

REINHOLD ENVIRONMENTAL Ltd.



2011 NO_x-Combustion Round Table & Expo Presentation

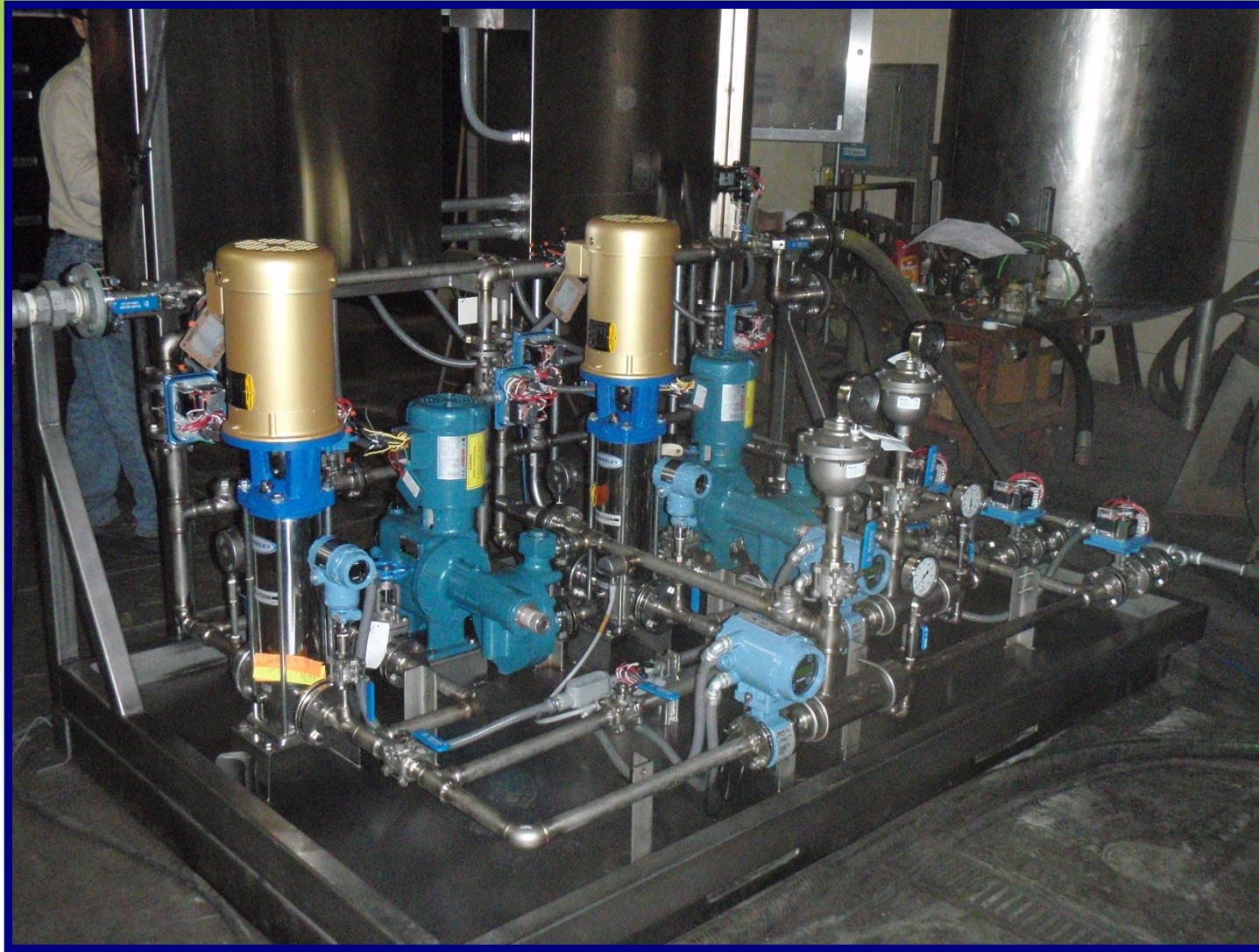
February 7-8, 2011, in Birmingham, AL / Hosted by Southern Company

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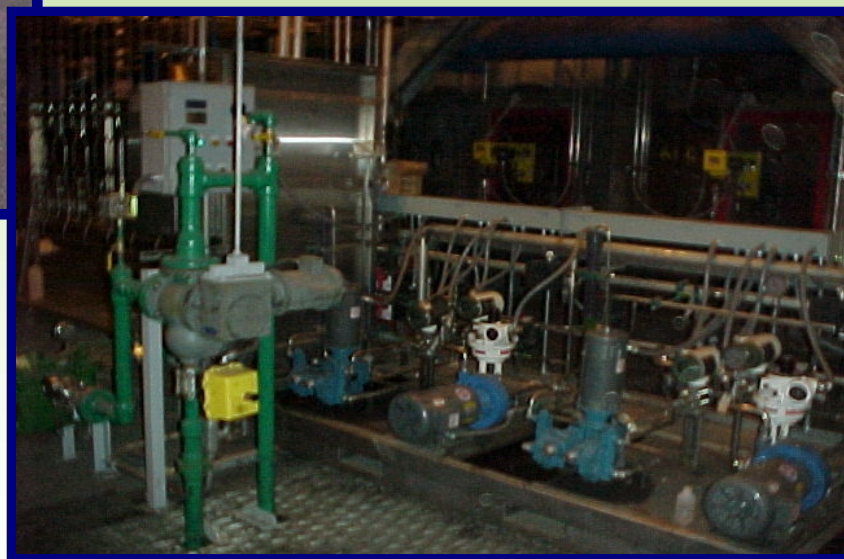
Circulation Modules



HERT Circulation Skid



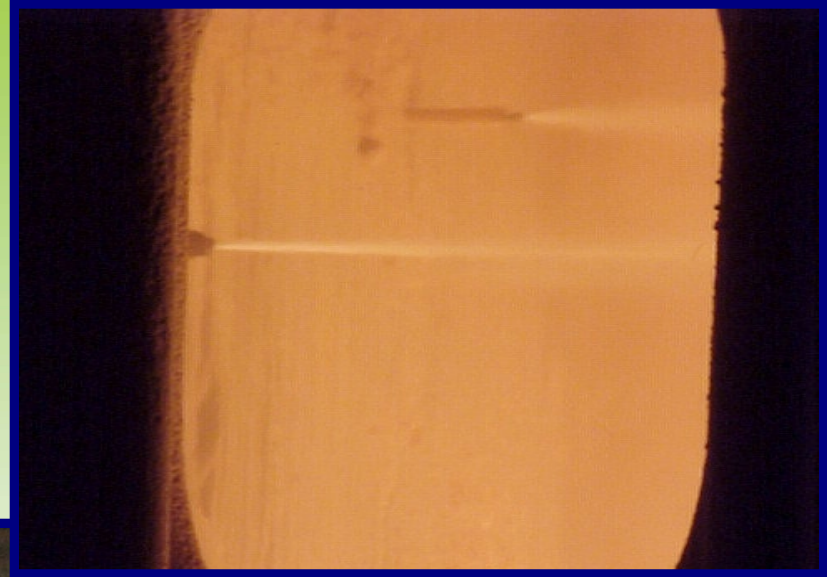
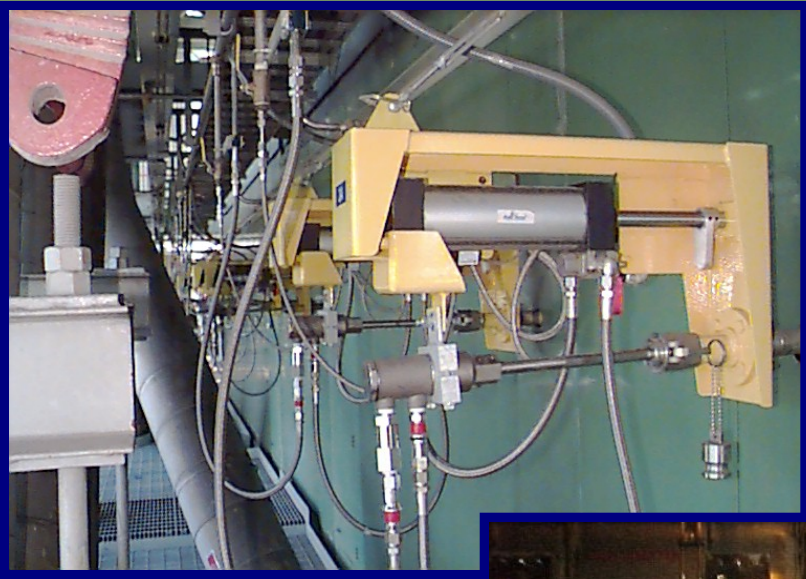
Metering Module



