Advanced Technology to control PM, Nox, VOCs in a cost effective Manner.....

Presented by :

SACHIN PANWAR

HALDOR TOPSOE

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Why Clean the Flue Gas?

Asian Age/New Delhi/February 14, 2013

'Air pollution 5th largest killer in India'

RASHMI SEHGAL
NEW DELHI, FEB. 13

Air pollution has jumped to number five spot amongst the top killers in India.

Releasing India-specific data, the Global Burden of Disease (GBD) warned that outdoor air pollution caused 627,000 deaths and 17.7 million healthy years of life lost in 2010.

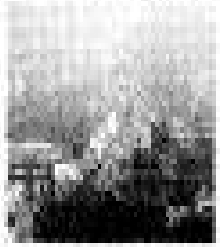
Worldwide, outdoor air pollution caused 3.2 million premature deaths and over 74 million years of healthy life lost in 2010.

A substantial rise in cardiovascular diseases, strokes and chronic obstructive pulmonary diseases in India in 2010 are directly attributed to rising levels of particulate matter pollution.

Two-thirds of the rising disease graph worldwide are found in South Asia.

Dr Vinod Raina, heading the oncology wing at AIIMS, confirmed that "we are getting 10 lakh new cancer cases every year, out of which approximately one lakh are lung cancer cases. We still have to quantify how many of these lung cancer cases are pollution-related".

Dr Aaron Cohen, principal scientist, Health Effects Institute, Boston, and chair of the Air Pollution Group at Institute for Health Metrics and Evaluation for Global Burden of Disease, pointed out that a study of lung cancer amongst non-smokers had shown a 9% per cent increase caused by air pollution.



Prof. S.K. Chhabra, heading the department of cardiorespiratory physiology at the Vallabhbhai Patel Chest Institute, warned against the risk from new generation pollutants, especially ozone which is currently responsible for a four per cent increase in mortality rates.

"Ozone has become a key ingredient of urban smog," said Prof. Chhabra.

Prof. Randeep Guleria, head, pulmonary unit, AIIMS, highlighted how indoor air pollution had emerged as another major killer amongst women using biomass for their cooking requirements. "Women in the Gujjar community suffer high incidence of cancer caused by indoor air pollution," Prof. Guleria explained.

The India-related data was calculated from the largest global database ever assembled using India-specific levels of baseline mortality and incidence of five leading causes of death in India and was released at a workshop organised by ICMR and CSE.

The 2010 GBD was produced by a rigorous scientific process involving 100 global experts led by the Institute of Health Metrics and Evaluation along with WHO and Harvard University.

CAPITAL BREATHES UNEASY

Tops global cities with worst air pollution

1. NEW DELHI, INDIA
2. BEIJING, CHINA
3. CAIRO, EGYPT
4. SANTIAGO, CHILE
5. MEXICO CITY, MEXICO

INDIA SLIPS IN RANK TOO

Is second most polluted among its neighbours

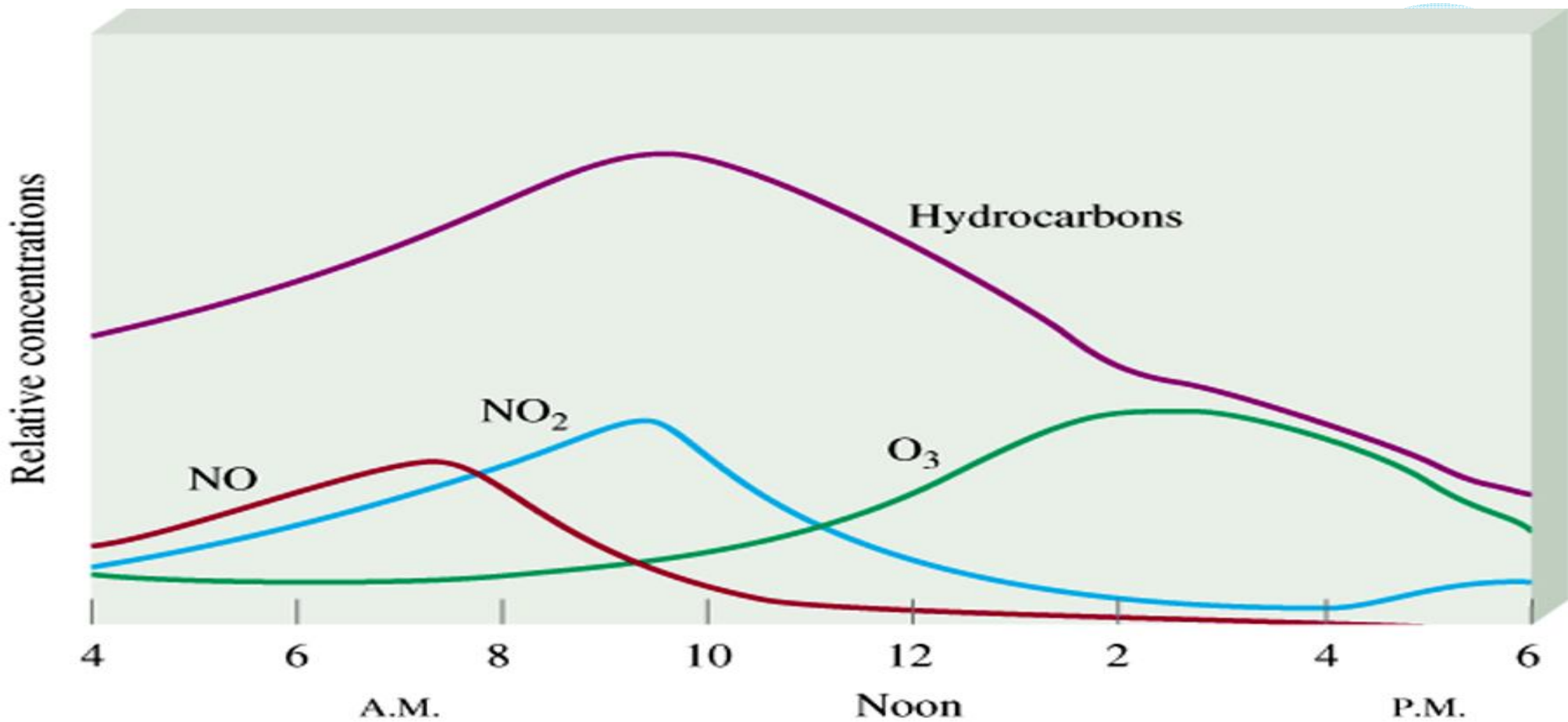
	2014	2010
Bangladesh	169	139
India	**155**	**123**
Pakistan	148	125
Nepal	139	38
China	118	121
Sri Lanka	69	58

- **Ranking based on 9 parameters:** Health impact, air pollution, water & sanitation, water resources, agriculture, fisheries, forests, biodiversity & habitat, climate change & energy
- On list of 178 countries, India ranks as low as 174 on air pollution, 127 on health impact

5 CLEANEST COUNTRIES: Switzerland, Luxembourg, Australia, Singapore and Czech Republic

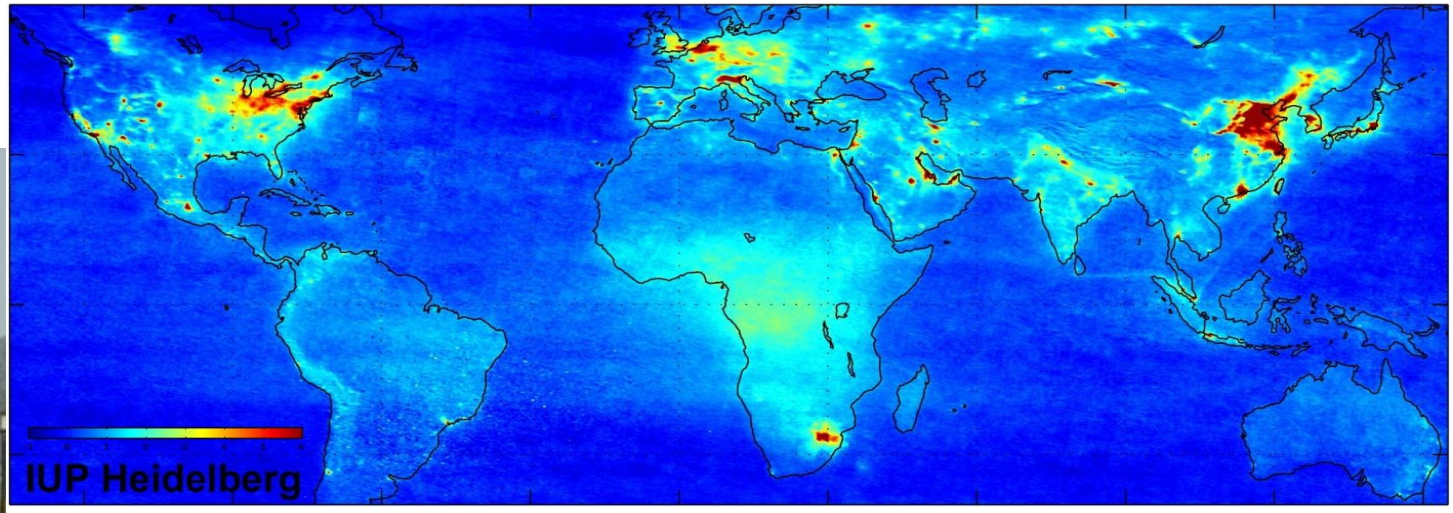
Major Contributing Factors
For Air Pollution

Daily cycle of pollutant concentration

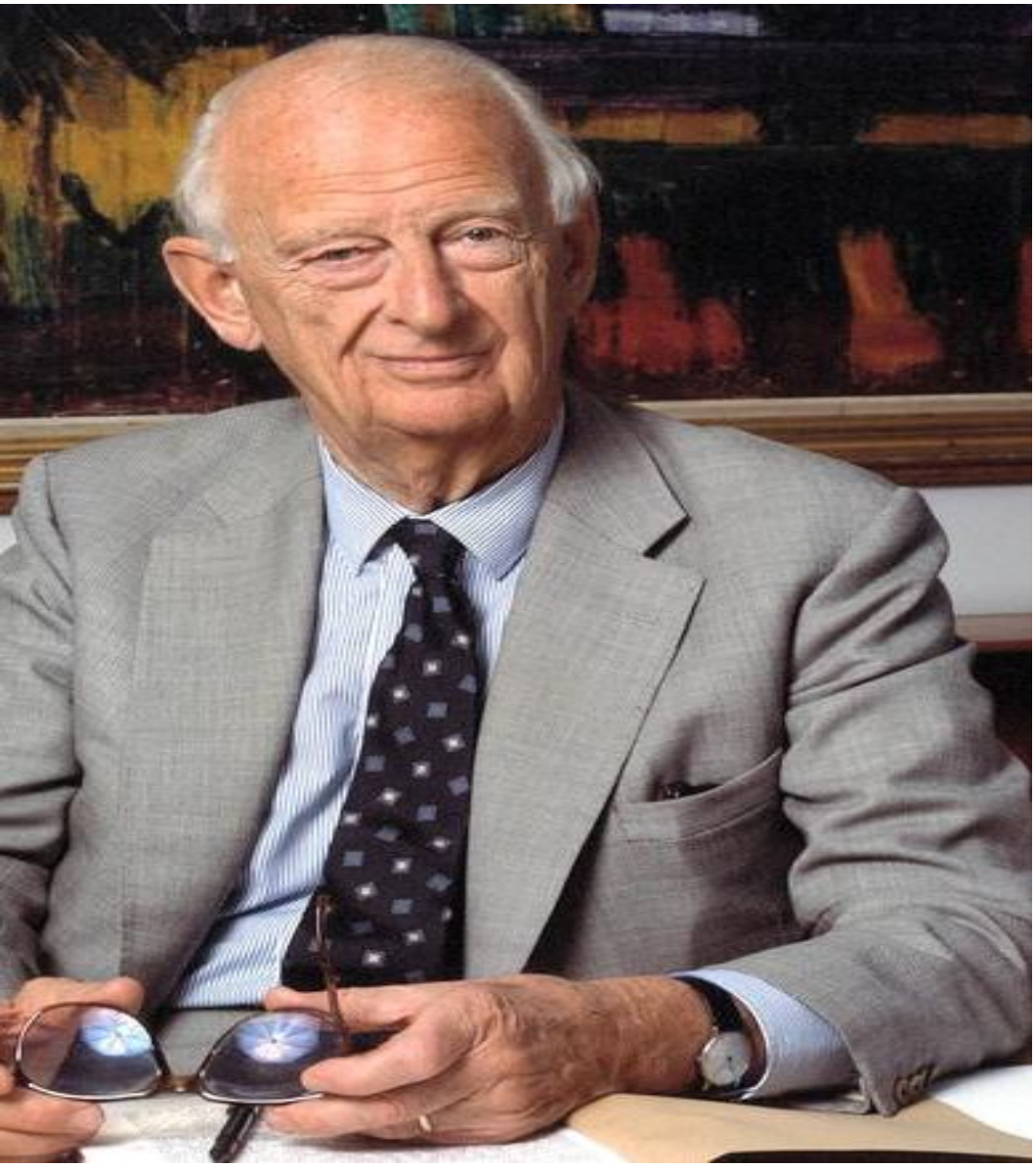


Why VOCs, NOx ,SOx, PM are threat?

