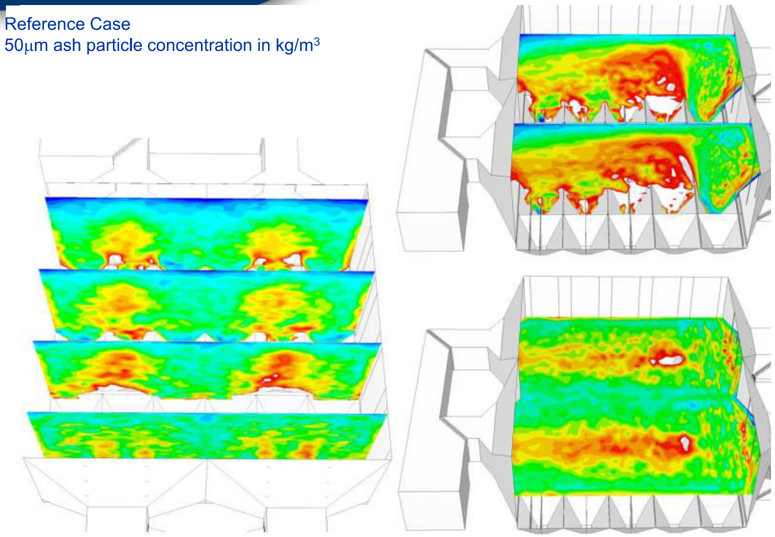
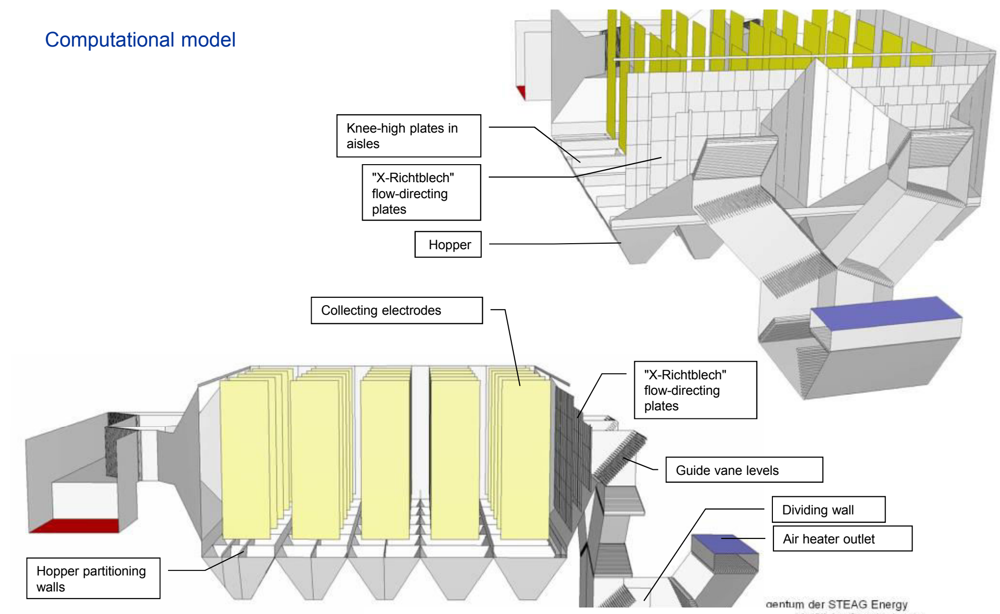
Dynamic Flow analysis and corrections to improve performance

PARAMETER	DESIGN VALUES	ACTUAL VALUES
Gas flow rate	789 M³/sec	930 M³/sec
Gas temperature	134°C	155°C
Collection efficiency	99.91%	99.47%
Inlet dust concentration	60 gm /Nm³	60 gm /Nm³
Outlet dust concentration	56.8mg/Nm³	315mg/Nm³
No of gas path /Boiler	4	4
No of fields /Boiler	56	56
Specific collection area	258.7m²/m³/sec	258.7m²/m³/sec

