NOx Emissions Control from Industrial Boilers & Cement Kilns

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DIRECTOR'S PROFILE

The Founder Director of NASEQUIP Systems Private Limited, Mr. Rajendran Nair, BE Mechanical from College of Engineering Trivandrum, India is having more than four decades of rich industrial experience. He has more than three decades of practical experience in GAS CONDITIONING SYSTEMS and has successfully designed, manufactured and installed more than 500 no's of customized systems in India and Overseas. Undergone training in Germany & USA for nozzles. Undergone training in Germany for DeNox Systems. Practice based knowledge is his USP. Visited Cement Plants worldwide and presented various papers in international forum.

Director of NASEQUIP Systems Private Limited, Mr. Manish Ganguli (Alumni - IIM Ahmedabad),MBA in Marketing Management has overall 25 years of enriching industrial experience and has worked with leading cement companies in near past. Undergone Training in Australia for Environmental Monitoring Systems. Presented papers on innovative monitoring and abatement technologies for emission. Participated in various international exhibitions & seminars worldwide.

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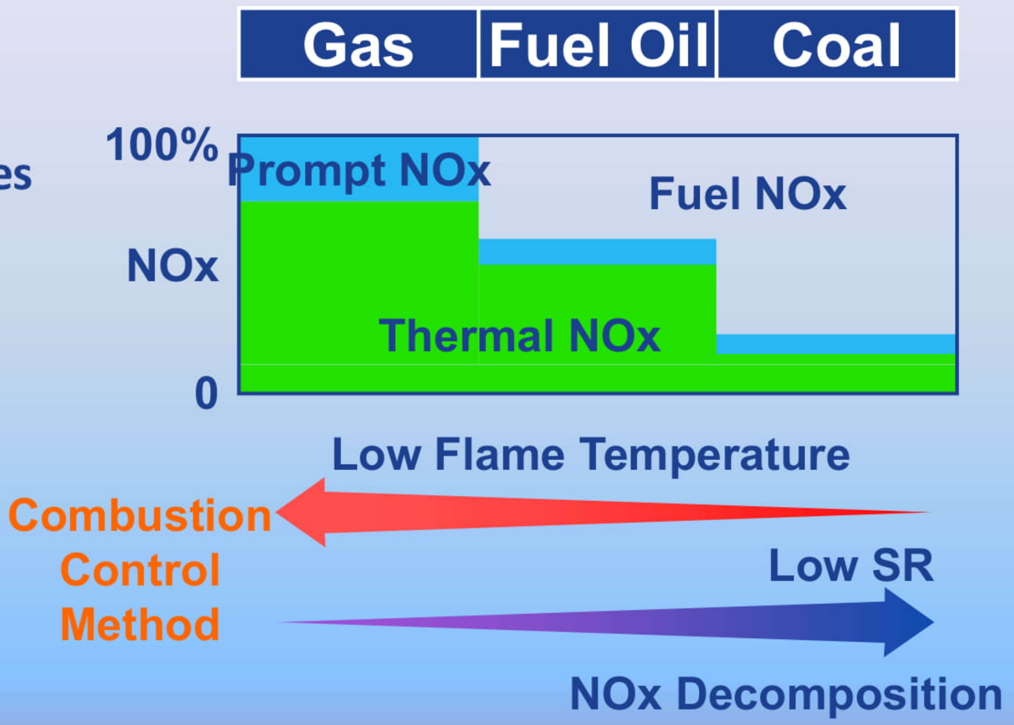
Fuel Impact on Sources of NOx

- **Thermal NOx**
  - Formed by the thermal fixation of molecular nitrogen, N_2
  - Requires high temperatures (> 1,370°C)
- **Fuel NOx**
  - Oxidation of nitrogen bearing species contained in the fuel
- **Prompt NOx**
  - Reaction of nitrogen with fuel fragments



