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Development of NH3-SCR Catalyst for Simple Cycle Gas Turbine

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Overview

- SCR Mechanisms Review
- Conventional SCR Catalyst Composition/Behavior
- Simple Cycle Performance Requirements
- NOxNON 700-HT Catalyst
  - Performance
  - Durability
- Plant Experience
- Summary

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Conventional SCR Catalyst

- Heterogeneous, Supported Metal Catalyst
- Support material consists of SiO_2, Al_2O_3 or other inert porous material.
- Support material is impregnated with Active Metal Oxides; TiO_2, V_2O_5, WO_3, MoO_3 which catalyze NOx conversion.

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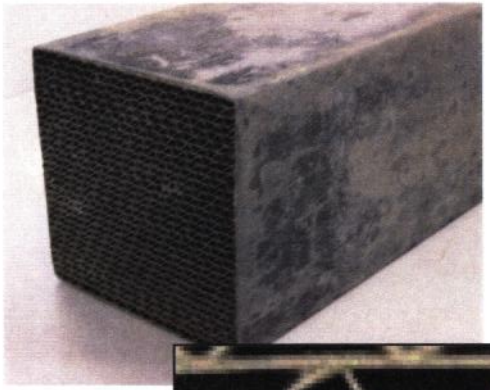
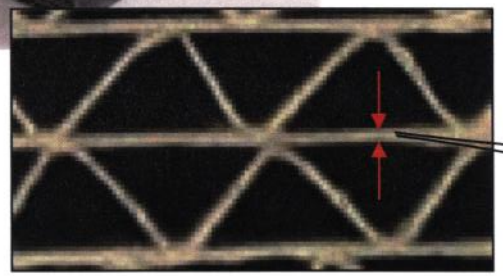
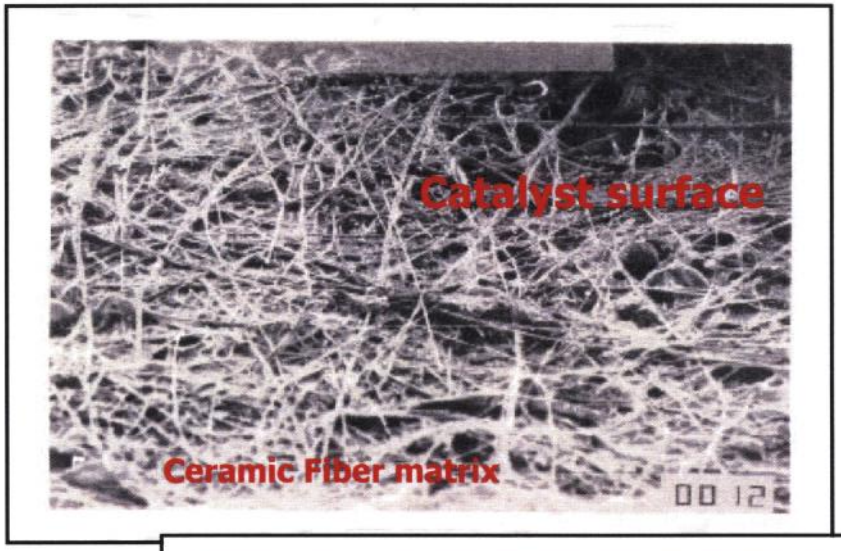
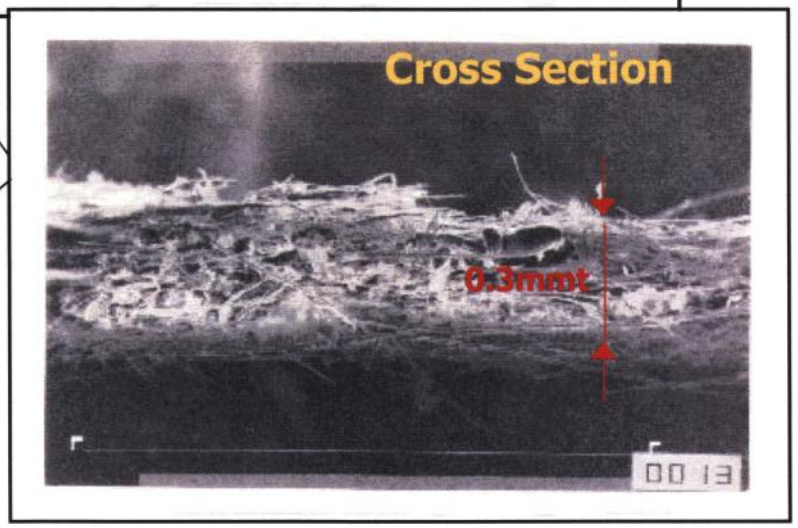
Catalyst Structure

