McIlvaine Hot Topic Hour
Air pollution control for gas turbines

RESEARCH | TECHNOLOGY | CATALYSTS

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Nathan White, Director – Air Pollution Control Catalyst & Technology
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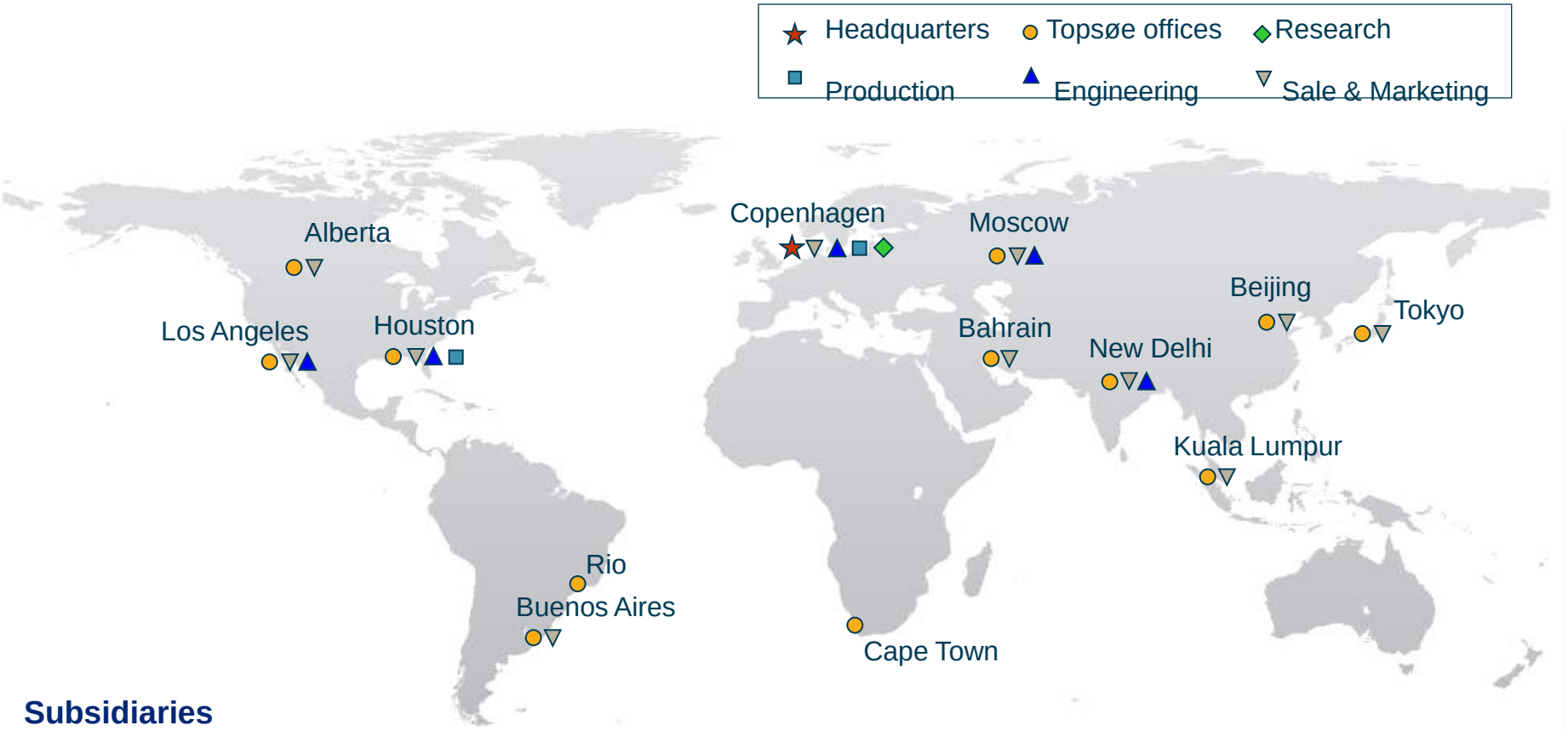
HALDOR TOPSØE

Topsøe
- A global supplier of catalysts and technologies



Subsidiaries

Haldor Topsoe, Inc.
Haldor Topsøe International A/S, Denmark
Haldor Topsoe India Pvt. Ltd. India
ZAO Haldor Topsøe, Russia
Subcontinent Ammonia Investment Company ApS (SAICA)
Topsoe Fuel Cell A/S, Denmark

HALDOR TOPSØE

Our business areas

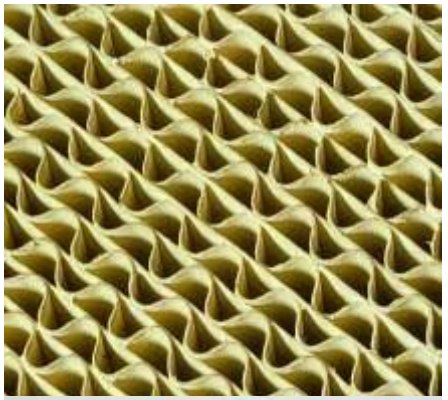
- Fertiliser industry
- Heavy chemical and petrochemical industries
- Refining industry
- Environmental and power sector
- Renewables

… and a leading market player

- Market share between 15-25% for established products
- Supplier of solutions for 50% of new ammonia plants built within the last decade
- More than 60% of ammonia is produced worldwide on Topsøe catalyst
- Supplier for 40% of catalysts for production of ultra-low sulphur diesel
- 30% market share of hydrogen catalysts
- 30% market share of FCC pretreatment catalysts
- References account for 60% of the worlds industrial production

Technologies cont.