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Approaches to NOx Control

Technique	Gas	Fuel Oil	Coal
Operational Modifications			
Low Excess Air	X	X	X
Reduced Air Preheat	X	X	
Fuel Biasing	X		
Burners Out of Service (BOOS)	X	X	
Combustion Equipment Modifications			
Flue Gas Recirculation (FGR)	X	X	
Overfire Air (OFA)	X	X	X
Steam Injection	X		
Low-NOx Burners (LNB)	X	X	X
Reburning		X	X
Post-Combustion Techniques			
SelectiveNonCatalyticReduction(SNCR)	X	X	X
Selective Catalytic Reduction (SCR)	X	X	X

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NOx emissions control technologies vary in performance and cost

Combustion Modification	Approximate Range of NOx Reduction	Type of NOx Reduced	Applicable Combustion Systems
Burner out of Service	40-50%	Thermal	Oil & Gas
Fuel Biasing	10-20%	Thermal	Oil & Gas
Overfire Air	15-30%	Thermal & Fuel	All
Fuel reburning	40-60%	Thermal & Fuel	Coal (cyclone)
Low excess air firing	10-20%	Thermal & Fuel	All
Flue gas recirculation	20-30%	Thermal	All
Low NOx burners	40-50%	Thermal & Fuel	All
Water / steam injection	50-70%	Thermal	Stationary engines

