Simple Cycle SCR Operating Experience

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Overview

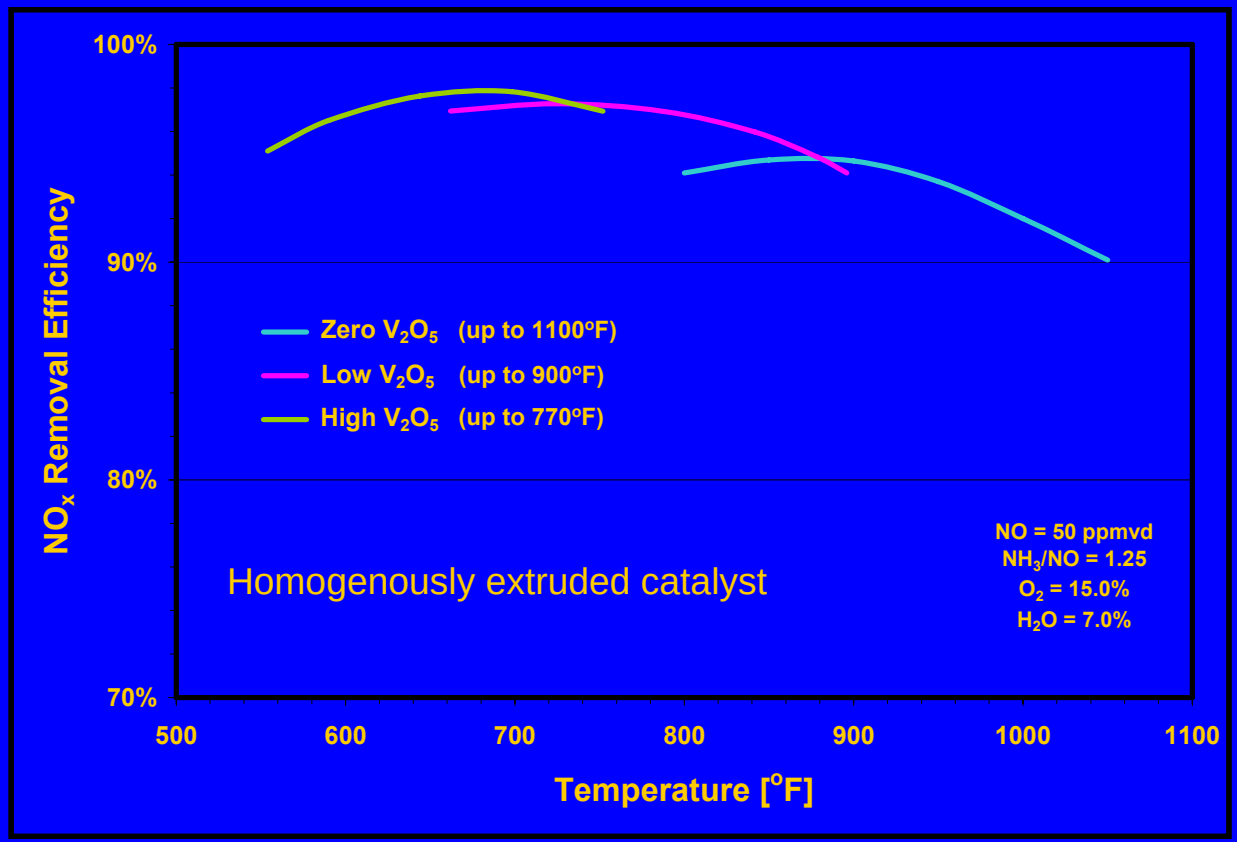
- SCR design considerations and catalyst selection for simple cycle gas turbines
- Field operating experience

Exhaust Gas Characteristics

Unit Type	Power [MW]	Flue Gas Flow [lb/hour]	Exhaust Gas Temp ºF
GE LM6000	45	1,051,200	840
GE LMS100	99	1,642,000	820
GE Frame 7EA	85	2,400,000	997
GE Frame 7FA	172	3,531,800	1113
SGT6-5000F	198	3,967,200	1070
MW-701D	144	3,595,300	991
MW-501D	150	2,810,000	1112

V_2O_5-WO_3/TiO_2 NH_3-SCR Catalysts

Large operating temperature range (350 - 1100°F)



Reaction Network

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

$4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$

$4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$

At higher temperature, reduce V:W ratio for

- Stronger NH_3 adsorption
- Lower NH_3 oxidation rate
- Higher DeNOx rate
- Lower sintering rate

SCR Design Considerations

Performance Requirements
(DeNOx, NH_3 slip, DP, Life (capacity factor))

Exhaust Gas
(T, Composition, Flow)

Add tempering air to cool exhaust gas?
(If yes, how much cooling?)