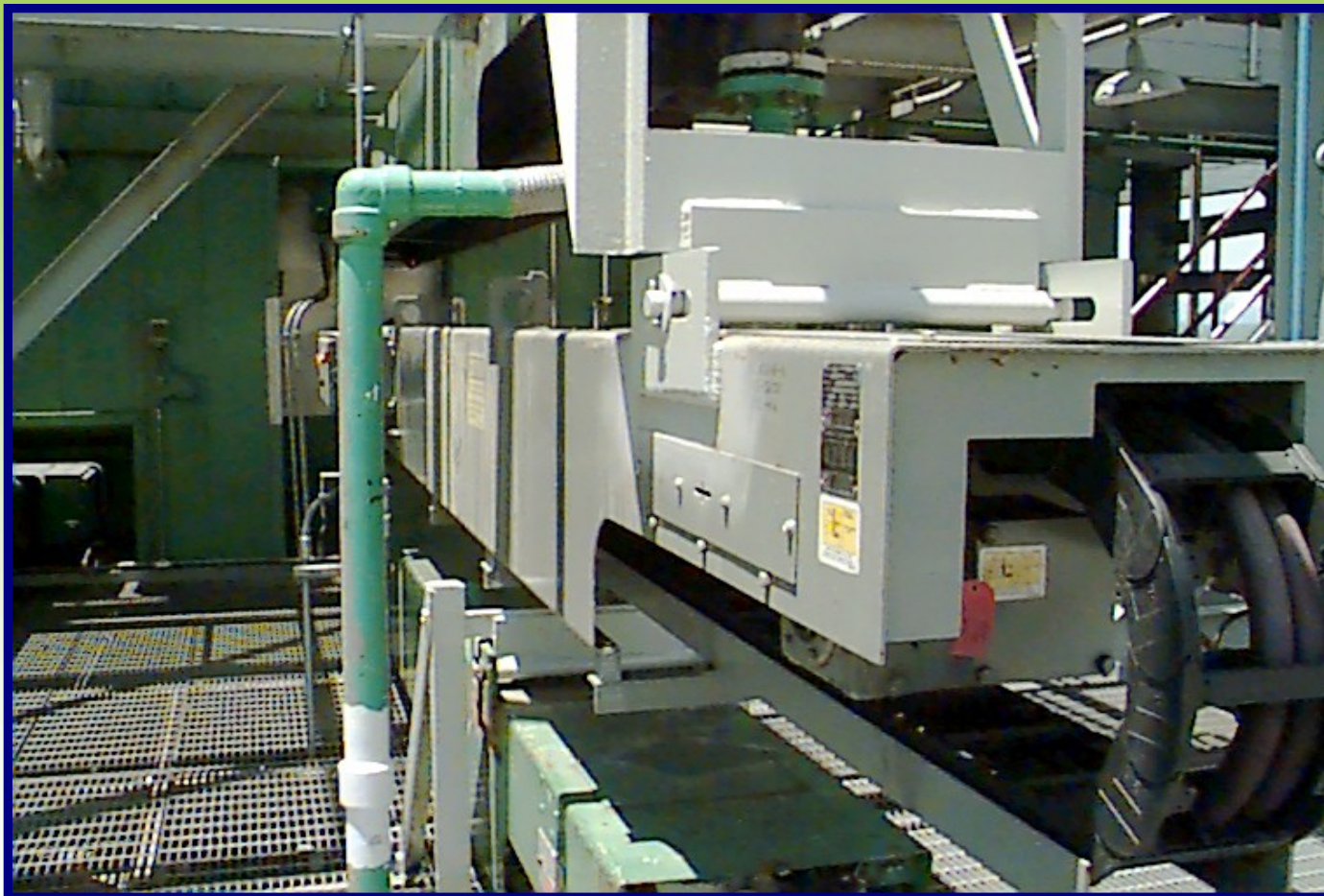
HERT System Solenoid Rack



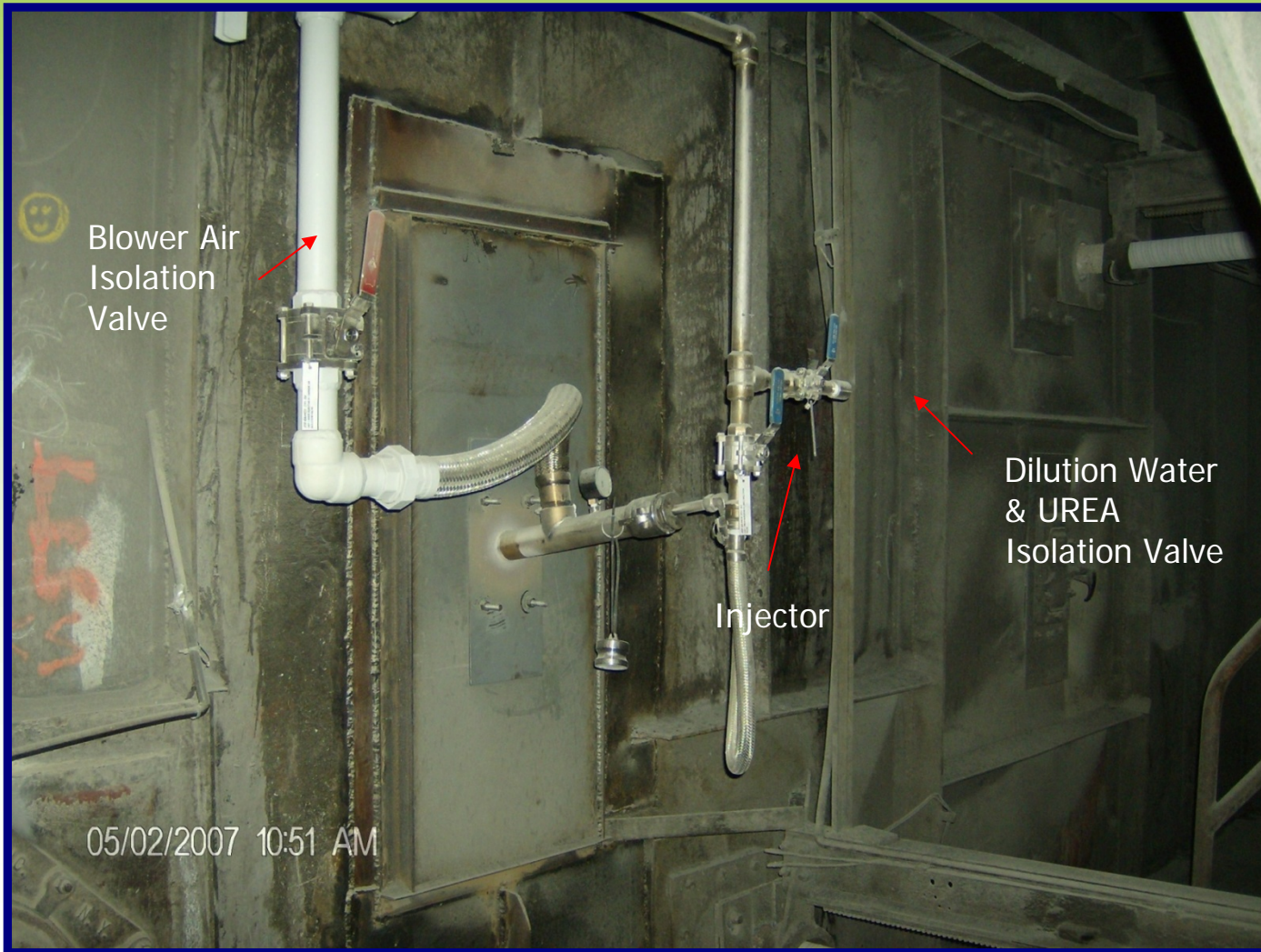
NOxOUT Injection



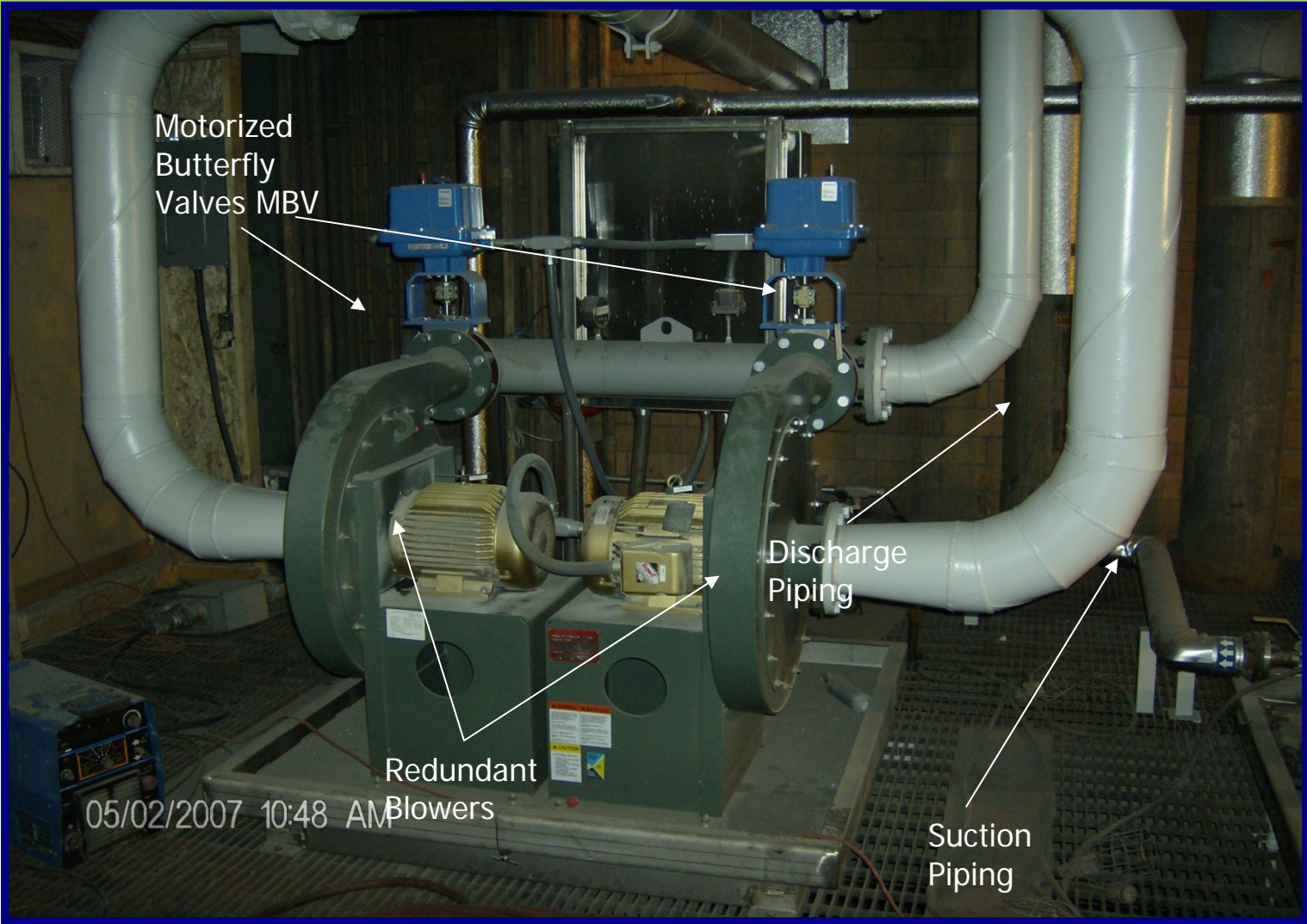
Multiple Nozzle Lances



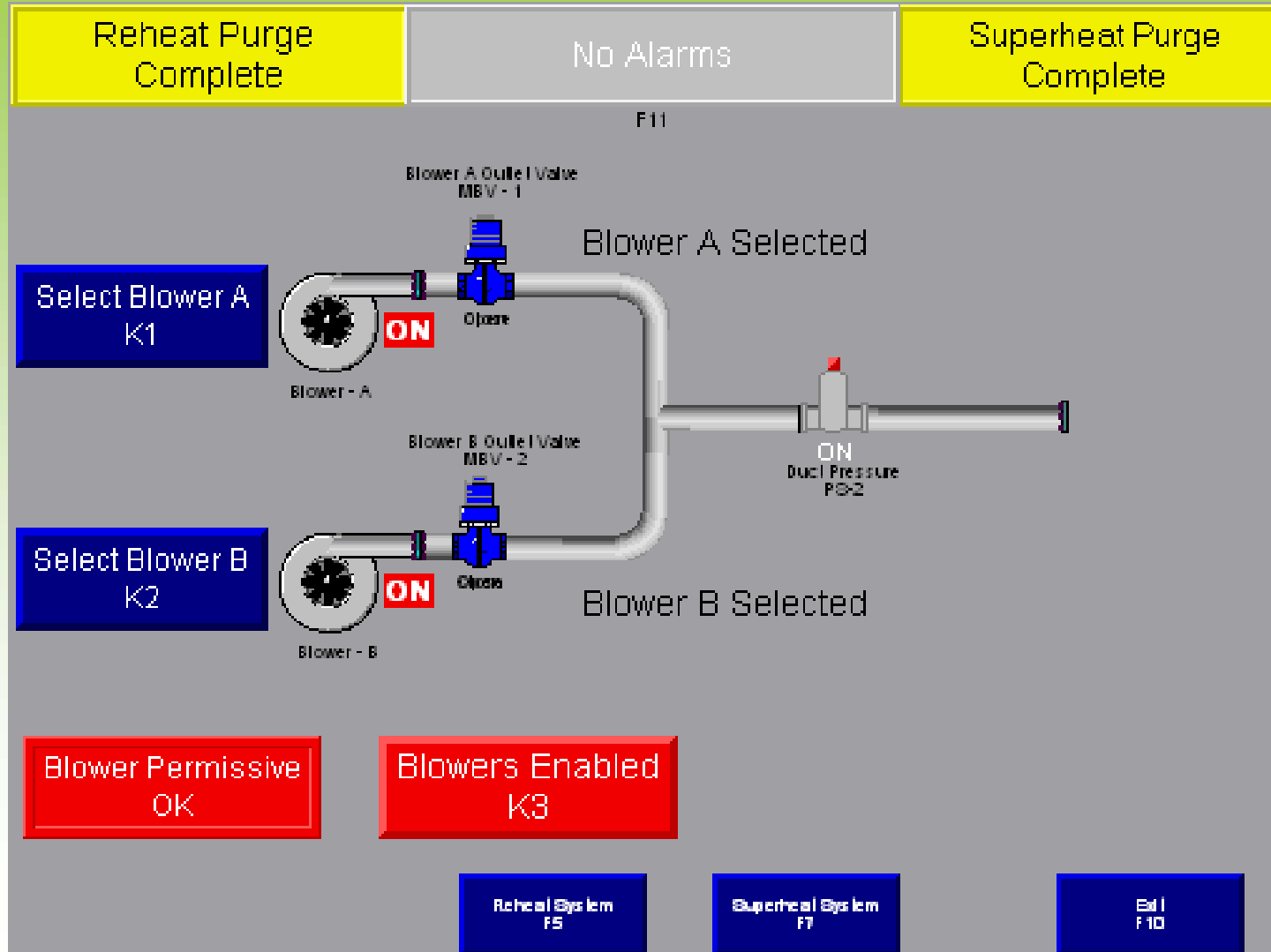
HERT INJECTOR



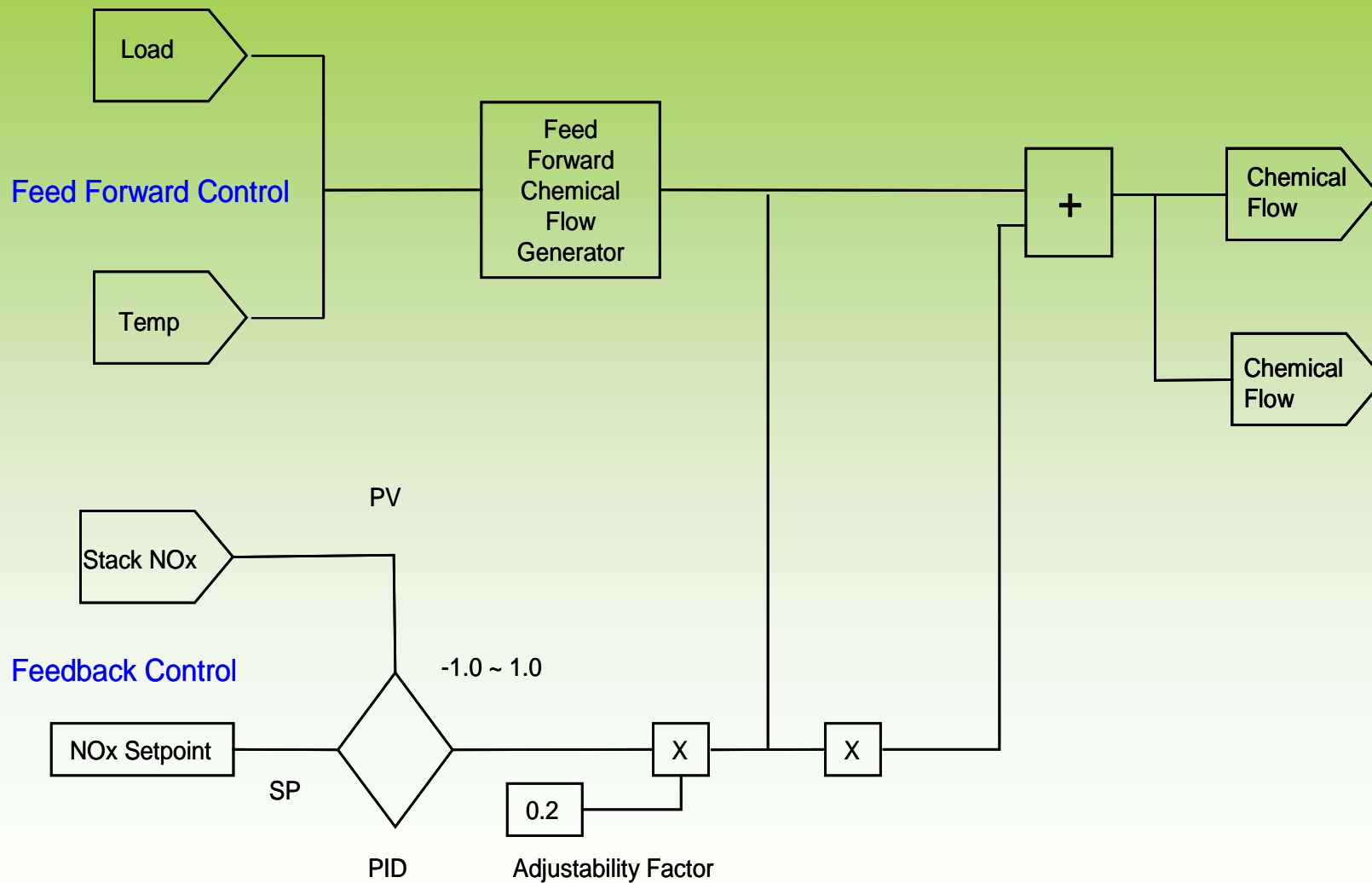
Blower Skid



Blower Skid Screen



NOxOUT[®] SNCR Control Loop

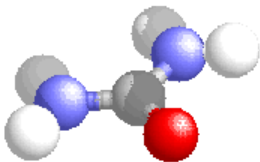




UREA REAGENT OPTIONS

Liquid Urea Properties - NH₂CONH₂

at 60°F		NOxOUT LT		NOxOUT A		Urea Liquor	
Urea Concentration		32.5%	40.0%	50.0%	60.0%	70.0%	85.0%
Specific Gravity		1.0897	1.1113	1.1400	1.1688	1.1976	1.2407
Pounds per Gallon		9.085	9.265	9.505	9.643	9.767	9.970
Crystallization Temperature (°F)		11.3	33	62	96	135	195
Boiling Point (°F)			220	225	231	240	
Biuret		0.14	0.17	0.21	0.3 to 0.4	0.3 to 0.4	0.36
pH		7.0 to 10.0	7.0 to 10.0	7.0 to 10.0	7.0 to 10.0	7.0 to 10.0	7.0 to 10.0
