Overview of SCR and SNCR solutions

Carolinas Air Pollution Control Association

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Introduction

- **YARA : Norwegian Group**

Fertilizers and urea production, Air cleaning treatment solutions, miscellaneous industrials solutions.

- **SCR/SNCR :**

30 years of experience, over 600 references, global coverage.

Our planet faces massive challenges

9,8 billion
+32%
People

+ 50 %

Increased food production

-40 to -70 %

Reduced greenhouse gas emissions*

Source: OECD, FAO, UN DESC
***To stay within the 2°C goal by 2050**

Harmful effects of NOx

- $NOx = NO, NO_2$

- **Acid Rain :**

Change of PH level of soil and water impacts ecosystems plants, wildlife.

- **Smog :**

Asthma, lungs irritation, birth defect.

NOx Removal : Theory of reactions

- SCR : Selective catalytic reduction

Converting NOx by injection of a reagent downstream from the combustion source. The chemical reaction is accelerated by a catalyst which is not consumed by the process.

- SNCR : Selective Noncatalytic Reduction

Reagent is directly injected without the presence of a catalyst

NOx Removal : Theory of reactions

- Aqueous Ammonia (NH_4OH):

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

  $6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$

- Urea solution $CO(NH_2)_2$:

  $CO(NH_2)_2 + 2NO + \frac{1}{2} O_2 \rightarrow 2 N_2 + CO_2 + 2H_2O$

NOx Destruction : Theory of reactions

- **Ammonia Slip :**

It is not possible to have 100% efficiency NH3 / NOx distribution

Ammonia is slightly overdosed and the unreacted NH3 is leaving the System without being converted.

Reagents for DeNOx System

- **Ammonia**

  Reaction is more direct, higher efficiency

  Freezing point of ammonia solution (24%): -53°C/-64°F

- **Urea solution**

  Reaction more complex, urea separates into NH_3 and isocyanic acid (HNCO), lower efficiency

