactor with a cleaning medium (Rake type cleaners) can be used effectively for persistent deposit removal.

Boiler Performance Effects on SCR Operation



	Flue Gas Temperature and Profiles	Fuel Use	Flue Gas Flow	Flue Gas velocity and Profiles	Flue Gas NOx and Profiles	Total Comb Air	Ash LOI	Reactor Cleanliness	NOx
Combustion Modifications	√ Reduced (50-70F)	√ Reduced	√ Reduced	√ Flat Profile	√ Lower NOx, Flat Profile	√ Reduced	√ Reduced	√ Reduced	√ Reduced
Boiler Cleaning Operations	√ Reduced (20-40F)	√ Reduced (1-3%)	√	√	√	√			√
SCR Cleaning								√	√



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THANK YOU