Ceramic fiber matrix









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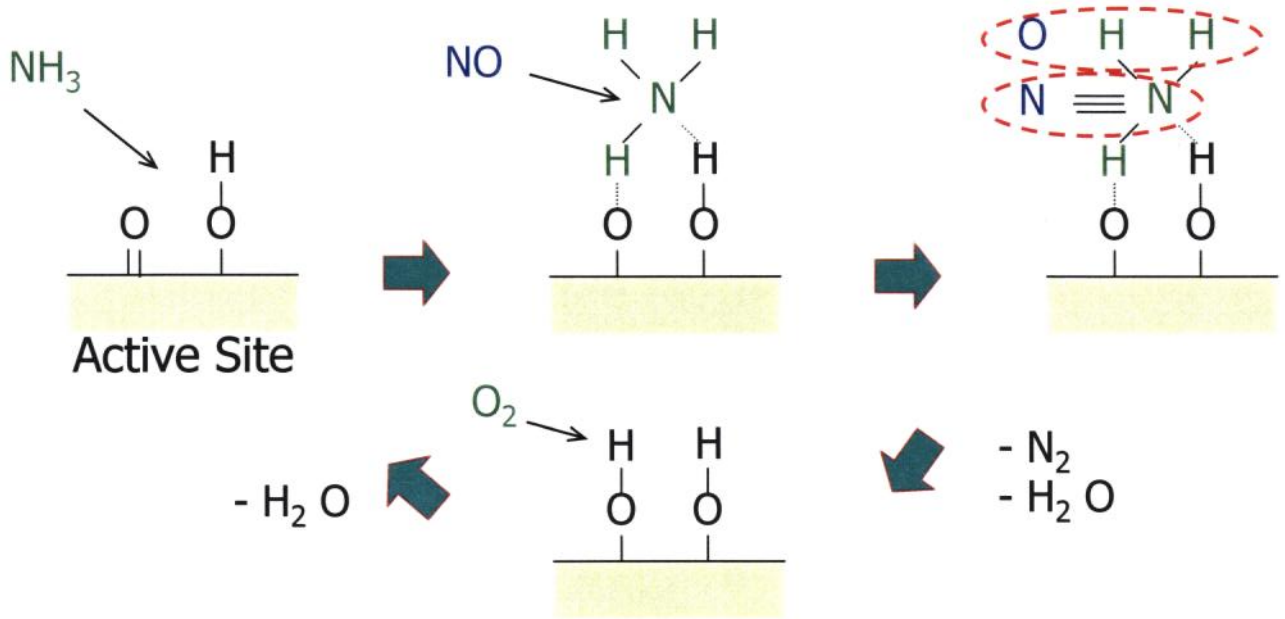
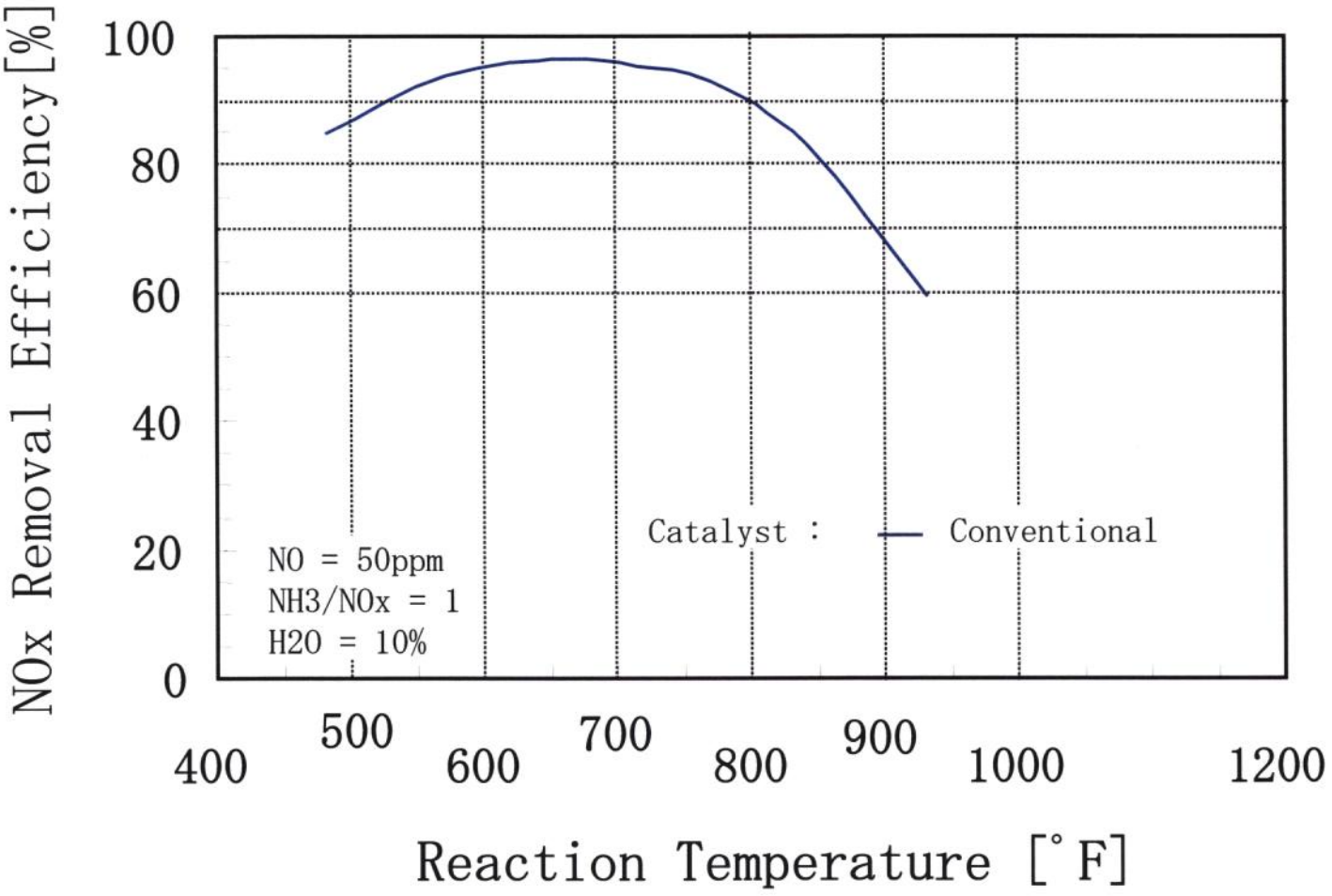
SCR Mechanism (Eley-Rideal Model)

