Reinhold Environmental Ltd.

2008 NOx-Combustion Round Table & Expo Presentation

February 4-5, 2008 in Richmond, VA

One Source…Many Solutions…One Purpose

SCR System Design

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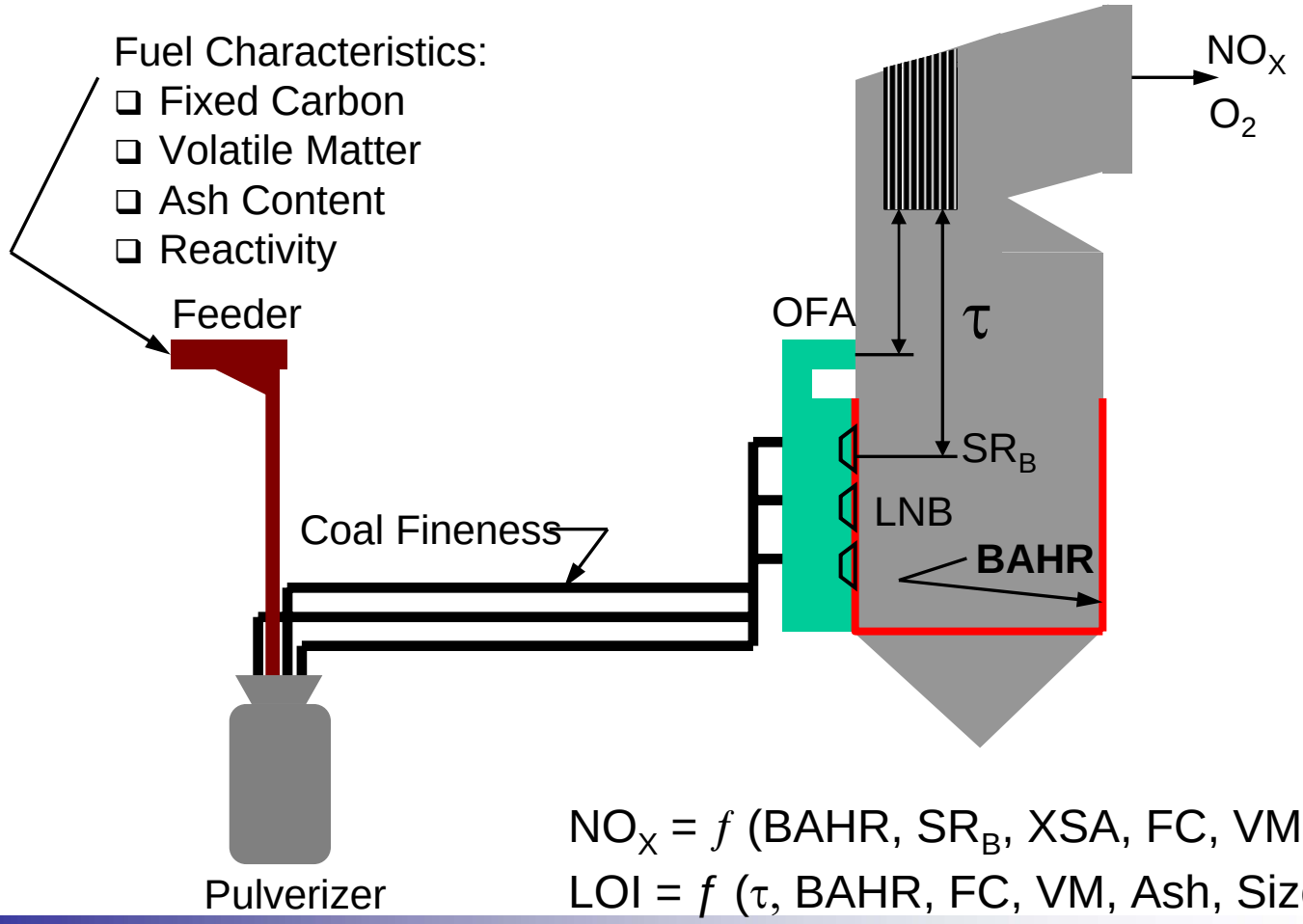
Process Engineering

Agenda
SCR System Design

- NO_x Formation
- Baseline Testing
- SCR Arrangements and Ductwork
- Ammonia Storage and Supply
- Ammonia Injection and Flue Gas Mixing

NO_X Formation



$NO_X = f$ (BAHR, SR_B, XSA, FC, VM, N, LNB)

LOI = f (τ, BAHR, FC, VM, Ash, Size, NO_X)

Baseline Testing

- Means to evaluate the boiler's pre-SCR operating conditions and to develop a mathematical model
- Boiler Tested at
  - Minimum Load
  - Intermediate Load
  - Maximum Load
    - Normal Excess Air
    - High Excess Air (+1.0%)
    - Clean Furnace
    - Dirty Furnace (Fouling effects on gas temperatures)

Baseline Testing

- Local data collected throughout system
  - NO_x, O_2, & CO at the economizer outlet / future SCR inlet
  - O_2 profile for leakage calculation
  - Gas Pressure and Temperature Profiles
  - Fuel Samples
  - Ash Samples
    - Economizer Hoppers
    - Air Heater Hoppers
    - Precipitator Hoppers

Baseline Testing

- Control room data includes
  - Air and gas temperatures and pressures
  - Steam and water flows, temperatures, and pressures
  - SH/RH spray flows
  - Valve and damper positions
  - Burner and pulverizer data
  - Emissions and operating O_2
  - Fan and motor data

Baseline Testing - Evaluation

- Results yield
  - Flue Gas Flows (calculated by heat balance)
  - Draft loss data
  - Auxiliary equipment performance (ID fan capacity)
  - Air Heater performance
  - Air infiltration/leakage rates
  - Flue gas temperatures
  - Emissions
  - Boiler water and steam temperature profiles
  - Mathematical model for future operation

