Topsoe's Emission Management Solution--DeNOx

Presented by :

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HALDOR TOPSOE

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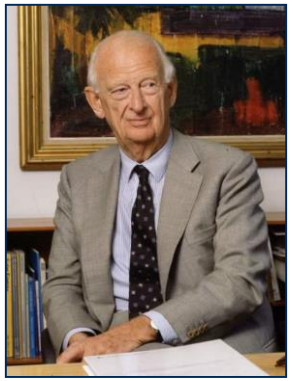
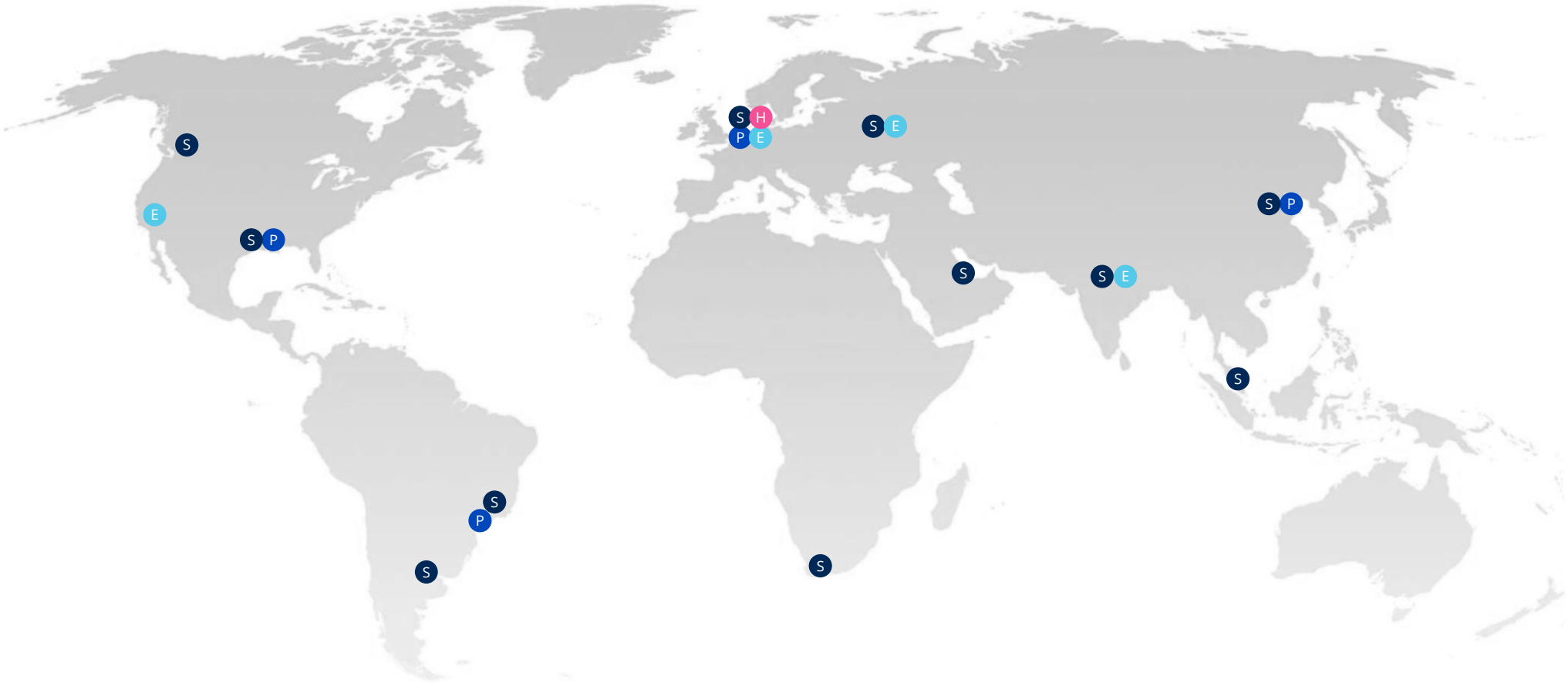
Haldor Topsoe Company in brief



- Established in 1940 by Dr. Haldor Topsøe.
- Market leader in heterogeneous catalysis and surface science for 75 years.
- More than 2,800 employees in 11 countries across five continents.
- 2015 revenue of approximately USD 1 billion
- Headquarters in Denmark.
- Production in Denmark, and Houston, Texas, USA.
- New plants in Tianjin, China, and Joinville, Brazil, in 2015.
- Spends more than 10% of revenue on R&D.

Headquartered in Denmark,
our 2,800 employees work with customers all over the globe

Locations:
Bahrain
Beijing
Buenos Aires
Cape Town
Copenhagen
Edmonton
Houston
Joinville
Kuala Lumpur
Los Angeles
Moscow
New Delhi
Rio de Janeiro
Tianjin

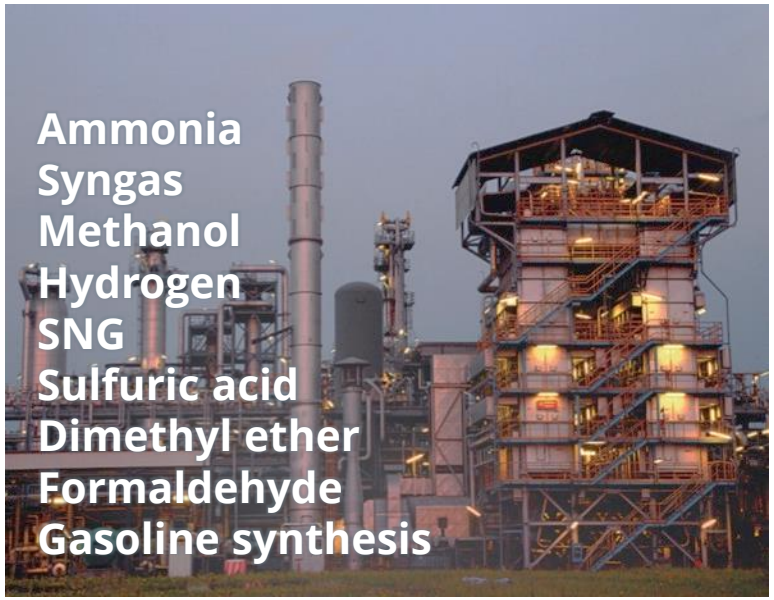


- H Headquarters
- P Production
- E Engineering
- S Sales & Service

HALDOR TOPSØE

We provide a full range of products and services for a broad range of business

Chemical Processing



Hydroprocessing

Emissions Management

Process design, Engineering, & licensing + High-performance catalysts + Proprietary equipment + Business & technical services