1. NOx and NH_3 diffusion to catalyst surface
2. NH_3 adsorption at active site (NH_4^+ formation)
3. Reaction between NH_4^+ and NOx
4. Regeneration of active site (to initial state)



Conventional Catalyst Performance



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Simple Cycle Operation

Features are…

- High temperature

  without HRSG

  Range : 840 – 1122° F

- Daily Start up & Shut down

  Ramp Rate @ GT Outlet : > 900° F/min

  (GE LM-6000PC)

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Catalytic Behavior in High Temperature

- NH_3 Adsorption Low at High Temperature

  NH_3 equilibrium balance on catalyst:

  Desorption > Adsorption

- NH_3 Combustion at High Temperature

  $4NH3 + 5O2 \rightarrow 4NO + 6H2O$ on catalyst:

  Active sites do not promote NOx conversion and produce NO

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High Temperature Catalyst Design

To Counteract NH3 Desorption…

There must be strong interaction
between NH3 and the catalyst
Acidic chemical composition is used in the catalyst

To Suppress NH3 combustion…

Metal oxides with lower oxidation
activity must be chosen
Optimum chemical formulation is used in the catalyst

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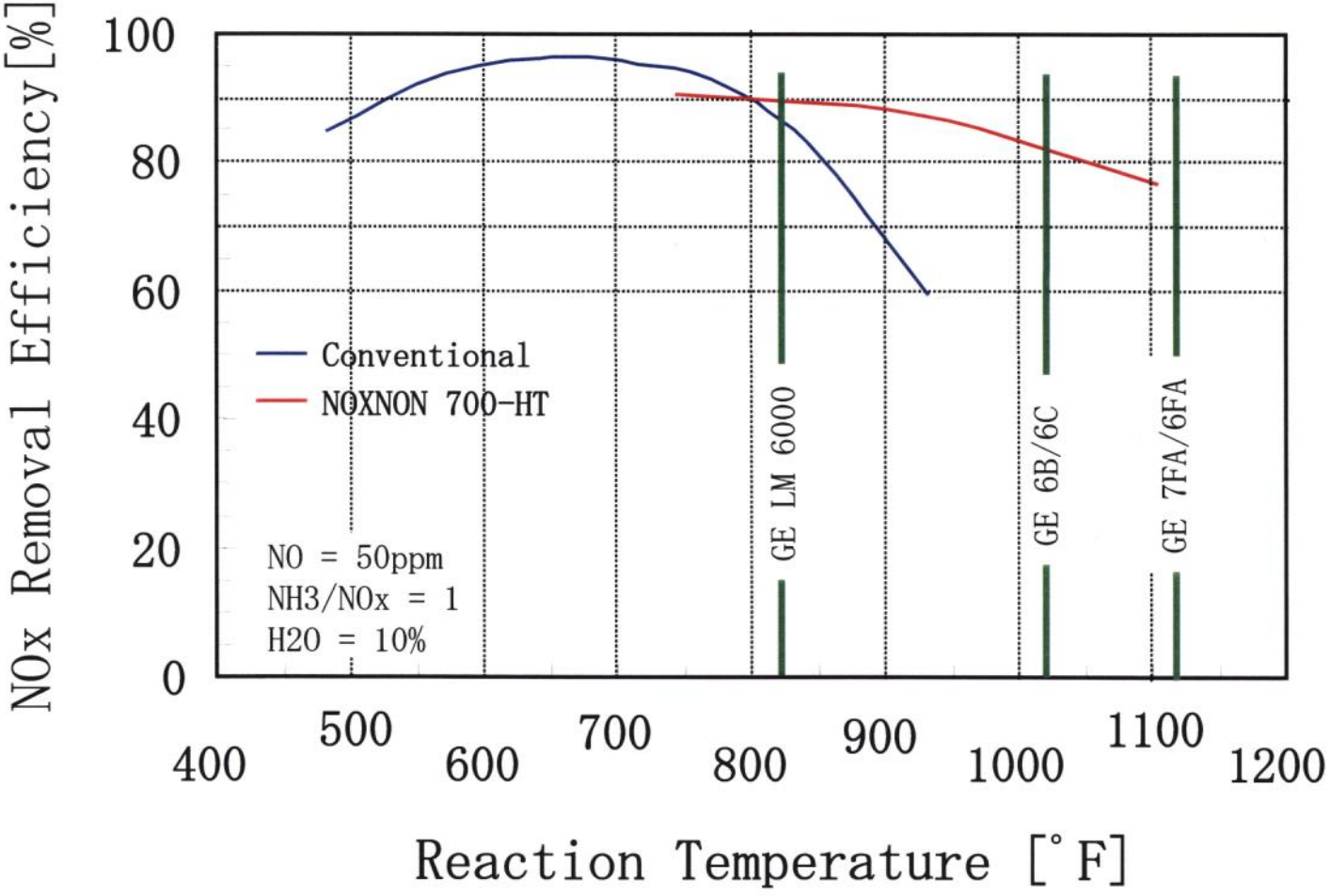
NOxNON 700-HT Performance