  Urea solution (40%) is crystalizing at temperatures below 10°C/50°F,

  Isocyanic acid (HNCO) is corrosive

SCR Technology

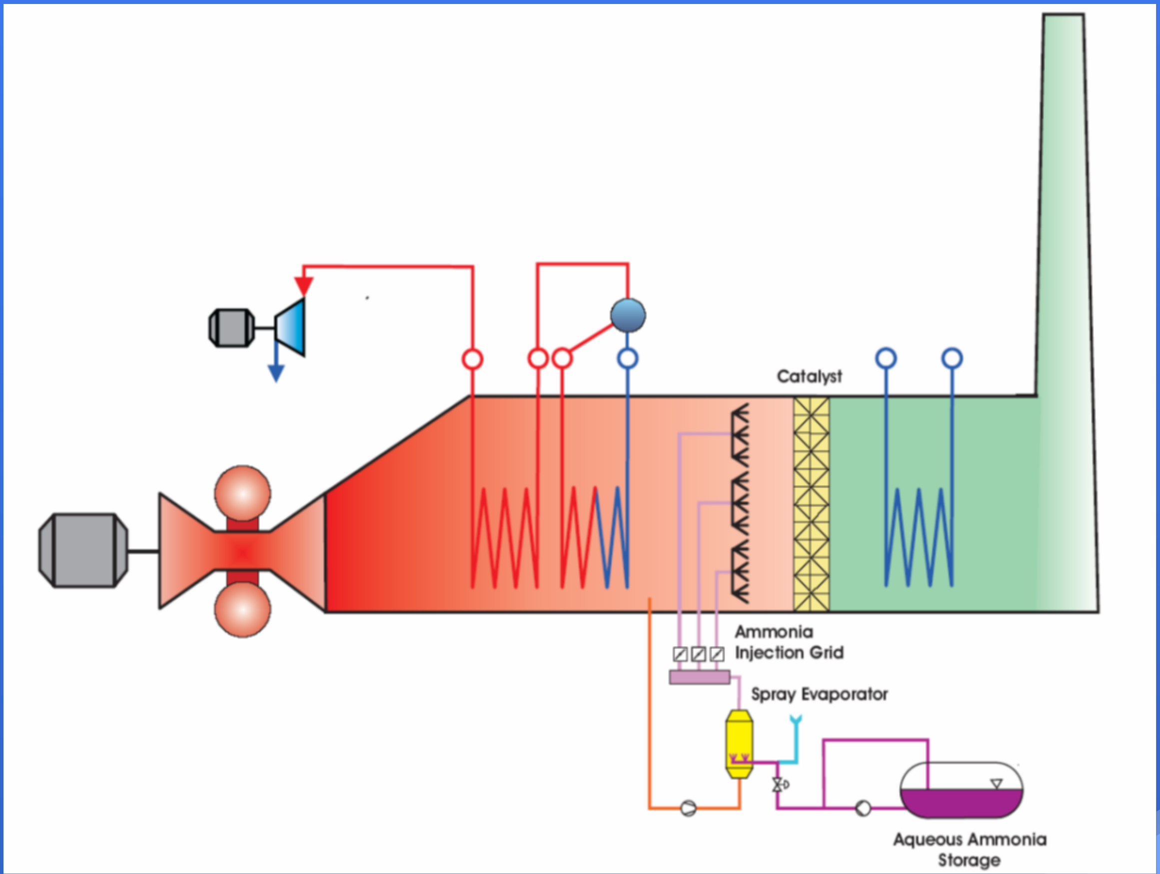
- System Overview

Ammonia storage and injection system

Ammonia Flow control Unit (AFCU) and vaporizing system

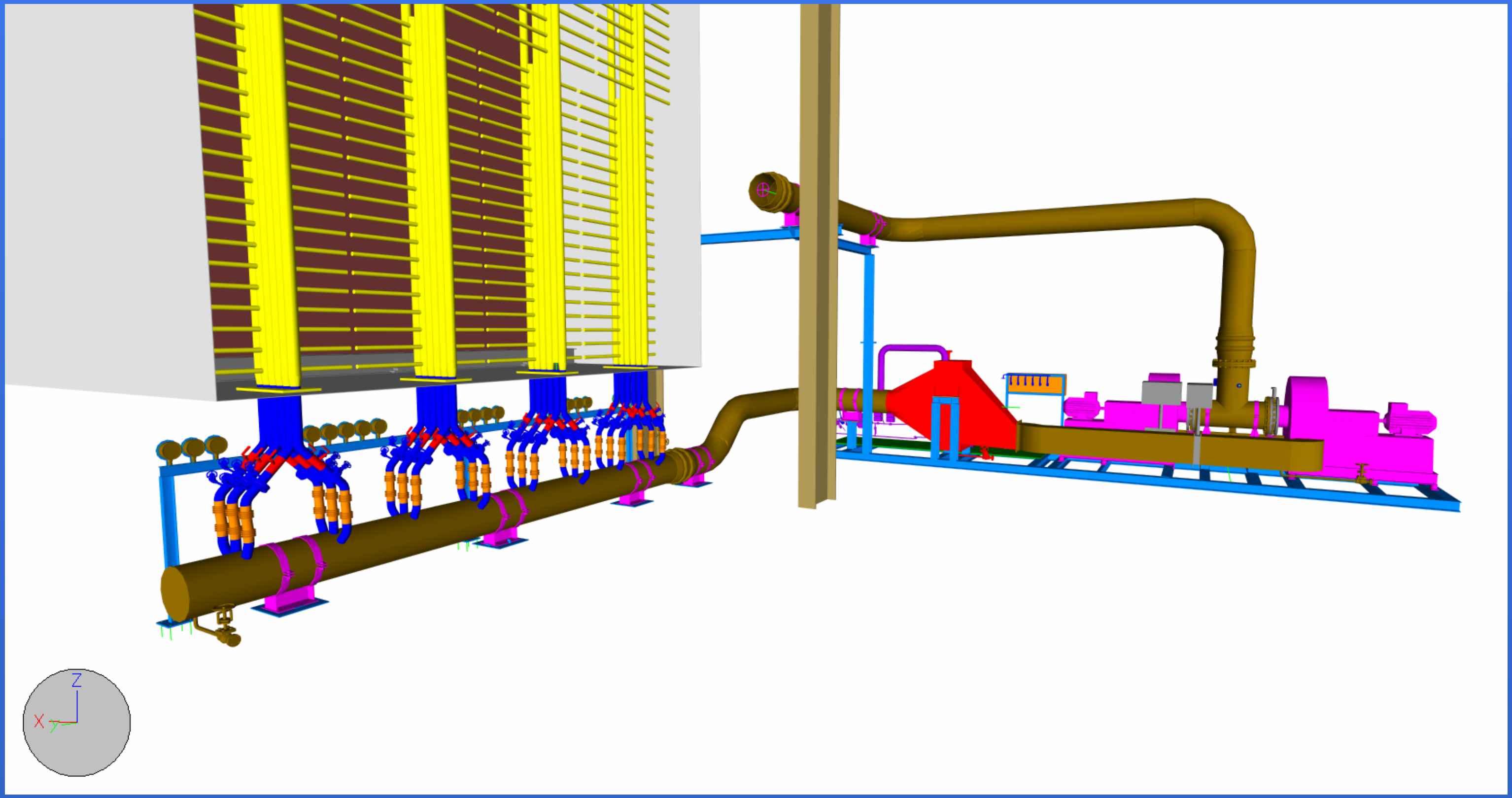
Ammonia injection grid (AIG)