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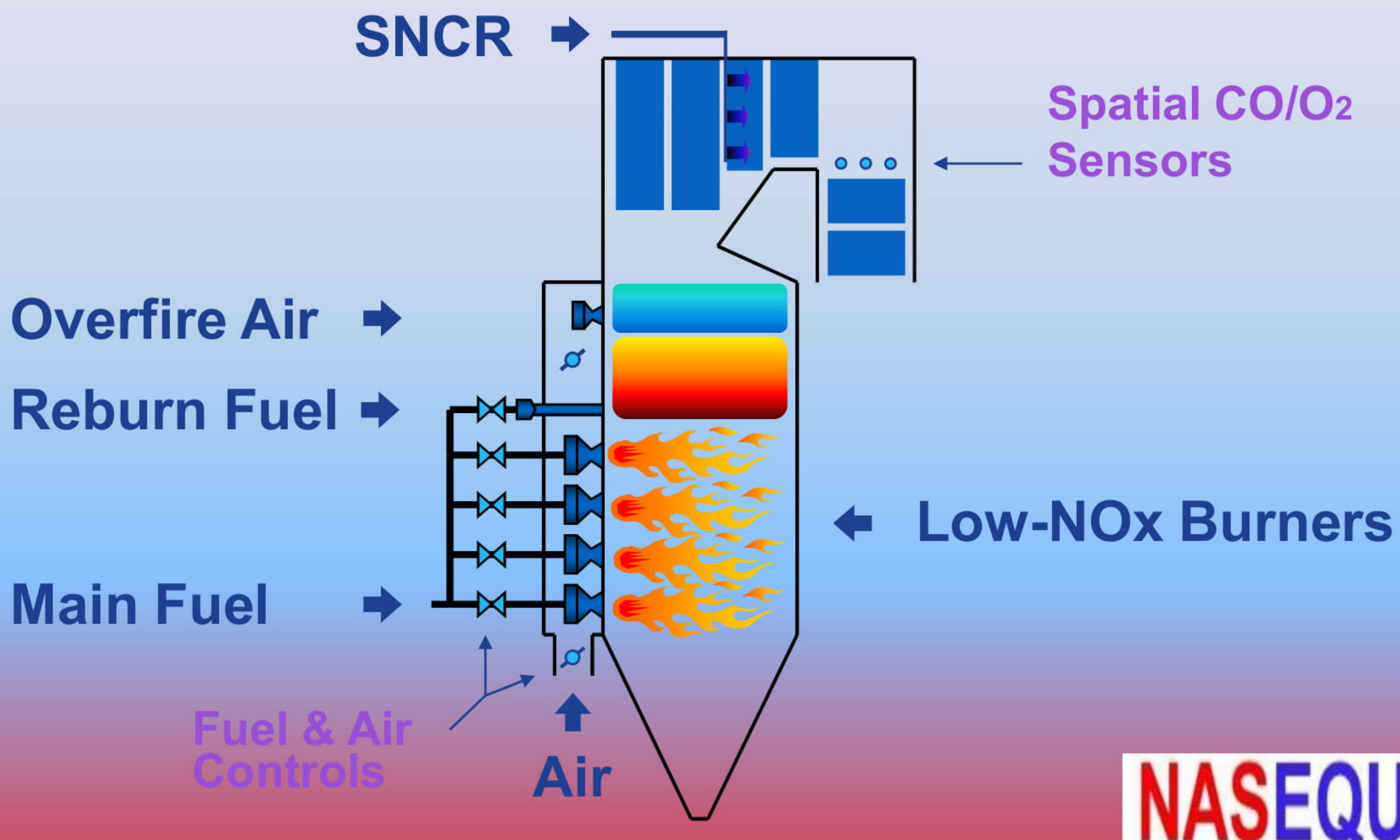
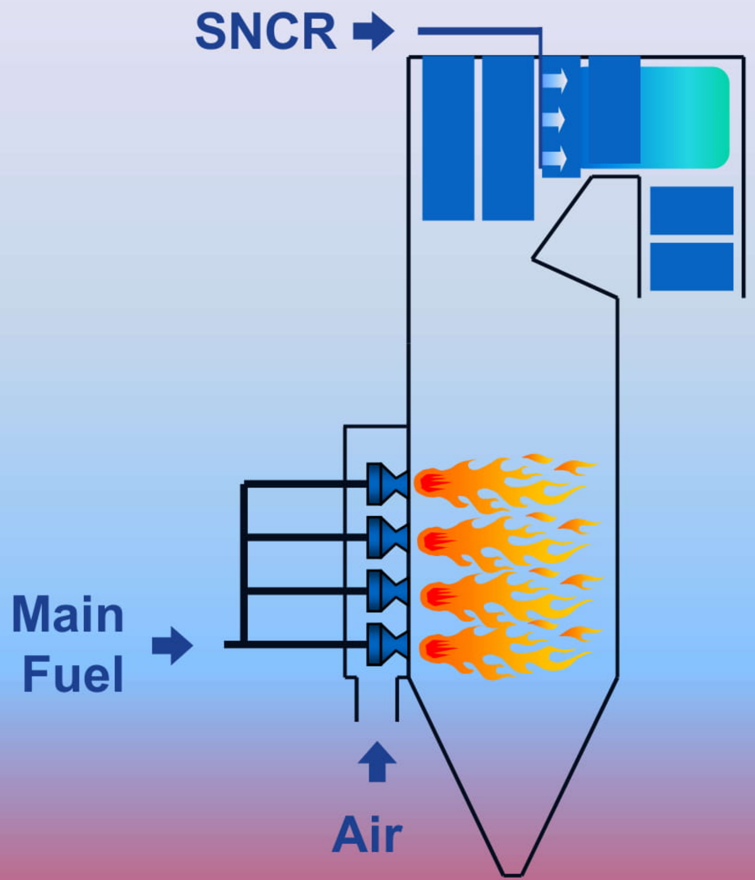
Technology layering reduces NOx emissions to low levels



Selective non-catalytic reduction consists of nitrogen agent injection



- Technology involves the injection of a nitrogen agent (ammonia, urea, etc.) into the post-combustion flue gases.
- At the proper temperature, the SNCR reagent selectively reduces NO to molecular nitrogen.