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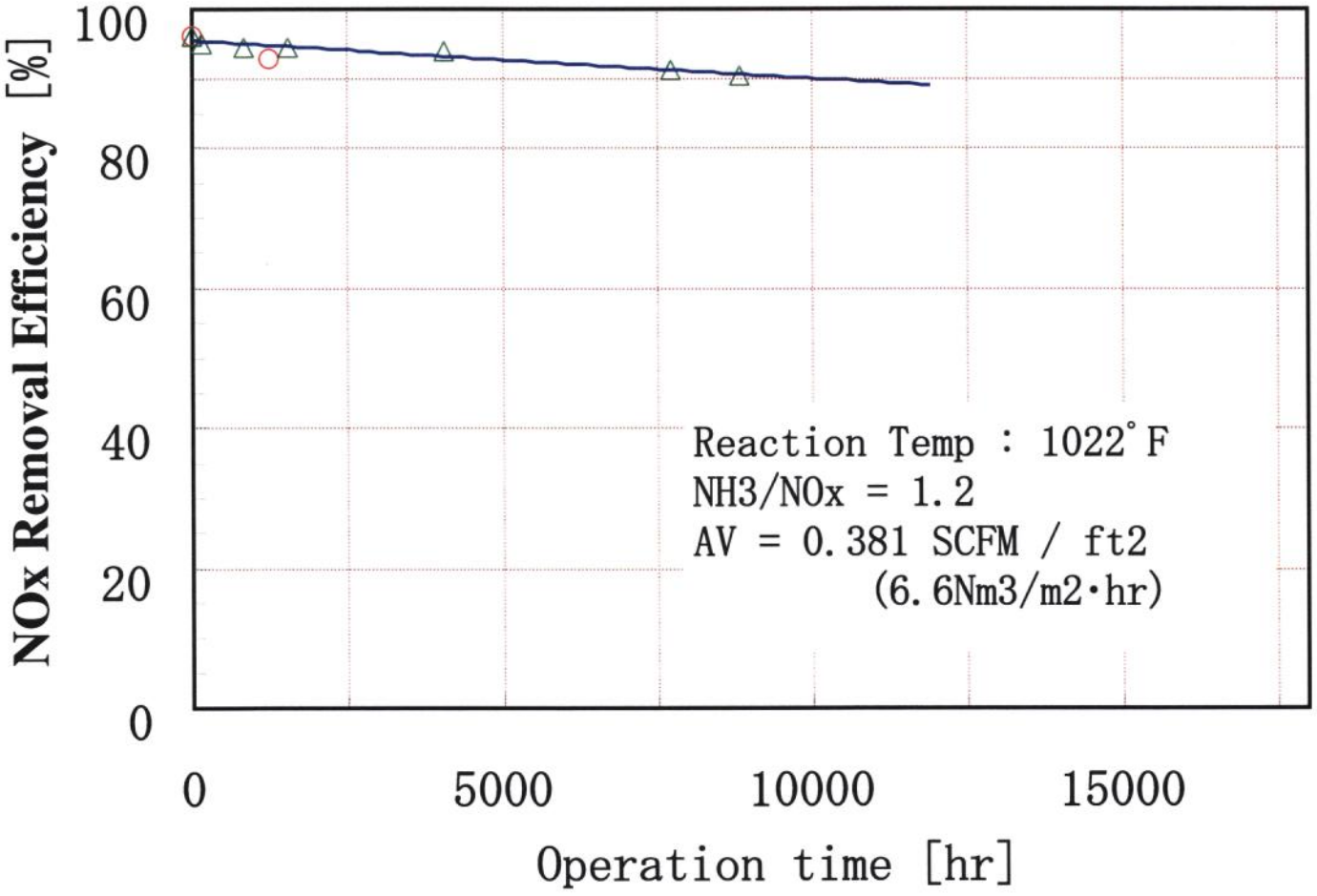
Catalyst Performance



Catalyst Durability

Catalyst Long Term Performance is affected by:

1. High Temperature Sintering

   Sintering causes micropore shrinkage on the surface of the TiO2 crystal, thereby reducing active site availability.

Catalyst Structural Strength is affected by:

2. Thermal Shock of Startup/Shutdown

   Thermal stress can cause cracking in catalyst support/substrate. This effect is minimized in ceramic fiber structures.