Haldor Topsoe Solution
For Environment Protection

Technology to transform sulfur pollutants into sulfuric acid

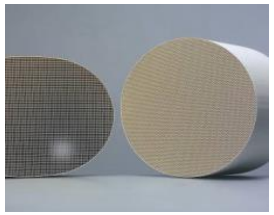
Catalysts to clean the vehicle exhaust

Technologiy to remove nitrogen oxides

Technology to treat volatile organic compounds

Topsoe's Environmental Solution

- SCR DeNOx for removal of NOx: DNX® catalysts
  Stationary sources: Power plants, turbines, engines, waste incineration, chemical processes etc.
- Automotive DeNOx
  Trucks, buses, generators, etc.
- Sulfuric acid: VK catalysts
  SO_2 to SO_3 conversion
- Treatment of sulfurous waste gases: WSA
  Refineries, gasification, coke, viscose, metallurgy, etc.
- Flue gas desulfurization: SNOX™
  Combined removal of SOx, NOx and particulates from combustion of high sulfur fuels
- VOC removal: CK catalysts
  Catalytic oxidation of solvents, etc.
- Catalytic filters
  Combined removal of particulates, NOx, CO, and VOCs



Wet gas Sulfuric Acid

A process for cleaning sulfur containing streams under production of concentrated sulfuric acid