- Forms ground level ozone (or smog)
- Triggers asthma attacks and cancer
- Contributes to acid rains



HALDOR TOPSØE



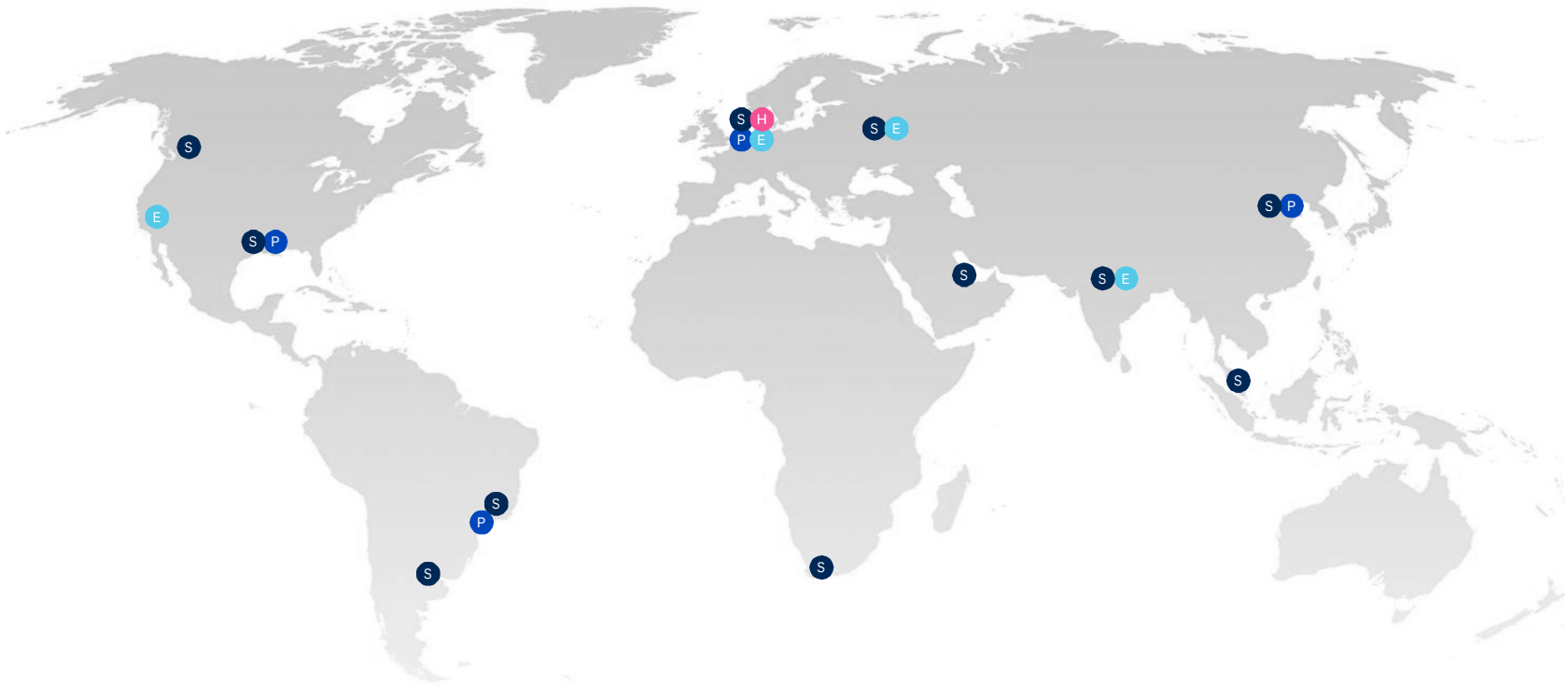
Haldor Topsoe in brief

- Established in 1940 by Dr. Haldor Topsøe.
- Private 100% family-owned company.
- Market leader in heterogeneous catalysis and surface science for over 70 years.
- Around 2,800 employees in 11 countries across 5 continents.
- Headquarters in Lyngby, Denmark.
- 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

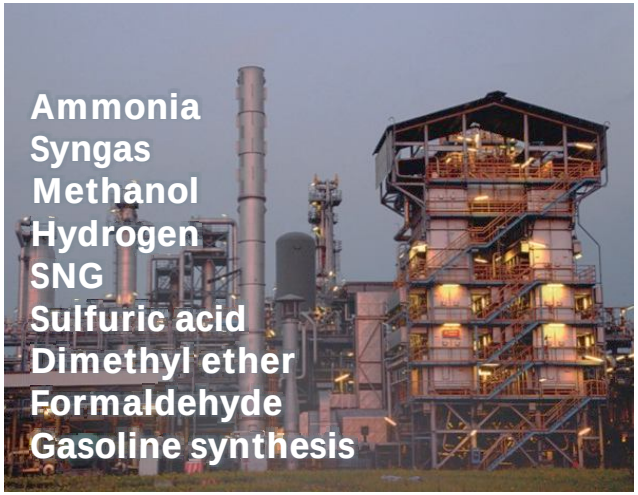
H Headquarters
P Production
E Engineering
S Sales & Service



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

Catalytic Process- Fundamental steps

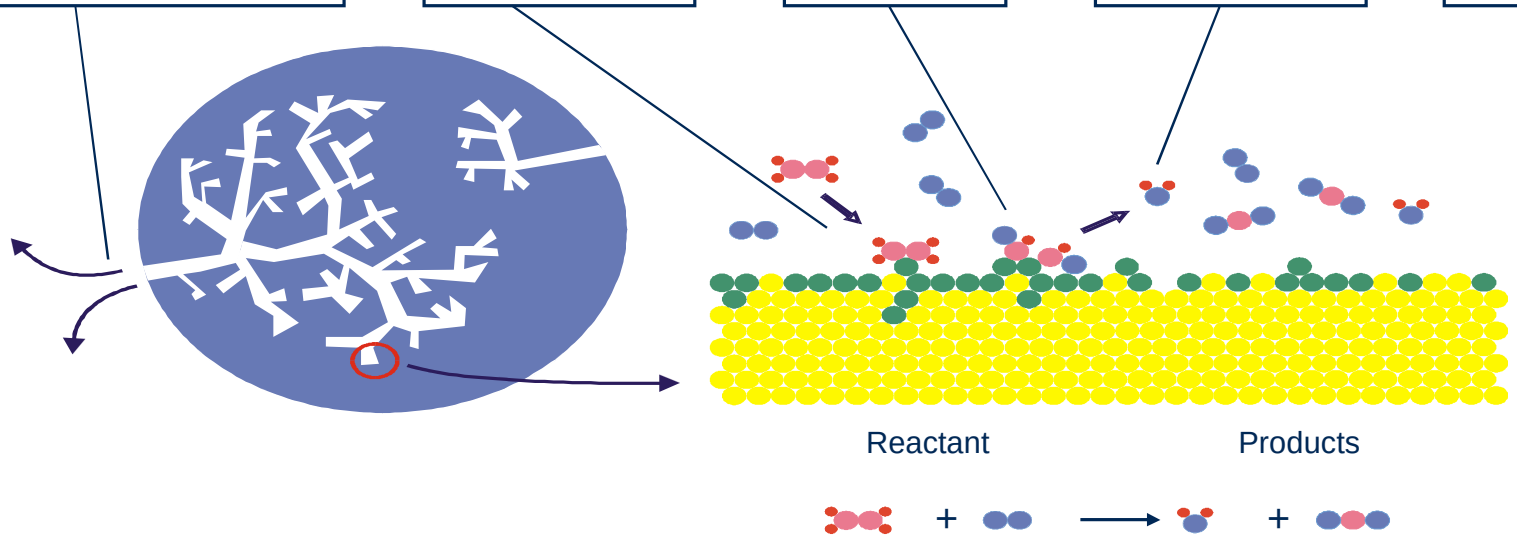
1. Step
Gas phase transport and pore diffusion of educts

2. Step
Adsorption of educts

3. Step
Surface reaction

4. Step
Desorption of products

5. Step
Gas phase transport and pore diffusion of products



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

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

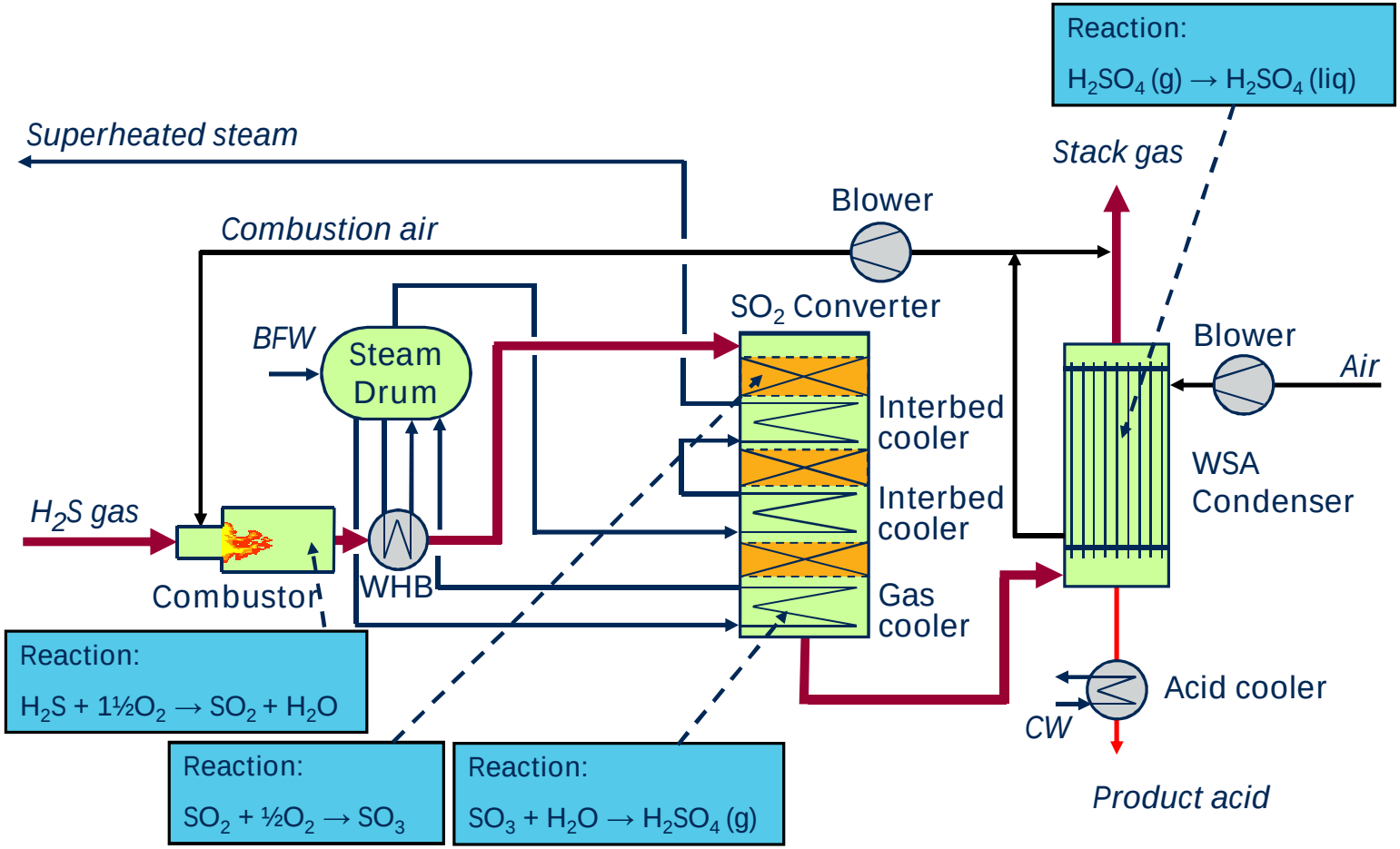
WSA

Cleaned gas

HP Steam

H_2SO_4

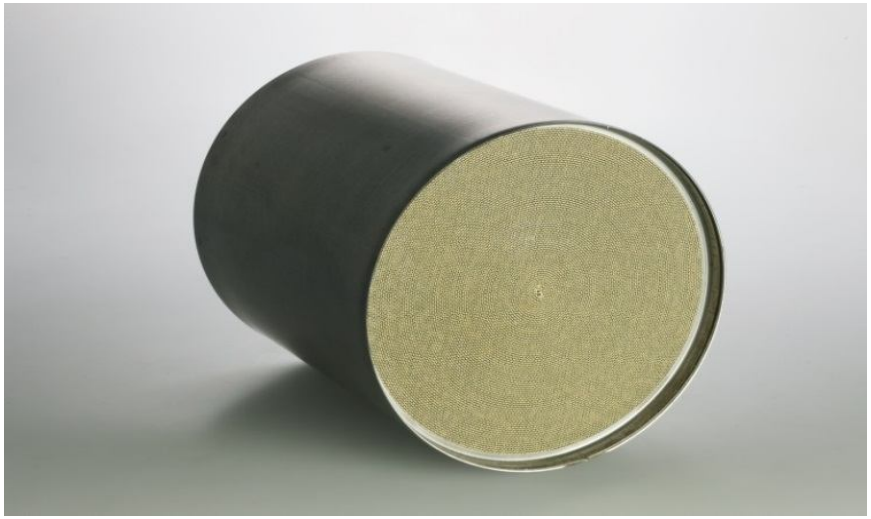
WSA process lay-out, H_2S gas



Topsoe Vanadium SCR for Indian automotive market

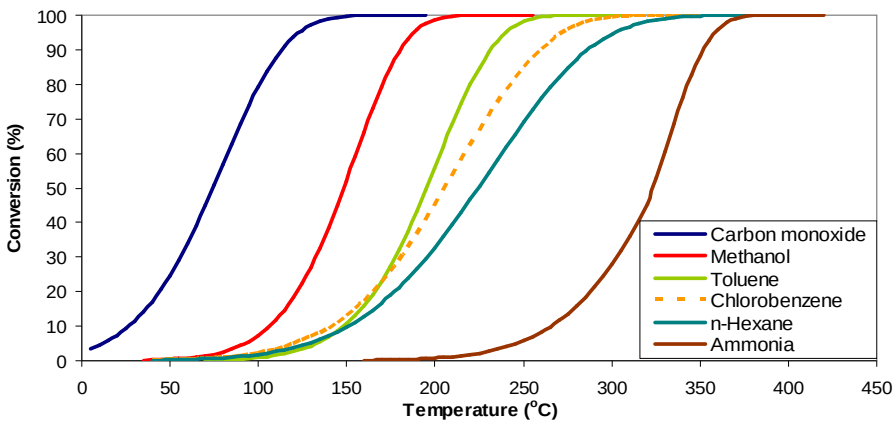
- Very good low temperature conversion
- **Full-body**, unlike coated SCR
- Best in class **dynamic response** to transient conditions
- Best in class sulfur tolerance, due to **high porosity substrate**
- **Low deactivation** over time
- Lowest weight
- Zone coated ASC, if needed
- Available in diameters 7.5” - 17”
- **Proven technology** for Euro IV/V/VI and Tier4i/f