Catalyst and Reactor



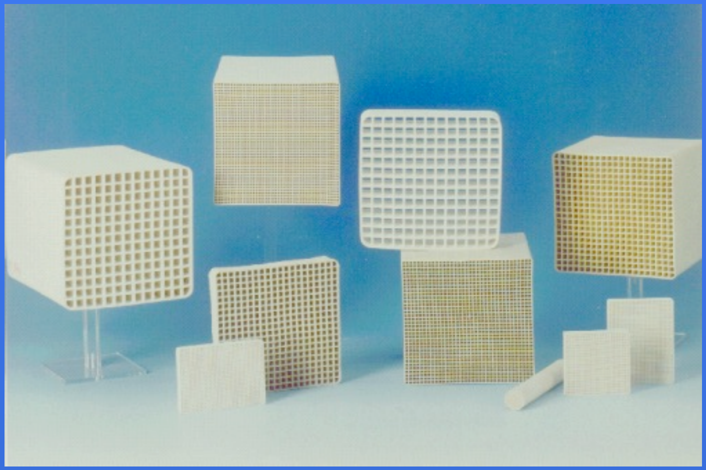
SCR Technology

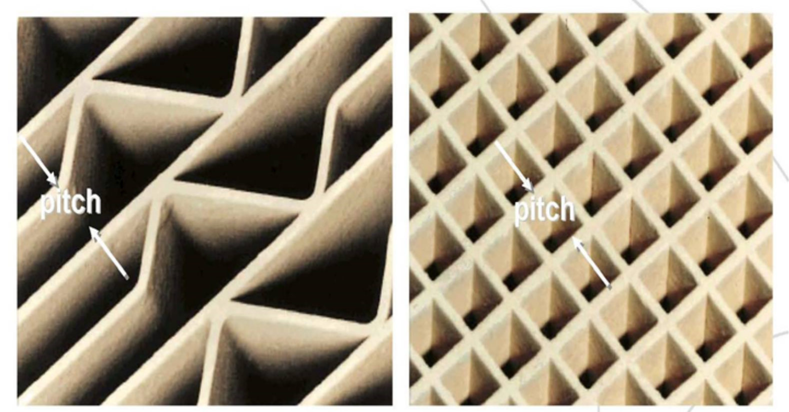
- System overview



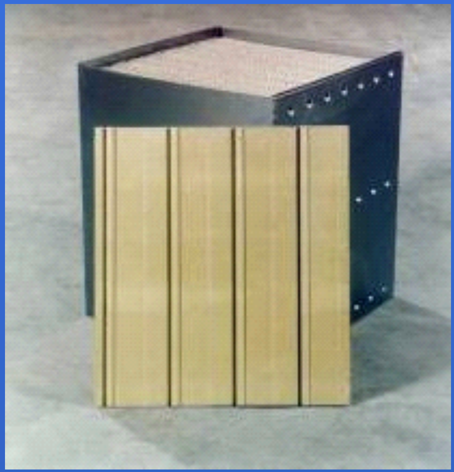
SCR Technology

- Catalyst types
  - Honeycomb
  - Plate
  - Corrugated



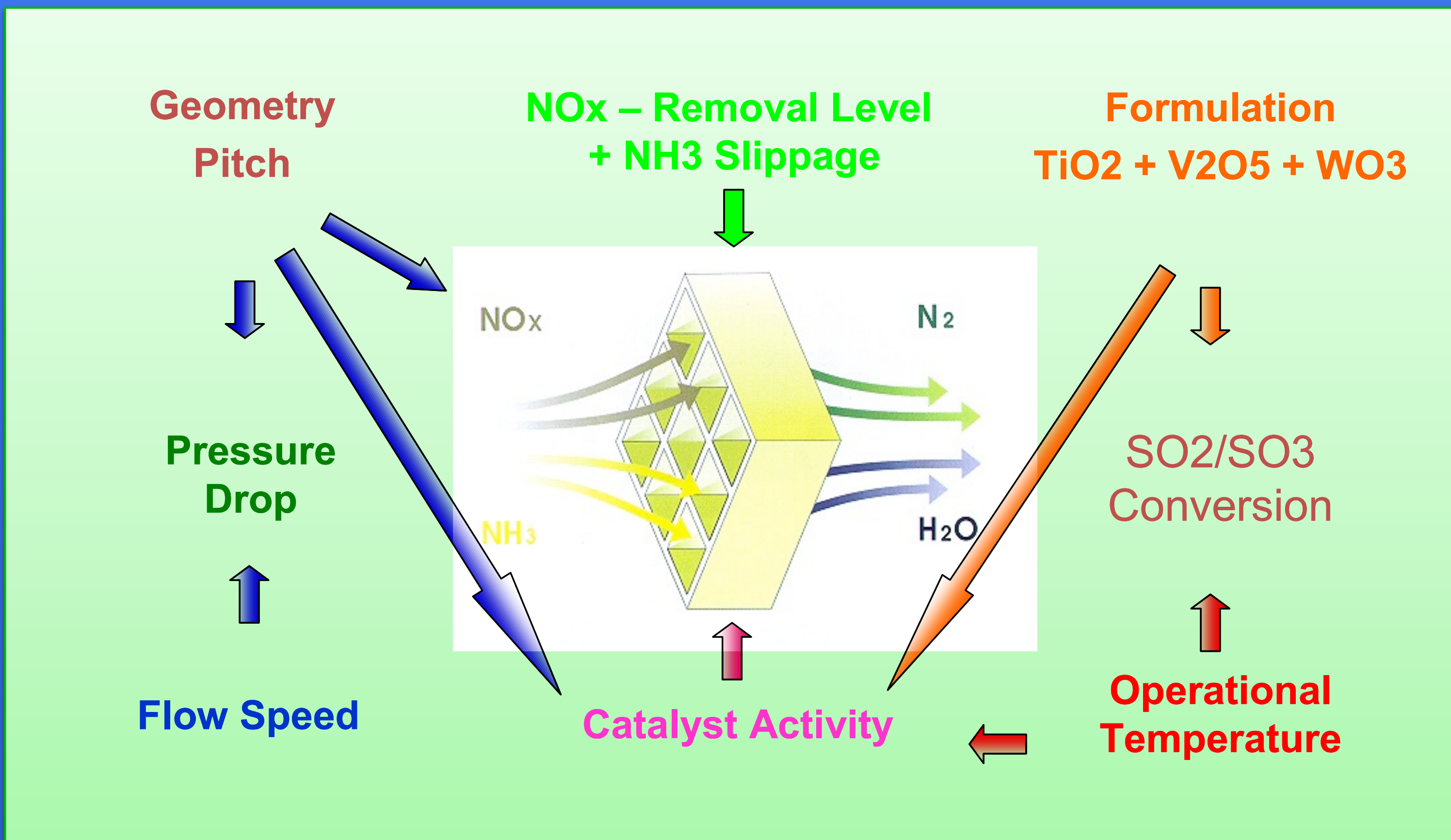


The pitch is defined as the center to center distance from one plate/wall to the other.



SCR Technology

- Catalyst design



SCR Technology

- Performance

  SCR system can reach from 75% up to 95% NOx reduction ratio.

  Highest performance are 2PPMVD NOx out and 2 PPMVD NH3 slip.

  2 to 5 years life time guarantee for catalyst

SCR Technology

- Constraints

Operating temperature range

Min:190°C / 375°F

Max : 450°C/ 850°F (few catalyst allows up to 600°C/1100°F)

Exhaust Flow must be uniformly distributed across the catalyst

Deactivation of catalyst with time

SCR Technology

- Constraints

  Pressure drop to be considered

  Damages due to ashes, high dust

  Sensitive to certain pollutants : Arsenic, Phosphorus, Potassium

  Side reactions : SO3 (corrosion), Ammonium (Bi)Sulfate (clogging)