Example: Frame 7FA
1113°F → 1000°F (zero V)
1113°F → 850°F (low V)
1113°F → 780°F (high V)

Catalyst Type and Volume
(NH_3 Oxidation, Thermal Shock, Start-up Dynamics)

Catalyst Modules
(Material, Size, Seals)

System Maldistribution
(Flow, T, AIG design, NH_3/NO_x)

Tempering Air System Design

Nooter/Eriksen experience

- successfully implemented tempering air systems designed through cold flow model testing on 11 LM6000 applications
- performed field testing to validate even temperature and velocity distributions at the catalyst face
- worked with NYPA to evaluate and improve the temperature distribution on LM6000 units

SCR with Tempering Air Cooling

Benefits

- + Use catalyst with higher V:W ratio
  - + Less volume
  - + Lower DP
- + Longer catalyst life guarantees
- + Module design
  - + May be able to use carbon steel; larger modules

Costs

- – Fans required (capital, operating costs; added space)
- – Catalyst can overheat if fan failure occurs

SCR without Tempering Air Cooling

Benefits

+ No fans required (save capital, operating costs; less space)
+ No risk of catalyst overheating

Costs

– Requires a catalyst with lower V:W ratio
  – More volume; Higher DP
– Shorter catalyst life guarantees if >1000^{o}F
  – Management plan (extend life, reduce total volume)
– Module design
  – Chrome-moly steel; Smaller modules

Determining the Optimal Solution

Economic Analysis

- Fans (size: capital, operating costs, failure risk), catalyst type and volume, DP, life (capacity factor), modules, catalyst management plan
- Space requirements, if any

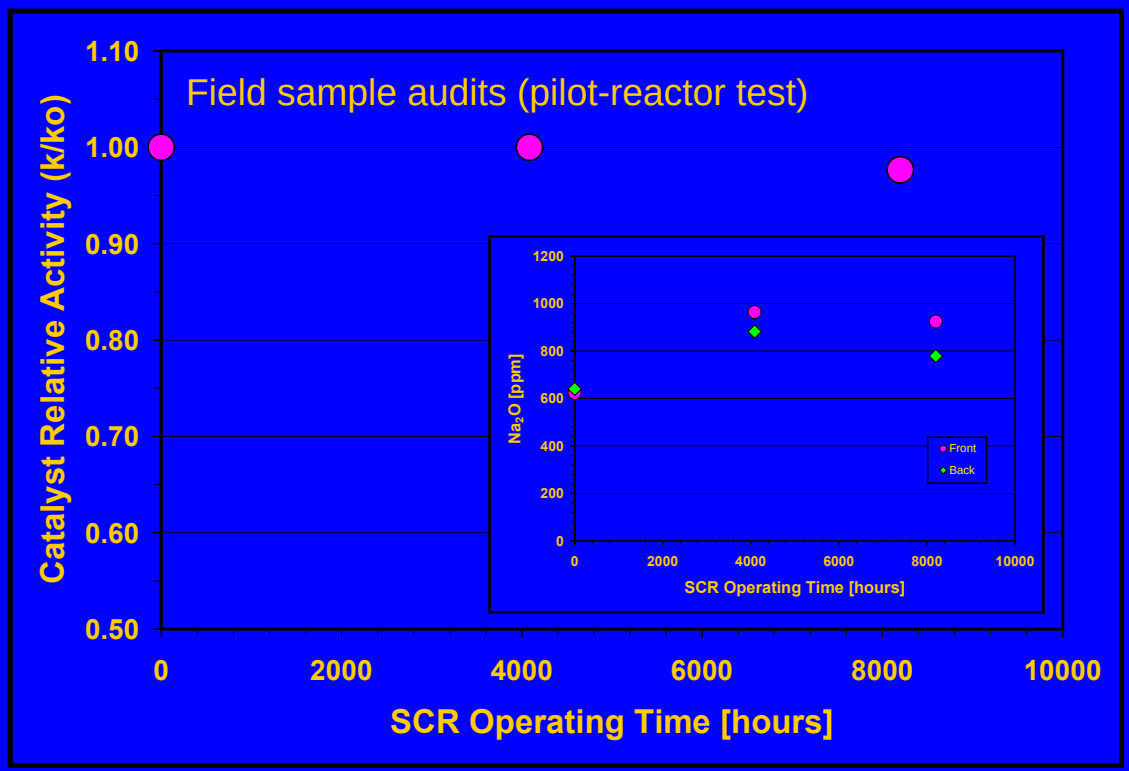
Bottom Line

- SCRs can be designed and successfully operated for simple cycle gas turbines using homogeneously extruded V-W-Ti catalysts, with or without tempering air cooling
- *Approach is very case specific*