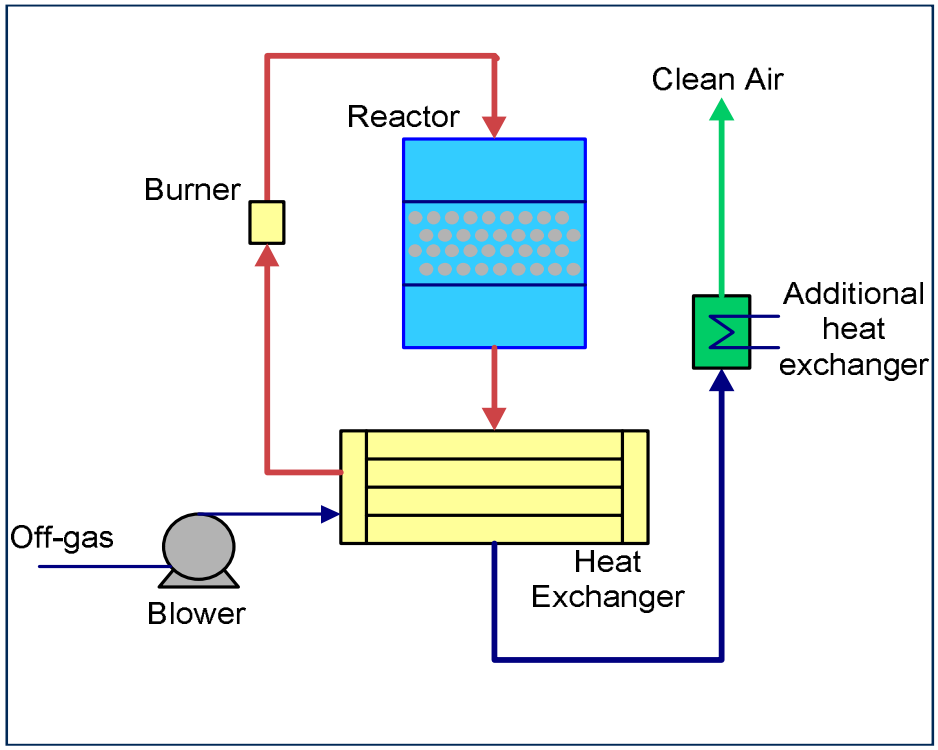
- Proprietary substrate, **no dependancy on substrate manufacturers**
- Local engine test and production planned
- Mechanical durability, simple canning



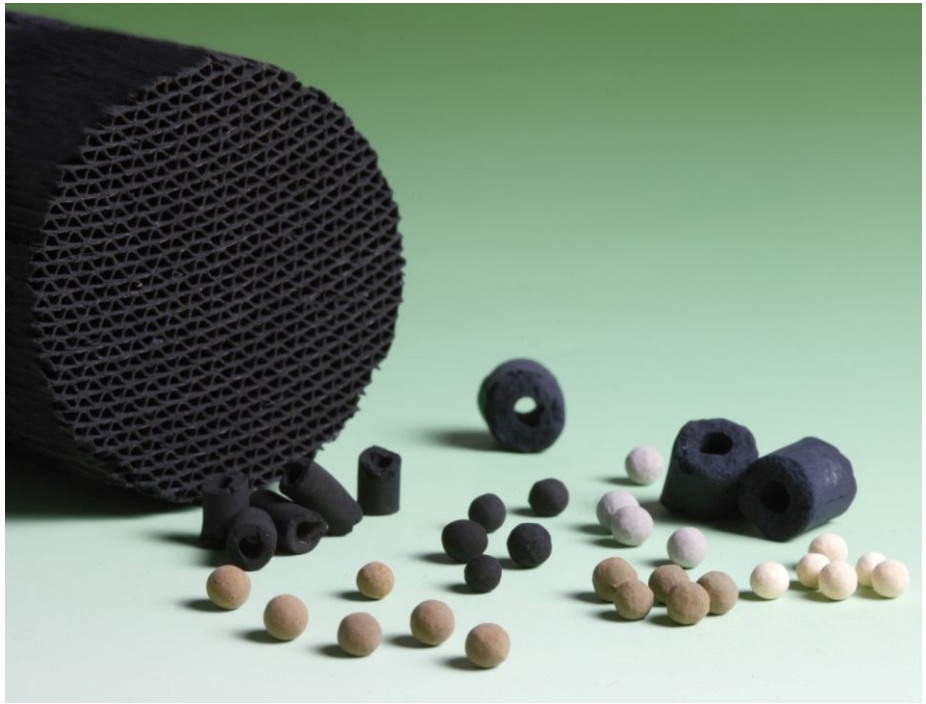
Catalytic combustion process
General

$$VOC + O_2 = CO_2 + H_2O$$





Oxidation catalyst portfolio
> 500 references



Type		Application
CK-302/322 CKM-2x CKM-3324	Cu-Mn	Hydrocarbons, hydrocarbons with oxygen and nitrogen. Silicon and bromine resistant
CK-304 CKM-3x, DNOC	Pd	Aromatics, CO, hydrogen, ammonia, short-chained alkanes
CK-305 CK-395	Cr Mn	Halogenated hydrocarbons
CK-306	Cr-Pd	Halogenated hydrocarbons, CO
CK-307	Pt	All hydrocarbons, CO, sulphur compounds (<200 ppm)
CK-428	Cu-Mn Pt	Sulphur compounds (>200 ppm), ammonia

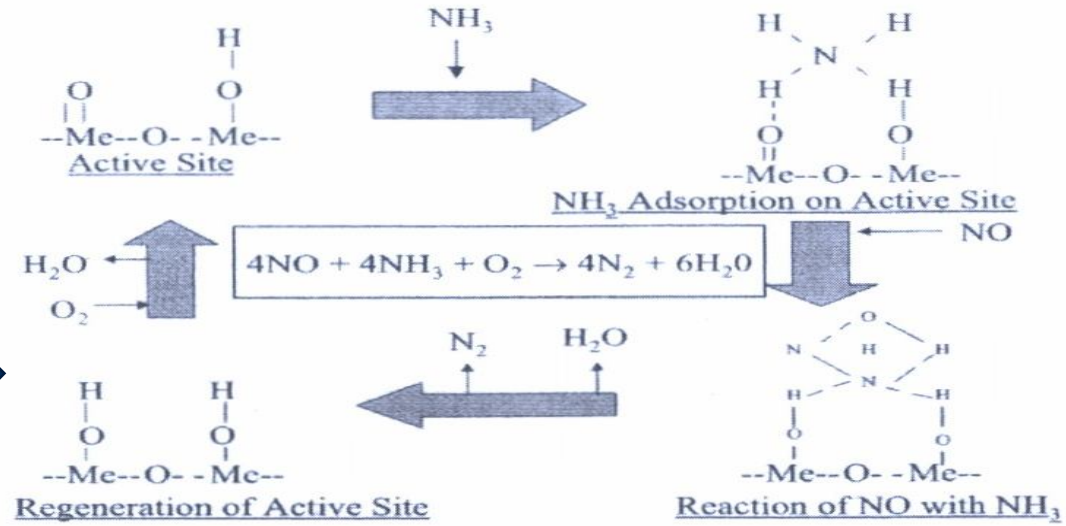
SCR DeNOx Technology

Chemical Reaction

- $6\ NO + 4\ NH_3 \rightarrow 5\ N_2 + 6\ H_2O$
- $6\ NO_2 + 8\ NH_3 \rightarrow 7\ N_2 + 12\ H_2O$

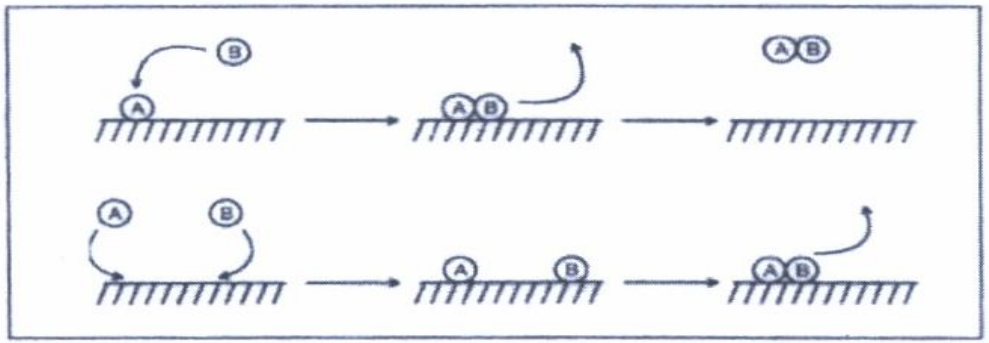
O_2 makes the reaction faster

Me=Vanadium or Tungsten



Mechanism:

- Adsorptions mechanism
- Elay-Rideal mechanism
- Langmuir-Hinshelwood mechanism



Reaction mechanism

(1) $NH_3 + V^{5+}\text{-}OH \leftrightarrow V\text{-}ONH_4$

(2) $V\text{-}ONH_4 + V{=}O \leftrightarrow V\text{-}ONH_3\text{-}V^{4+}\text{-}OH$

(3) $NO + V\text{-}ONH_3\text{-}V^{4+}\text{-}OH \rightarrow N_2 + H_2O + V^{5+}\text{-}OH + V^{4+}\text{-}OH$