Reference Case
50µm ash particle concentration in kg/m³

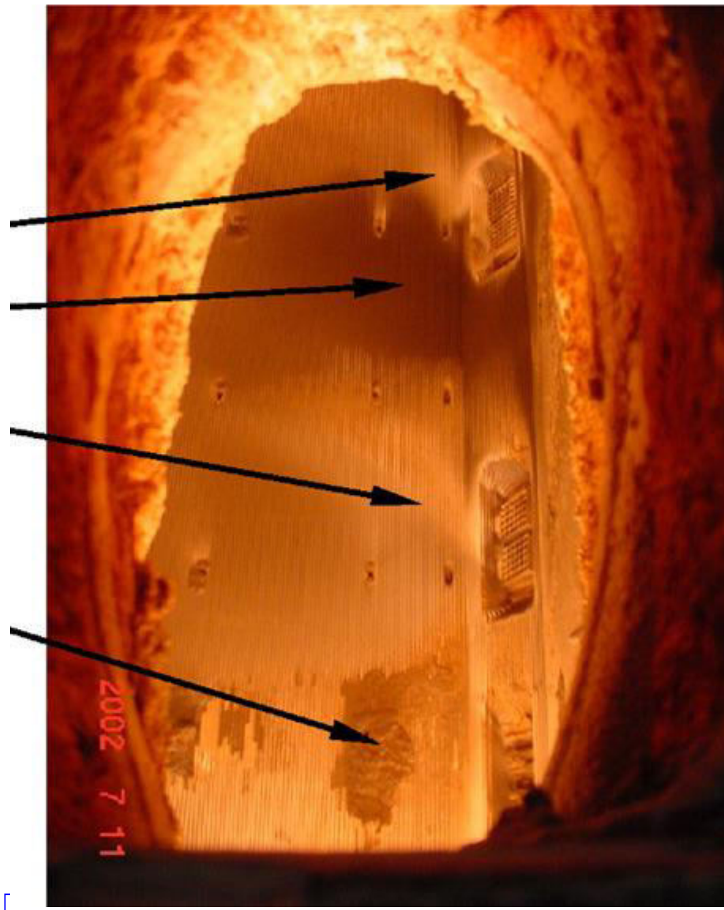


Computational model



160 mg/m³ => 50 mg/m³

Nitrogen Oxides Control
NOx



[mg NO_2/m^3]

for 6% O_2 in dry flue gas

at normal conditions

ppm → mg/m³

$$NO\ [mg/m^3] = 1.3387\ NO\ [ppm]$$

$$NO_x\ [mg/m^3] = 2.0525\ NO_x\ [ppm]$$

NOX and its control in coal combustion

NOX in flue gas : 90-95% **NO** and balance as NO2

NOX : oxidation Nitrogen in Air-(**Thermal Nox)** or 25%

Nitrogen in fuel(**fuel Nox**) 75%

Thermal NOx :minimised by **reducing combustion zone** temperatures.

Fuel NOx formation depends on **Fuel/Air ratio**

Low Nox burners introduce reduced oxygen levels for combustion.

Nox emission control:

Two methods : (1)COMBUSTION CONTROL

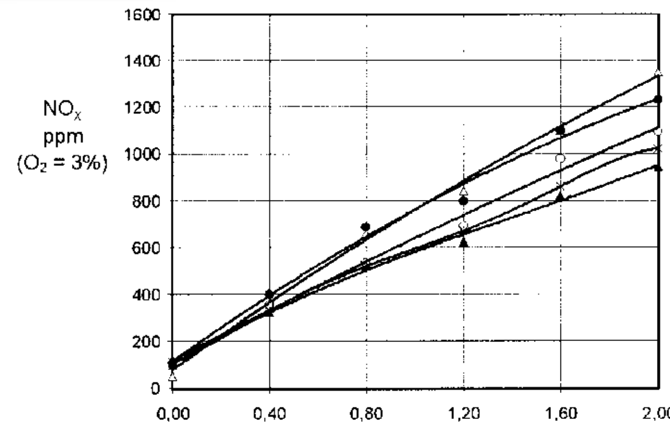
(2) POST COMBUSTION CONTROL

Combustion control : Low Nox burners, air staging, fuel staging

Post combustion control : Selective catalytic reduction(**SCR),** Selective Non catalytic Reduction(**SNCR)**-Hot zone, adequate mixing time

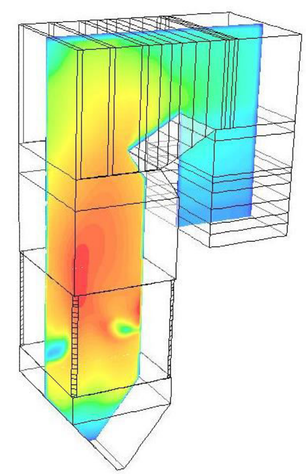
Catalysts :Vanadium-Titanium mixture.(30% of capex)

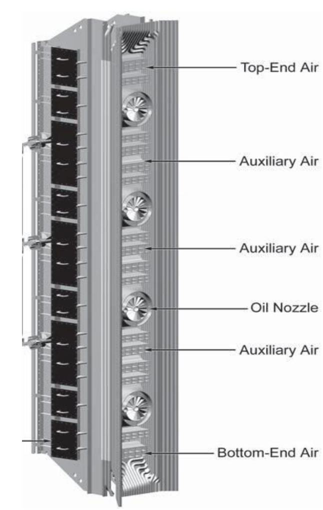
Alkali elements in ash, poison the catalyst



N_F in different coals:

Bituminous coal:	0.6 - 2.8% N (85% C)
Anthracite	<1% N
Lignite:	0.6 - 2% N.