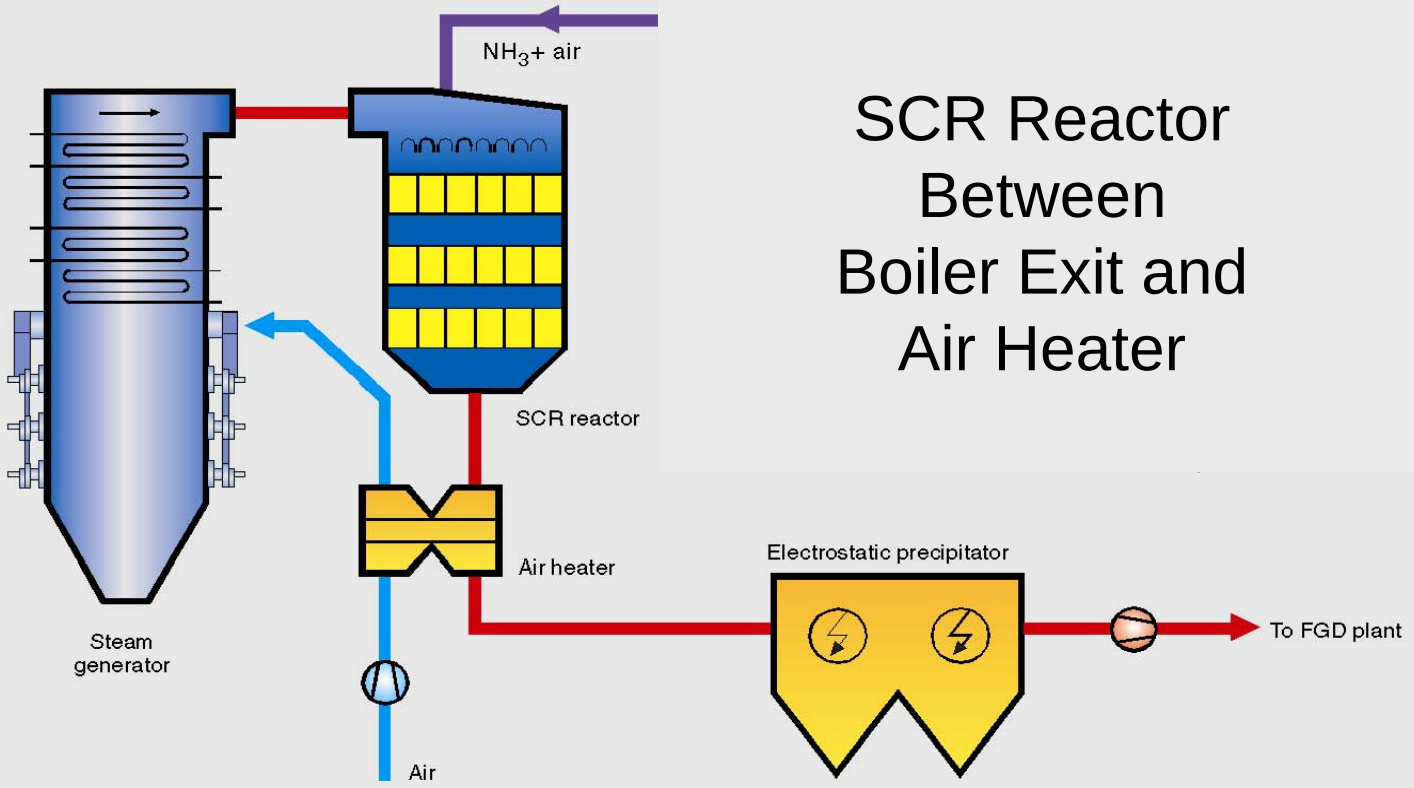
Baseline Testing - Evaluation

- Total Flue Gas Flow (Combustion + In-Leakage)
  - Ductwork sizing
  - Reactor Sizing
- Flue Gas Temperature vs Load
  - Minimum Operating Temperature & Load
  - Economizer Bypass Evaluation
- Boiler Conversion of SO_2 to SO_3
- I.D. Fan Operation
  - Evaluation of Impact of SCR on Existing Fans

SCR Arrangements and Ductwork

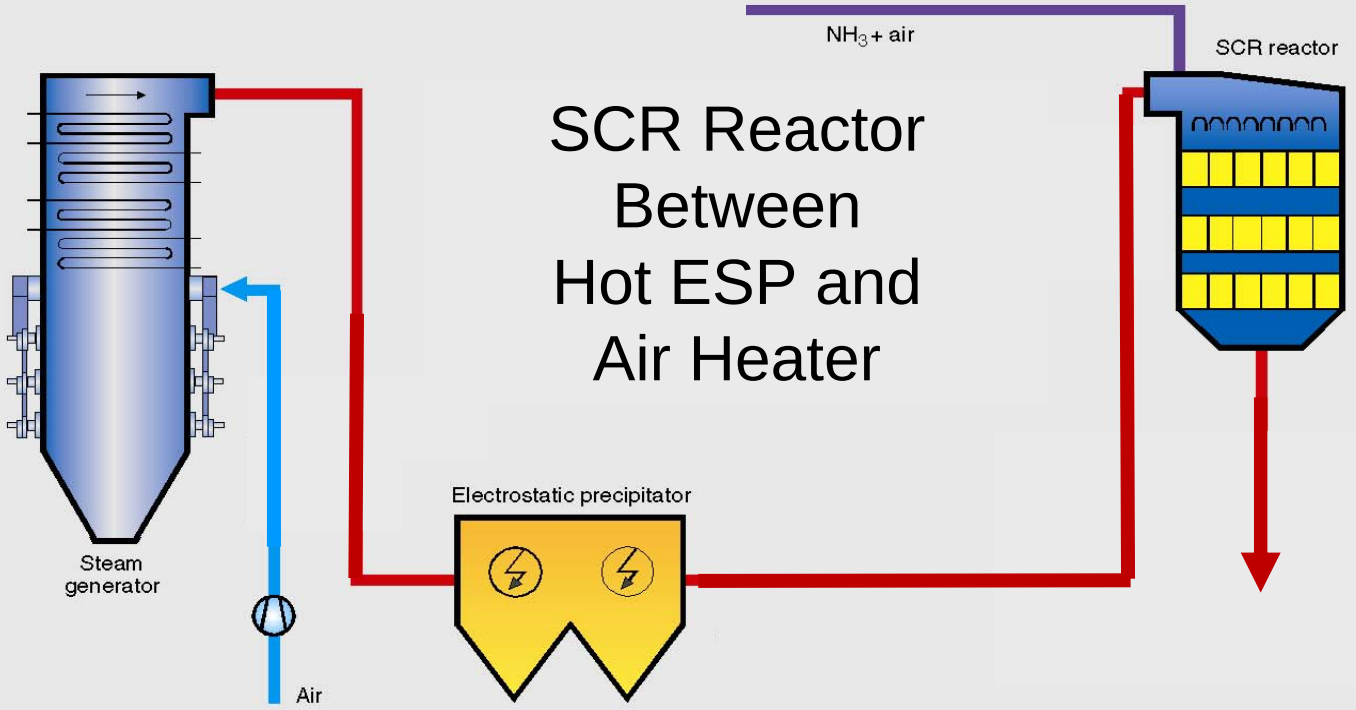
- SCR System Configurations
- Damper and SCR Bypass Configurations
- Low Load Temperature Control
- Catalyst Cleaning
- Large Particle Ash (Popcorn ash)