(4) $2V^{4+}\text{-}OH \leftrightarrow H_2O + V^{3+} + V{=}O$

(5) $O_2 + 2V^{3+} \rightarrow 2V{=}O$

(6) $H_2O + V^{5+}\text{-}OH \leftrightarrow V^{5+}\text{-}OH_3O$

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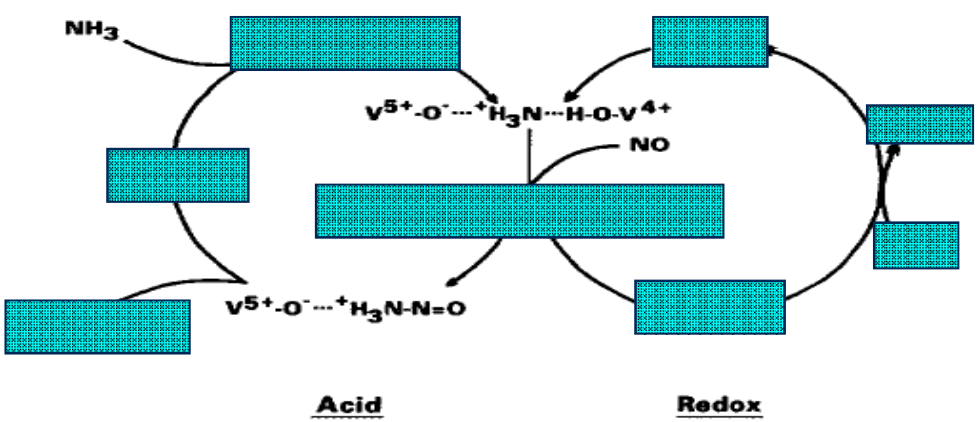
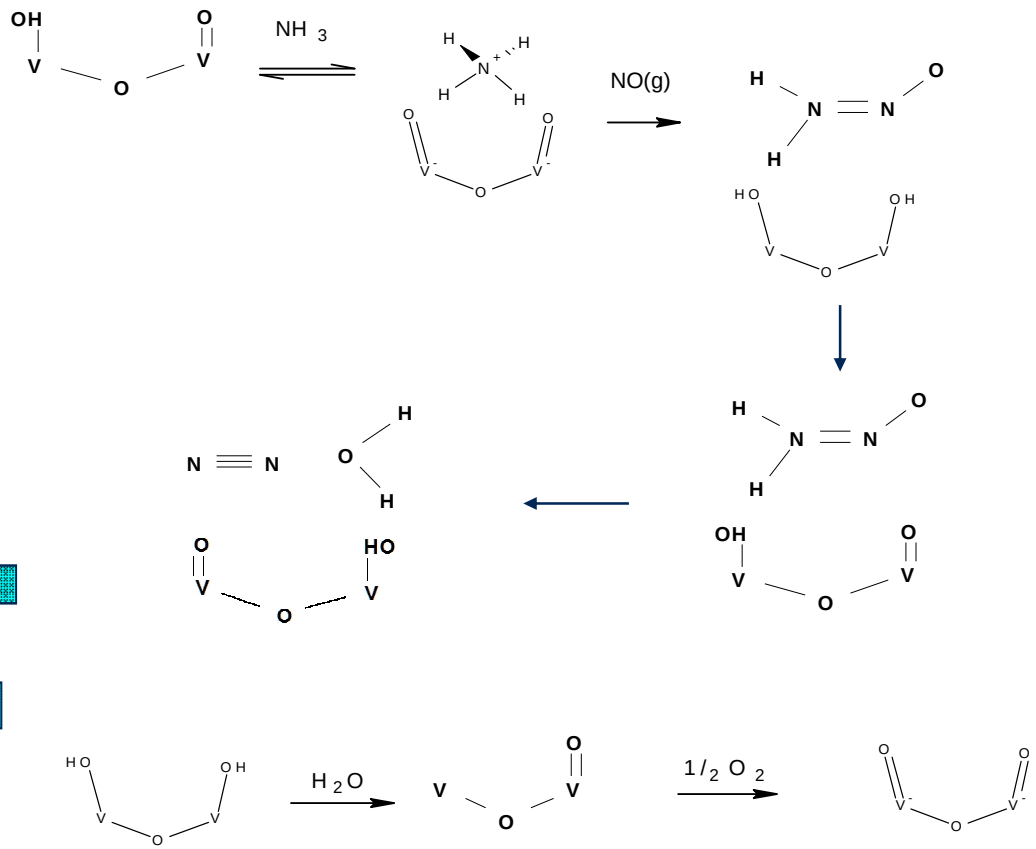
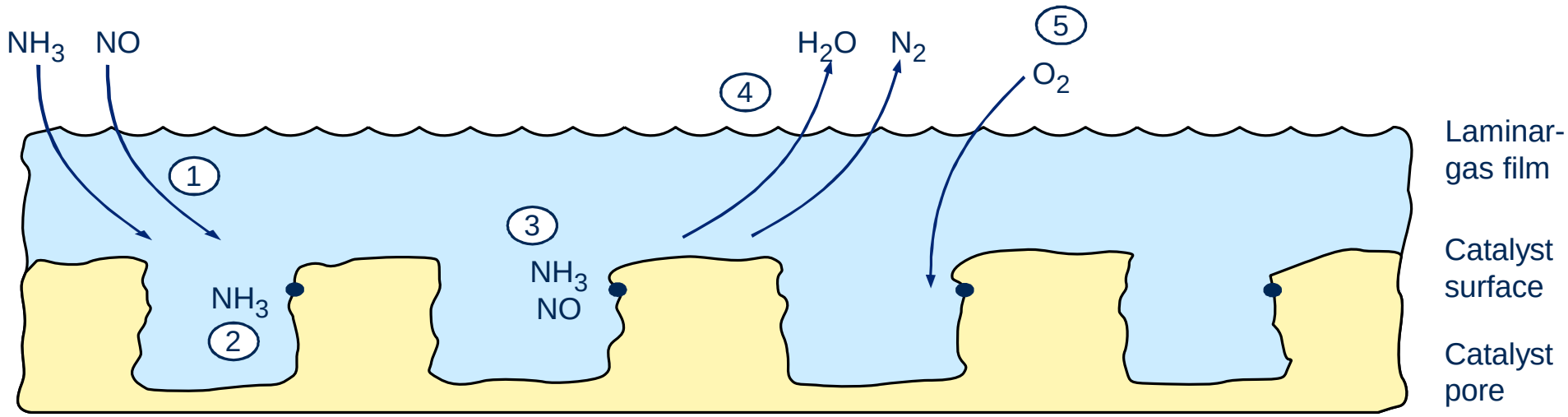




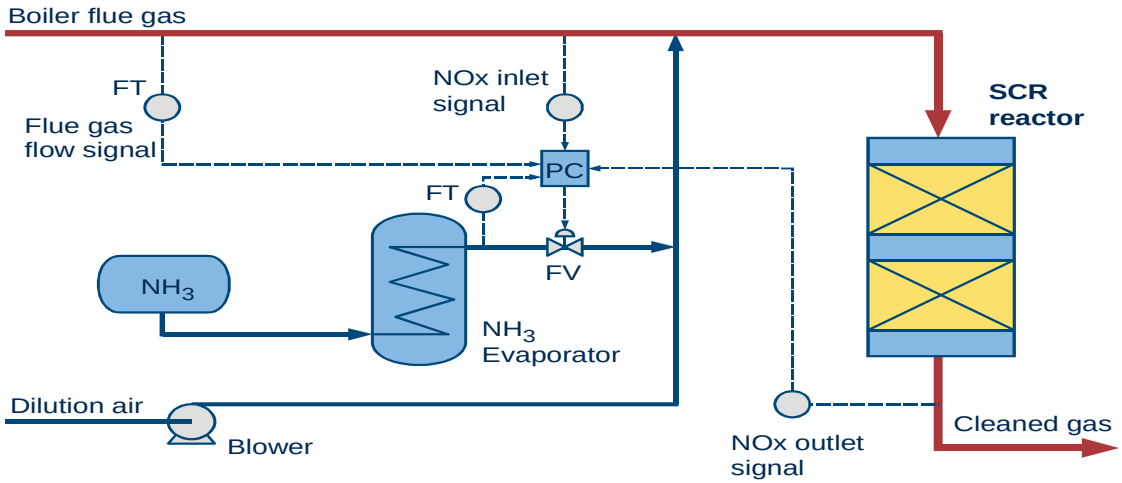
DeNOx reaction mechanism

1. Diffusion of the reactants to the catalyst surface
2. Adsorption of NH_3 on an active site
3. Reaction of NH_3 with NOx
4. Diffusion of products back to the flue gas
5. Reoxidation of vanadium site

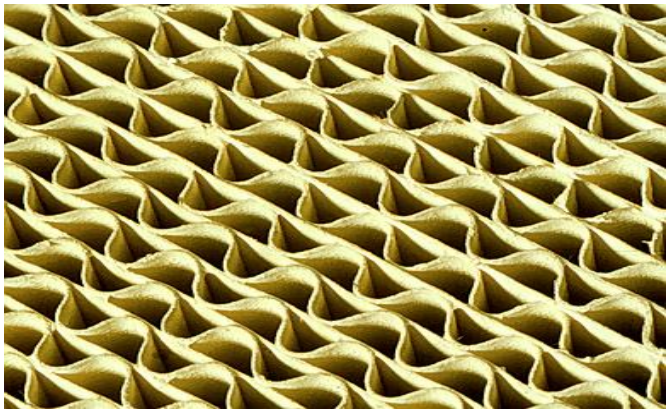


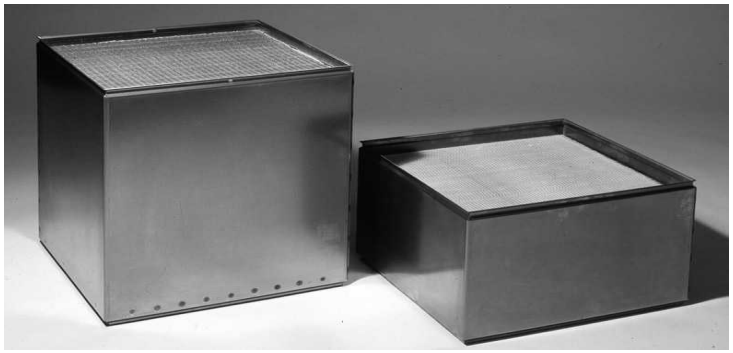
DeNOx technology
General system layout

- Ammonia storage
- Ammonia evaporation
- Ammonia injection
- Flow stratification
- Soot blowers
- SCR reactor and catalyst
- Control system



Topsoe DNX catalyst characteristics





- Corrugated honeycomb
- Open geometry
- Titania based and impregnated with vanadium and tungsten
- High strength – fibre reinforced
- Very porous structure
- High poisoning resistance
- Low SO_2 oxidation
- Thermal shock resistant
- Temperature range:
  180°C – 555°C