- Environmental technologies
  - DeNOx (SCR DNX® catalyst): Removal of nitrogen oxides
    - Coal fired power plants
    - Gas fired boilers
    - Diesel and gas engines
    - Waste incinerators
    - Co-Gen units
    - Single cycle
    - Furnaces
    - FCC unit
    - Other refinery processes
    - Hydrogen units
  - WSA: Sulphur removal
  - SNOX™: Combined WSA/DeNOx
  - CATOX/REGENOX: VOC removal



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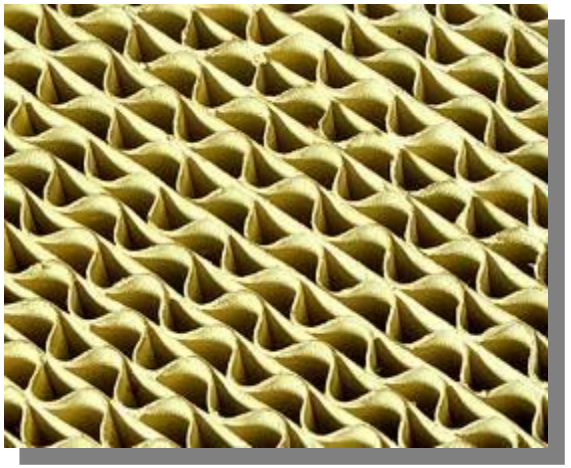
Haldor Topsoe's SCR Catalyst Products

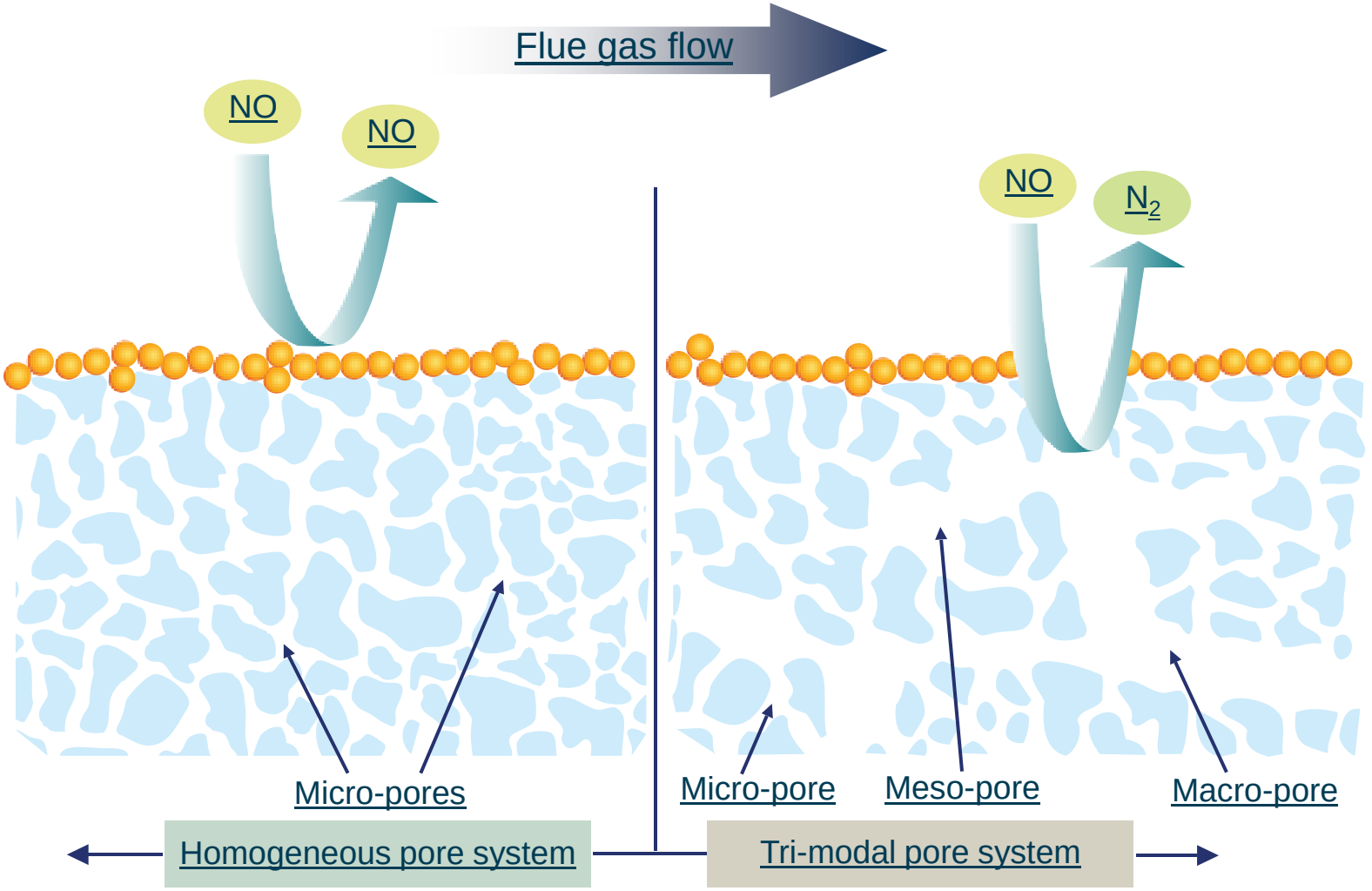
- Homogeneously Corrugated Composite SCR Catalyst
- TiO_2 with V_2O_5 as the principal active component including WO_3
- Design temperature range: 300 – 1,050^oF
  - ➢ low temperature SCR → higher V:W ratio
  - ➢ high temperature SCR → low V:W ratio (low V to no V catalyst is optimal choice for simple cycle SCR if no dilution air is used