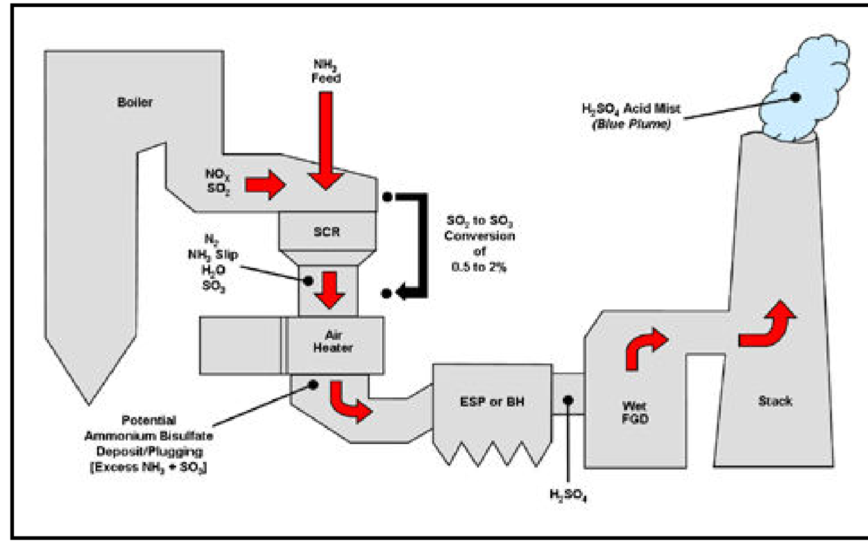




Control of Fuel Nox Post combustion

Selective catalytic(or non catalytic) Reduction(SCR or SNCR)

In both SCR and SNCR, Nox is reduced into N2 & H2O, with a reagent injected into the flue gas.

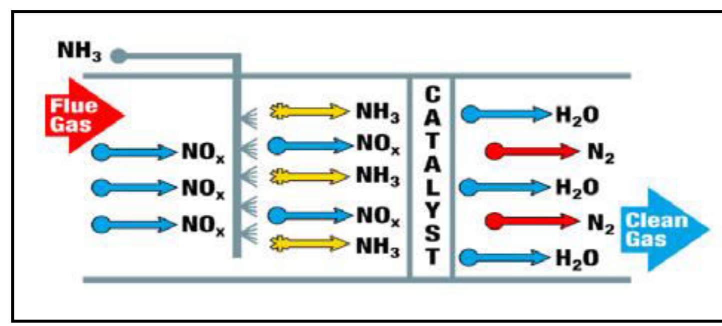


For SNCR, the reagents are Ammonia and Urea

SNCR high temperature zone injections(900 C)- NOX removal rates are 15-35%.

For high NOX removal, SCR is used(catalytic reactor)

For SCR, the reagents are anhydrous and aqueous ammonia and urea.



Flue gas is mixed with ammonia and then the mixture is led to a catalytic convertor(350-450 C). NOX removal rates are 50-70%

$$4\,NO + 4\,NH_3 + O_2 \xrightarrow[\text{Temperature}]{\text{Catalyst}} 4\,N_2 + 6\,H_2O$$

Concerns to be addressed in SCR and SNCR

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- **Ammonia Storage & handling:** Associated safety issues Ammonia(BP -28C)
- **Increased System pressure drops** with increase in catalyst pitching[10-20mmwcl]
- **Catalyst management:** provision for future layers in the furnaces/ducts. Cost for replacement
- **Hazardous waste management**
- Furnace and ducts modifications: For SNCR, temperature is a criteria for effectiveness.
- **Air heater choking**, ammonia fouling
- **Effect on ash disposal:** Ammonia concentration in fly ash can affect ash disposal

The Need:

- **online/continuous monitoring monitoring and control system for safe and efficient operation of the unit.**

Steag capabilities

Steag & SCR

STEAG's own SCR fleet consists of:
30 SCRs in operation servicing 31 units totaling 10,555 MW since 1980s.