Lean H_2S gas
Rich H_2S gas
SRU tail gas
SWS gas
SO_2
SO_3
Spent H_2SO_4

WSA

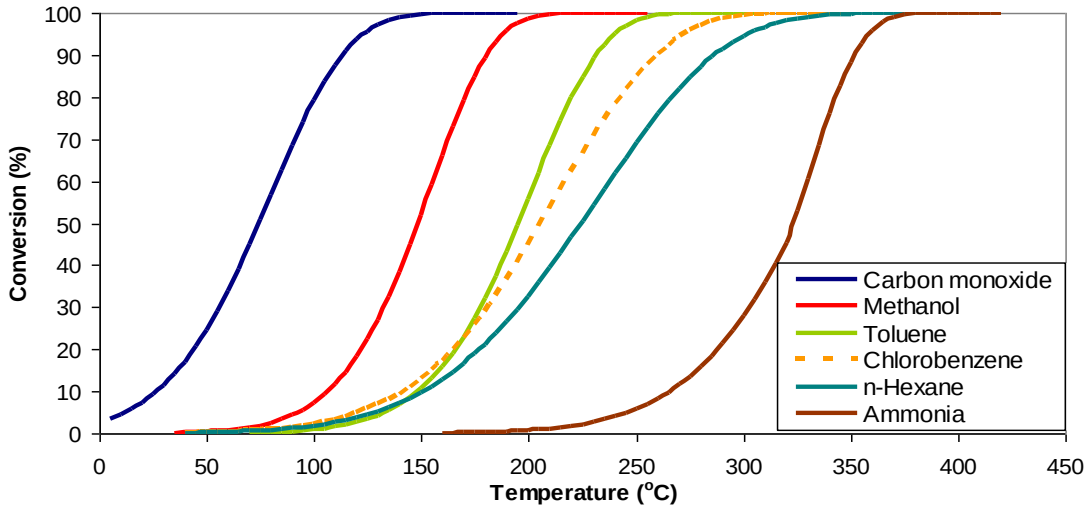
Cleaned gas

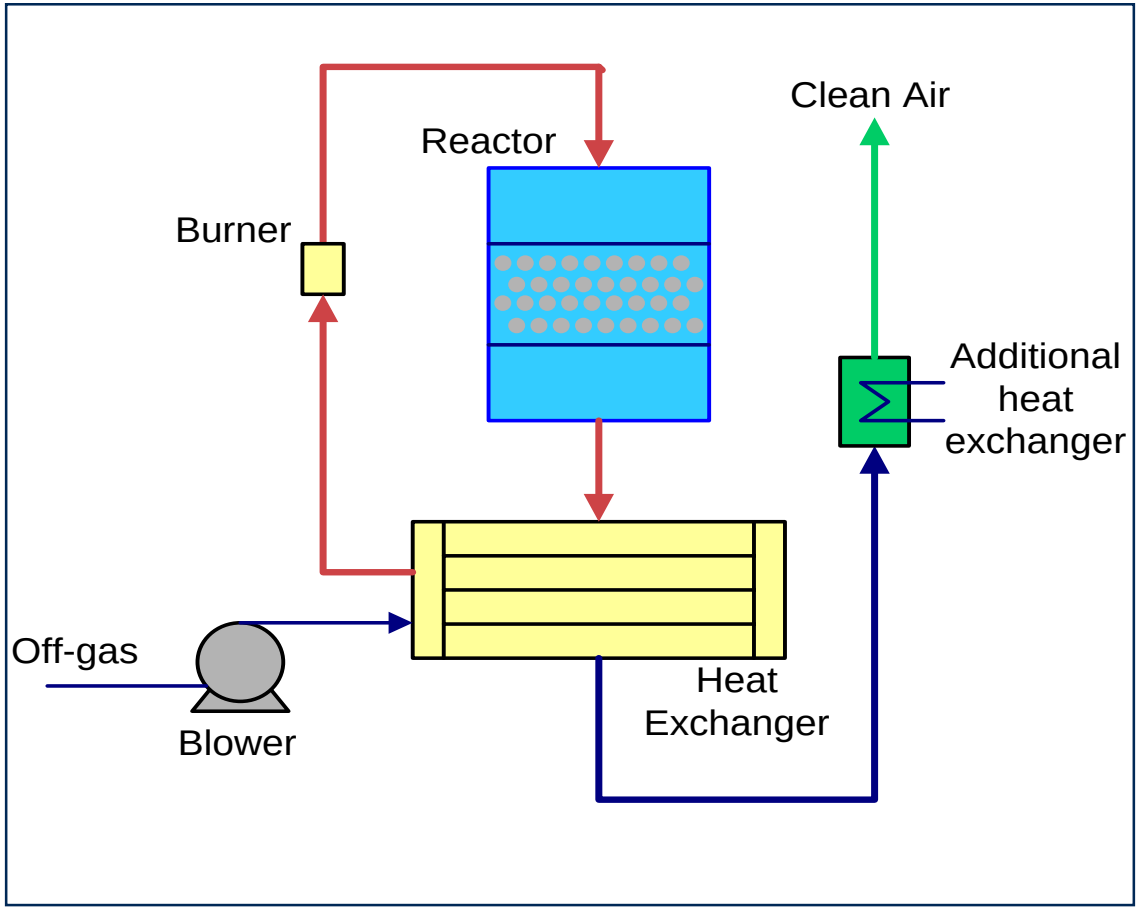
HP Steam

H_2SO_4

Catalytic combustion process
General

$$VOC + O_2 = CO_2 + H_2O$$



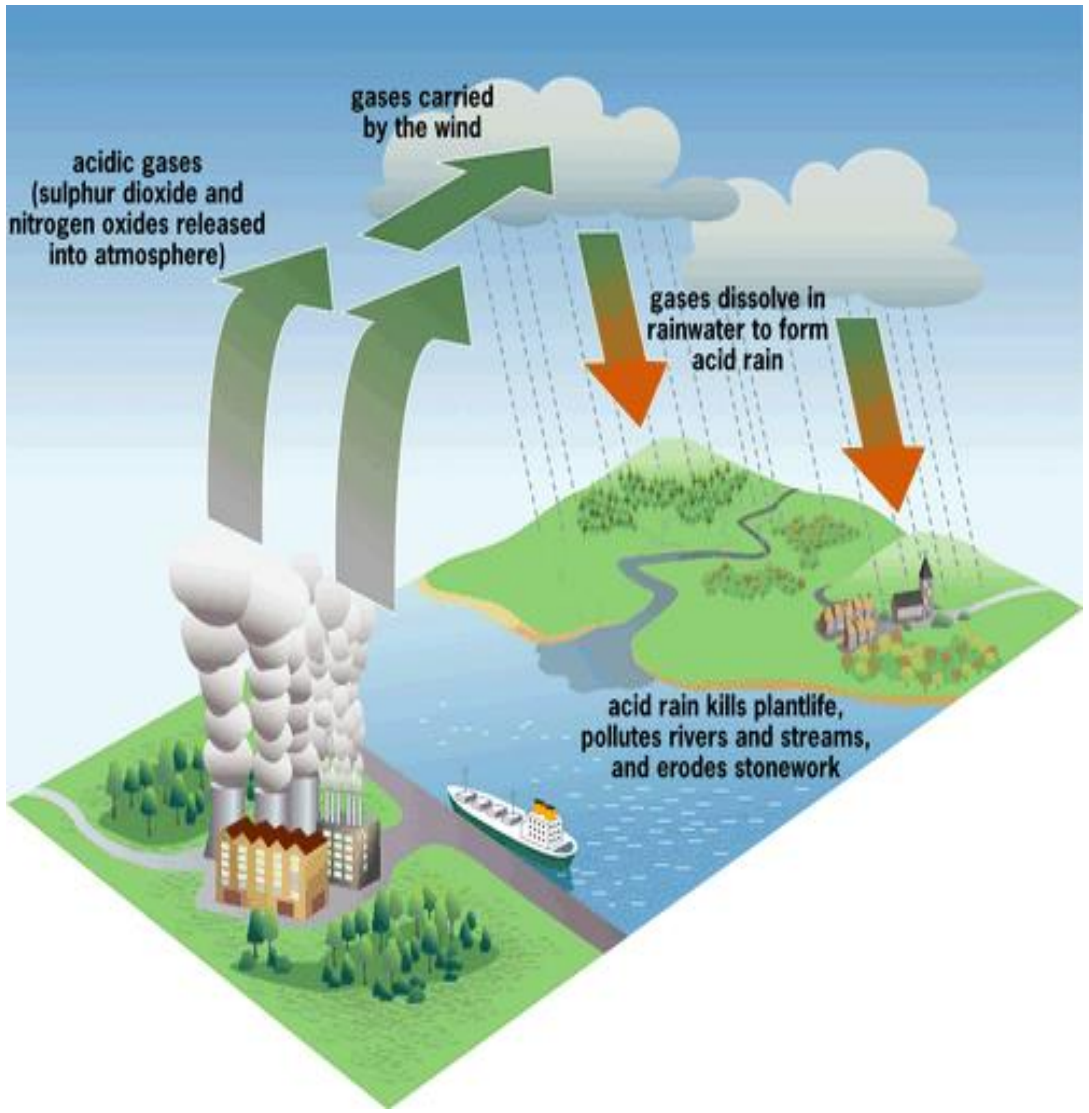


01

DeNOx Technology

What is NOx?

- NOx is oxides of nitrogen, NO and NO_2
- NOx is formed by:
  - Natural sources like lightning
  - Biogenic sources like nitrogen fixing plants and microorganisms
  - Man made from combustions processes
- NOx emissions cause adverse effects on health, property, and the environment:
  - Smog, PM, acid rain causing deforestation and destruction of water life, ground-level ozone
    - $NO_2 + O_2 + hv \rightarrow NO + O_3$
    - $4\ NO + 3\ O_2 + 2\ H_2O \rightarrow 4\ HNO_3$
- Emission of NOx is regulated in many regions of the world
  - Maximum NOx emission vary local environmental requirements



NOx formation by combustion

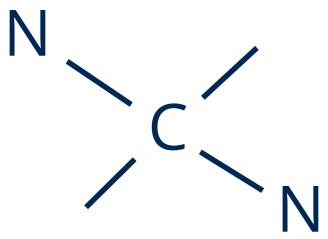
Fuel NOx

- Formed by oxidation of nitrogen containing compounds in the fuel

Governed by:

- Temperature
- Oxygen level
- Residence time

Predominate in fossil fuels as oil and coal



$+ O_2 \rightarrow NOx$

Thermal NOx

- Formed by oxidation of atmospheric nitrogen from the combustion air:

$$N_2 + O_2 \rightarrow 2\ NO$$

$$2\ NO + O_2 \rightarrow 2\ NO_2$$

Predominate in gas firing

Why clean the flue gas - DeNOx

- Normally driven by legislation
- Fines or taxes as function of the amount of NOx emission

BUT .....

- Turn the picture around?
  - look at the benefit of DeNOx and use it as a green image!

A green image sells

- ”Green” and ”Environment” safe technology is desired today
- Many companies around the world have a green strategy and use it actively in their marketing

NOx reduction is green image

Range of NOx reduction options

Operating Considerations

- Combustion modifications
- Excess air maintenance
- Flue gas recirculation
  - Up to 30% reduction
- Burner operation & maintenance
- Fuel conditioning