DeNOx catalyst – product range

Channes size

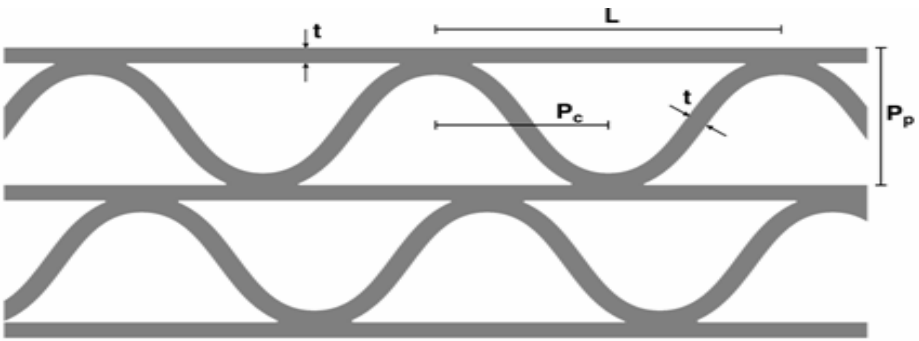
- 2.5-10.0 mm

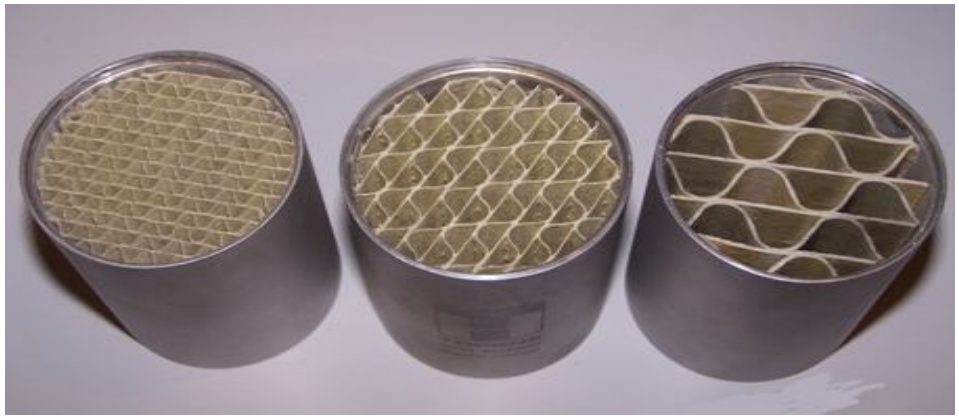
Wall thickness

- 0.4, 0.8 and 1.0 mm

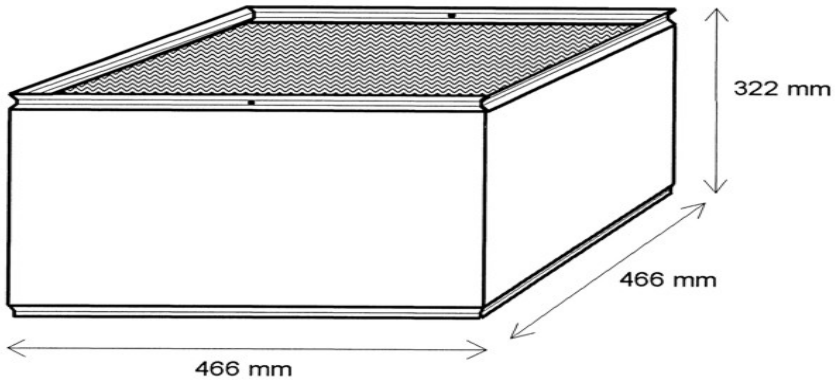
Chemical compositions

- 10 different to optimise activity/SO_2 oxidation

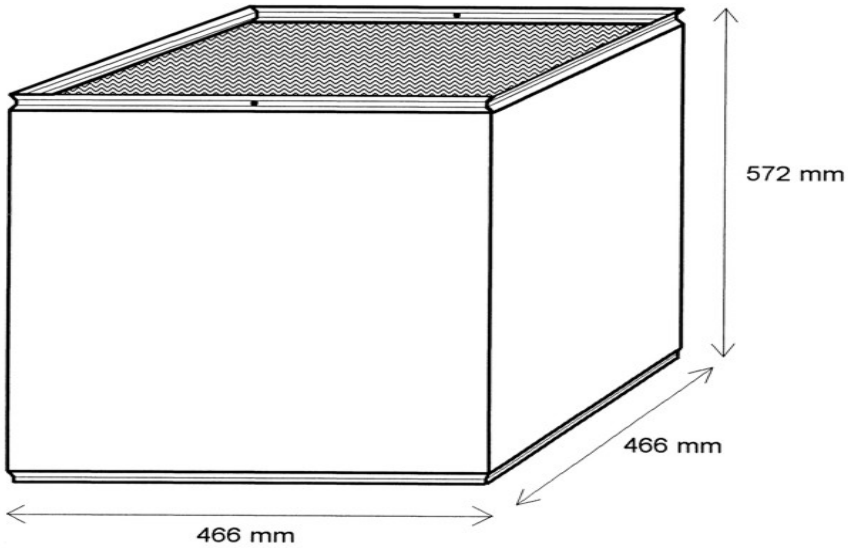


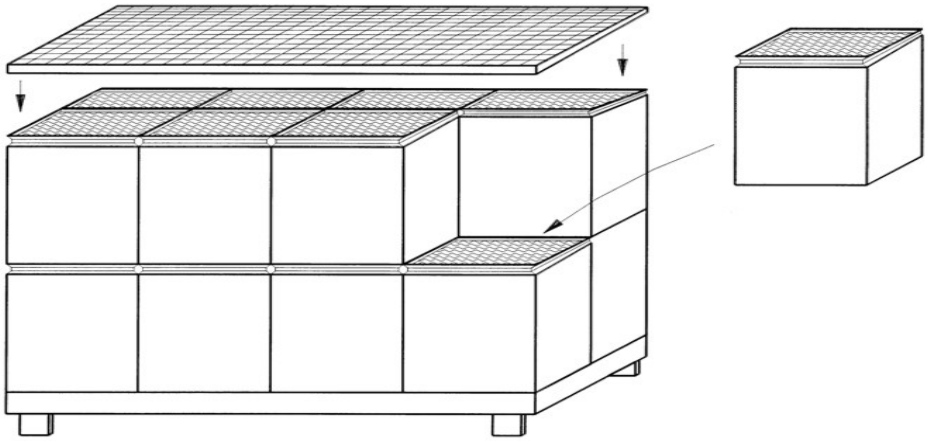


Catalyst Modules

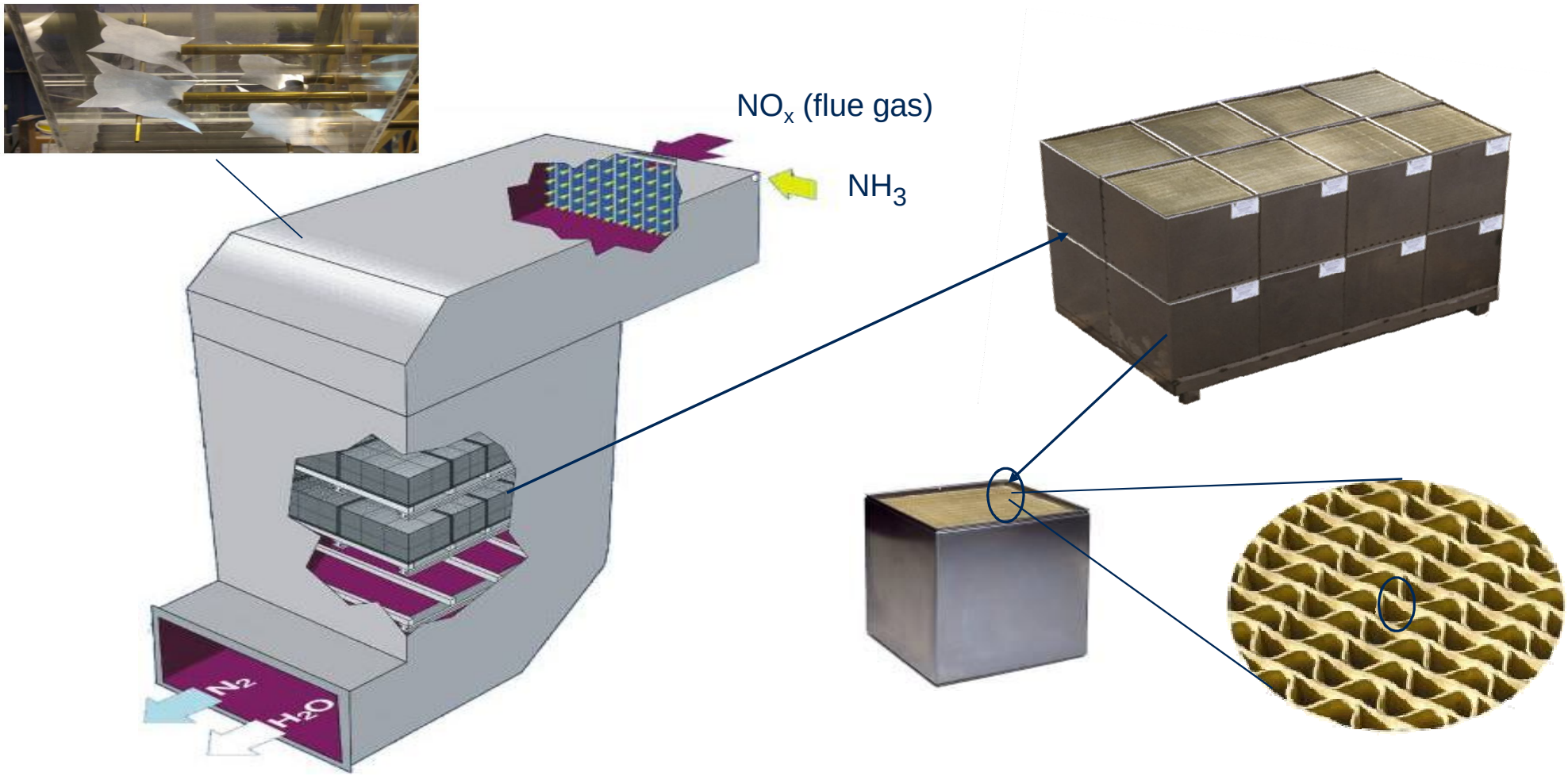


- Modular Design
- 0.25, 0.50, 0.75, 1.00 meter catalyst height
- 2 x 4 cassette standard design



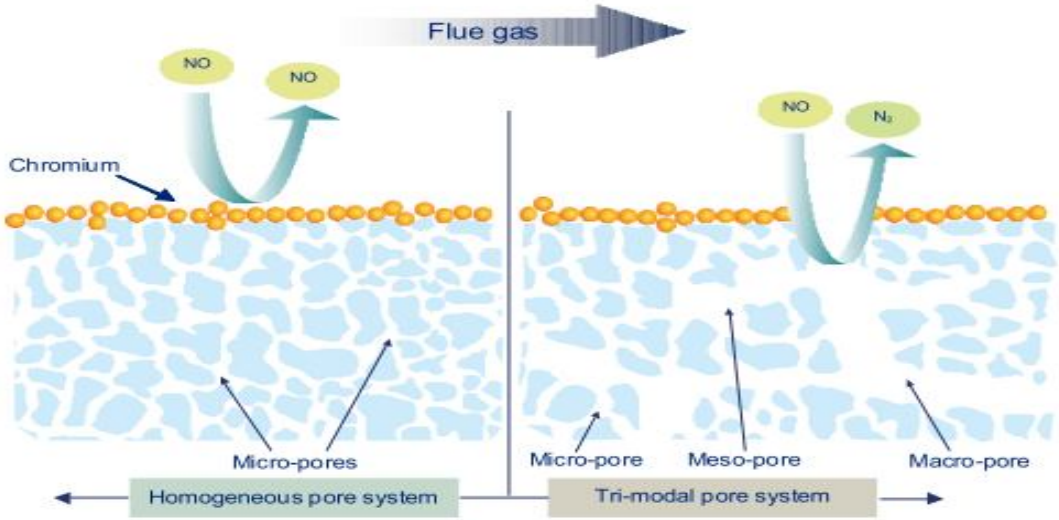


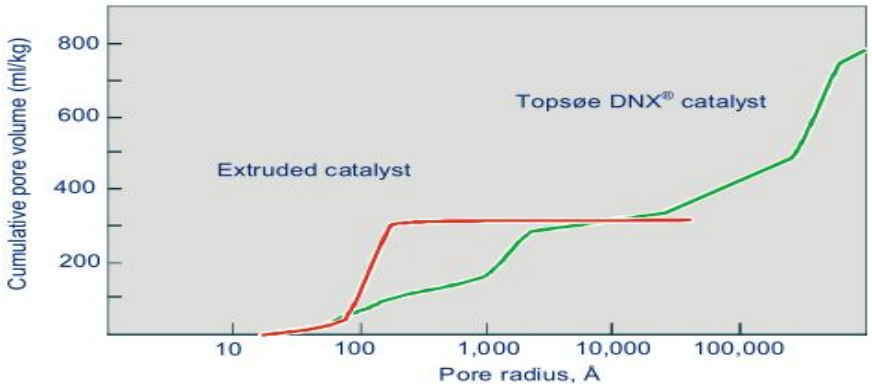
SCR process - Reactor



DNX catalyst features
Easy loading

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 180 and 475˚C.

Performance Sheet

S.No.	Parameter	Outlet
1.	NOx, ppm	<25
2.	NH3 slip, mg/Nm^3 @ 6% O2 dry	<10
3.	NH3 reagent consumption, Kg/hr	Low
4.	Pressure Drop, mmH20 (4 ^oC)	20

Reference

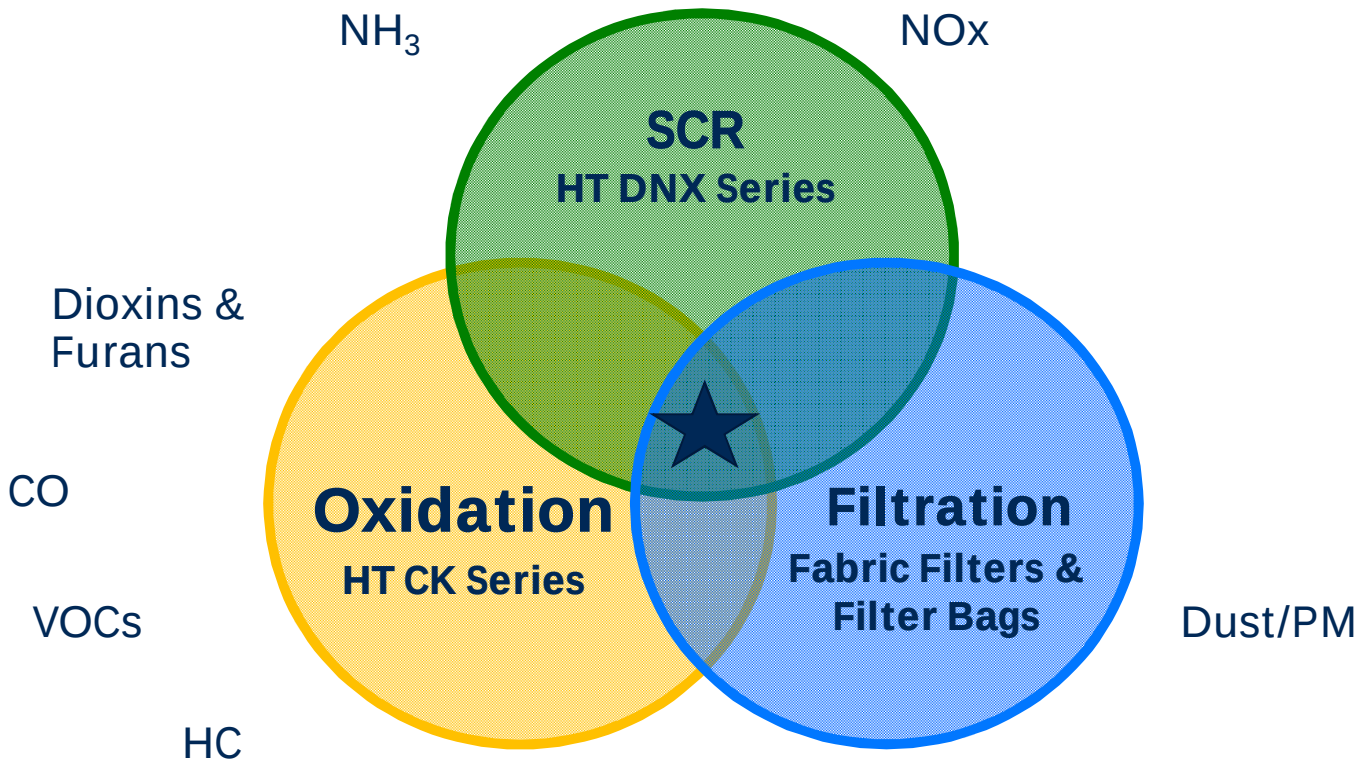
149	Coal fired boilers
108	Oil and gas fired boilers
23	Biomass fired boilers
2	Petcoke fired boilers
107	Stationary diesel engines
31	Marine diesel engines
53	Gas engines
342	Gas turbines
203	Refinery/Petrochemical
37	Waste incineration
97	Other

Topsoe DeNOx Technology has around ≈1200 references world wide in different sectors:

Catalytic Filtration Solution

Over View

Combining competences
Haldor Topsoe



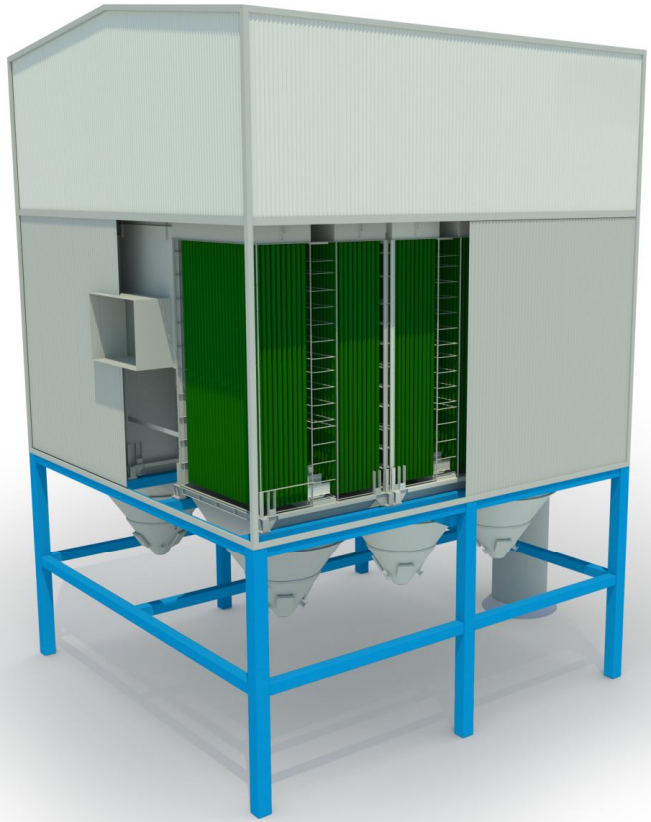
Technology

EnviroTex™ Catalytic filter bags

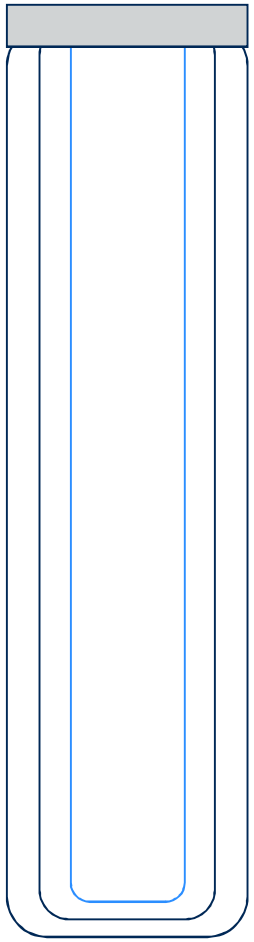
- Each bag consist of three fabric layers (bags) which individually are impregnated
- High filtration efficiency
- Filter bag up to 464 F (240 deg. C)
- VOC, ammonia removal, and DeNOx at low temperature
- No poisoning of catalyst

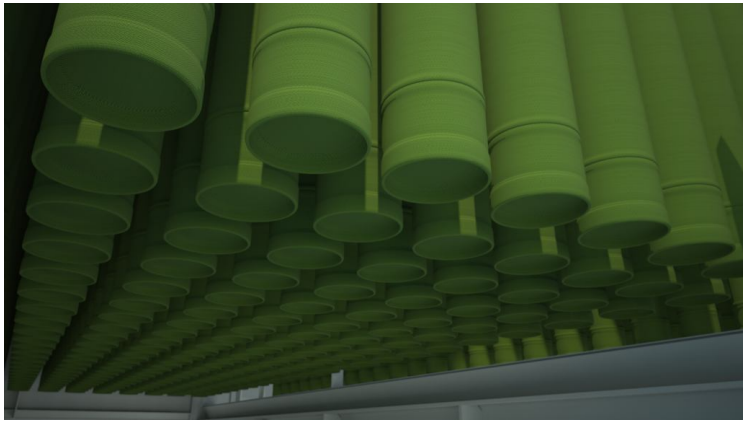
Design T: 410-464 F (210-260 C)
Dimension: app. 20-40 feet (6-12m) length

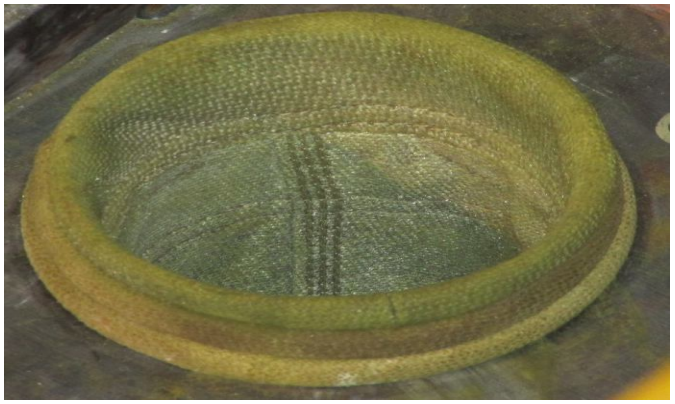
Catalytic filter bag



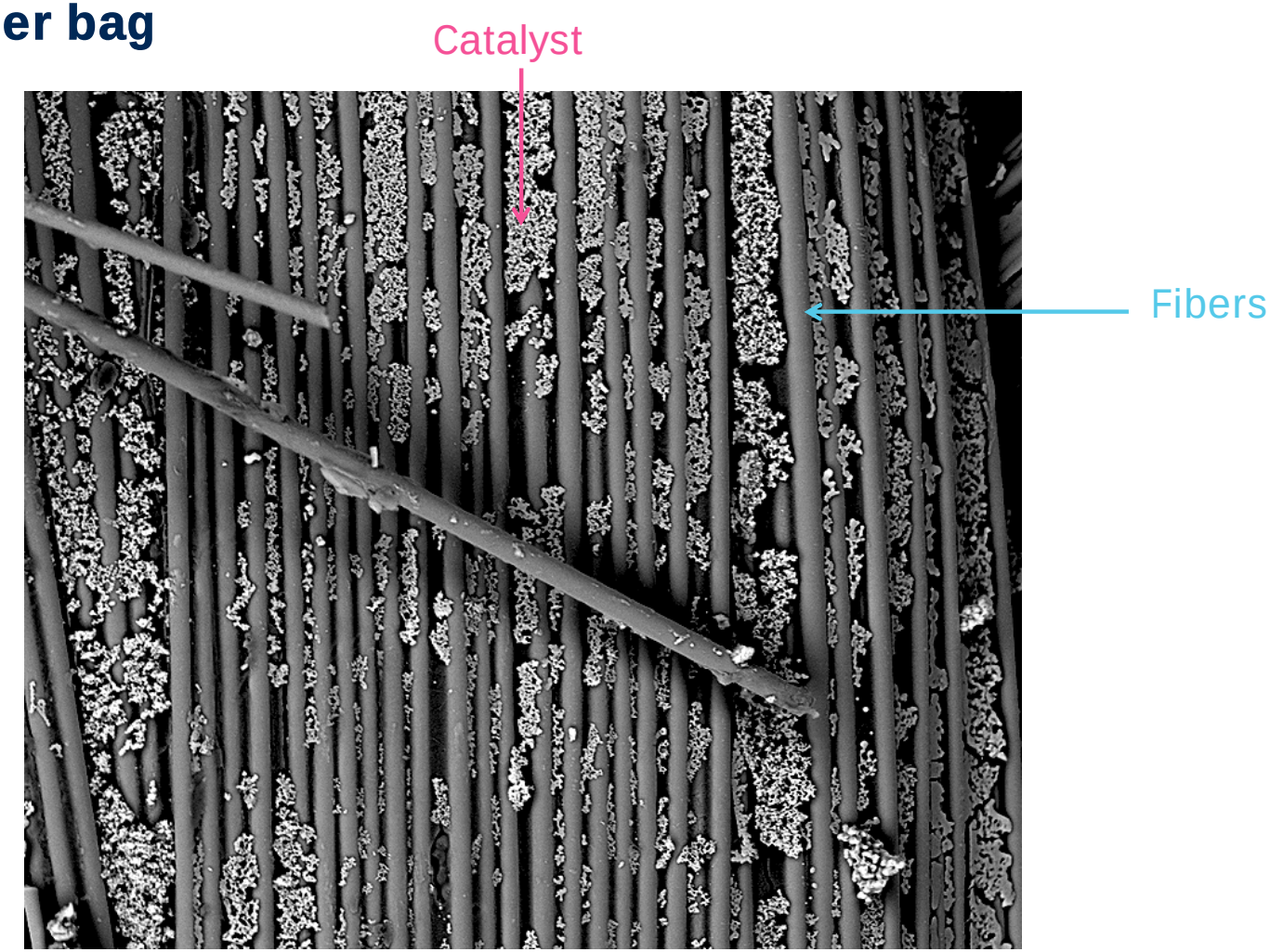
Catalytic Filter Bag







Catalytic filter bag



Technology

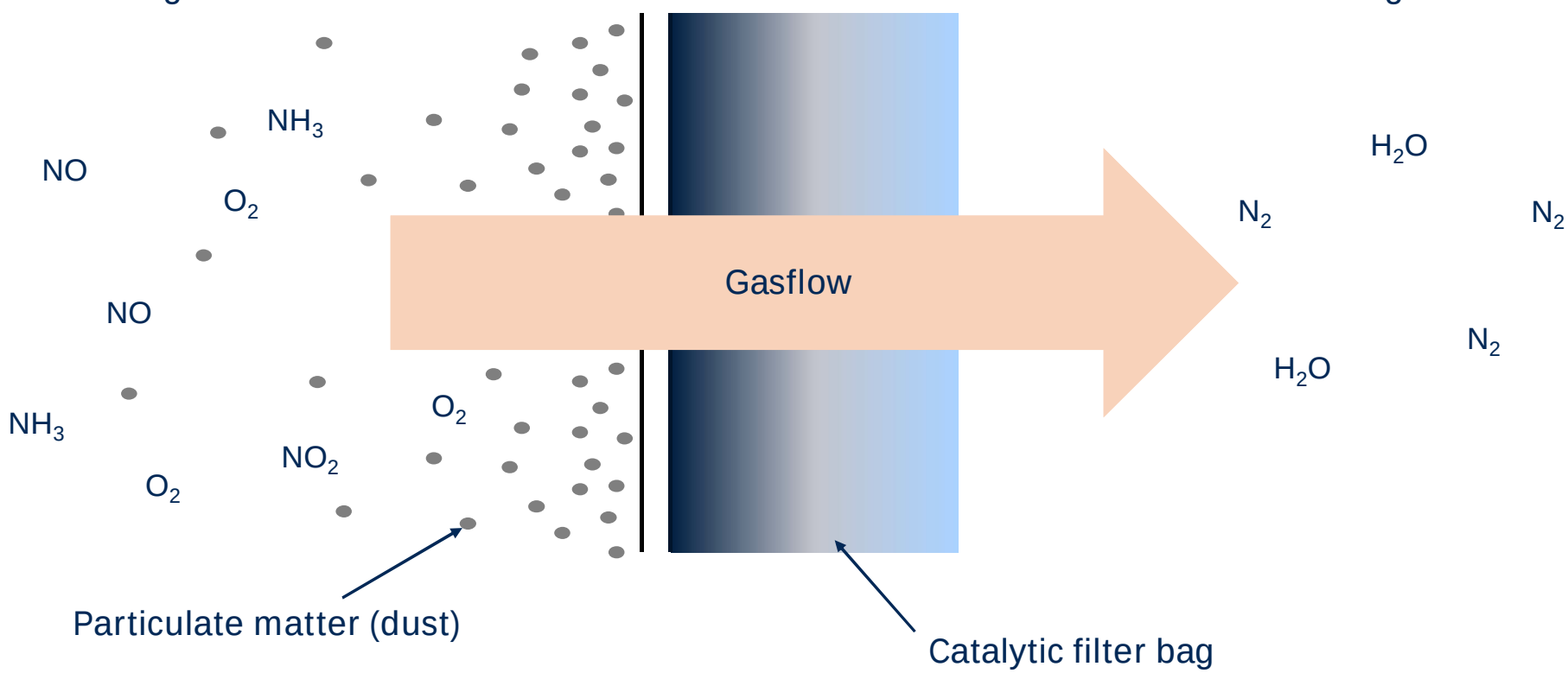
TopFrax™ Catalytic ceramic filters

- Each filter consist of a ceramic fiber based filter impregnated with a catalyst in the filter wall (20 mm thick)
- High filtration efficiency (<2 mg/Nm^3)
- Up to 662 F (350 deg C) with present catalyst (filter up to 900 deg. C)
- DeNOx, ammonia and VOC removal.
- No poisoning of catalyst