SCR TECHNOLOGY

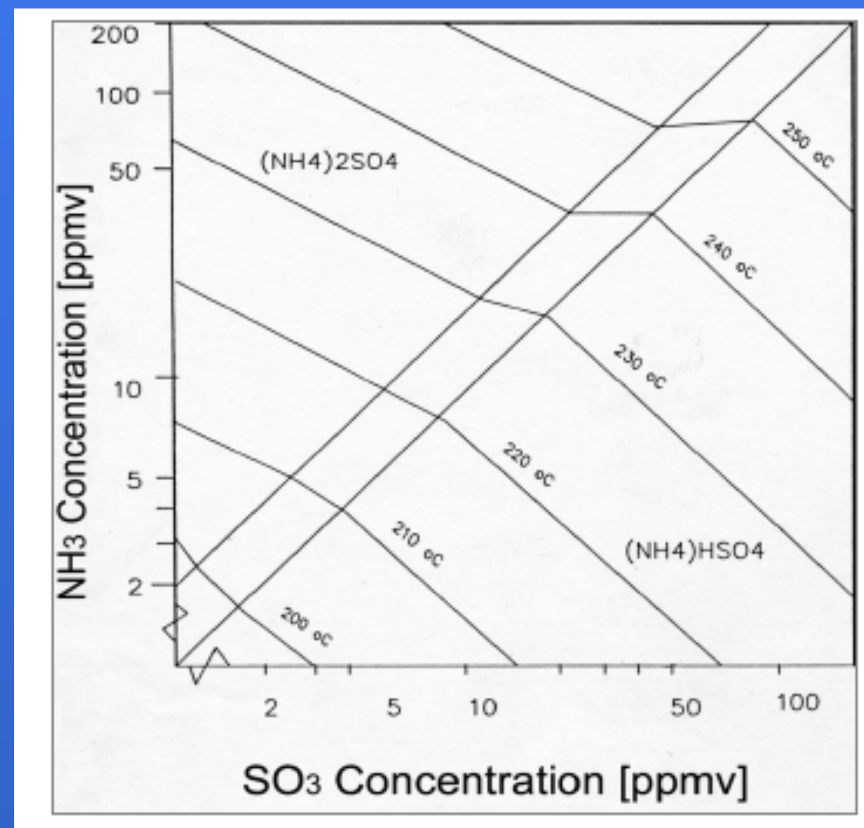
- Side Reactions

$2SO_2 + O_2 \rightarrow 2SO_3$

Ammonium Bisulfate (dusty)
$(NH_4)_2SO_4$

Ammonium Sulfate (sticky)
NH_4HSO_4

Sulfuric Acid
H_2SO_4 (corrosion)



SCR Technology

- CAPEX

Wide range depending on scope, sizing and performance required

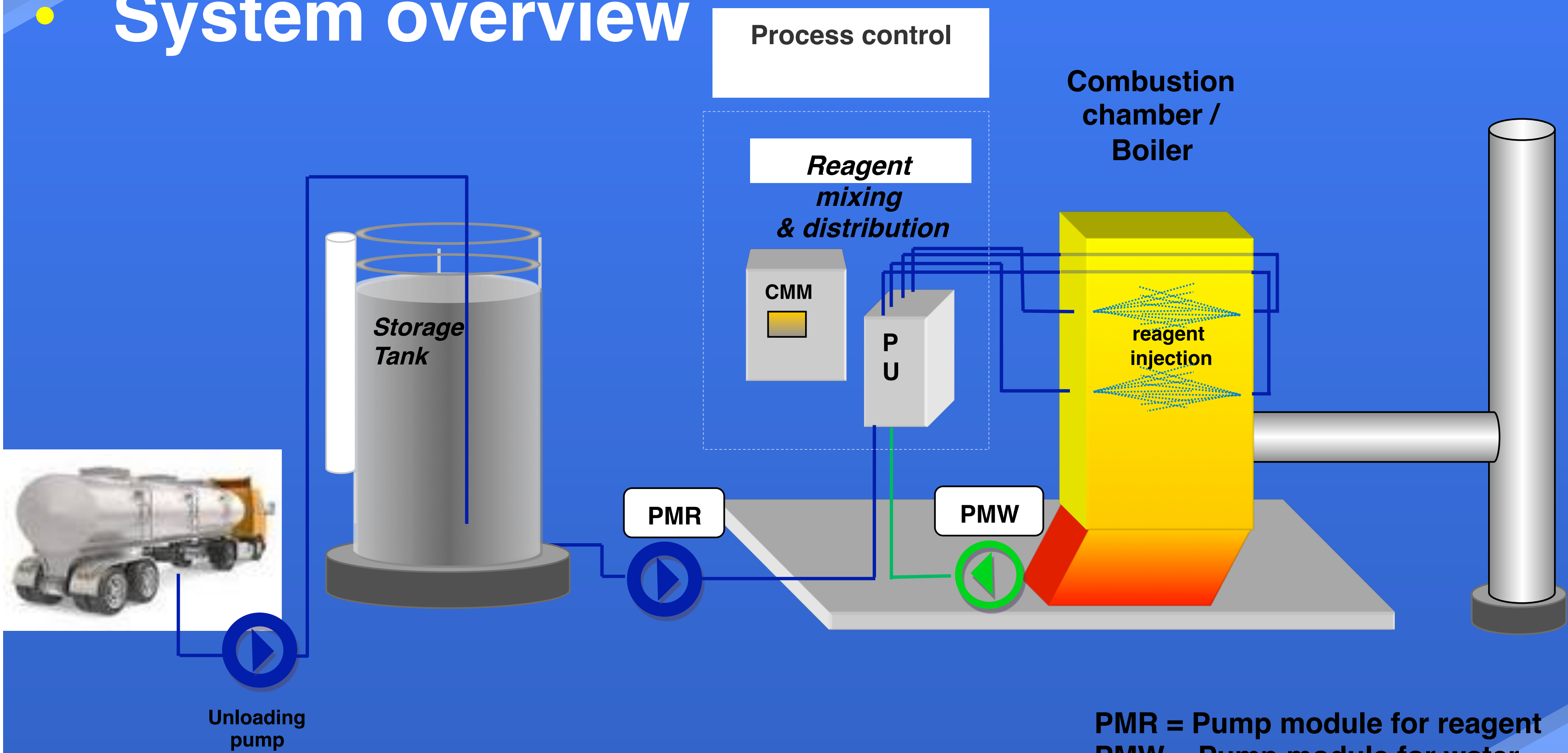
Catalyst Cost can represent up to 40%

Unloading, storage, injection and catalyst USD 750K – 2,000K* for reduction rate >80%