Technology Considerations

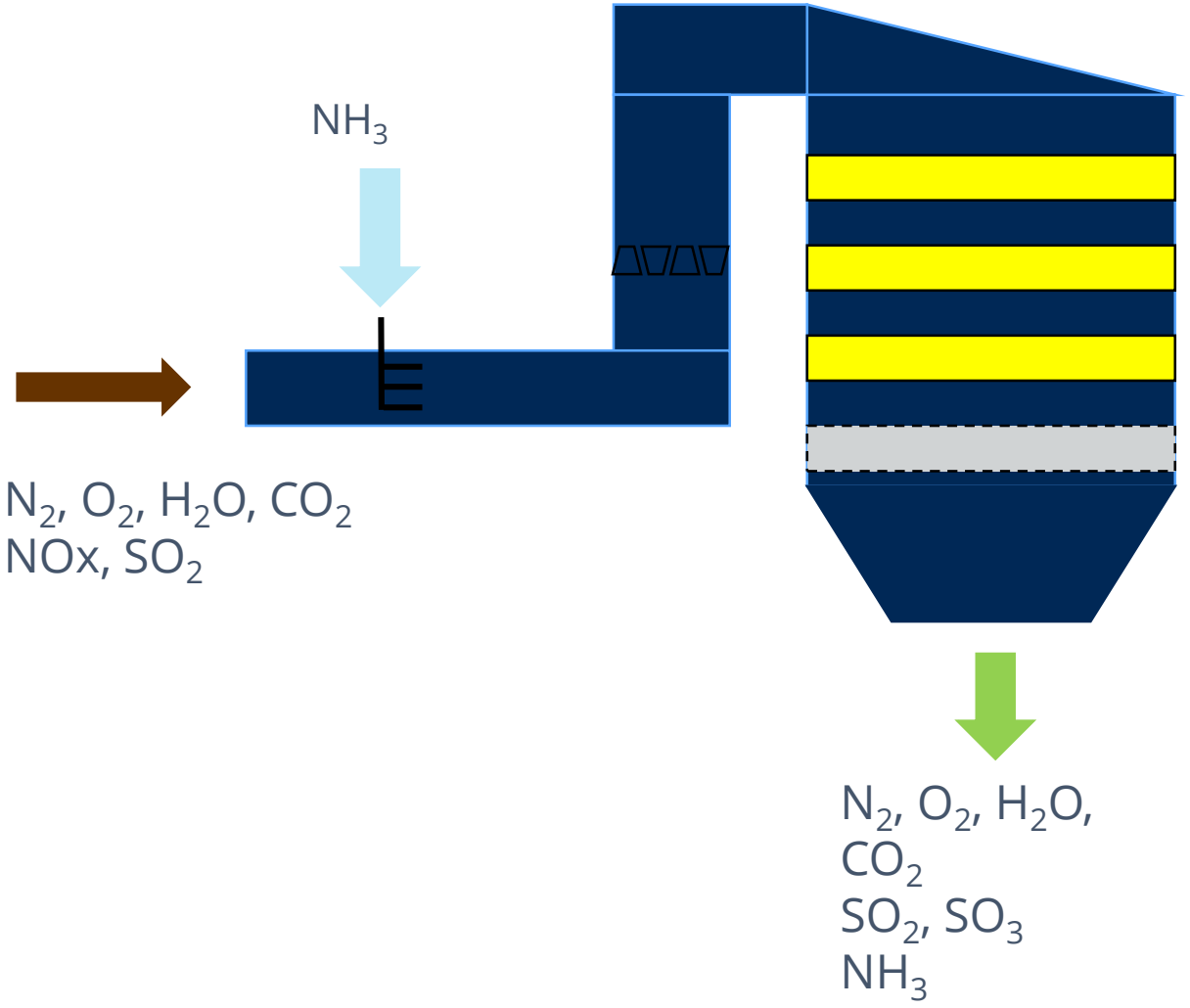
- Low NOx burners
  - Up to 40% reduction
- Selective Non-Catalytic Reduction, SNCR
  - Up to 30-60% reduction
- Selective Catalyst Reduction, SCR
  - Up to 98-99% reduction

.....Best Available Technology

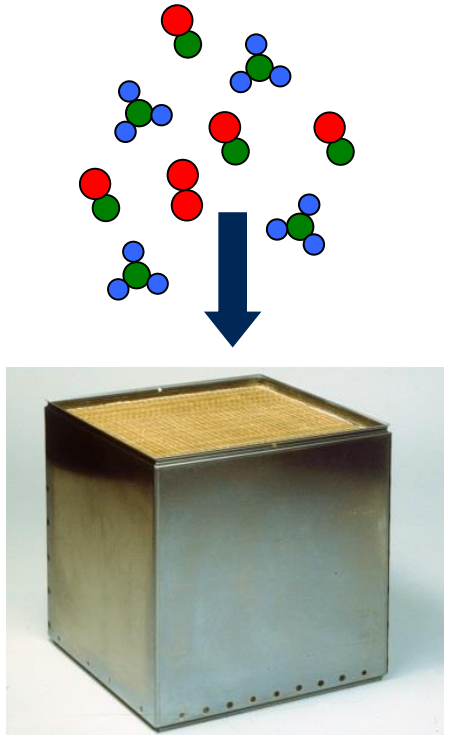
SCR – What it does

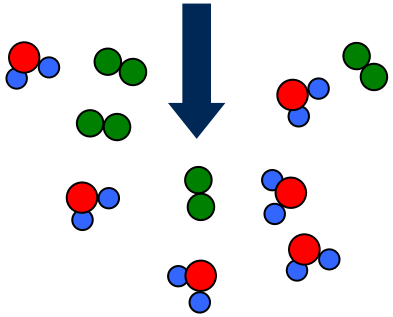
Inject NH_3, mix with NOx, pass through a catalyst = DeNOx

- A reducing agent, most commonly ammonia (NH_3), is injected and mixed into the process gas stream, sometimes using mixing plates.
- The mixed gas then passes through the catalyst layers where the NH_3 reacts with NOx on the catalyst surface and in the pores to form N_2 and H_2O vapor
- Temperature is typically 350-400°C (160-550°C)
- Catalyst is based on vanadium pentoxide