High Dust Arrangement

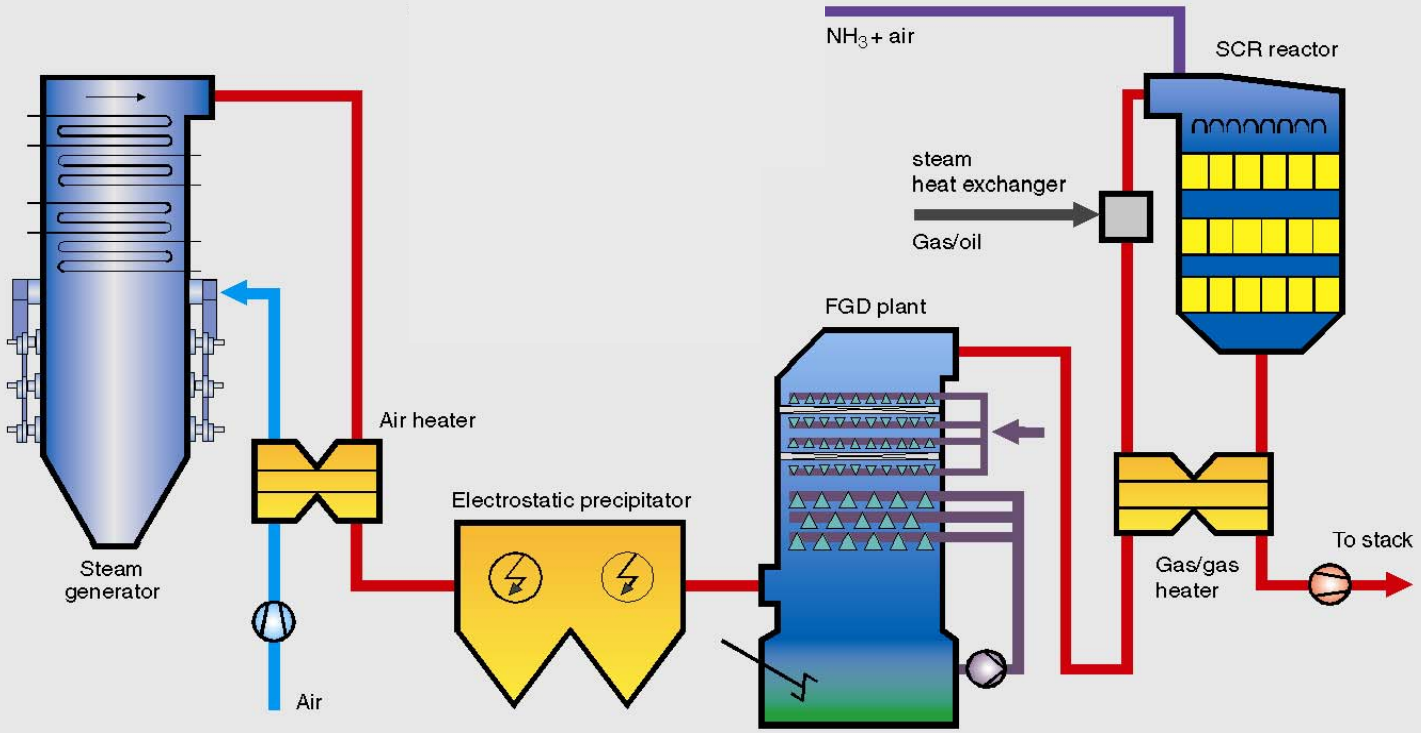


SCR Reactor Between Boiler Exit and Air Heater

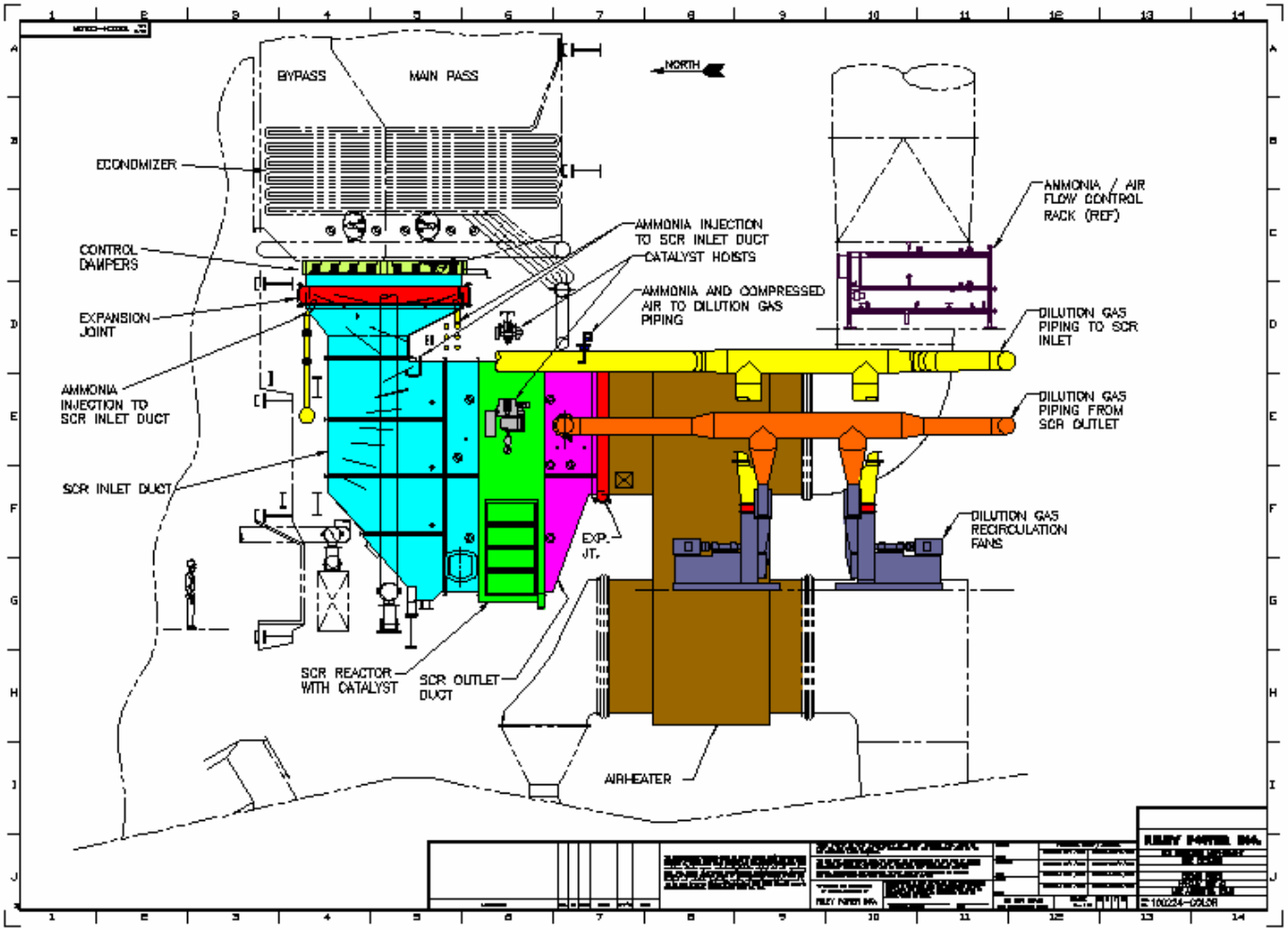
Low Dust Arrangement



Tail End Arrangement



In Duct SCR

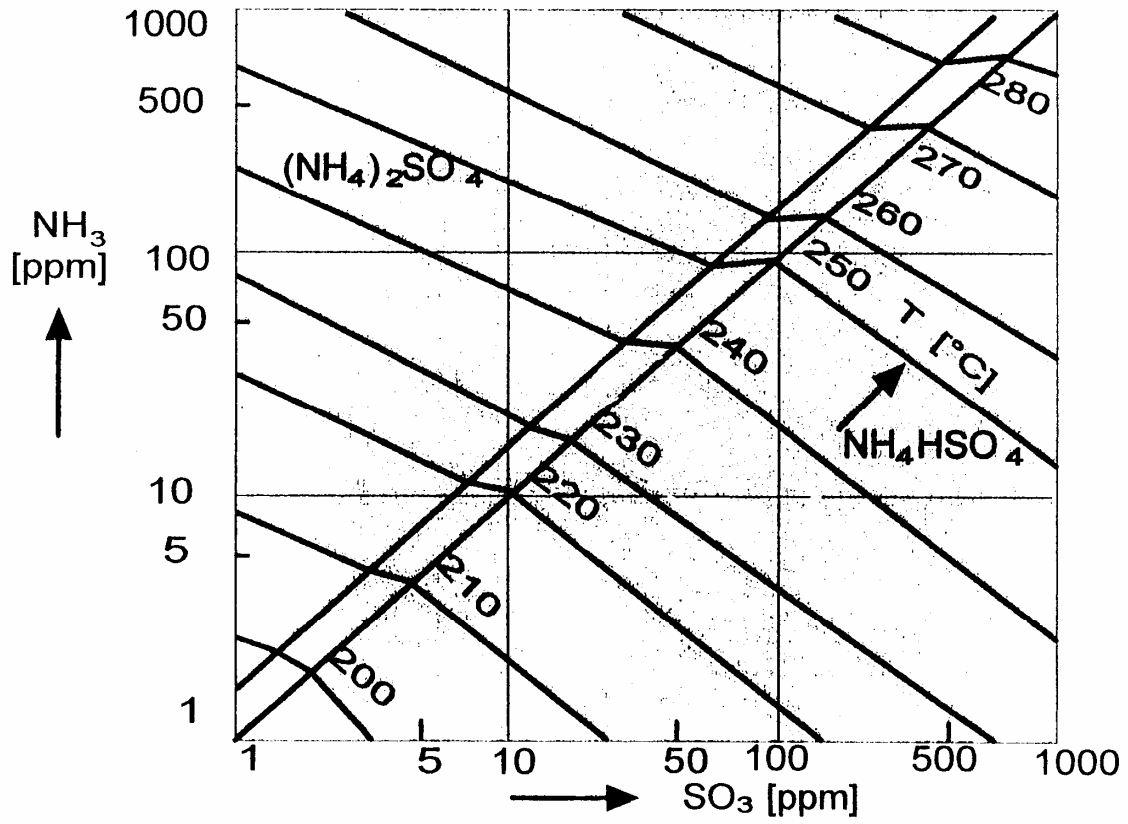


SCR Reactor and Ductwork

- Full SCR bypass
  - Able to isolate reactor during operation and startup
  - No catalyst deactivation during non-ozone season
- Partial SCR bypass for startup
  - Able to isolate during startup only
- No SCR bypass or dampers