Long Island Simple Cycle LM6000

With tempering air cooling for SCR design (720°F)

Installed (2002): Cormetech high V_2O_5 catalyst



Guarantees:

2.5-ppmvdc Outlet NO_x

91.5% $DeNO_x$

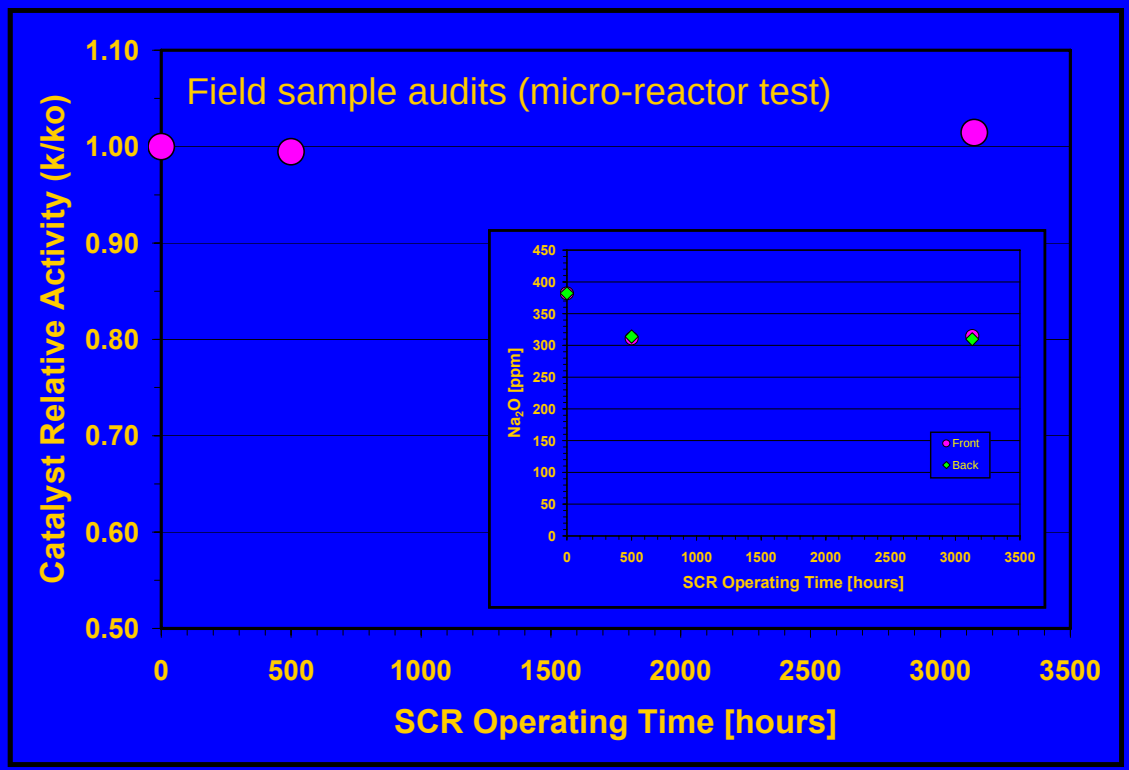
9-ppmvdc NH_3 slip

3-years life

NYC Simple Cycle LM6000

No tempering air cooling for SCR design (840ºF)

Installed (2004): Cormetech low V_2O_5 catalyst



Guarantees:

2.5-ppmvdc Outlet NO_x

90% $DeNO_x$

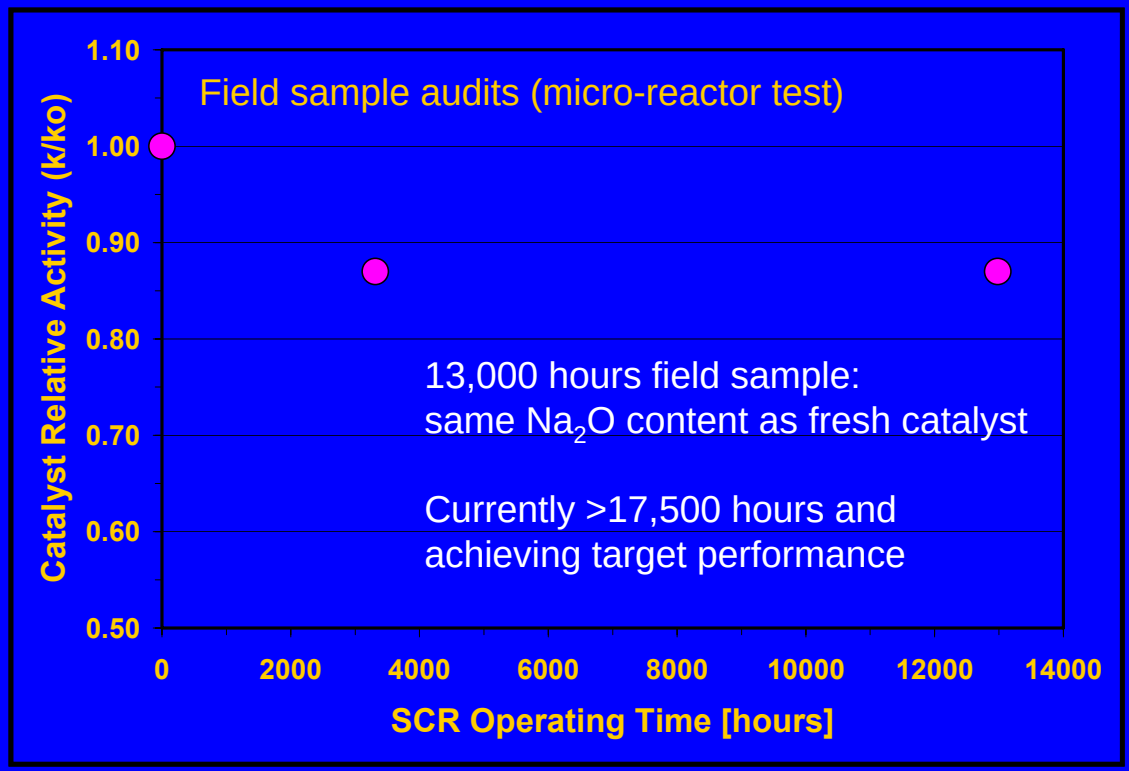
7-ppmvdc NH_3 slip

18,000-hours or 5-years

California Simple Cycle LM6000

No tempering air cooling for SCR design (874ºF)

Installed (1996): Cormetech zero V_2O_5 catalyst



Guarantees:

2.5-ppmvdc Outlet NO_x

90% $DeNO_x$

7-ppmvdc NH_3 slip

18,000-hours life

California Simple Cycle Frame 7EA

No tempering air cooling for SCR design (1000°F)

Installed (2003): Cormetech zero V_2O_5 catalyst

Guarantees:

4.2-ppmvdc Outlet NO_x

90.1% DeNO_x

10-ppmvdc NH_3 slip

8,400-hours life

Current status:

315 operating hours

46 starts and stops

Outlet NO_x = 3.5 ppmvdc

NH_3 slip = 3.1 ppmvdc

Simple Cycle Field Experience

Unit Type	# Operating Sites	Tempering Air	Catalyst Type	Op Temp °F	Op Hours
LM6000	12	no / available	low vanadia	760-840	up to 3,100
LM6000	9	yes	high vanadia	720-750	up to 8,200
LM6000	1	none	zero vanadia	864	>17,500
LM5000	1	no / available	low vanadia	805	>700
LMS100	1	no / available	low vanadia	846	construction
7EA	1	no / available	zero vanadia	1000	315
MW701D	1	none	zero vanadia	991	>4,000
MW501D	1	none	zero vanadia	1112	>4,000
diesel engine	4	none	zero vanadia	750-1020	>100
boiler	2	none	zero vanadia	910-925	up to 8,000

Summary

Extruded honeycomb V-W-Ti SCR catalyst is a proven solution for simple cycle gas turbine applications

- Can design with or without tempering air for exhaust cooling
- Extensive, successful field experience

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