*excl. installation/erection

SNCR Technology

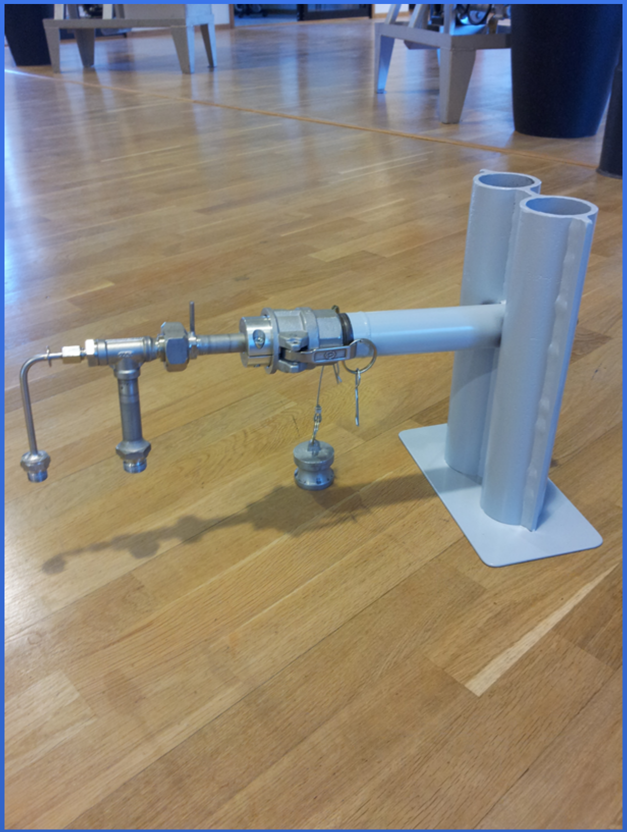
- System overview

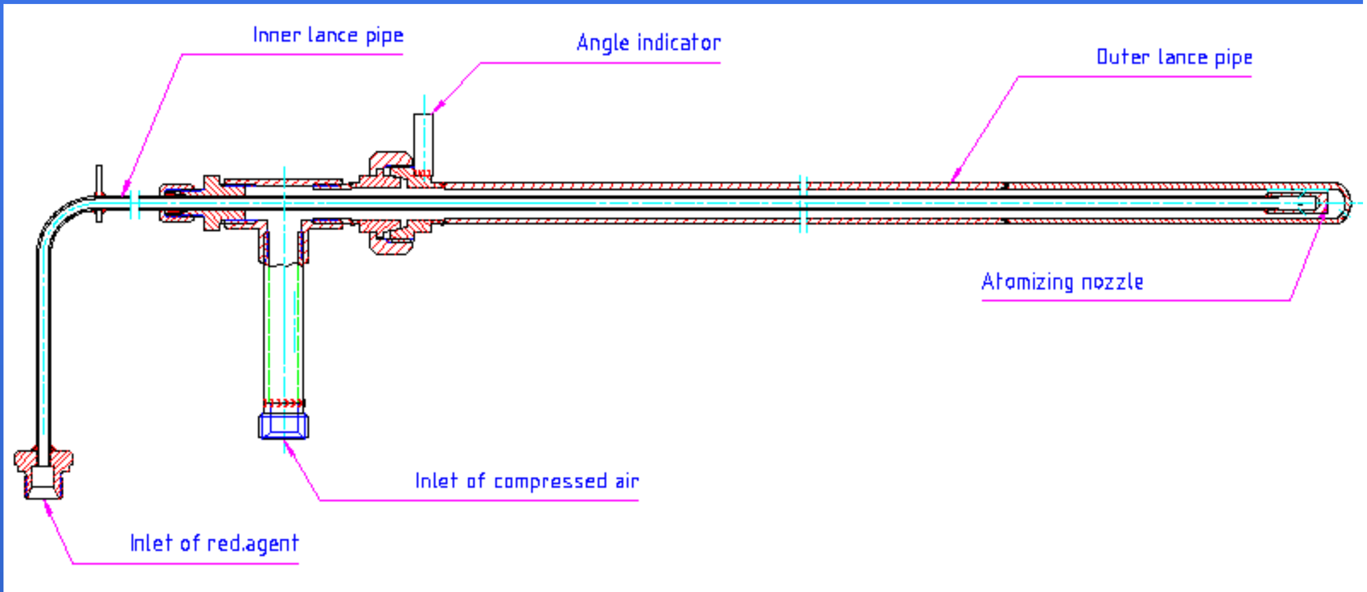


PMR = Pump module for reagent
PMW = Pump module for water

SNCR Technology

- Injection Lances

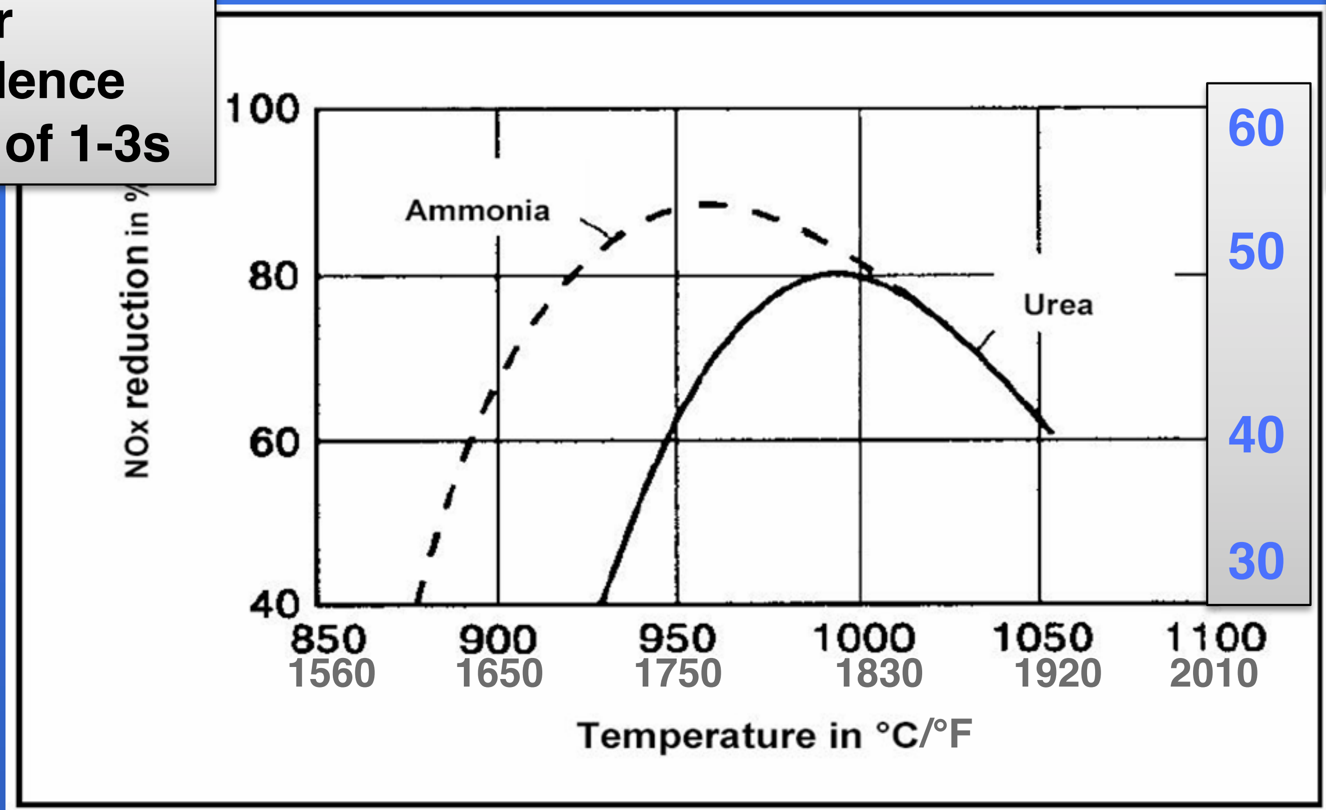




SNCR Technology

- Residence time and Temperature

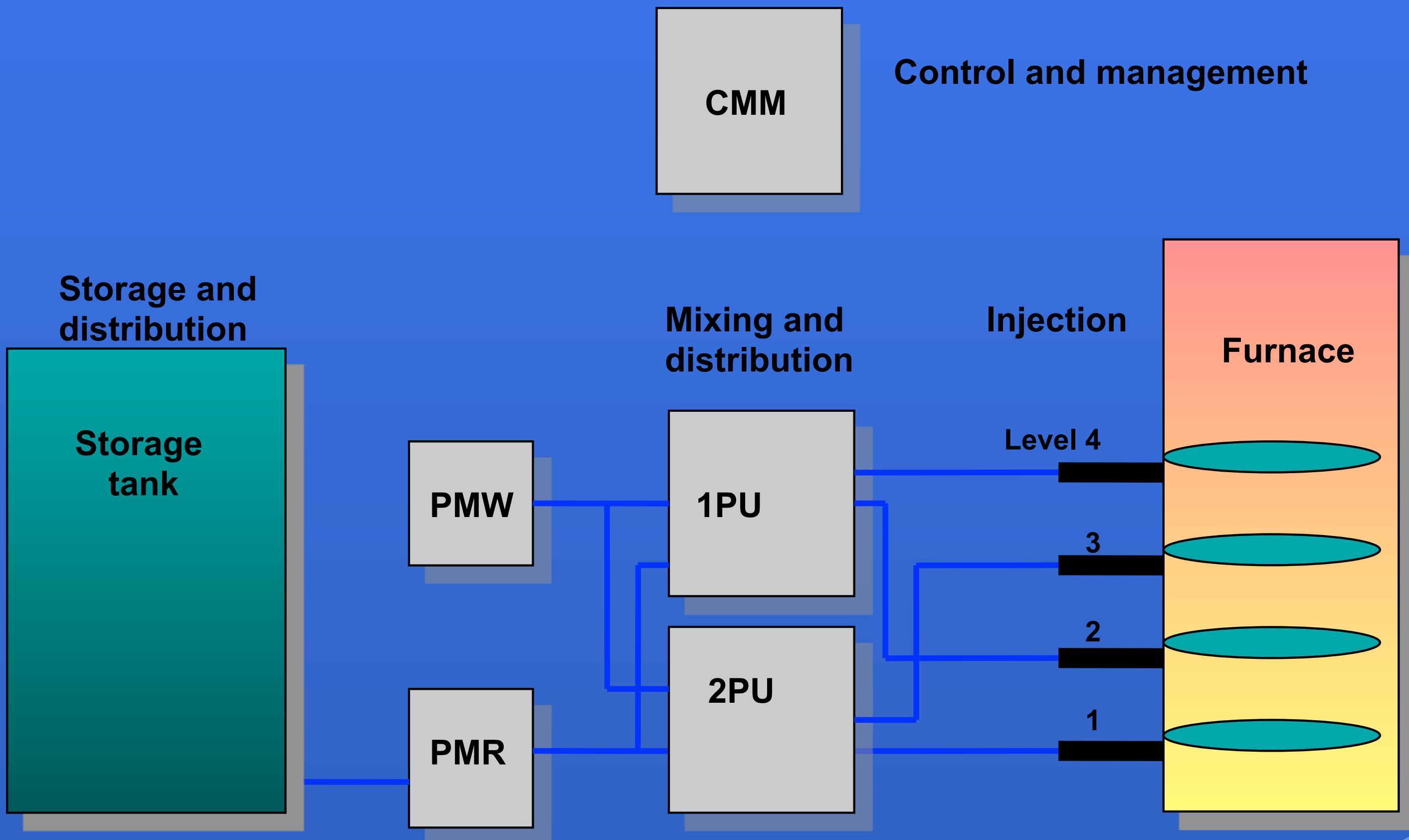
% for residence time of 1-3s



% for residence time of 0,5-1s

SNCR Technology

- Injection on multiple levels



SNCR Technology

- Performance

From 30% to 90% NOx reduction ratio