lb-NH ₃ /gallon		1.67	2.10	2.70	3.28	3.88	4.81



Urea and Dilution Water Quality

QUALITY SPECIFICATIONS – UREA

	NOxOUT® A	NOxOUT® HP	UNSTABILIZED UREA	NOxOUT® LT
Description	Modified 50% Aqueous Solution of Urea	Modified 50% Aqueous Solution of Urea	50% Aqueous Solution of Urea	Modified 32.5% Aqueous Solution of Urea
Density (g/ml @ 25° C)	1.13 - 1.15	1.13 - 1.15	1.13 - 1.15	1.085 - 1.105
pH	7.0 - 10.8	7.0 - 10.8	7.0 - 10.8	5.0 - 10.8
Appearance	Light Yellow, Clear to Slightly Hazy	Light Yellow, Clear to Slightly Hazy	Light Yellow, Clear to Slightly Hazy	Light Yellow, Clear to Slightly Hazy
Salt Out Freeze Point	64°F (18°C)	64°F (18°C)	64°F (18°C)	40°F (4°C)
Foam (after bottle is shaken)	Foam Lasts > 15 seconds	Foam Lasts > 15 seconds	Not Applicable	Foam Lasts > 15 seconds
Free NH3	< 5000 ppm	< 5000 ppm	< 5000 ppm	< 3000 ppm
Biuret Content	< 5000 ppm	< 5000 ppm	< 5000 ppm	< 3000 ppm