STEAG's SCR design engineering, project management, construction supervision and long-term SCR management experience comprises of:

• bituminous coal-fired:	41,075 MW
• PRB coal-fired:	16,305 MW
• oil/gas-fired:	4,420 MW
• CCGT/SCGT:	2,080 MW
• total SCR experience:	61,800 MW

- Steag offers online monitoring ,control and optimization systems

STEAG provides the following **SCR engineering services:**

- Process design engineering
- CFD modeling and flow optimization
- Basic equipment design engineering
- Design review
- Catalyst loading and unloading logistics
- Startup and commissioning assistance
- Lifecycle studies

STEAG provides the following **SCR equipment supplies:**

- Turn key ammonia systems (NH_3, NH_4OH, UREA)
- Large Particle Ash screens
- Used, regenerated catalyst including seal systems and lifting devices

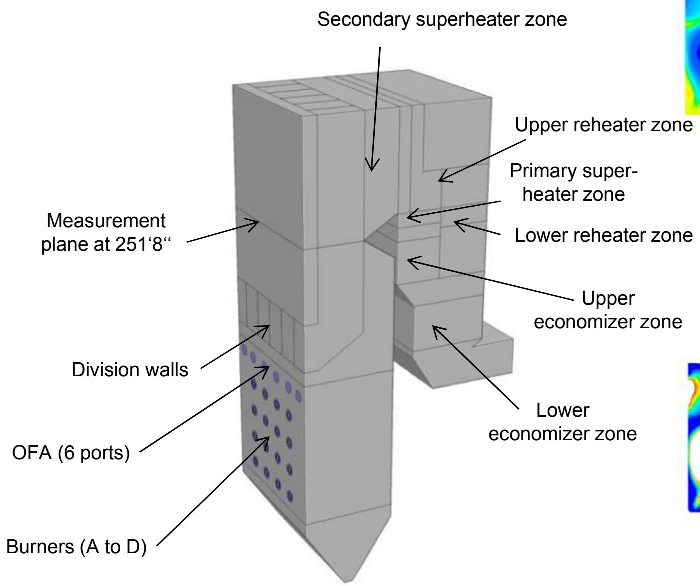
STEAG provided SCR technology licenses to:

- Black & Veatch (expired 2006)
- Clyde Bergemann (ongoing)

Advanced Control for NOX

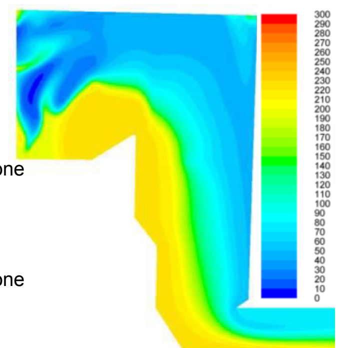
The constantly varying composition of the fuel changes the combustion behavior of the fuel, causing considerable variations in the heat release and as a consequence the furnace temperature

CFD-model

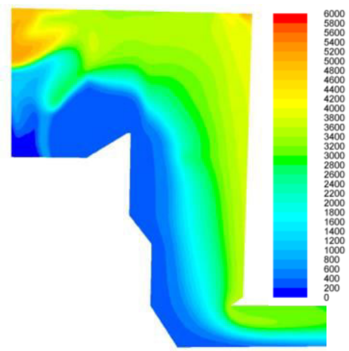


references: San Juan

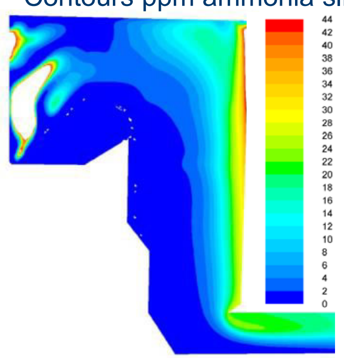
Contours ppm NO (dry)



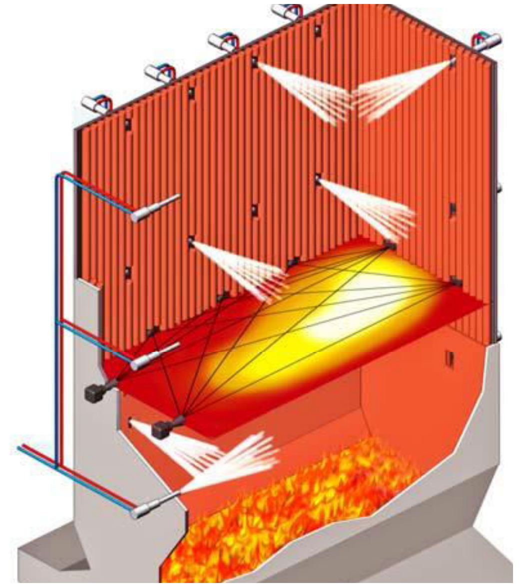
Contours ppm CO (dry)