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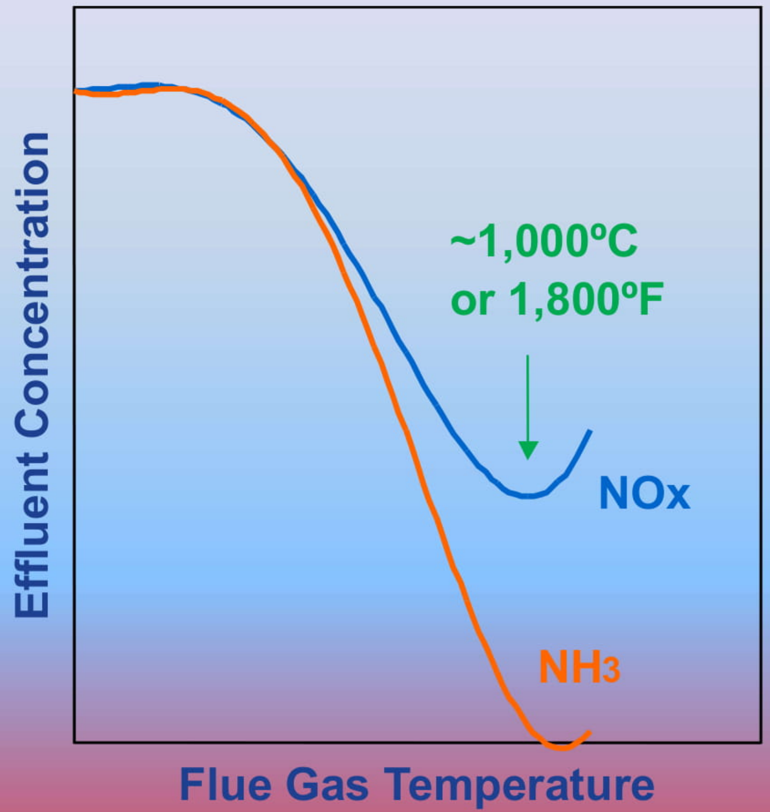
SNCR reaction occurs in narrow temperature window



Reaction chemistry involves reagent activation and reaction with NO:

$$NH_3 + OH \rightarrow NH_2 + H_2O$$

$$\downarrow$$

$$NO + NH_2 \rightarrow H + OH + N_2$$

$$\downarrow$$

$$H + OH \rightarrow H_2O$$

At high temperatures, reagent is oxidized to NOx.

At low temperatures, reagent does not react, leading to ammonia slip.