Coal fired plants < 100 MWth → 30-50 %
WtE/Biomass < 90 MWth → <= 60%
Cement / Kilns → up to 90%
Industrial Kilns → 20-60%
Large Size Boiler (~ 220 MW) → ~20-30%

SNCR Technology

- Constraints

Operating Temperature : Min 850 °C/1560°F

Max 1100°C/ 2010 °F

Residence time >= 0.5 s

Sensitive to reagent type : Ammonia vs Urea

Injection of water and energy loss (boiler)

SNCR Technology

- **CAPEX**

  Wide range depending on scope, sizing and performance required

  Unloading, storage, injection

  USD 200K – 500K*

  excl. installation/erection

Comparison SCR/SNCR

	SNCR	SCR
NOx reduction Efficiency	90% best, 65% avg	Up to 95%
Design Temperatures	From 1,500 to 2,000 °F	From 375 to 850 °F
Reagent	Ammonia/Urea	Ammonia/Urea
Molar Ratio (NH3/NO)	1 to 2	1
Ammonia Slip	7 ppmvd best, 15 ppmvd avg	2 ppmvd
Catalyst	no	yes
Reactor	no	yes
Maintenance	minor	Catalyst replacement or regeneration to be considered
Pressure Drop	No	Yes
Capex	USD 500K	USD 2,000K

Conclusions

- Proven technologies
- Not a “one size fits all” type of solution
- Lower temperature, higher complexity
- Consideration for future regulations