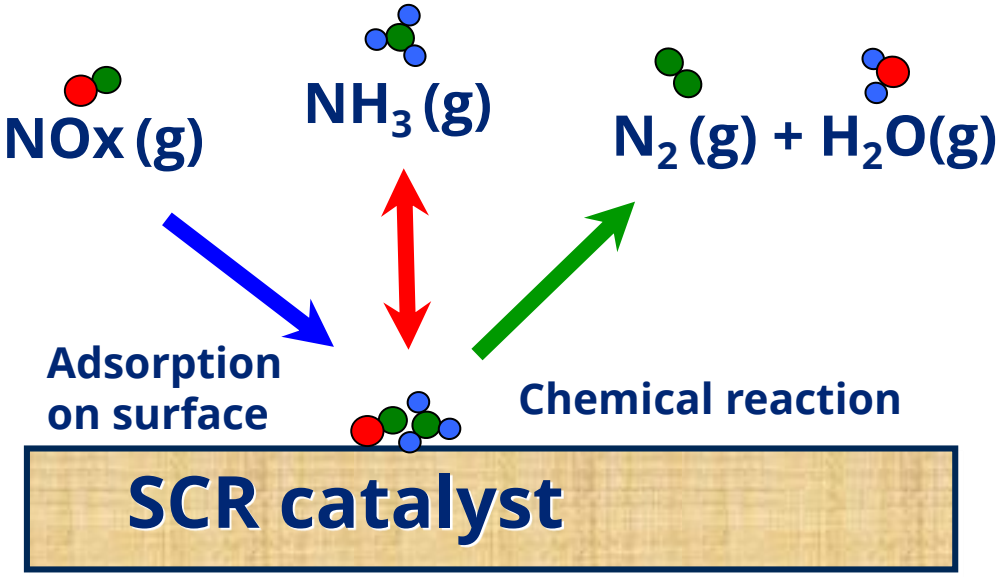
SCR DeNOx reactions



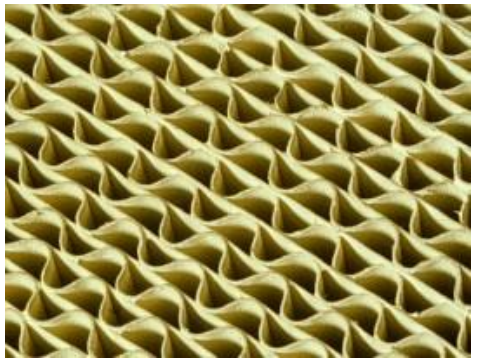


$$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$$

$$NO + NO_2 + 2\ NH_3 \rightarrow 2\ N_2 + 3\ H_2O$$



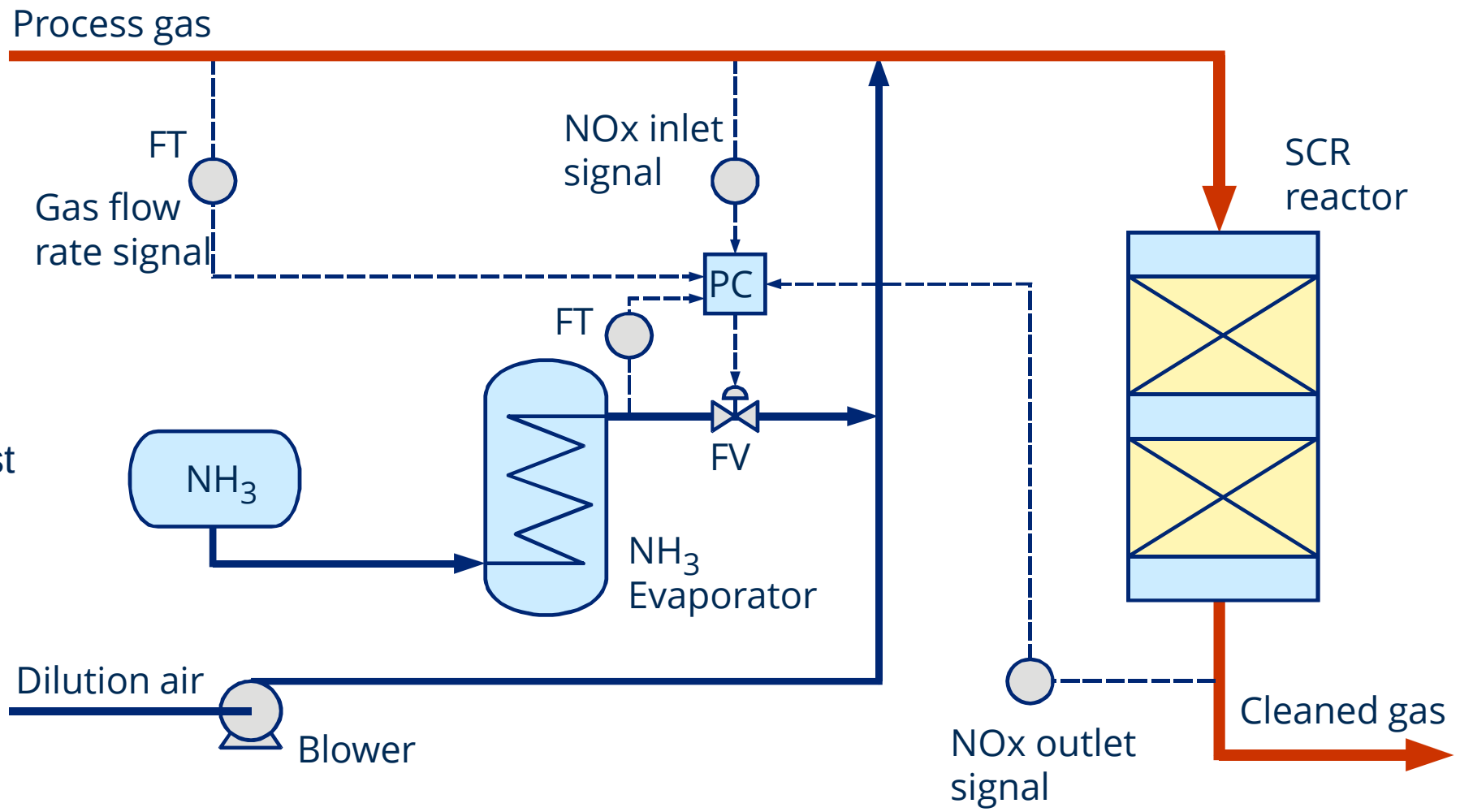
Vanadium pentoxide, V_2O_5
Tungsten trioxide, WO_3
Titanium dioxide carrier, TiO_2



General SCR layout

Main components:

- Ammonia storage
- Ammonia evaporation
- Ammonia injection
- SCR reactor and catalyst
- Control system



SCR of NOx by NH_3

Proven technology for effective NOx removal

Operating temperature: 180 – 450 °C

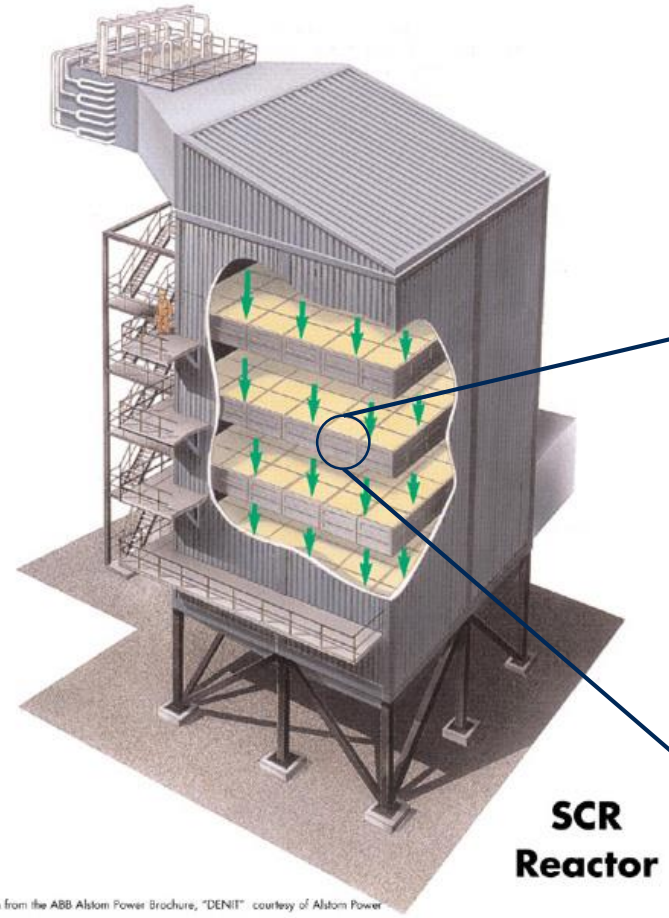
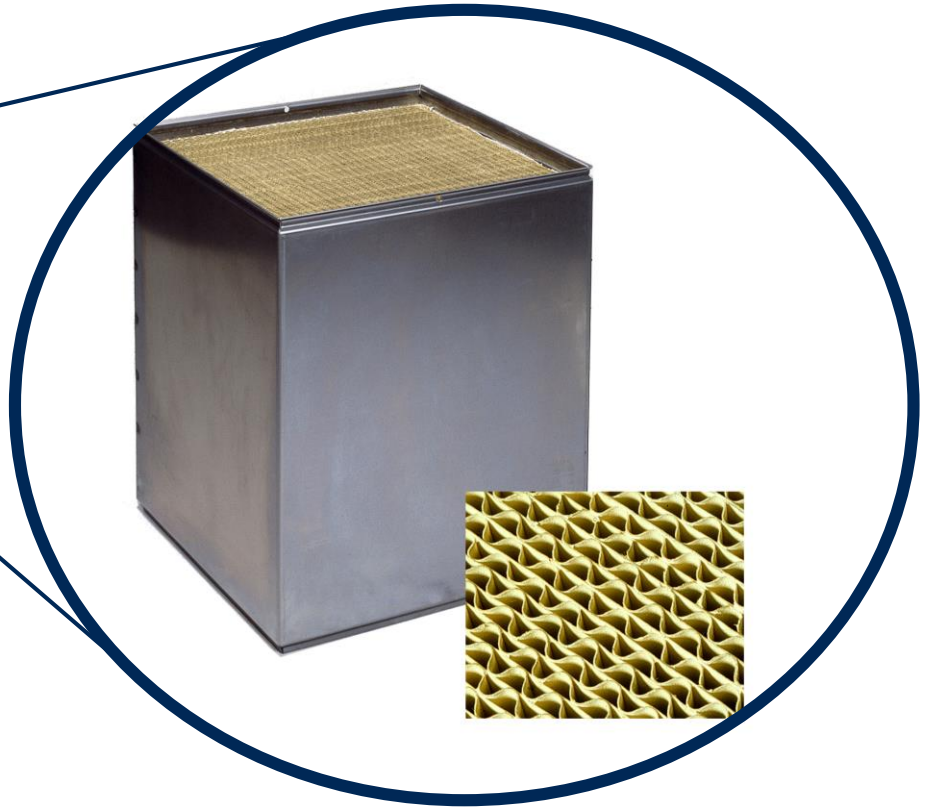
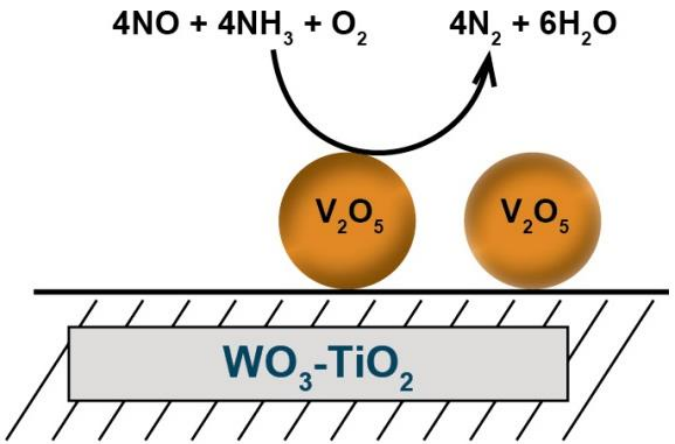