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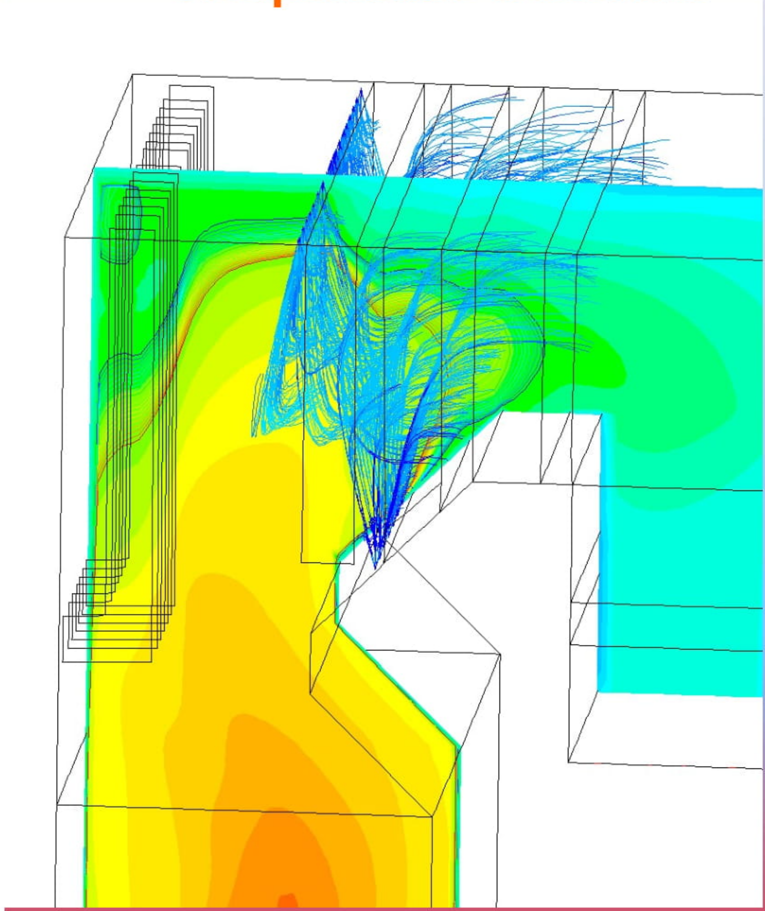
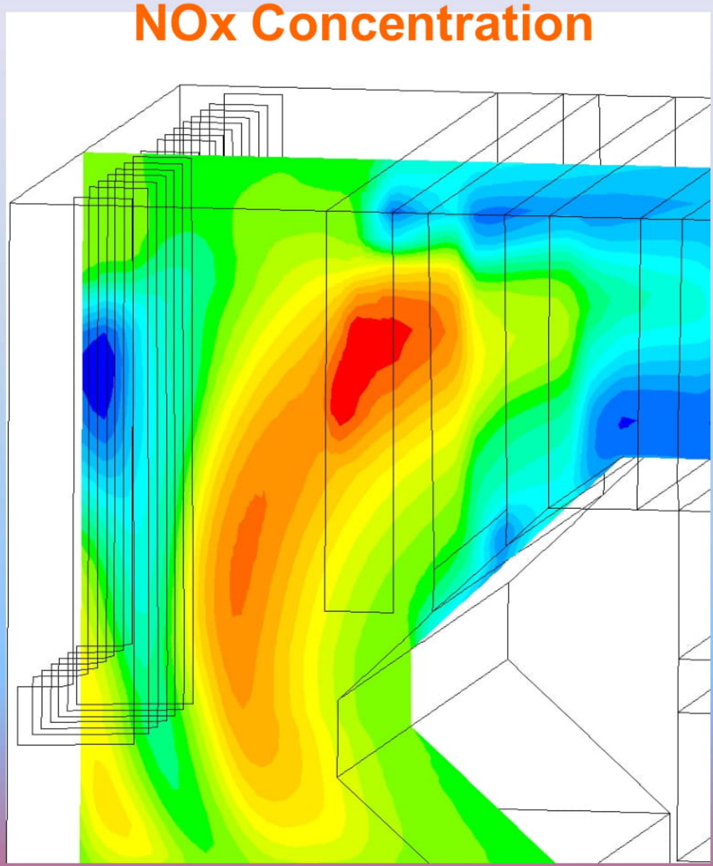
Use of CFD for SNCR system design for Boilers