Organic Phosphate	55 - 85 ppm as PO4	22 - 40 ppm as PO4	Not Applicable	55 - 85 ppm as PO4
Orthophosphate	< 6 ppm as PO4	< 6 ppm as PO4	< 2 ppm as PO4	< 6 ppm as PO4
Suspended Solids	< 10 ppm	< 10 ppm	< 10 ppm	< 10 ppm
Urea Makeup Water	Total Hardness as CaCO3 ≤ 300 ppm	Total Hardness as CaCO3 ≤ 150 ppm	Total Hardness as CaCO3 ≤ 20 ppm	Total Hardness as CaCO3 ≤ 300 ppm

QUALITY SPECIFICATIONS – DILUTION WATER

	NOxOUT® A	NOxOUT® HP	UNSTABILIZED UREA	NOxOUT® LT
	Dilution Water Analysis	Dilution Water Analysis	Dilution Water Analysis	Dilution Water Analysis
Total Hardness as CaCO3 (ppm)	<450	<150	<20	<450
"M" Alkalinity as CaCO3 (ppm)	<300	<100	<100	<300
Conductivity (µmho)	<2500	<1000	<1000	<2500
Silica as SiO2 (ppm)	<60	<60	<60	<60
Iron as Fe (ppm)	<1.0	<1.0	<1.0	<1.0
Manganese as Mn (ppm)	<0.3	<0.3	<0.3	<0.3
Phosphate as P (ppm)	<1.0	<1.0	<1.0	<1.0
Sulfate as SO4 (ppm)	<200	<200	<200	<200
Turbidity (NTU)	< 10	< 10	< 10	< 10
pH	<8.3	<8.3	<8.3	<8.3