Minimum Catalyst Operating Temperature

- SCR inlet SO_3, NH_3 and H_2O
- Varies with fuel
- Catalyst pore size effects

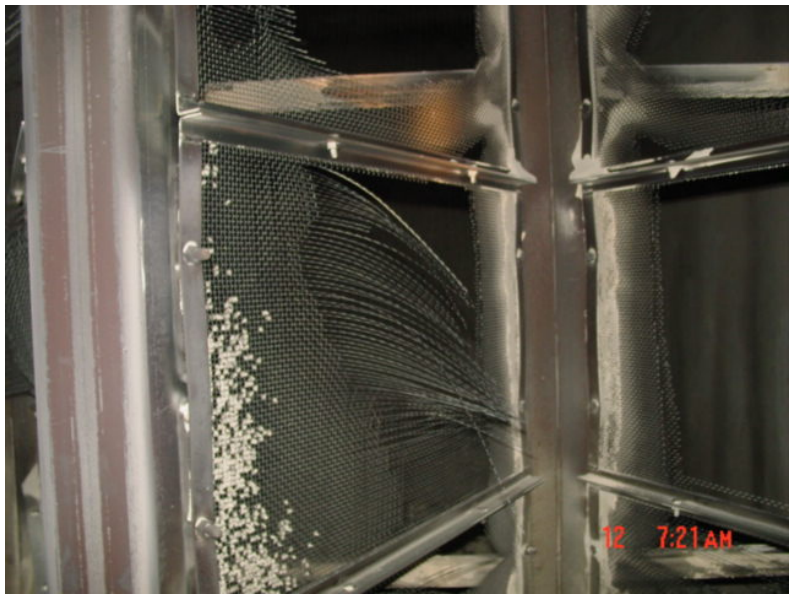


SCR Reactor and Ductwork

- Low Load Temperature Control
  - Flue gas economizer bypass
  - Economizer water side bypass
  - Split economizer
  - Feed water heater pegging
- Catalyst Cleaning
  - Steam rake type soot blowers
  - Sonic horns

Large Particle Ash Design

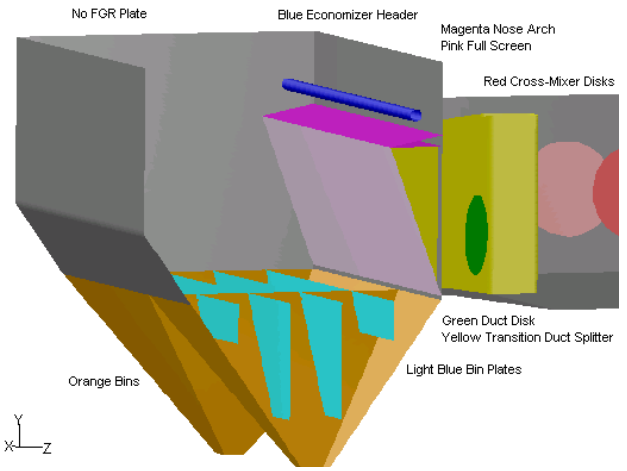
- LPA Properties
  - Size >4.0 mm
  - Density 0.7 to 1.25 g/cc
  - Sphericity 0.7 to 0.99
  - Coefficient of Restitution 0.15 to 0.2

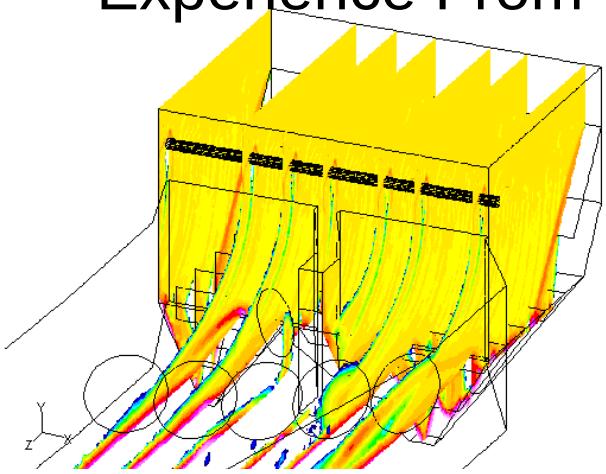


- Screen Design Important
- Pluggage
- Erosion

Large Particle Ash Design

- Design and Modeling
  - CFD Modeling
  - Industry Coated Screens
  - Experience From Past





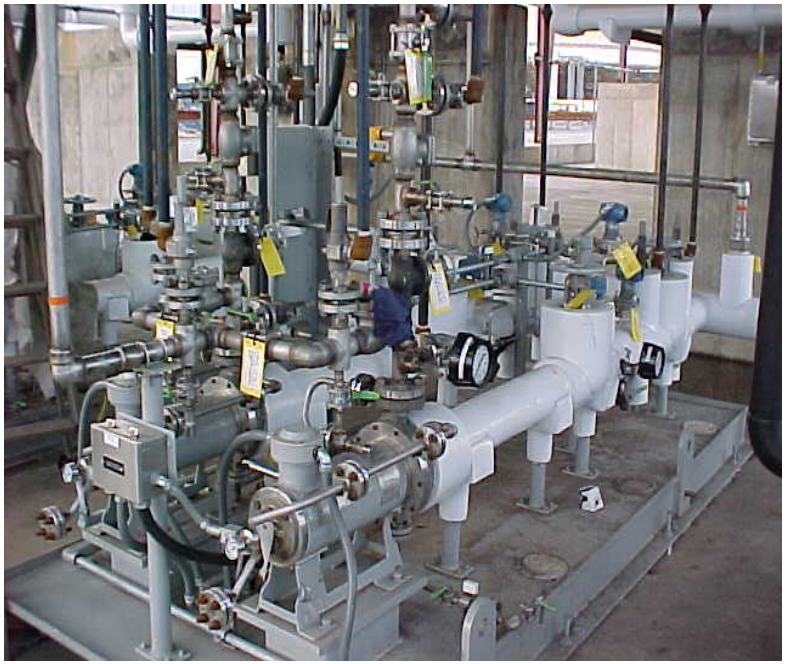
- Soot Blowers
- Low Velocity
- Low Pressure Loss