DeNOx catalyst production - “3-step approach”

- Corrugated catalyst based on a glass fibre structure
- TiO_2 and other raw material are used to provide the porous structure
- Impregnation with V_2O_5 and WO_3 to generate the active catalytic sites
- Front edge reinforcement for all applications

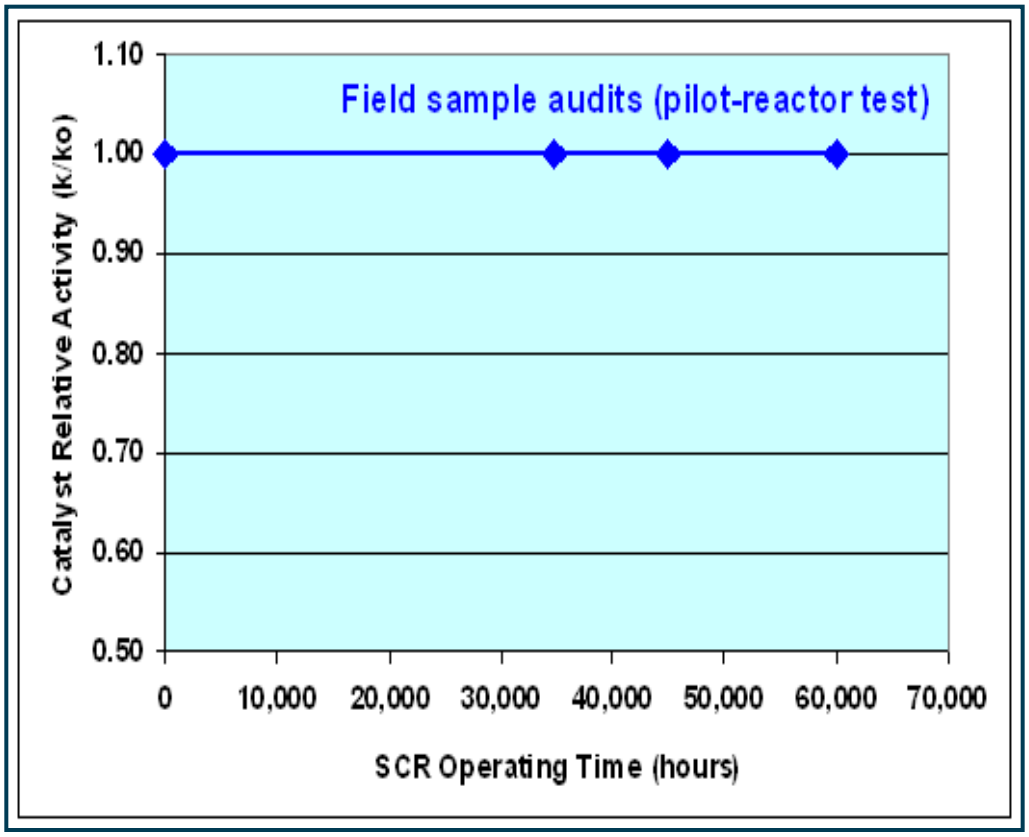


Catalyst Performance – Benefits of a meso- and macro-pore



Catalyst Performance

New Jersey Combined Cycle GE7FA DNX® Catalyst Installed (2001)



Guarantees:

3.5-ppmvdc Outlet NOx

86% DeNOx

5-ppmvdc NH_3 slip

2.0 in. wc draft loss

3-yrs life

Catalyst Performance

Alabama Combined Cycle Siemens 501F
DNX-929 Catalyst Installed (2010)

Test		Before Brand X Catalyst Replaced	Guarantees	Current
Outlet NOx	ppmvdc	3.5	3.5	3.5
NH_3-slip	ppmvdc	20	10	< 3
SCR Inlet Temp.	deg. F	600 - 650	-----	600 - 650
29% NH_3 Injection Rate	gph	> 500	394	266
SCR Draft loss	in. wc	> 2.75	1.6	< 1.4
Service Life	Hours	-----	40,000	4,380
Power Generation	MW	156.4	-----	160.1

- ✓Power Output increased by 3.7 MW
- ✓Ammonia usage decreased by over 50%

HTI Experience

• Utility Boilers	80 units
• Combustion Turbines	352 units
• including (> 800 F up to 1,050 F)	135 units
• Refinery & Industrial Boilers, Heaters	328 units
• Stationary Diesel and Gas Engines	56 units
Total Experience	816 units

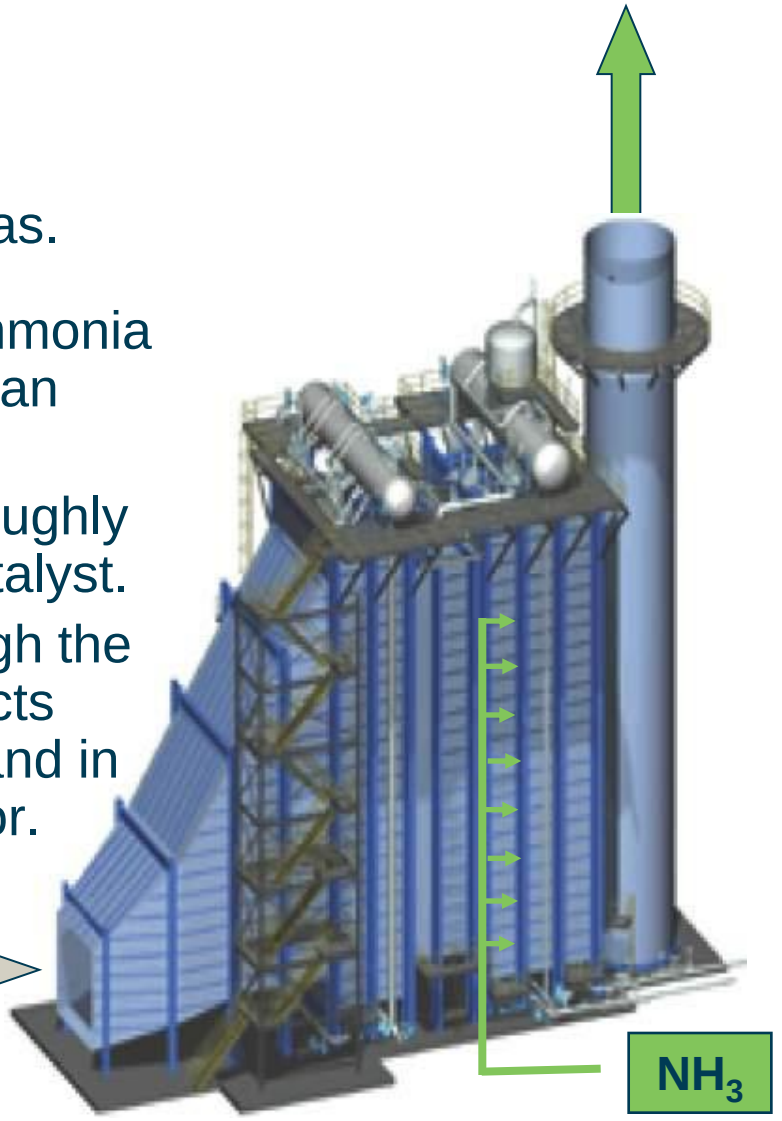
* Additional HTAS experience of ~ 400 units includes refinery units.

* Leading supplier of Combustion Turbine, Refinery, and Industrial DeNOx catalyst in the US.