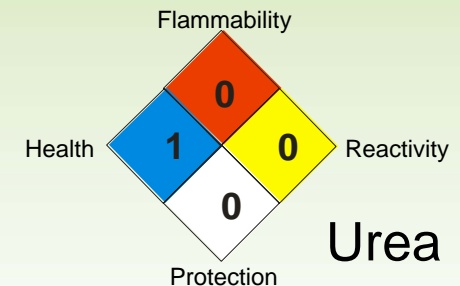
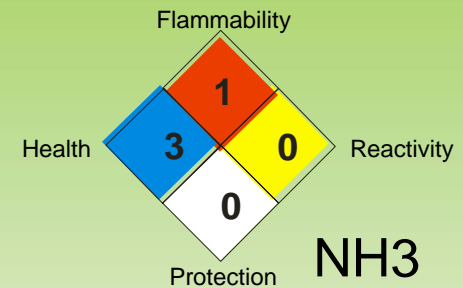
Urea vs. Ammonia

- **Safety Considerations**
 - Safety can be Engineered into the Design, but Considerations may Drive the Decision
- **Natural Gas Pricing**
 - Elevated Price of NG in North America is Forcing the Shutdown of NH₃ Productions and an Increase in Dry Urea Imports
 - LNG is an Alternative but Supply Insufficient to Cover Demand
- **On-site Ammonia Storage**
 - DHS has Promulgated Final Rule for On-site Storage of Chemicals – Unsure How this Will Impact Anhydrous NH₃ Storage for SCR's
- **Transportation**
 - “Chain of Custody” Regulations for TIH* Rail Shipments Driving Transportation Costs Considerably Higher, Some Carriers May Opt and are Currently Being Forced to Reroute Shipments to Avoid HTUA's

* The TSA component of the DHS is about to implement a series of federal regulations affecting the transportation of Toxic Inhalation Hazard (TIH) materials such as Chlorine and Anhydrous Ammonia – will require “documented chain of command handoffs” along distribution zone.

Reagent Alternatives for SNCR Systems

- **Anhydrous Ammonia**
 - Highest Risk Reagent
 - Decrease in US Ammonia Production
- **Aqueous Ammonia**
 - 19% Concentration
 - 29% Concentration - limited availability
- **Urea for On-Site Ammonia Generation**
 - Significant Safety Advantages
 - Worldwide Availability of Urea
 - Equivalent SCR Performance



Anhydrous Ammonia – Safety Considerations

- **Ammonia Storage**
 - Department of Homeland Security (DHS) has indentified ammonia as a chemical of interest for anti-terrorism standards
- **Transportation**
 - Rail carrier risks and freight rate increases to handle anhydrous ammonia
 - Department of Transportation Restrictions
 - State and local restrictions on shipping and routing
- **Safety Risks**
 - **EPA Worst Case Release Analysis – Toxic Endpoint for 60,000 Gallon Release Covers a Radius of 7 to 10 Miles¹**

¹ [http://yosemite.epa.gov/oswer/ceppoweb.nsf/vwResourcesByFilename/backup.pdf/\\$File/backup.pdf](http://yosemite.epa.gov/oswer/ceppoweb.nsf/vwResourcesByFilename/backup.pdf/$File/backup.pdf)

Aqueous Ammonia – Safety Considerations

- **Ammonia Storage**

- Containment for possible liquid leaks/spills

- **Transportation**

- 29% Aqueous ammonia is restricted by Department of Transportation in many areas
- State and local restrictions on shipping and routing

- **Safety Risks**

- Increased transportation risk due to more shipments of dilute chemical
- 1.2 mile toxic radius for 60,000 gallon spill
- Much higher unloading frequency at plant site raises potential incident probability

Licensed NOxOUT Reagent Suppliers

Licensee Corporate Office	Address	Contact Person	Telephone/Fax
CDI, Inc.	P.O. Box 9083 Brea, CA 92821 -or- 471 W. Lambert Rd Suite 100 Brea, CA 92821	Luis Cervantes Rick Gross	714.990.3940 714.329.2281 (cell) 714.990.4073 (fax) (901) 867-8186 office (901) 233-2336 mobile
<i>Distribution Points</i>	– Crossett, AR – Casa Grande, AZ - City of Industry, CA – Imperial, CA – San Jose, CA – Stockton, CA – Greeley, CO – Jacksonville, FL – Augusta, GA – Kimberly, ID – Baltimore, MD – St. Paul, MN – Albany, NY – Elizabeth, NY – Cincinnati, OH – Lima, OH – Deer Island, OR – Russellville, SC – Memphis, TN – Houston, TX – Lufkin, TX – Pasco, WA		
Mosaic Company (formerly Cargill, Inc)	12800 Whitewater Dr MS 190 Minnetonka, MN 55343	Bob Ness	800.918.8270 763.577.2781 952.742.7313 (fax)
<i>Distribution Points</i>	– Brandon, FL – Baltimore, MD – St. Paul, MN – Albany, NY – Cincinnati, OH – Wellsville, OH – Philadelphia, PA – Menomonie, WI		
PCS Nitrogen, Inc	1101 Skokie Blvd Northbrook, IL 60062	Jennifer A. Zagorski	847.849.4377 (office) 847.612.5301 (cell) 847.849.4489 (fax)
<i>Distribution Points</i>	– Augusta, GA - Lima, OH		

Licensed NOxOUT Reagent Suppliers

Monson Companies, Inc.	One Runway Rd P.O. Box 2405 South Portland, ME 04116-2406	Jeff Pellerin	207.885.5072 x 423 207.885.0569 (fax)
<i>Distribution Points</i>	– South Portland, ME		
Agrium USA	13132 Lake Fraser Dr SE Calgary, AB T2J7E8 CANADA	Gerry Kroon	403.335.7597 403.471.6473 (cell)
<i>Distribution Points</i>	– Stockton, CA		
The Andersons, Inc.	480 W. Dussel Drive P.O. Box 119 Maumee, OH 43537	Bill Wolf	419.897.3689
<i>Distribution Points</i>	– Logansport, IN – Maumee, OH		
Colonial Chemical Co.	78 Carranza Rd Tabernade, NJ 08088	Eric Wegelius	609.268.1200 x 112 609.268.2117 (fax)
<i>Distribution Points</i>	– Frederick, MD – Tabernade, NJ		
Information Needed by Licensees: <ul style="list-style-type: none"> ▪ Company Name ▪ Location ▪ Scheduled Start-Up Date ▪ If rail delivery- specify railroad ▪ NOxOUT® Reagent Type Required (A,HP,LT) ▪ NOxOUT® Reagent Usage Rate ▪ NOxOUT® Reagent Storage Tank Size 			



SNCR Combined with other NO_x Control Technologies

Layered NOx Reduction

- **Combustion NOx Control**
 - Combustion Tuning
 - Low-NOx Burners
 - OFA
- **Post-Combustion NOx Control**
 - Rich Reagent Injection
 - Selective Non-Catalytic Reduction
 - Selective Catalytic Reduction

Combining NO_x Reduction Technologies

Technology	Strength	Limitations
Low-NO _x Burners	Low Capital and Operating	Combustion, Corrosion, CO
Combustion Mods / OFA	Low Capital and Operating	Combustion, Corrosion, CO
SNCR	Low Capital NO _x Red ⁰ %	NH ₃ Slip ABS
SCR	NO _x Red ⁰ % Low NH ₃ Slip	High Capital SO ₃ Oxidation

Retrofit Low-NO_x Burner Installation

Technology	Strength	Limitations
Low-NO _x Burners	<u>Low Capital and Operating</u>	Combustion, Corrosion, CO
Combustion Mods / OFA	Low Capital and Operating	Combustion, Corrosion, CO
SNCR	Low Capital NO _x Red ⁰ %	NH ₃ Slip ABS
SCR	NO _x Red ⁰ % Low NH ₃ Slip	High Capital SO ₃ Oxidation

Moderate Combustion Modifications

Technology	Strength	Limitations
Low-NO _x Burners	<u>Low Capital and Operating</u>	Combustion, Corrosion, CO
Combustion Mods / OFA	<u>Low Capital and Operating</u>	Combustion, Corrosion, CO
SNCR	Low Capital NO _x Red ⁰ %	NH ₃ Slip ABS
SCR	NO _x Red ⁰ % Low NH ₃ Slip	High Capital SO ₃ Oxidation