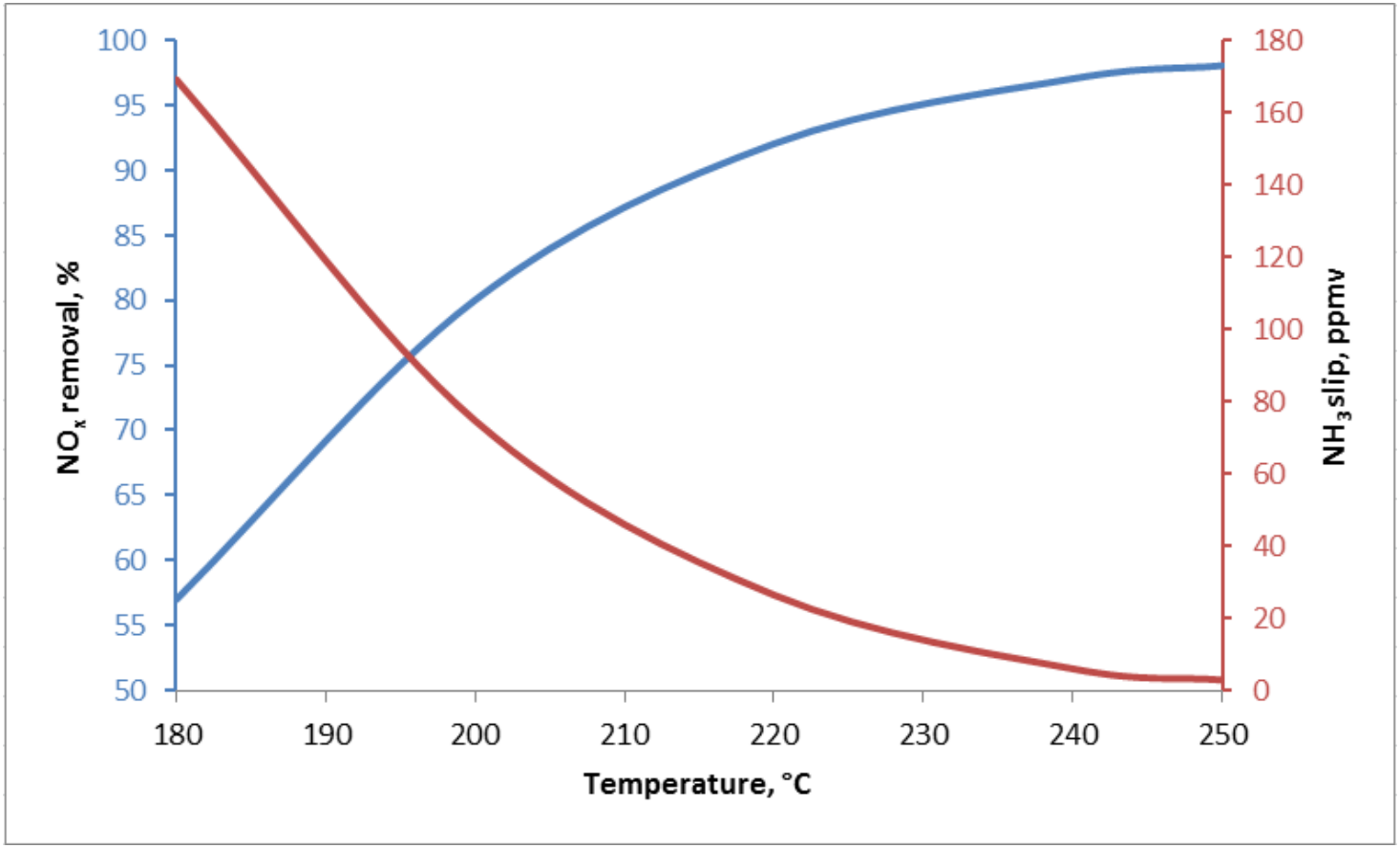
Design T: 410-752 F (210-400 C)
Dimension: 1-3m length

NO_x and NH_3 removal (SCR)

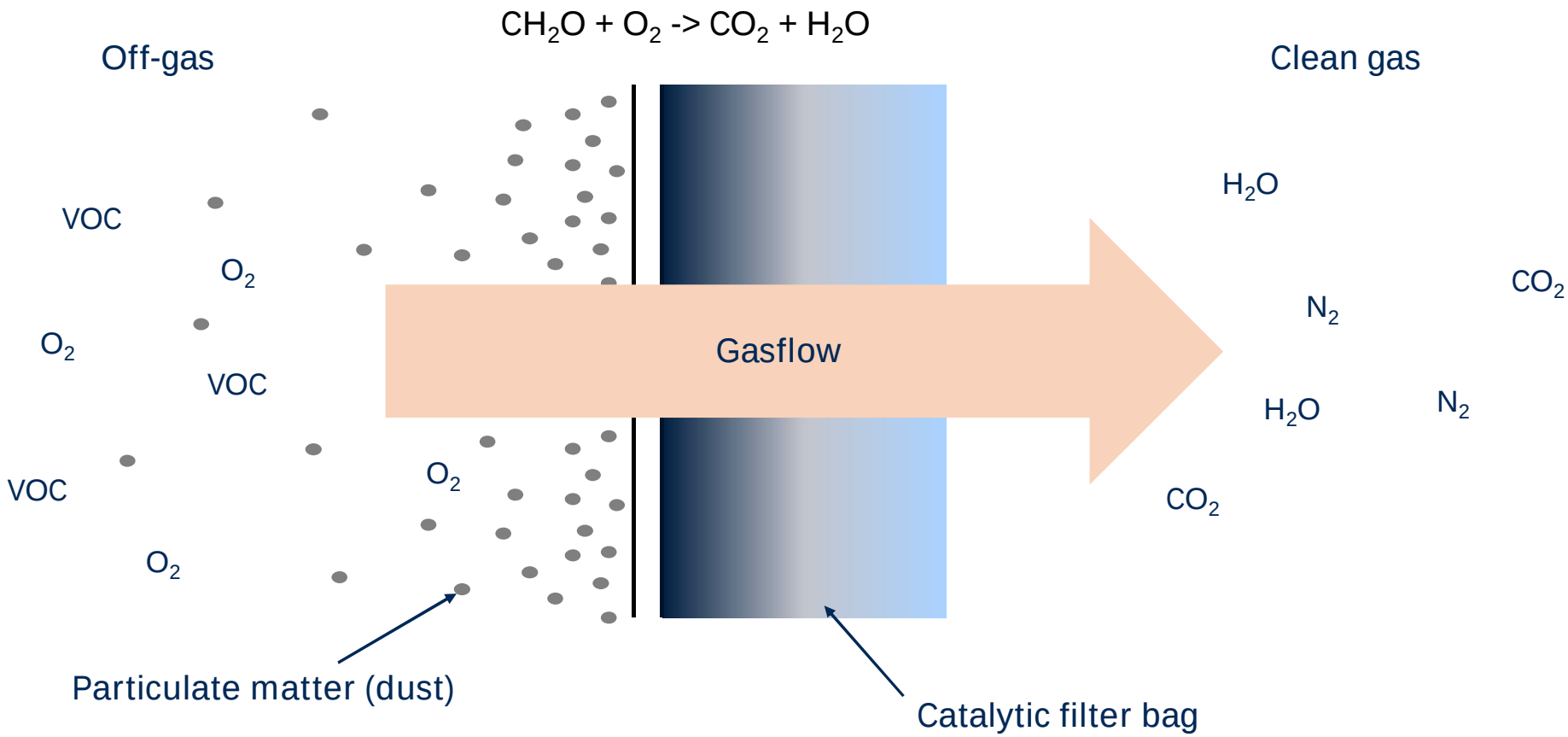
$$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$$



NO_x and NH_3 removal (SCR)

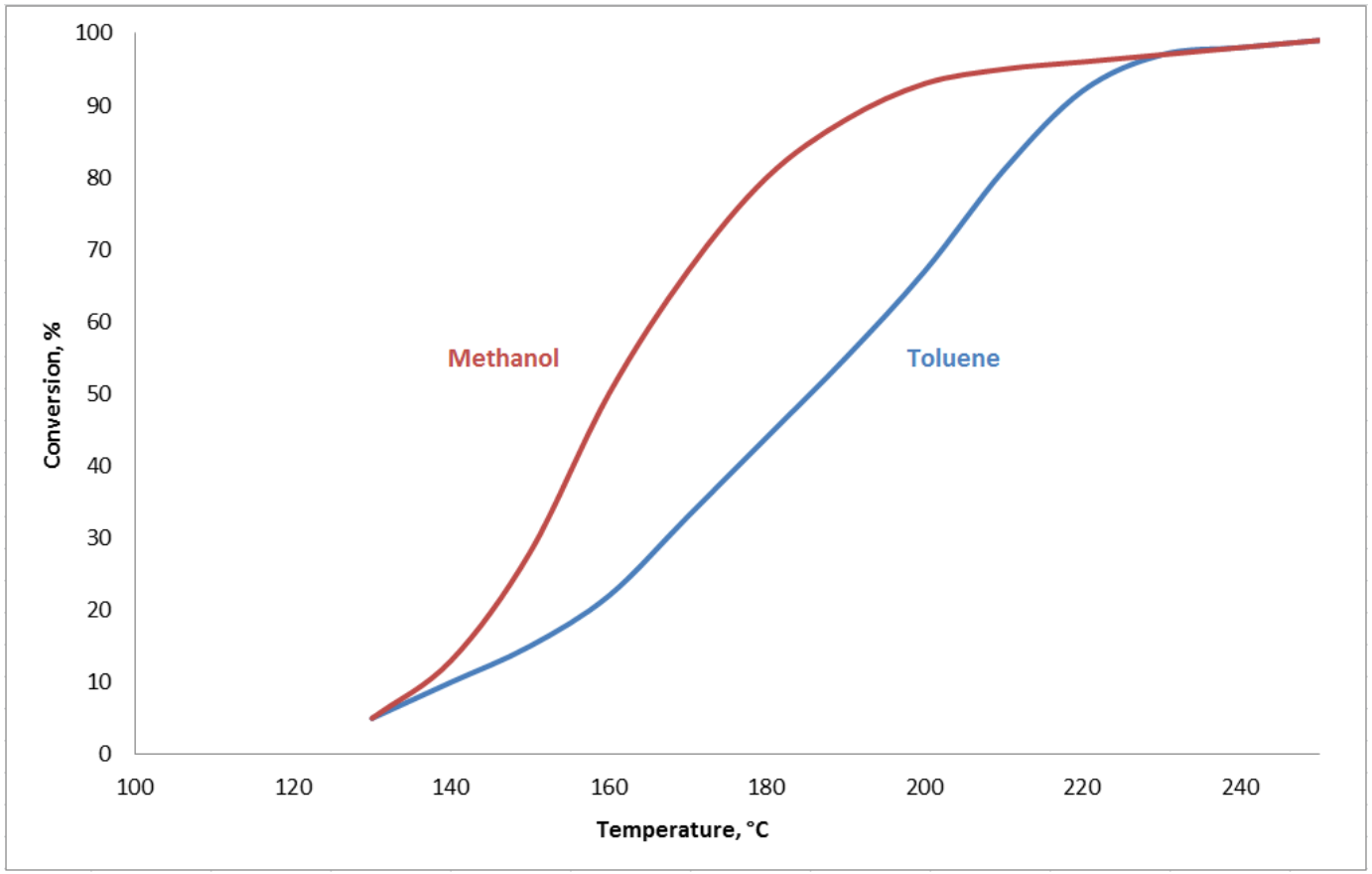


Removal of VOC's / Organic HAP



VOC = Volatile Organic Compound: CO, Toluene, Benzene, Formaldehyde etc.
HAP = Hazardous Air Pollutant