Ammonia Systems

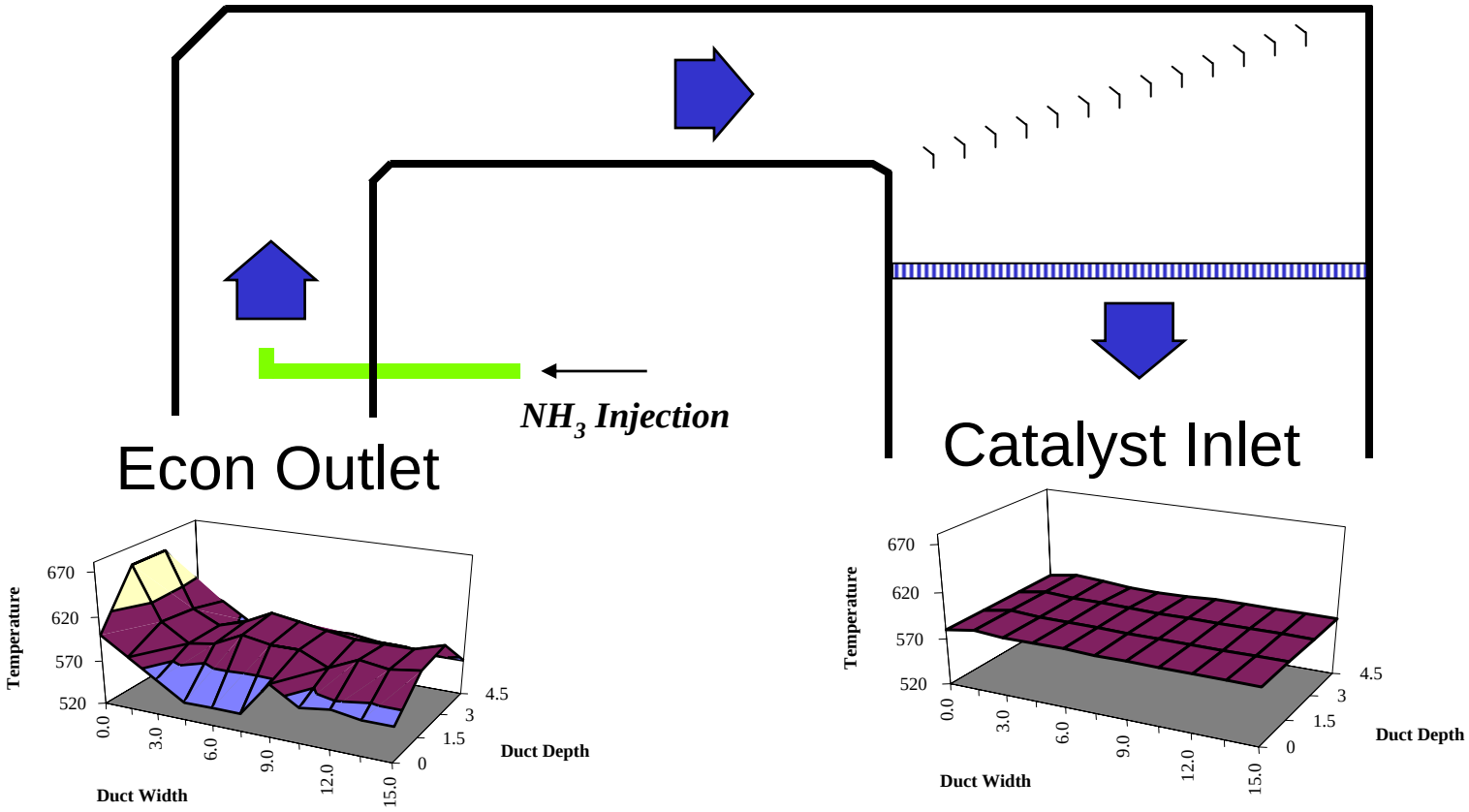
- Anhydrous Ammonia
  - Hazardous chemical governed by codes
- Aqueous Ammonia
  - Concentration based codes, maybe changed in future
- Urea Based Ammonia
  - Safe storage, more equipment and complex

Ammonia Injection

- Anhydrous
  - Vaporizers
  - Direct Injection
  - Dilution air, 5% by Volume
- Aqueous
  - Vaporizers
  - Direct Injection
  - Dilution air, 5% by Volume
- Urea
  - Direct Injection
  - Dilution air, 5% by Volume