Conservative SNCR application

Technology	Strength	Limitations
Low-NO _x Burners	<u>Low Capital and Operating</u>	Combustion, Corrosion, CO
Combustion Mods / OFA	Low Capital and Operating	Combustion, Corrosion, CO
SNCR	Low Capital NO _x Red ⁰ %	No NH ₃ Slip No ABS
SCR	NO _x Red ⁰ % Low NH ₃ Slip	High Capital SO ₃ Oxidation

Aggressive SNCR application

Technology	Strength	Limitations
Low-NO _x Burners	<u>Low Capital and Operating</u>	Combustion, Corrosion, CO
Combustion Mods / OFA	Low Capital and Operating	Combustion, Corrosion, CO
SNCR	Low Capital > Red ⁰ %	NH ₃ Slip ABS
SCR	NO _x Red ⁰ % Low NH ₃ Slip	High Capital SO ₃ Oxidation

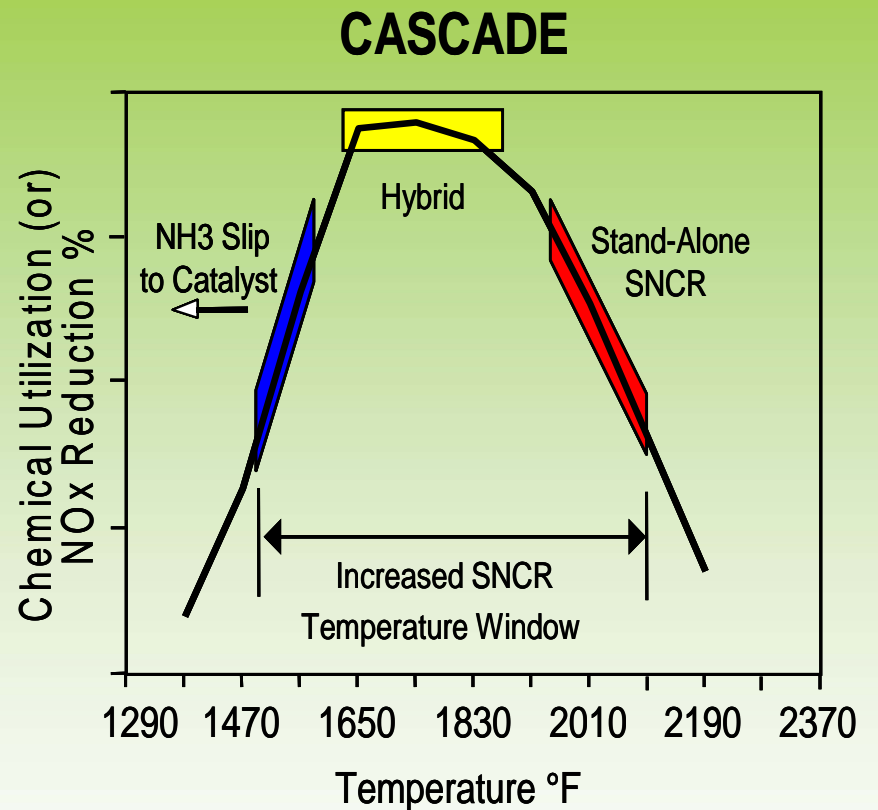
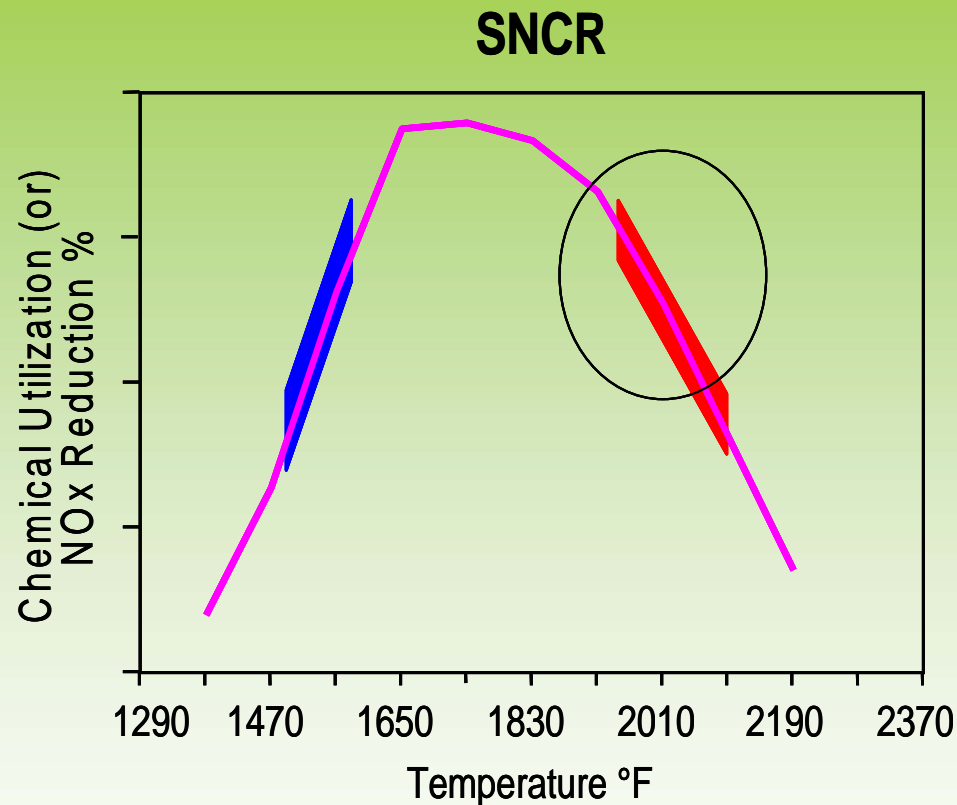
In-Duct or Small SCR Space

Technology	Strength	Limitations
Low-NO _x Burners	<u>Low Capital and Operating</u>	Combustion, Corrosion, CO
Combustion Mods / OFA	Low Capital and Operating	Combustion, Corrosion, CO
SNCR	Low Capital > Red ⁰ %	NH ₃ is OK Feed to SCR
Single Layer SCR	More Red ⁰ % Low NH ₃ Slip	Mod Capital, SO ₃ and Cost

Advanced SCR Application

Technology	Reduction	Total %
Low-NO _x Burners	30%	30%
Combustion Mods / OFA	30%	51%
SNCR	30%	66%
Single Layer SCR	45%	81%

Chemical Release Point Comparison



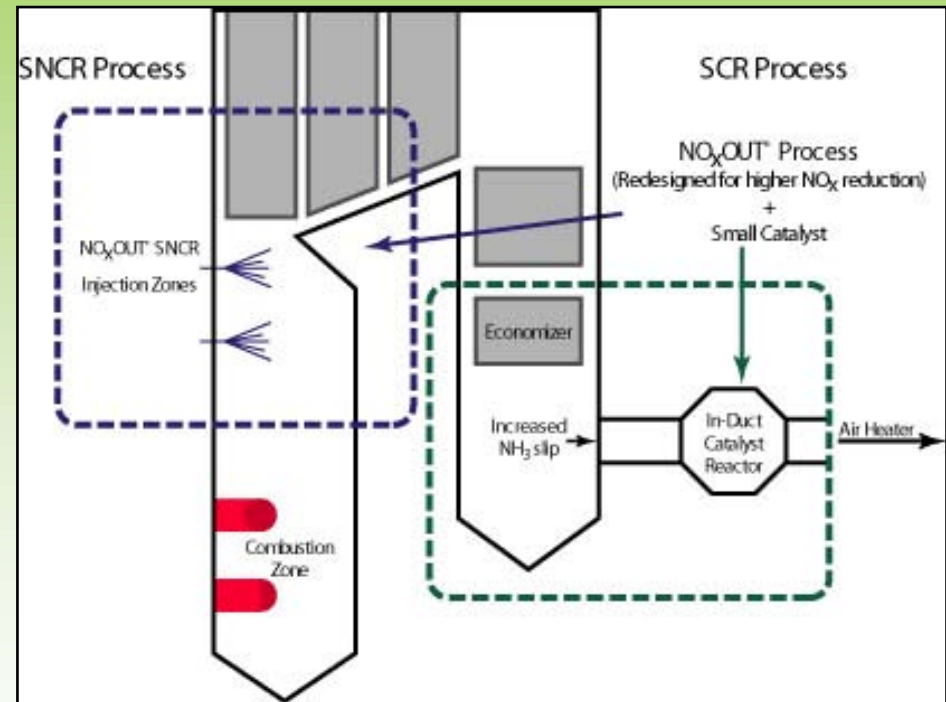
Releasing chemical at or near the top of the curve versus “right side of the slope” favors increased NOx reduction efficiency and better utilization of reagent – NH₃ slip is absorbed by catalyst.