Removal of VOC's / Organic HAP



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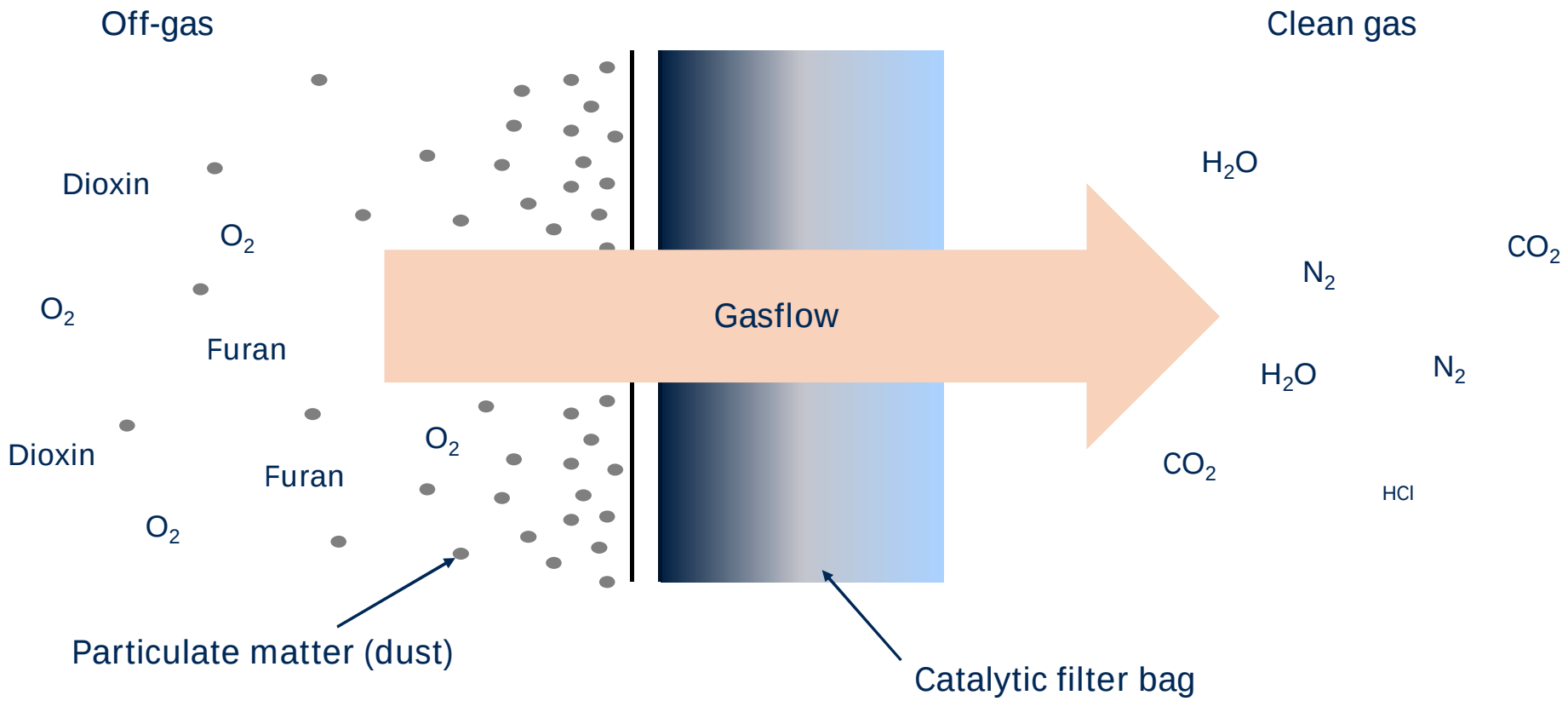
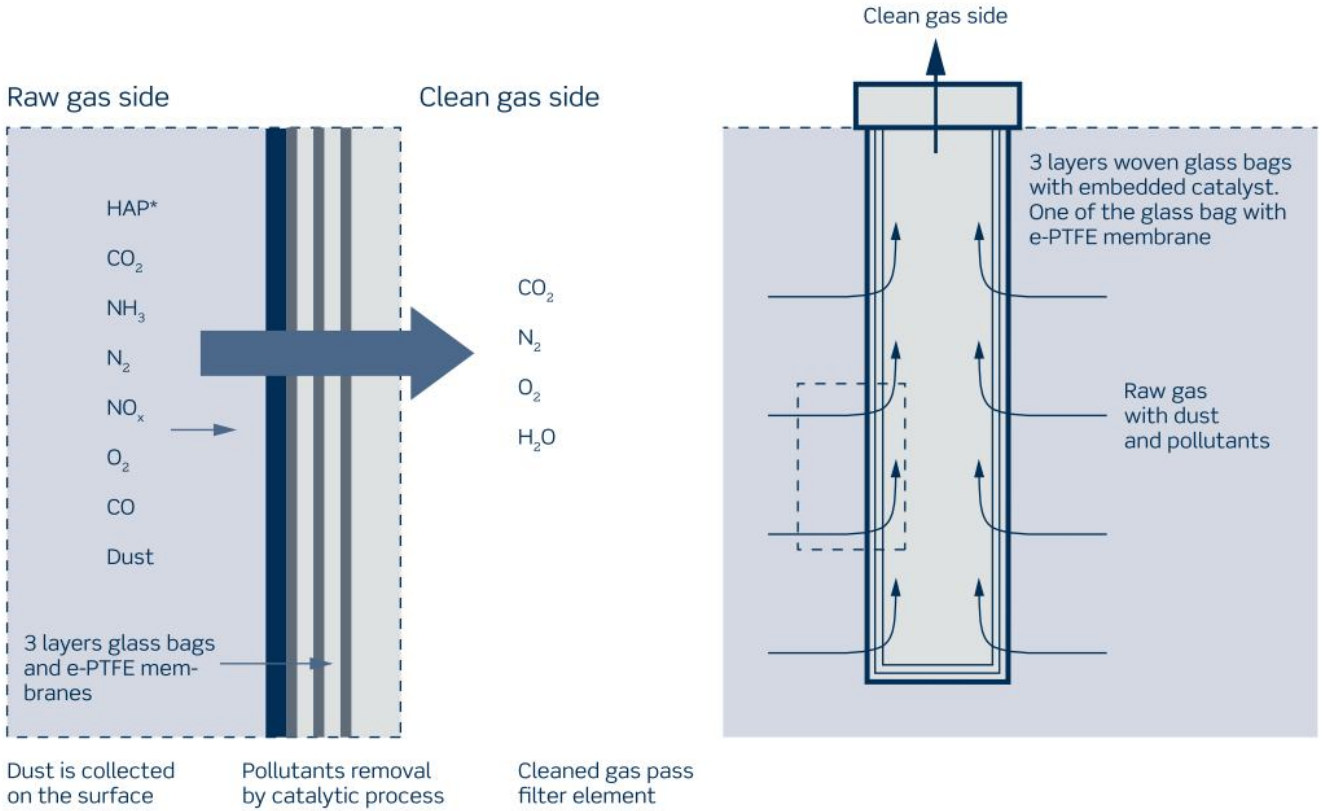
Furan/dioxin removal

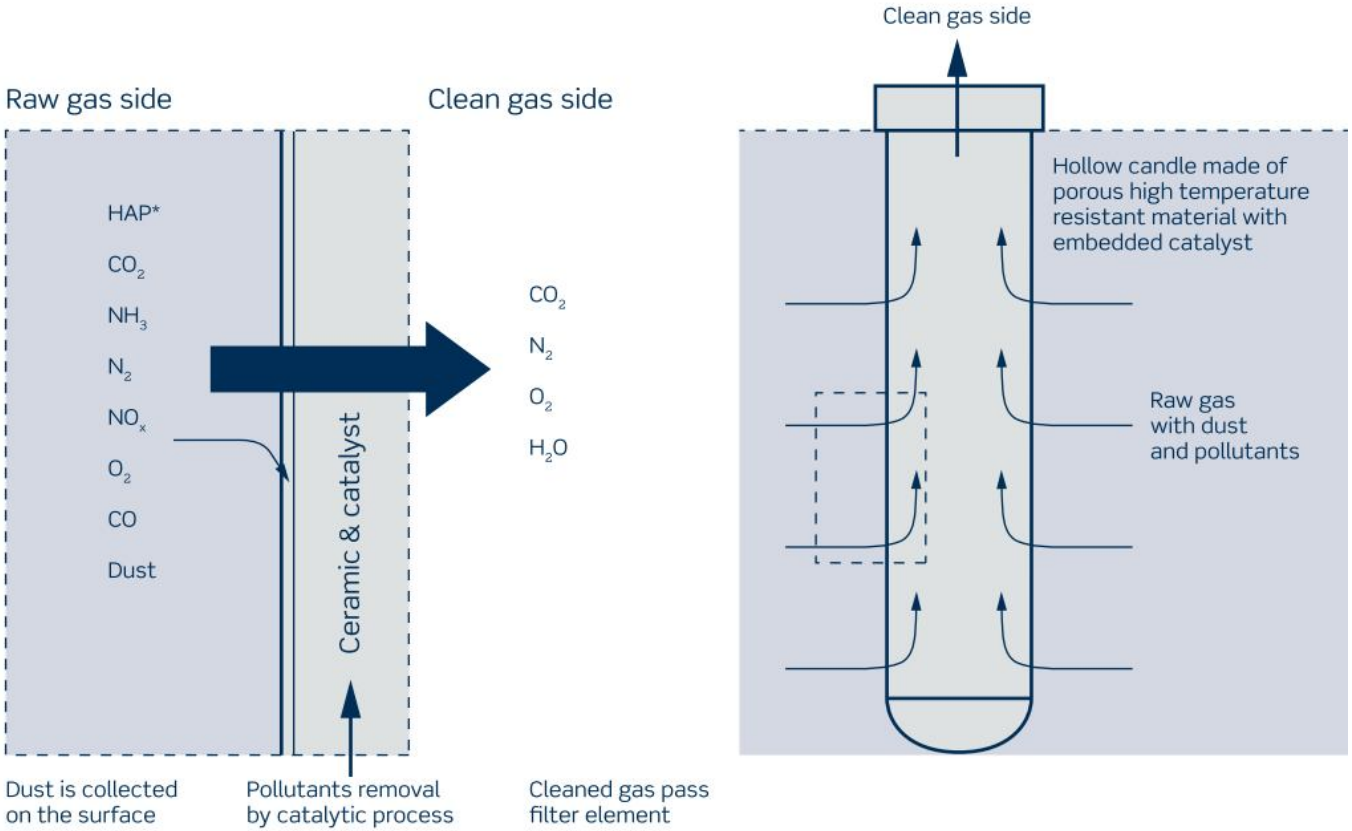


CataFlex™ Catalytic filter bag principle



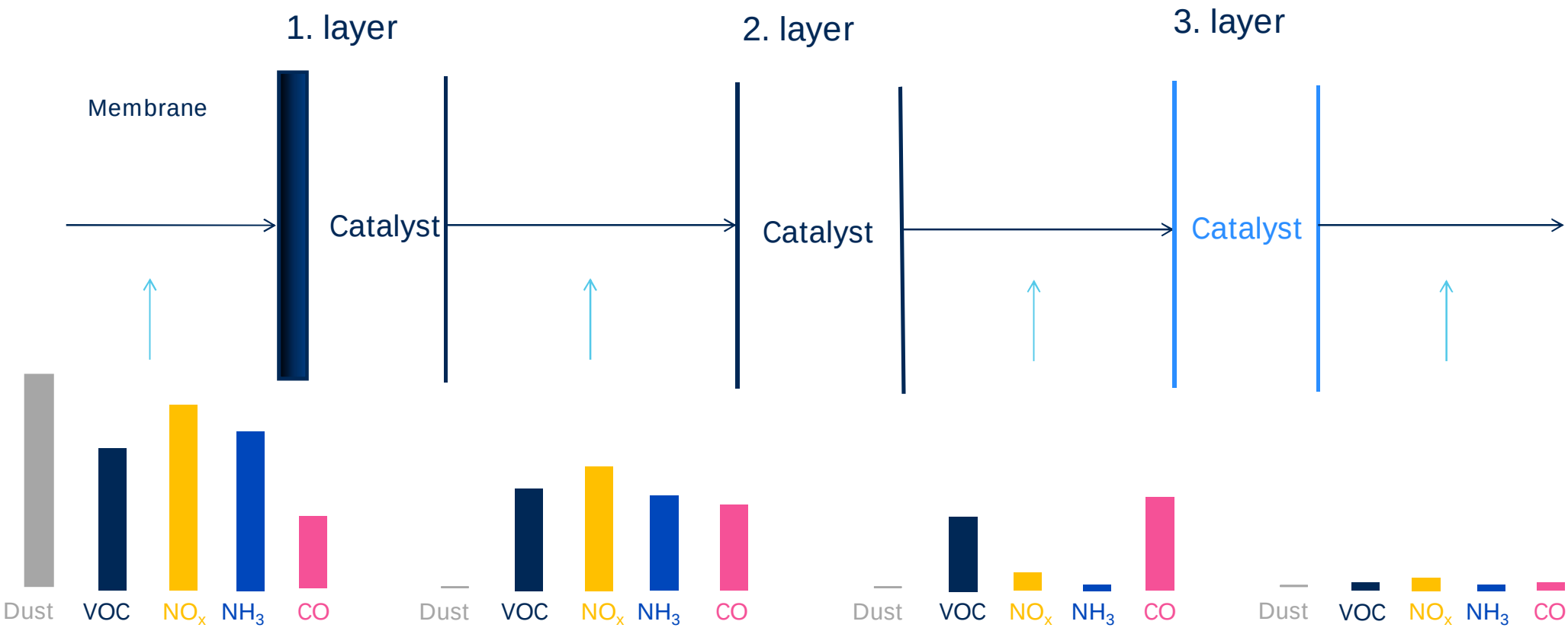
* Organic HAP includes formaldehyde, benzene, toluene, styrene (m-, p-, o-) xylene, acetaldehyde and napthalene

TopFrax™ Ceramic filter principle



* Organic HAP includes formaldehyde, benzene, toluene, styrene (m-, p-, o-) xylene, acetaldehyde and napthalene

Schematic illustration of the catalytic filter bag



Application of catalytic filtration Technology

- Cement kilns

- Power plants

- Waste incinerators

- Chemical industry

- Biomass
- Glass plants
- Metal production (sintering)
- Roasting (Corn, cacao, cofee)
- Carbon black

Etc....

Overview – Legislation within Cement Manufacturing

mg/Nm^3 @ 10 vol. % O_2 (dry)

	USA	Germany	China (Common) ¤	World (Financing)
Pollutant	NESHAP/NSPS	BImSchV 17	GB30485-2013	World bank
HCl	5	10	10	10
THC (TOC)	3.6	10*	10	10
SO_2	94	50*	200	400
NO_x	360	200	400	600
NH_3	-	30	10	-
Hg	0.005	0.03	0.05	0.05
Dust	1.8	10	30	30

*) Exceptions for raw materials possible
¤) Cement plants co-processing waste in common regions. The key region limits are stricter.

Catalytic Filtration Solutions

conclusion

- New cost efficient solution for removing gas emission along with particulate matter
- Making the plants staying in compliance with even the stringent regulations
- Saves up to 80% on CAPEX compared to existing solutions used today
- Saves operational cost (OPEX) compared to existing solution used today
- Saves foot print of the total installation compared to existing solution used today
- Targeting Waste to Energy, Boilers, Cement Plants, Glass Plants
- ...and similar industries with a flue gas containing hazardous compounds and dust
- Removal of (separately or combined at the same time):
  - NOx
  - HAP (hazardous air pollutants)
  - VOC (volatile organic compounds)
  - CO
  - Dioxin and Furans
  - NH_3
  - Dust and particulate matter (PM)

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Questions?

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