SCR Process Basics

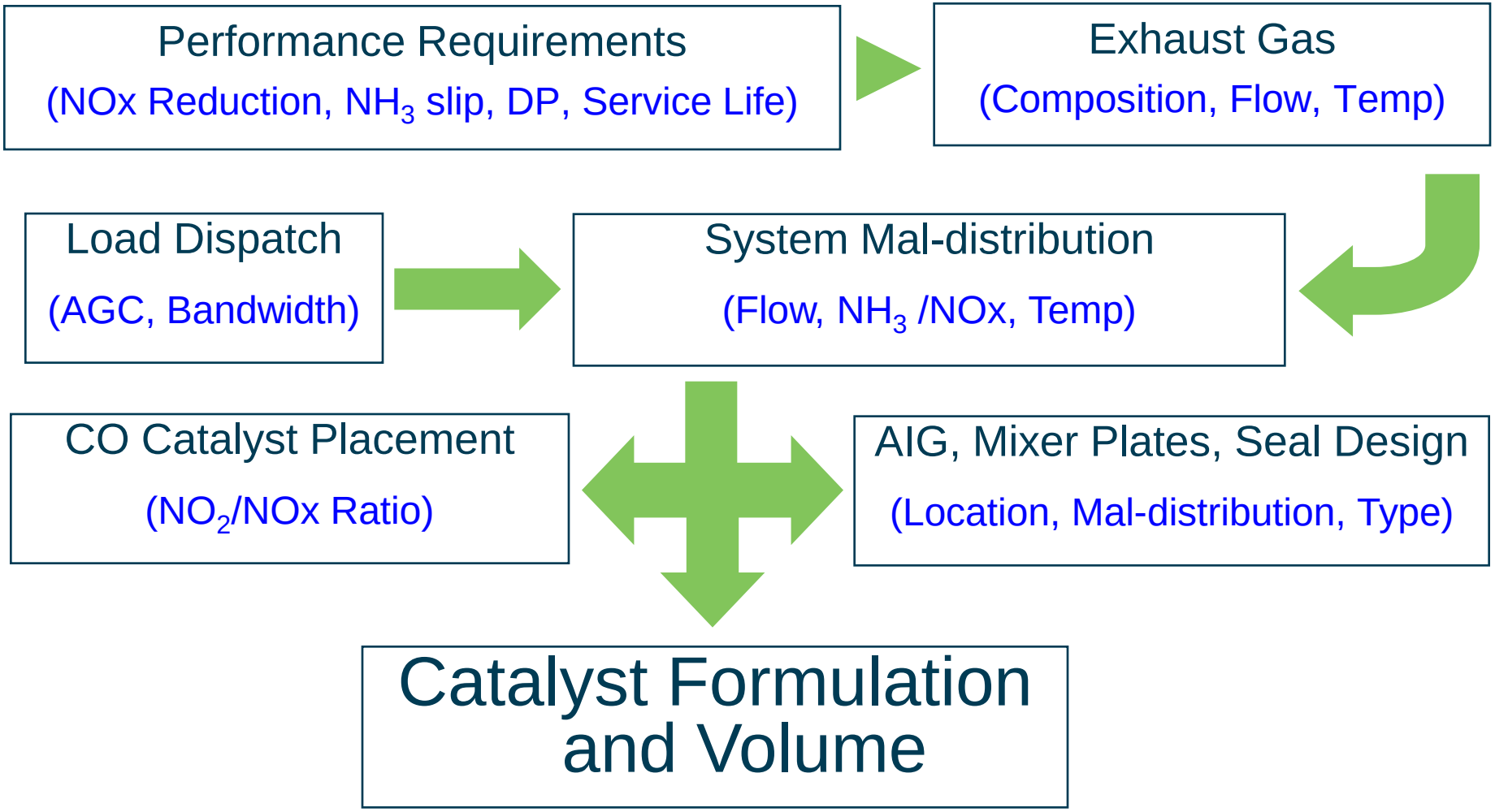
- SCR = Selective Catalytic Reduction
- Purpose is to reduce NOx from flue gas.
- A reducing agent, most commonly ammonia (NH_3), is injected into the flue gas via an Ammonia Injection Grid (AIG).
  - The NH_3 must be distributed thoroughly into the gas stream prior to the catalyst.
  - The mixed gas 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_20 vapor.

Clean Gas : N_2, H_2O, O_2, SO_2, (SO_3)