Benefits of Hybrid SNCR + SCR System

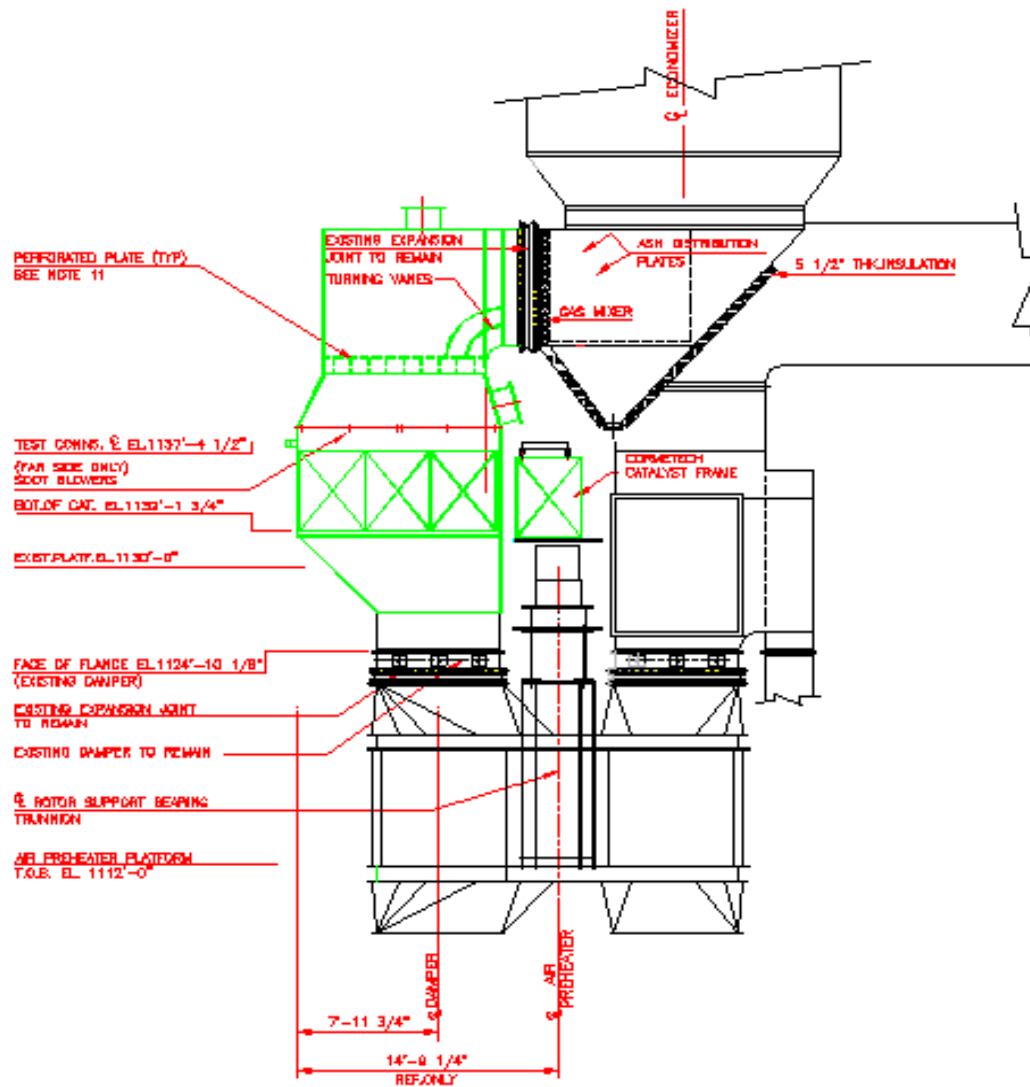
- ◆ **SNCR Not Restricted to “Right Side of Slope” Injection Strategy**
- ◆ **Impact of “High” CO can, in many cases, be Minimized**
- ◆ **Controlled Increase in Ammonia Slip (versus SNCR) is Desirable, Significant Improvement in SNCR Efficiency and Chemical Utilization**
- ◆ **Relax Inlet Conditions to SCR, Design for Incremental SCR Reduction and NH₃ Absorption**
- ◆ **Pressure Drop is Minimized as a Result of Reduced Volume and Treatment Length, Allowable Gas Velocity Now Higher with State-of-the-Art Flue Gas Mixing and Straightening Devices**
- ◆ **Reduced Conversion of SO₂ to SO₃**
- ◆ **Lower Catalyst Replacement Cost, Single Layer**

NO_xOUT CASCADE[®] Technology Overview

- Combined SNCR/SCR Process
- Single Layer SCR Catalyst – Reduced Volume
- Improved SNCR Chemical Utilization and Reduction Efficiency with Higher, Controlled Level of Ammonia Slip
- Ammonia Slip from SNCR Provides Reagent for Catalytic Reactions
- NO_x Reduction Performance - 65-85%
- Lower Capital Cost (\$30 to \$75 per kW) compared to Full Scale SCR (Up to >\$300/kW)
- Demonstrated Mercury Oxidation of >90% with Single Layer Catalyst for Capture with FGD System



Penelec Seward Duct Modifications



AES Greenidge – Multi-P w/ CASCADE

AES Greenidge Unit 4 (Boiler 6)



- Dresden, NY
- Commissioned in 1953
- 107 MW_e (net) reheat unit
- Boiler:
 - Combustion Engineering tangentially-fired, balanced draft
 - 780,000 lb/h steam flow at 1465 psig and 1005 °F
- Fuel:
 - Eastern bituminous coal
 - Biomass (waste wood) – up to 10% heat input
- Existing emission controls:
 - Overfire air (natural gas reburn not in use)
 - ESP
 - No FGD - mid-sulfur coal to meet permit limit of 3.8 lb SO₂/MMBtu