Contours ppm ammonia slip (dry)



With urea injection and SNCR chemistry switched on



Changing the lances for the injection of urea depending upon the temperature zone reduces the Nox emission

$$4\,NO + 4\,NH_3 + O_2 \xrightarrow[\text{Temperature}]{\text{Catalyst}} 4\,N_2 + 6\,H_2O$$

Experiences in Germany with SCR performance STEAG-Power Plant

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Power Plant	Capacity MW	Combustion	$DeNO_x$ System	Catalyst	Operating Hour Jan. 1999	NO_x-Inlet concentration mg/m^3	No_x-separation %
Bergkamen	747	Dry-bottom	HD	honeycomb	67,000	760	74
Voerde A	710	Dry-bottom	HD	honeycomb	56.000	600	78
Voerde B	710	Dry-bottom	HD	honeycomb	58.000	600	66
Herne 1/2	2 x 150	Slag-tap	TE	plate honeycomb	60.000	1100	88
Herne 3	1 x 300	Slag-tap	TE	honeycomb	62.000	1400	90
Herne 4	500	Dry-bottom	HD	plate	48.000	450	53
Luenen 10	150	Dry-bottom	TE	honeycomb	46.000	1100	88
Luenen 11	350	Slag-tap	TE	honeycomb	66.000	1300	89
Walsum 9	410	Dry-bottom	HD	plate	76.000	500	67
Walsum 7	150	Slag-tap	LD	honeycomb	40.000	1100	88
West 1	350	Slag-tap	TE	honeycomb	58.000	1300	89
West 2	350	Slag-tap	TE	honeycomb	58.000	1300	89
Leuna	160	Heavy oil	HD	plate	13.000	880	81
			Total		**583,000**		

HD=High Dust, LD= Low Dust, TE= Tail End

Sulfur di-oxide(SOx) emission control

TECHNOLOGIES: WET AND DRY SCRUBBERS

Flue Gas desulfurisation -FGD
Sox Control

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Concept
Lime stone(CaCo3) reacts with SO2 in presence of oxygen to form Gypsum(commercial)
Dolomite(limestone) has magnesium and requires more Ca/S ratio.
SO2 capture is influenced by Temperature(850C)

Combustion : Furnace sorbent injection**(lime stone)**

Post Combustion:
wet scrubbing : Flue gas is passed through alkaline solution where sulfur is captured and the product is further oxidised to Gypsum.
Most efficient
Dry systems, the efficiencies are low. Lime consumption is more.
Quality of lime stone affects performance
For effective control: Ensure Scrubber availability(>95%)
Loading of particulates increases, requires frequent soot blowing , tube damages
Sea water is alkaline and can be used to absorb Sox(Indian power stations use)

STEAG Power Plants with FGD

STEAG‘s Development of FGD-Technology

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1968	5,000 m³/h (stp)	Pilot plant at STEAG power station Lünen
1971	140,000 m³/h (stp)	Pilot plant at STEAG power station Lünen (Bischoff-Process)
1974	150,000 m³/h (stp)	Pilot plant at STEAG power station Lünen (ACT - Process)
1981	750 MW	First commercial FGD plant at STEAG power station Bergkamen
1999	10,000 m³/h (stp)	Pilot plant at STEAG power plant Herne (Ammonia water process)
		FGD Operating experience
Today	~ 9,000 MW	Total capacity of operational FGD - system
	> 2.0 million	Total FGD operating hours
	> 25 years	FGD operating experience
	~ 10,000 MW	Total capacity of designed STEAG FGD - system
	> 12,000 MW	Total capacity of internat. engineering services as Owner’s engineer
	> 20,000 MW	Total capacity of FGD retrofits

Steag‘s capability

STEAG can provide unique engineering services transferring extensive long-term FGD operating experience to our customers:

- **Basic design**
- **Specify optimal process, arrangement concept and equipment design**
- **Design review**
- **Material and equipment selection**
- **Material handling**
- **Maintenance assistance**
- **Measuring services**
- **Operator training / in FGD - plants**

References

1.Combustion of Fuels:

2.Advance emission control technologies, Babcock and wilcox

2.Flue gas conditioning: S N Trivedi,R C Phadke- chemithon Engineers

4.Power plant engineering-Black and Veatch

5.Steag experiences: Dr Wolfgang Benesch

Through the Gates Foundation, Bill and his wife Melinda have already given away nearly $30 billion of their fortune and there are tens of billions more in the pipeline.

Bill Gates is the single most influential voice in global health, so when he turns his attention to an issue, it is worth listening.