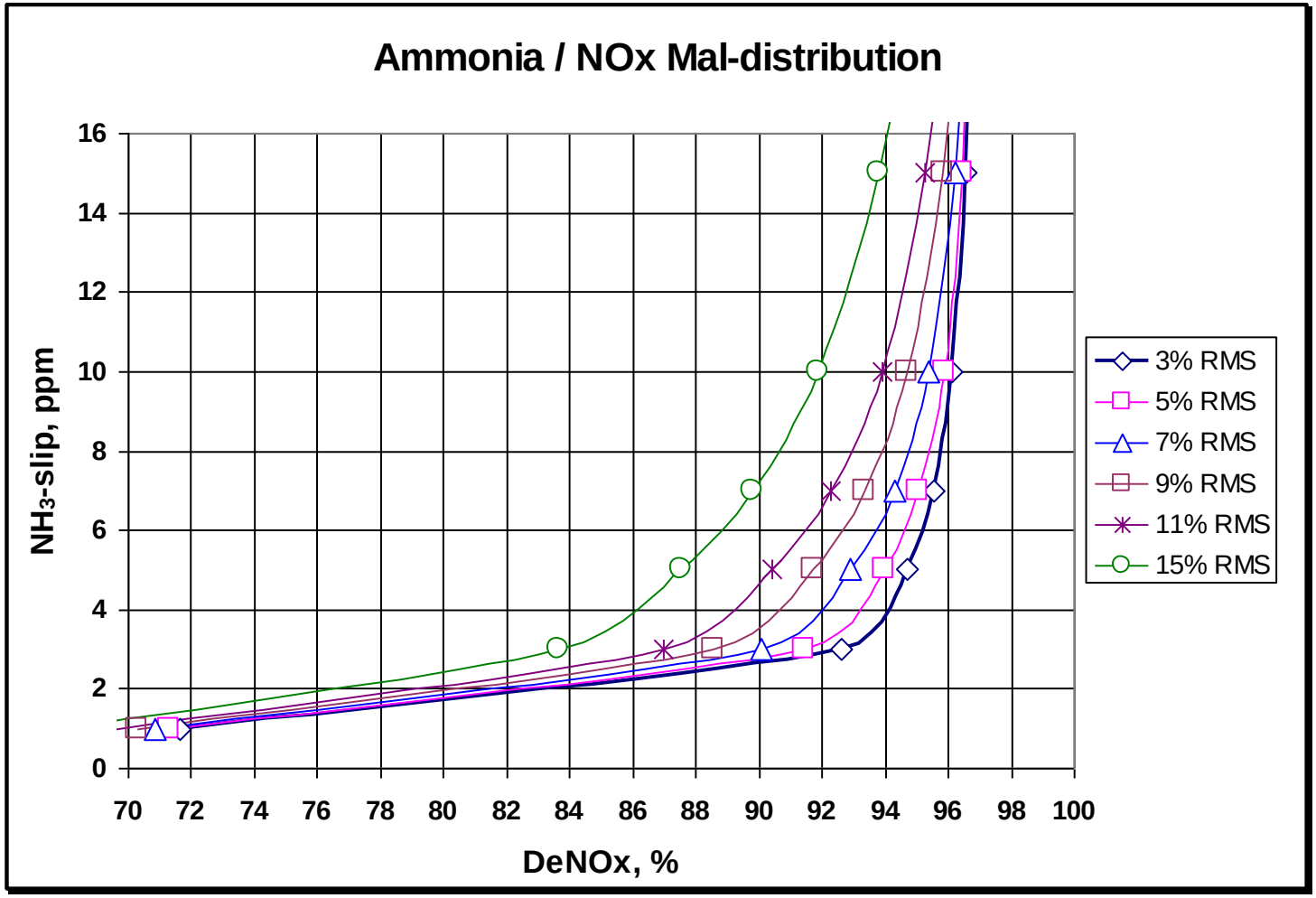


Flue Gas: NOx, SOx, CO_2, O_2

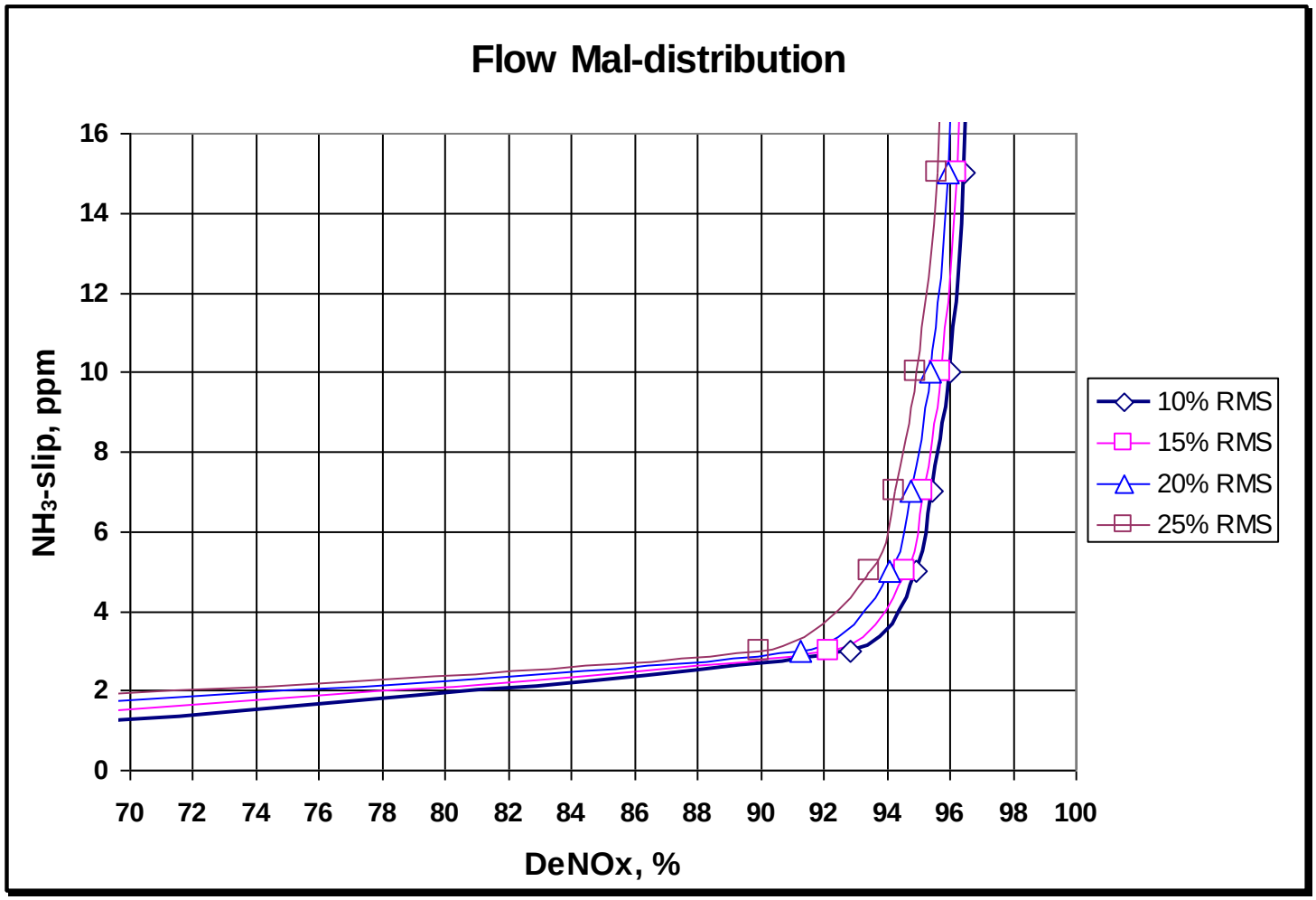
SCR Design Considerations



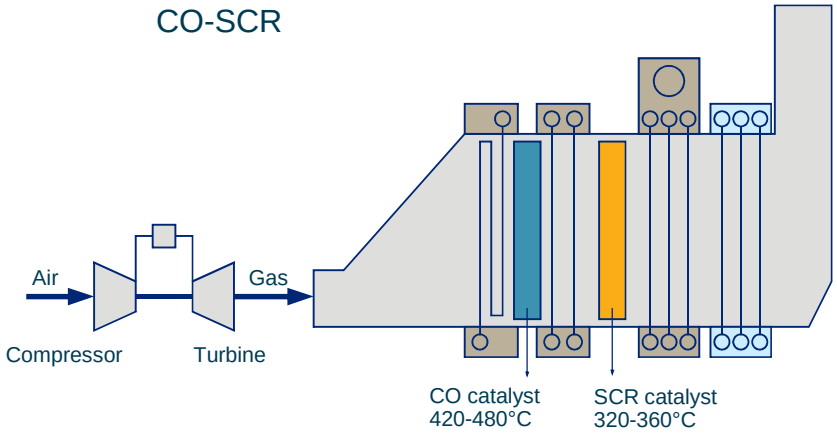
SCR Design Considerations

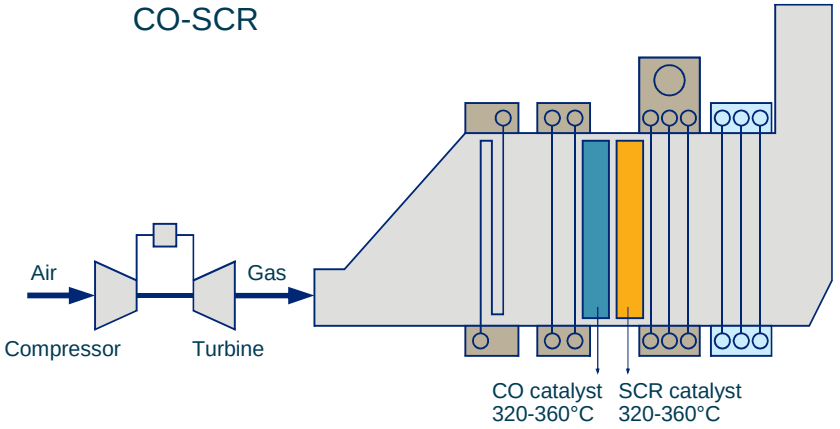


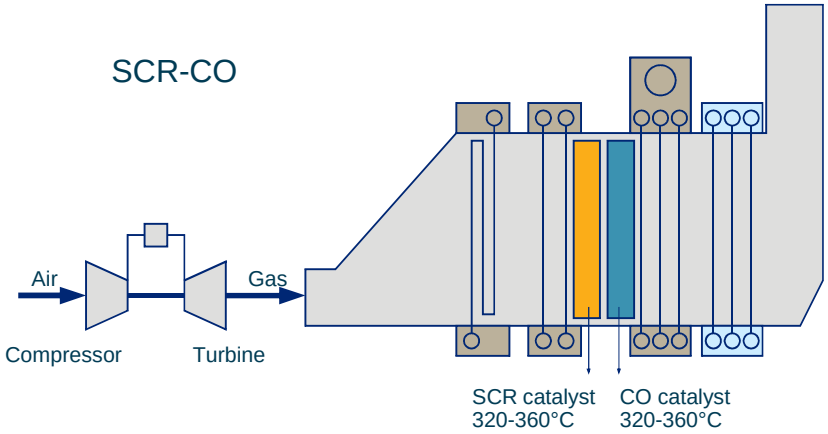
SCR Design Considerations