Illustration from the ABB Alstom Power Brochure, "DENIT" courtesy of Alstom Power





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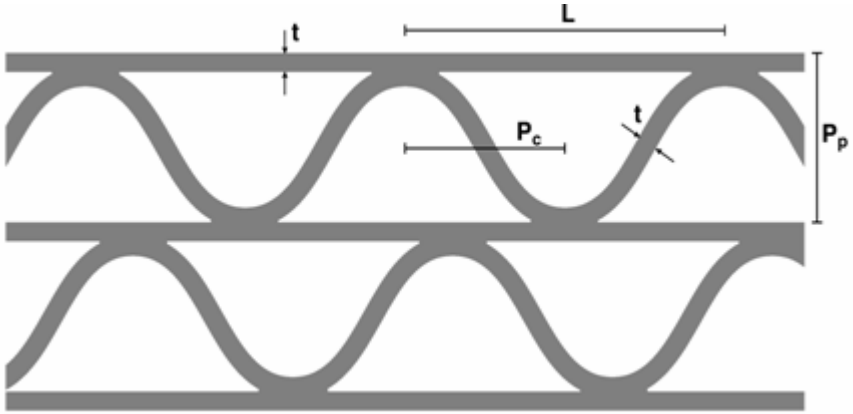
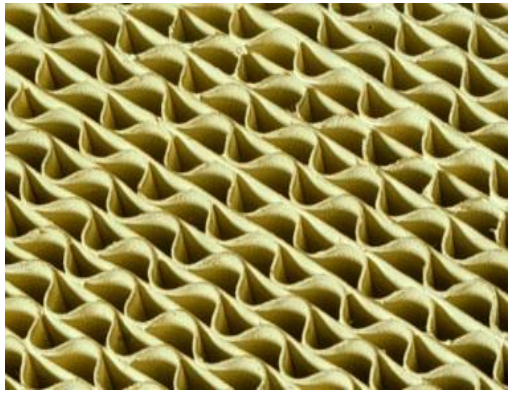
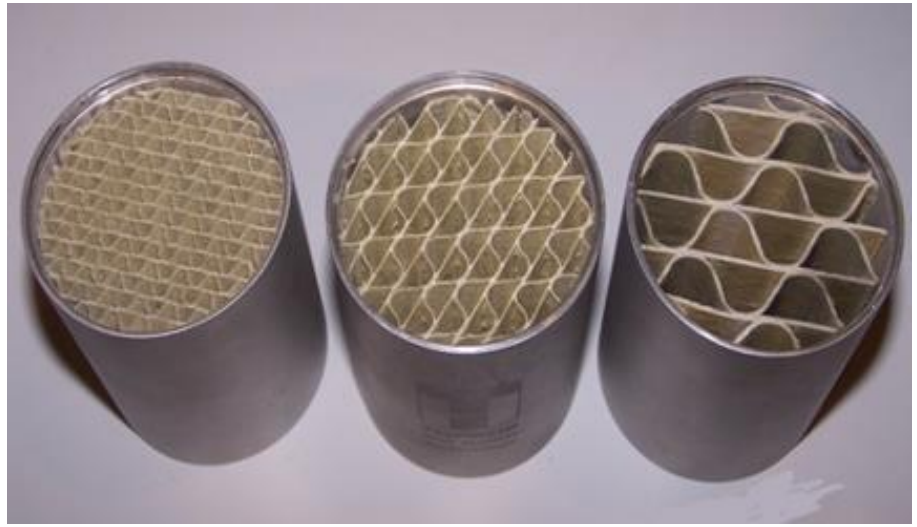
Topsøe DNX® catalyst - product range