Droplet Trajectories & Temperature Contours



Resulting Contours of NOx Concentration



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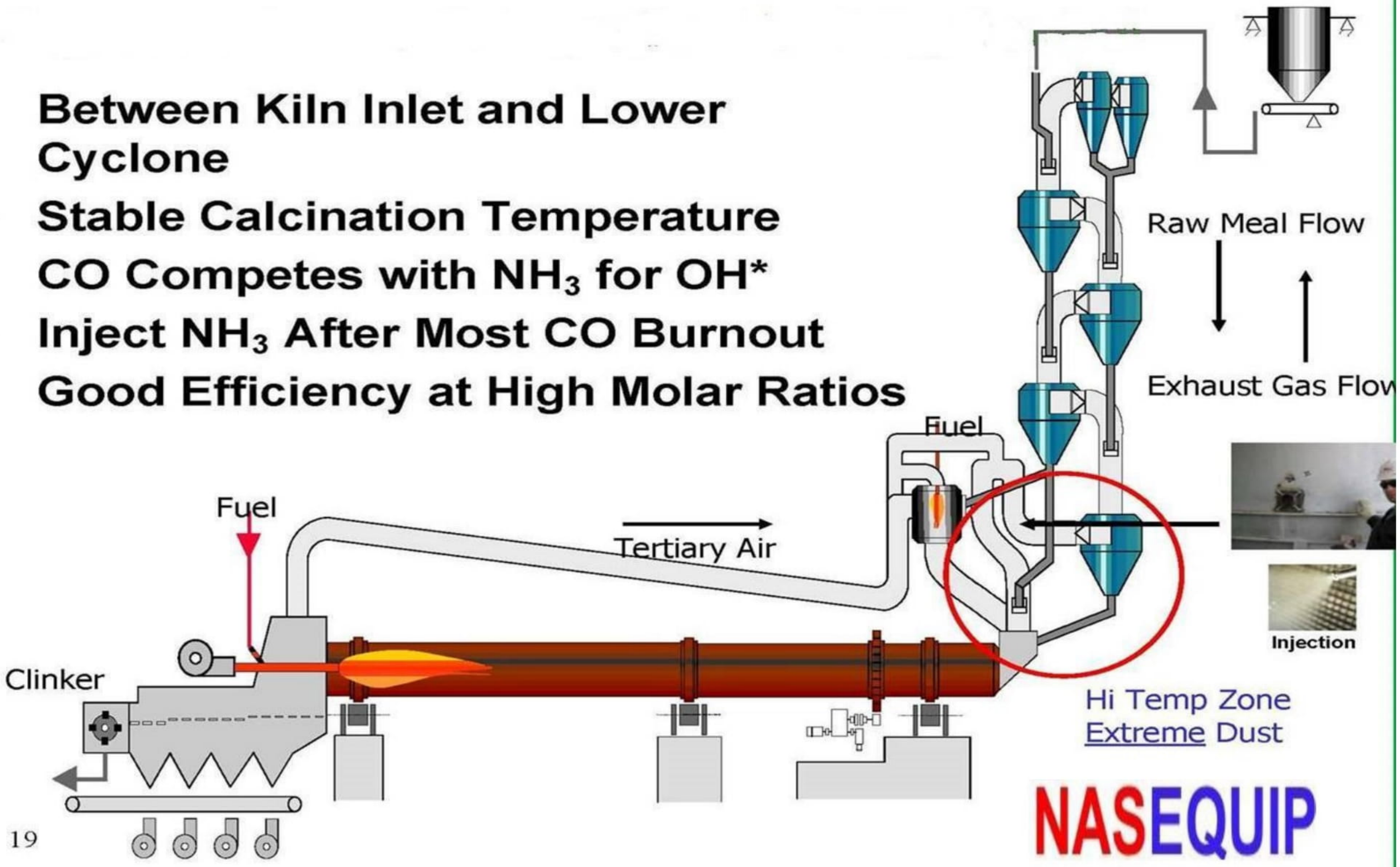
SNCR FOR CEMENT KILN (Aqueous Ammonia Injection)

- **Between Kiln Inlet and Lower Cyclone**
- **Stable Calcination Temperature**
- **CO Competes with NH_3 for OH***
- **Inject NH_3 After Most CO Burnout**
- **Good Efficiency at High Molar Ratios**



Concepts for the reducing of nitrogen in flue gases

SNCR Process	Selective, non-catalytic Nox-reduction at high flue-gas temperatures.
SCR Process	Selective, catalytic Nox-reduction at low flue-gas temperatures.
Combination Process	The cost-effective combination of SNCR and SCR processes.