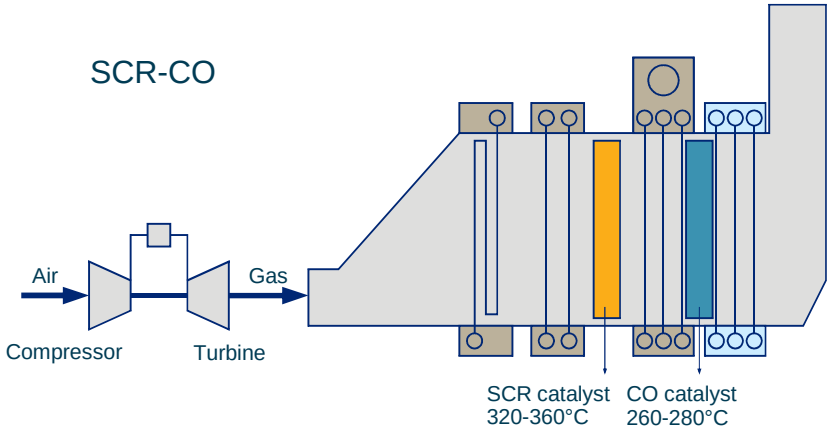


What's New - Basic HRSG layouts









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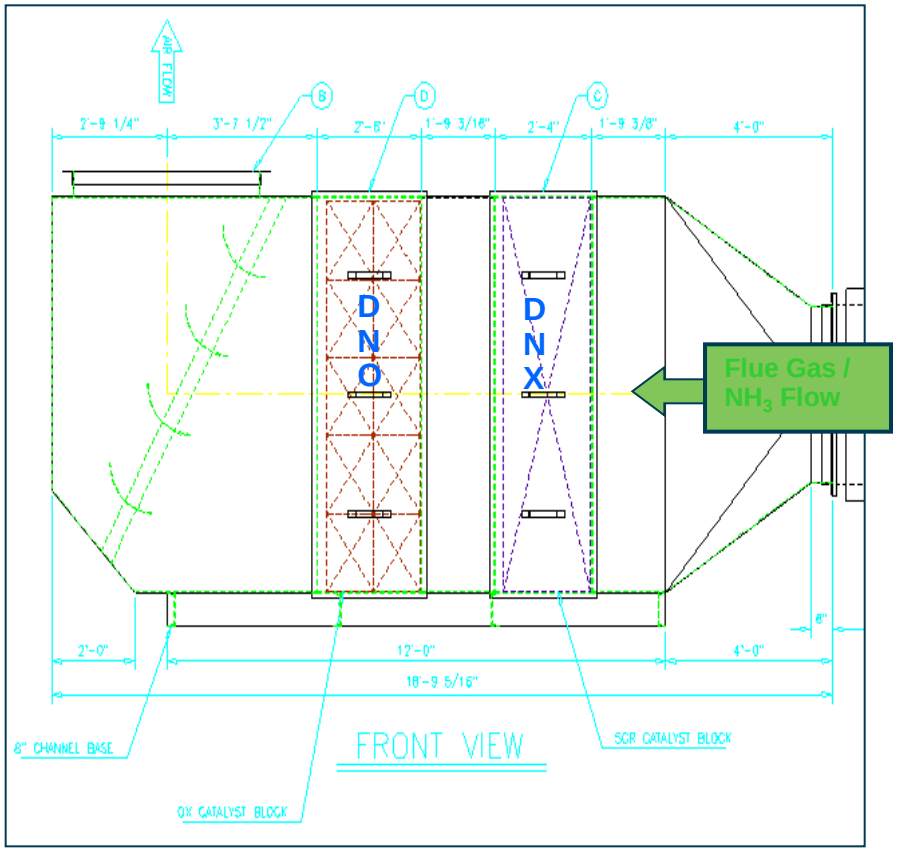
New Developments for CO (DNO) Catalyst

Pennsylvania Plant: NOx Catalyst (DNX-929), CO Catalyst (DNO-1920) Installed (April 2011)



DeNOx Guarantees:

12.24 lb/hr Outlet NOx

90% DeNOx @ 10-ppmvdc NH_3 slip

2-yrs life

CO Guarantees:

98% Outlet CO Conversion

41% Outlet VOC (C6+) Conversion

2-yrs life

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Haldor Topsoe, Inc.

Thank you

Questions

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