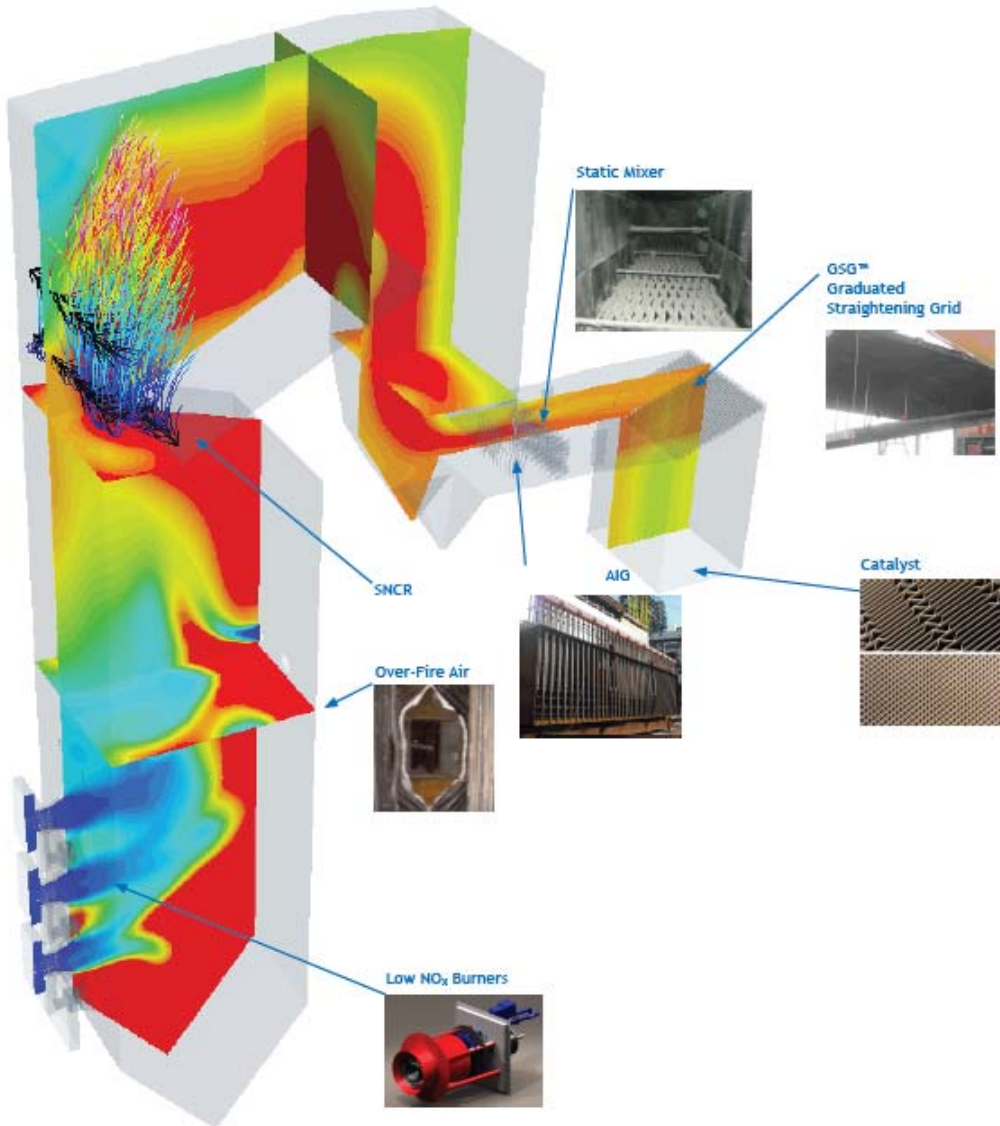


AES Greenidge – Multi-P w/ CASCADE

- ◆ DOE Cooperative Agreement signed May 2006
- ◆ Goal: Demonstrate a Multi-pollutant Control System to Cost-effectively Reduce Emissions of NO_x, SO₂, Hg, Acid Gases (SO₃, HCl, HF), and PM Smaller Coal-fired Power Plants
- ◆ 115 MW Coal-fired Boiler, 2.9% Sulfur Bituminous Coal, 10% Biomass
- ◆ SNCR: Two Levels of Wall Injectors, plus Multiple Nozzle Lances
- ◆ BPI Designed SCR Reactor and Delta Wing Flue Gas Mixing
- ◆ In-duct SCR Reactor, Single Layer of Catalyst
- ◆ SNCR NO_x Reduction = 42%, SCR NO_x Reduction = 30%
- ◆ Overall Post-combustion NO_x Reduction ≈ 60%
- ◆ SNCR Chemical Utilization ≈ 40%

ASCR™ Advanced SCR

- 80+% NO_x Reduction
- 40-60% less than conventional SCR



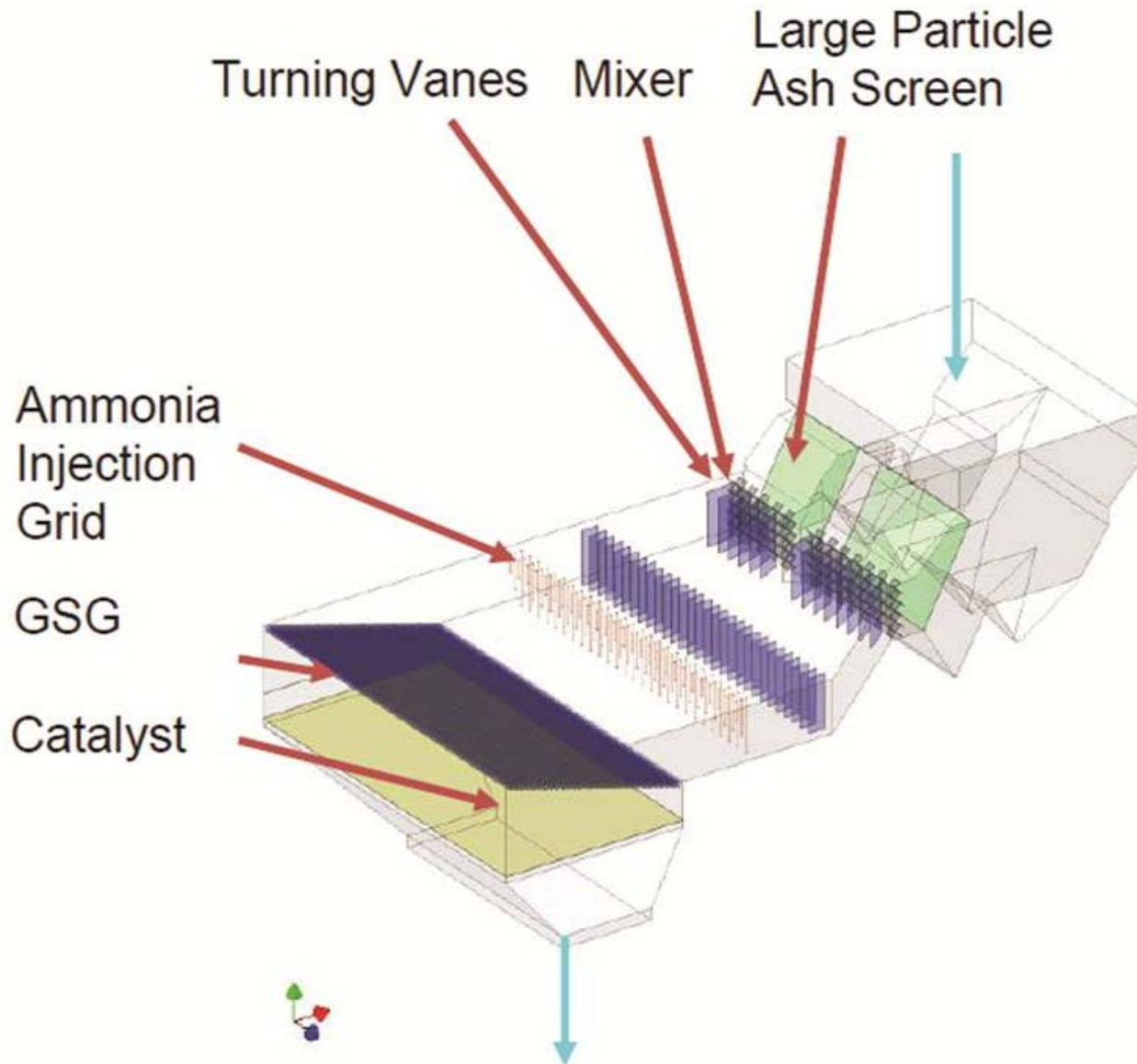
Advantages of ASCR Technology

- **Capital Cost**
 - Limited Structural Steel – Modify Existing, No New Steel to Grade
 - Less Catalyst
 - Less Ductwork
- **Better Reagent Utilization**
 - SNCR Process
 - Separate AIG
- **Low Pressure Drop**
- **Low SO₂ to SO₃ Conversion Rate**
- **Broader Range of Operation**
 - Lower Electrical Demand

ASCR™ Advanced SCR

- ◆ **Maximize In-furnace NOx Reduction through Combustion Modifications and Post-combustion Controls**
- ◆ **Apply SNCR for Maximum Performance, NH3 Slip Control**
- ◆ **On-site Urea Conversion with AIG for 90+% Chemical Utilization**
- ◆ **Employ FTI Mixing and Flow Correction Devices to Provide Uniform Flow and Distribution Across Catalyst Face**
- ◆ **Utilize Catalyst That Maximizes Use of Available Space**
- ◆ **NOx Reduction Efficiency Across Single Layer is Increased As the NOx Entering the SCR is Reduced**

Optimized SCR System



Summary

- **Flexible, Cost Effective NOx Reduction**
- **SNCR complementary to other NOx control technologies**

Questions?