Ammonia Injection & Flue Gas Mixing



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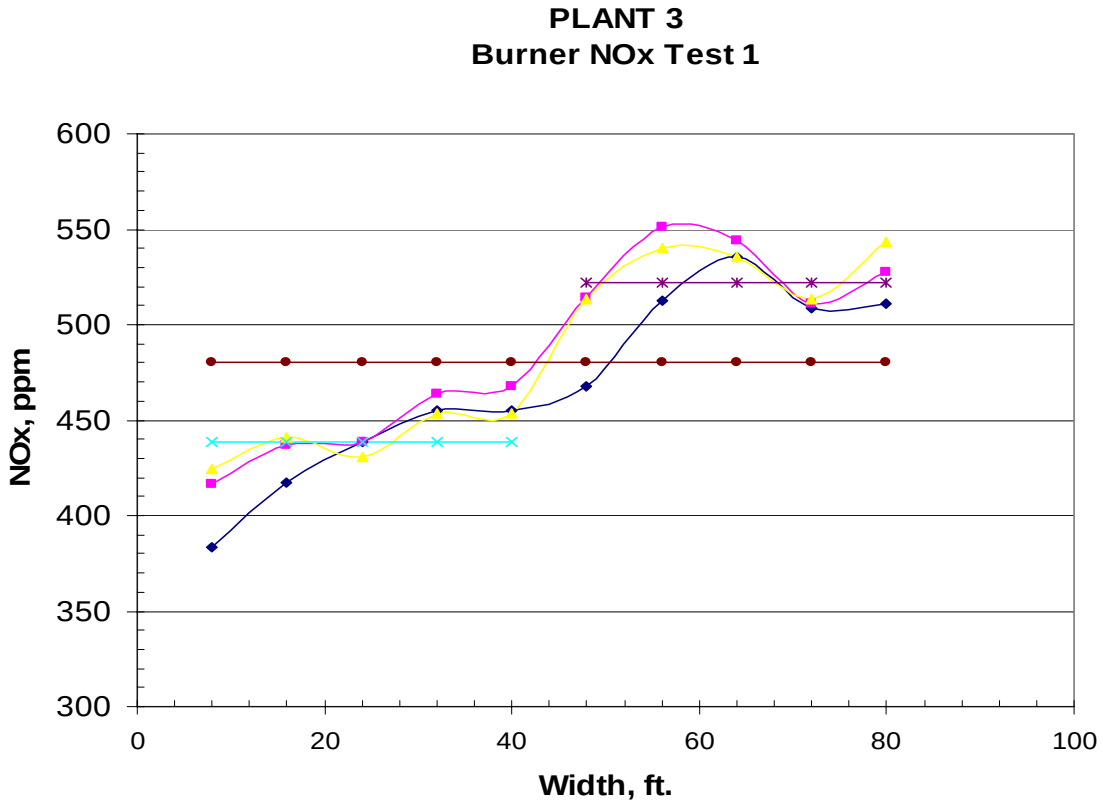
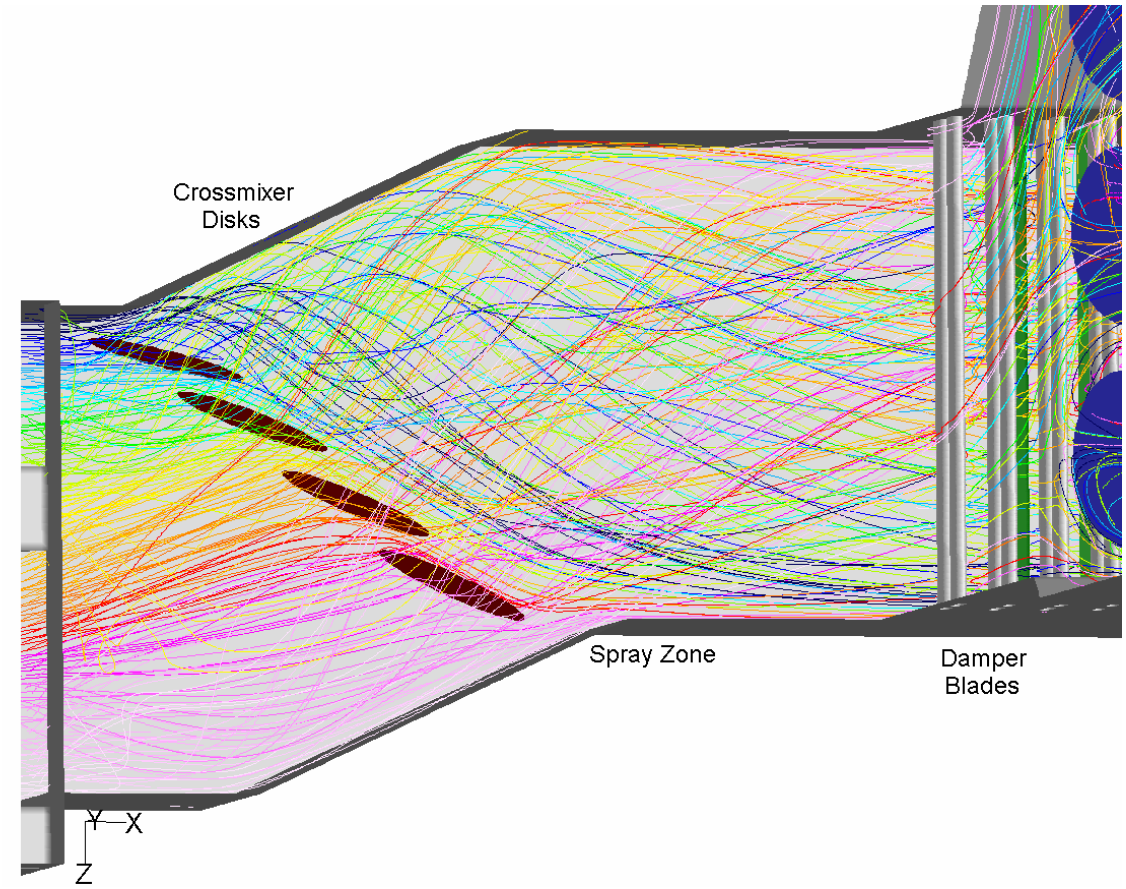


- Inlet variations of flue gas composition
- Load and burner group dependent
- Mix prior to ammonia injection