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BASIC OF NO_x- REDUCTION

OVERALL REACTION WITH AMMONIA

$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$

RADICAL FORMATION

4 NH3 + 2 O2 > 4 NH2- + 4 OH-
NH3 + OH- > NH2- + H2O

DEGRADATIVE REACTION

$NH_2 + NO \rightarrow H_2O + N_2$

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AMMONIA SLIP AND POSSIBLE REACTIONS

AMMONIA SLIP

Unreacted NH_3 injected by to low flue gas temperature< 850°C

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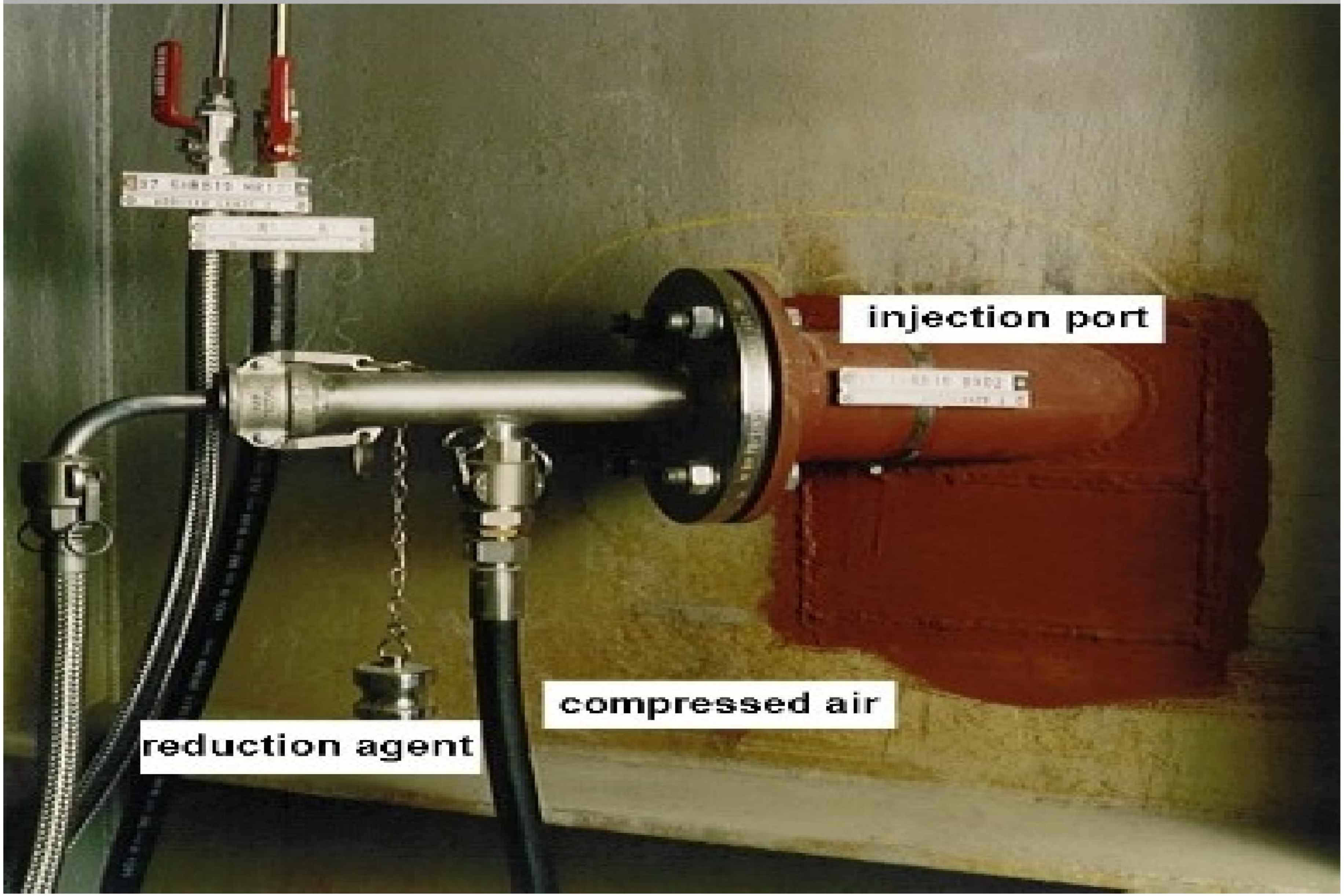
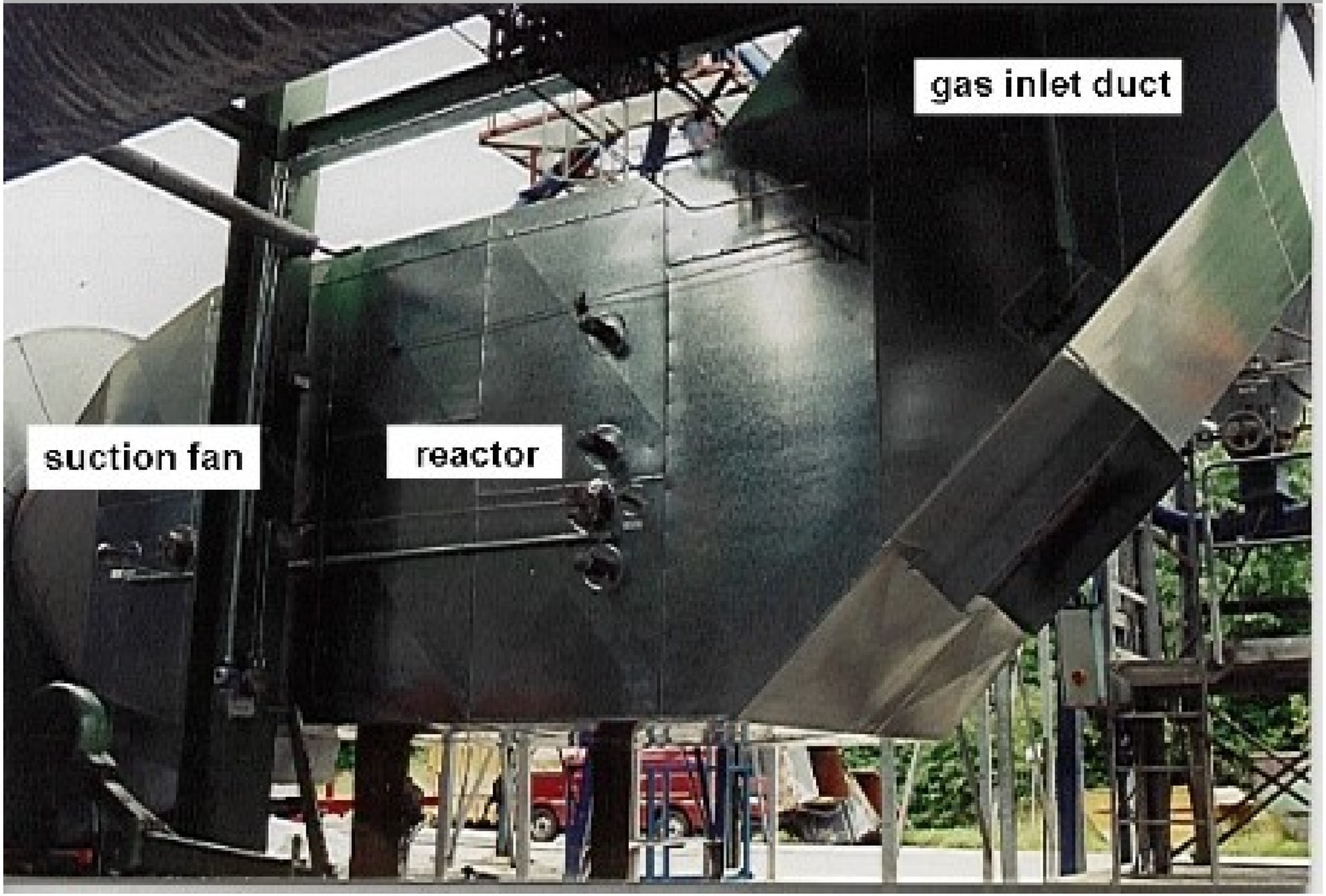
Injection lance



Catalytically DENOX-Stage



STORAGE

METERING AND MIXING MODULE

INJECTION SYSTEM

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THANK YOU