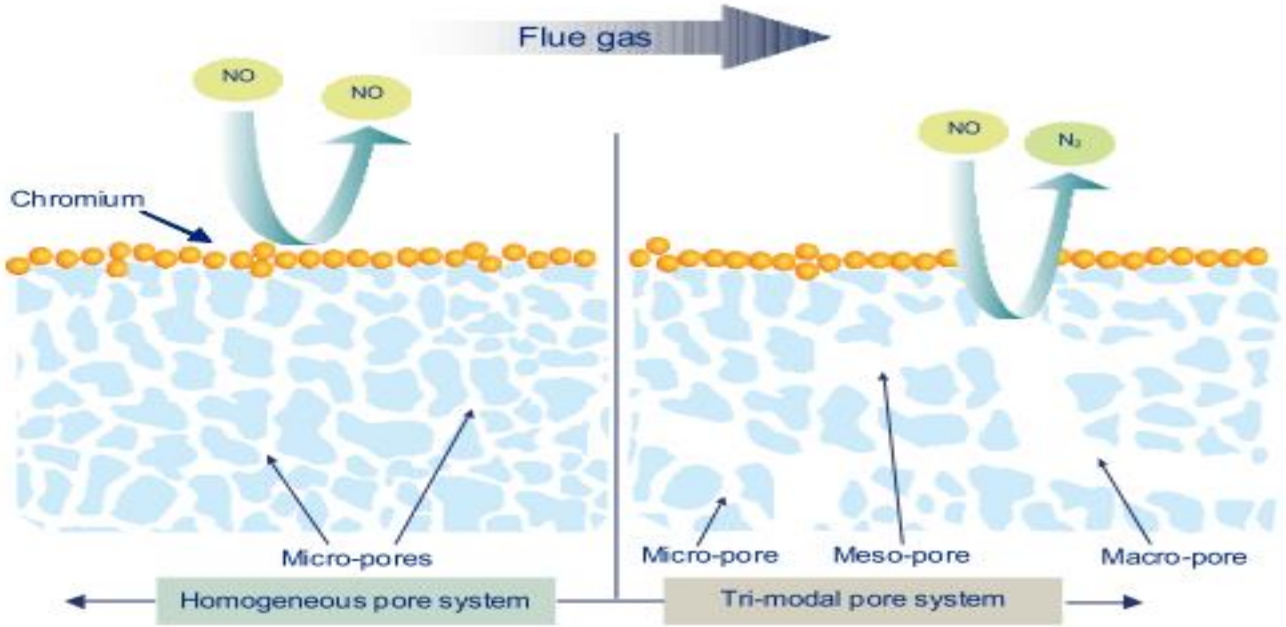
- Channel size
  - 2.7 – 9 mm
- Wall thickness
  - 0.3 – 1.0 mm
- Chemical compositions
  - 10 different to adapt to specific operating conditions

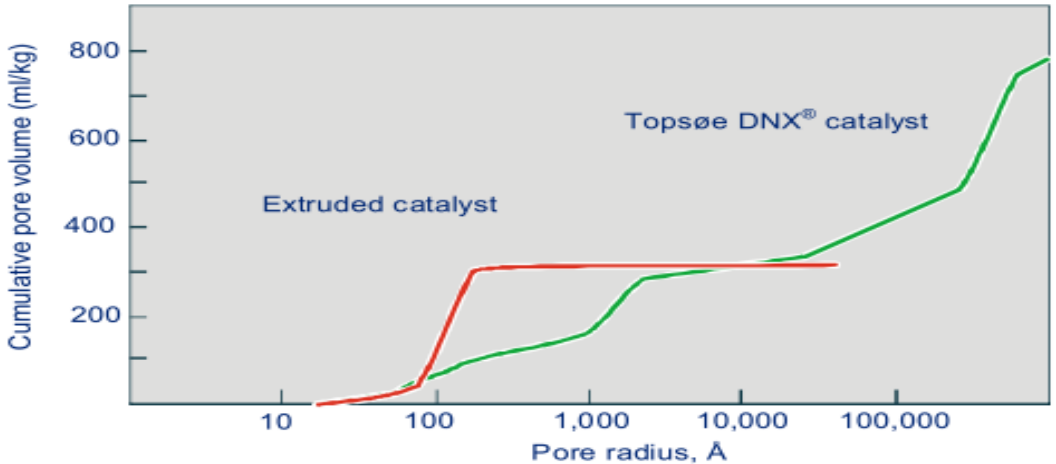






Advantages of Topsoe DNX Catalyst & Technology

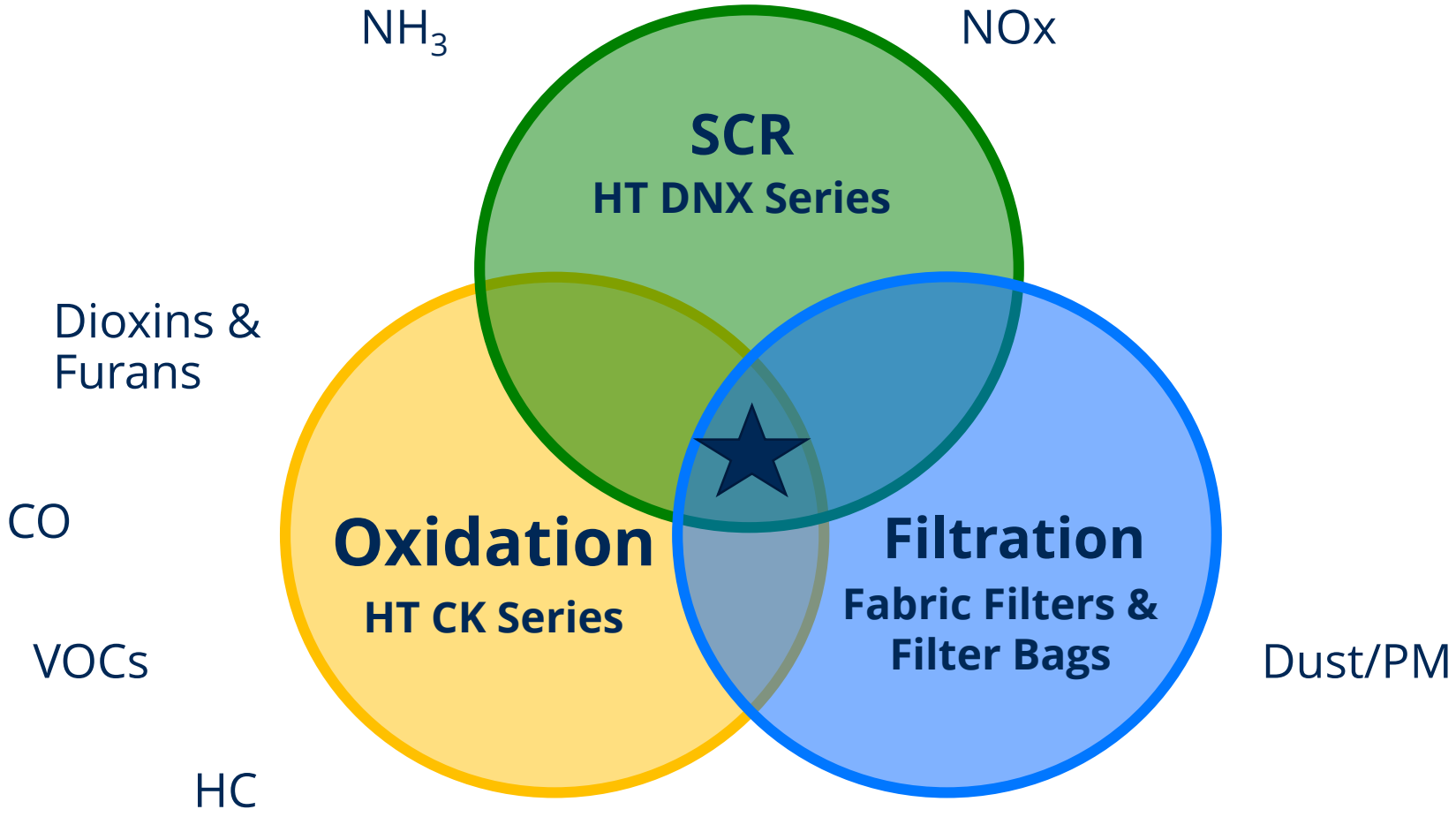




Topsoe Operating Experience:

- Gas flows up to 2.7 million Nm^3/h.
- SOx contents up to 5% (vol.).
- Temperatures between 225 and 475˚C.
- Pressures up to 4 bar.
- Dust contents up to 50 g/Nm^3

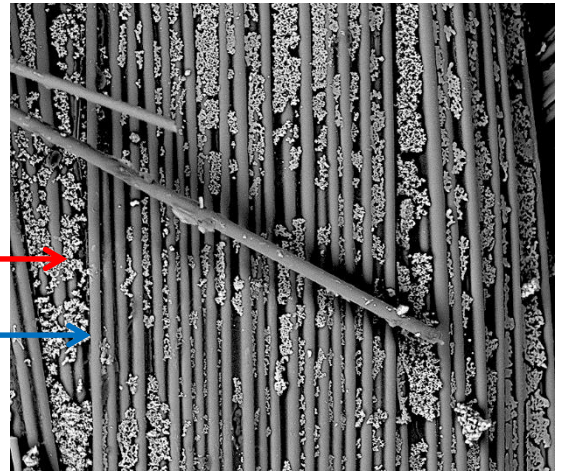
Combining competences
Haldor Topsoe

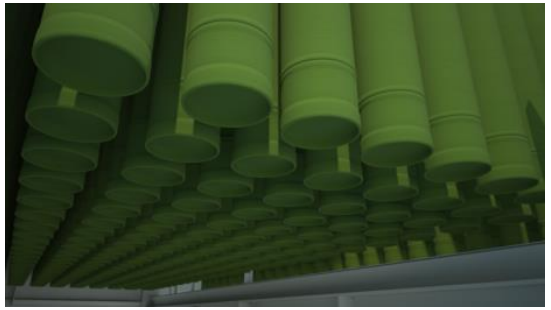


CataFlex™ catalyzed filter technology

CataFlex™ catalytic filter bags

- Each bag consists of up to three fabric layers, impregnated individually
- Combined removal of NOx, ammonia, CO, VOCs, and dust
- No poisoning of catalyst
- Temperature from 180°C up to 260°C
- High filtration efficiency, less than 2 mg/Nm^3
- 6 - 12 m length
- Can replace existing bags in any baghouse



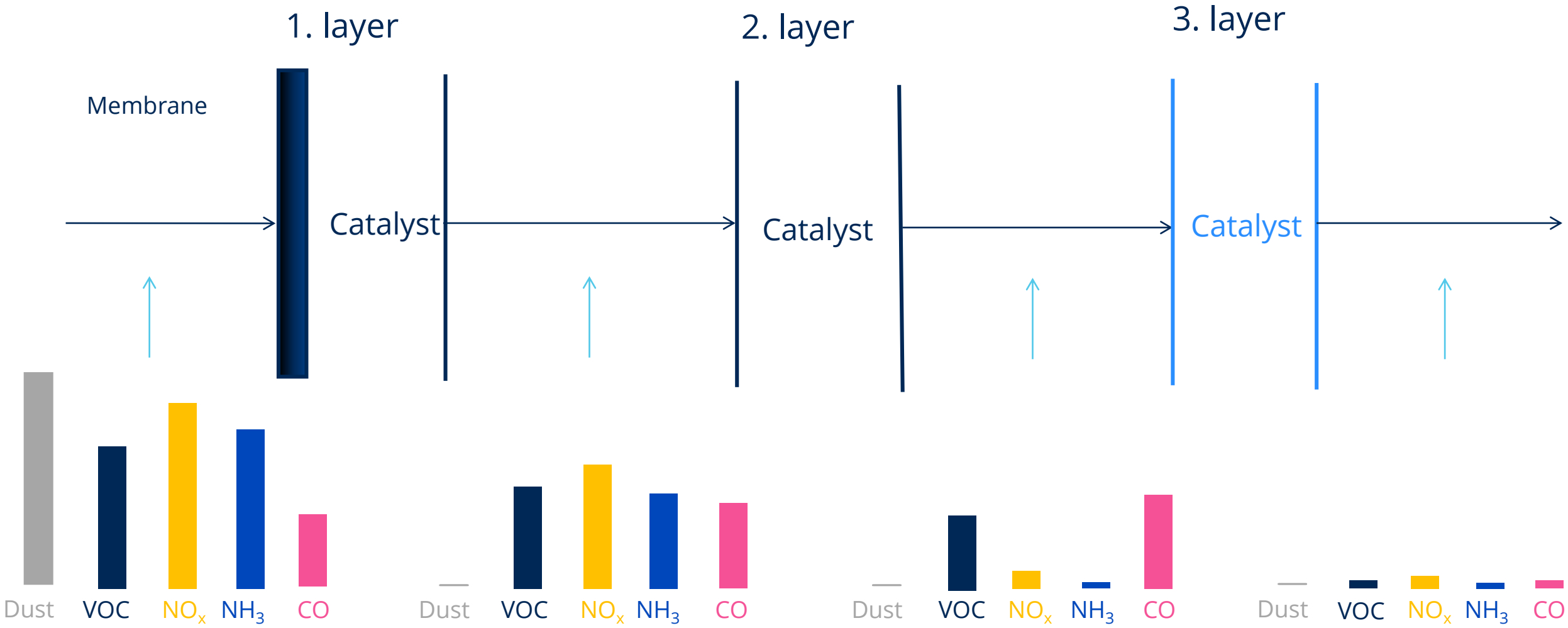


TopFrax™ high temperaure filter technology

TopFrax™ catalytic ceramic filters

- The filter candles consist of a ceramic fiber based filter impregnated with a catalyst in the filter wall (20 mm thickness)
- Combined removal of NOx, ammonia, CO, VOCs, and dust
- No poisoning of catalyst
- Up to 350-400°C (filter up to 900°C)
- High filtration efficiency, less than 2 mg/Nm^3
- 1-3 m length

Schematic illustration of the catalytic filter bag



Concluding remarks

Some key messages:

- NOx is major problem globally, causing great damages to the environment, the health, and to property
- NOx emissions are becoming regulated in still more areas and limits are continually being tightened
- SCR is considered BAT, Best Available Technology, for most applications
- Costs for reducing NOx is far less than the damage costs
- New catalytic technologies become available, enabling e.g.
  - Combined removal of several air pollutants as NOx, CO, dust
  - Application of SCR DeNOx also in difficult areas as waste incineration and cement production

Let's Make India
Clean &
Green.....
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