Mixing Prior to Ammonia Injection

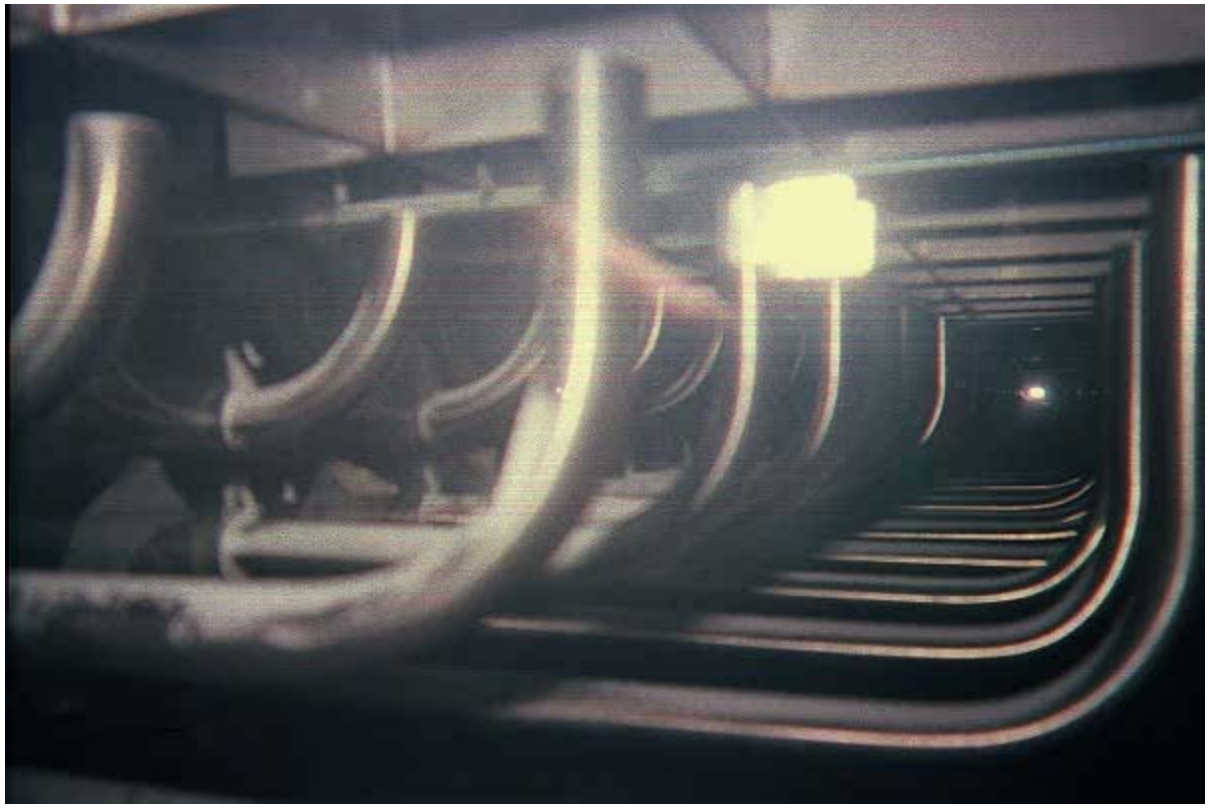
Gas Flow from Boiler



Delta Wing Ammonia Injection

Static Mixer

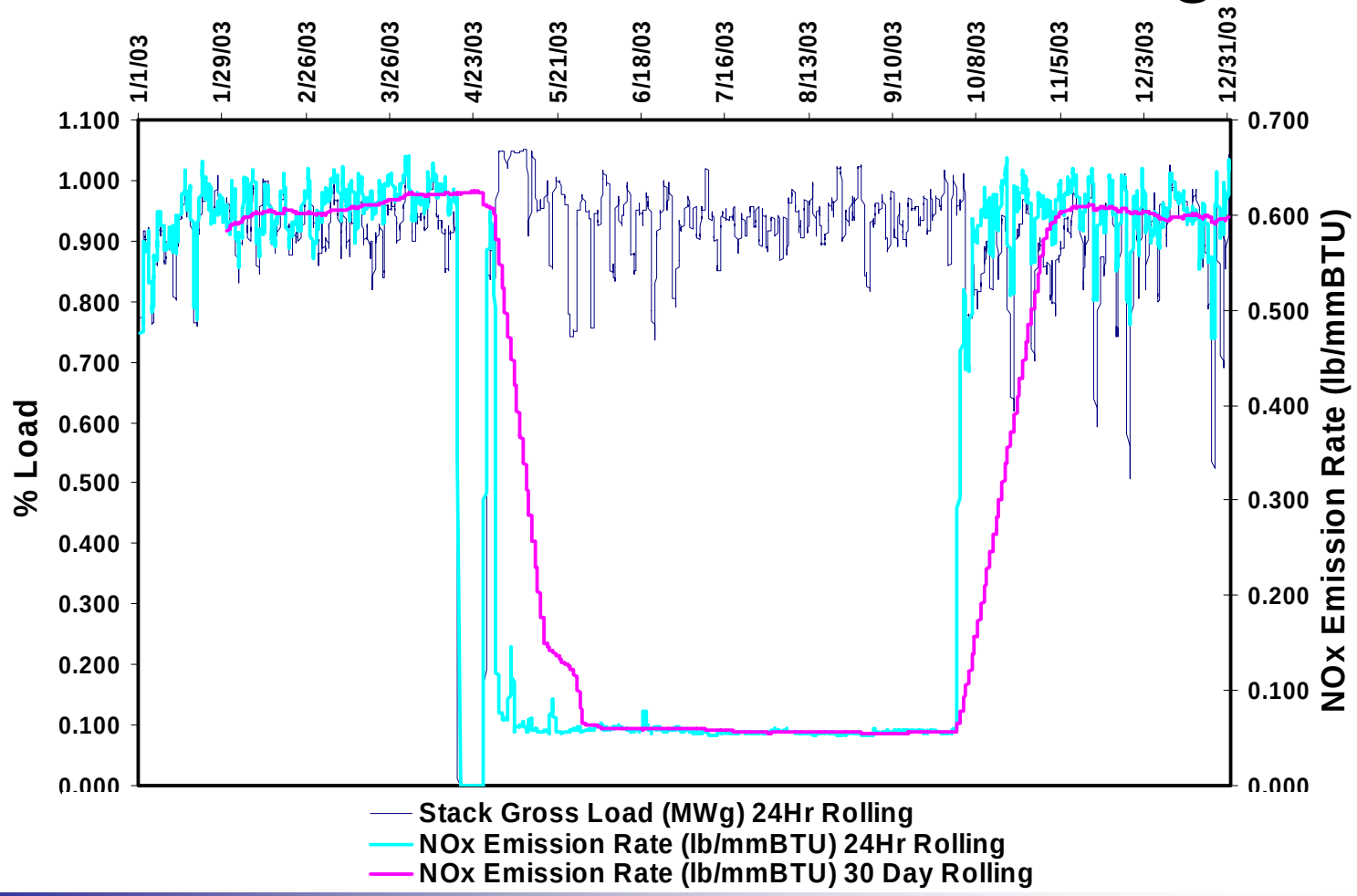
Static Mixer – Injection Grid



Ammonia Injection Control

- **Adjusted based on testing**

Results of Successful Design



Questions

Thanks You