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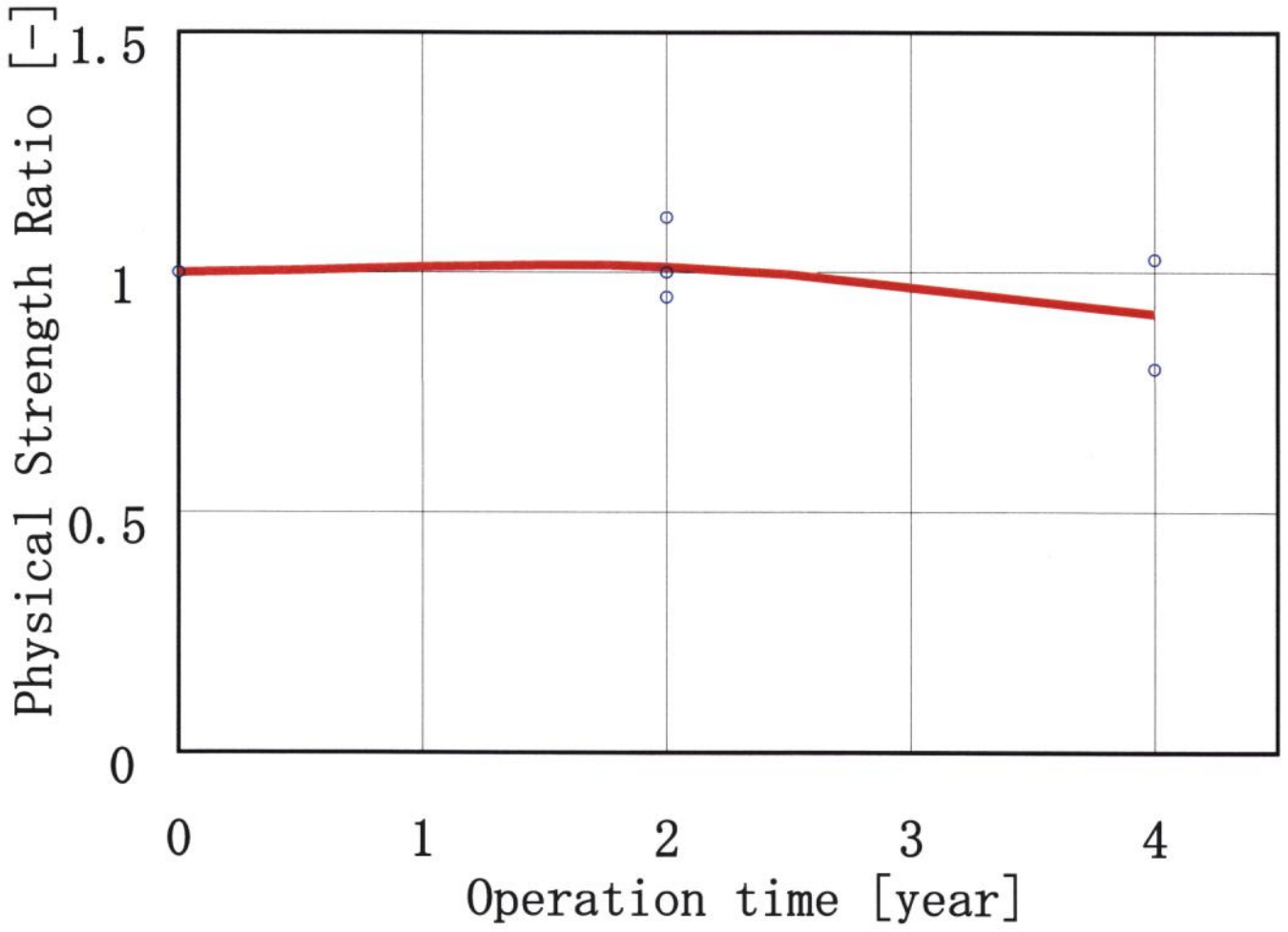
Physical strength of Catalyst Unit



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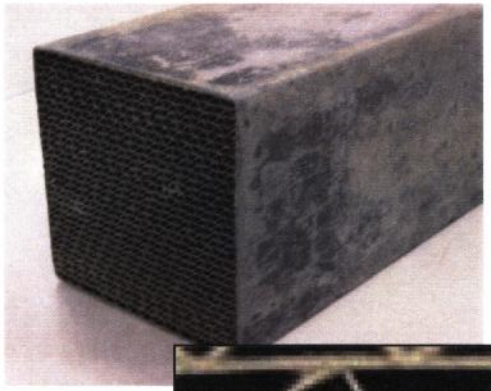
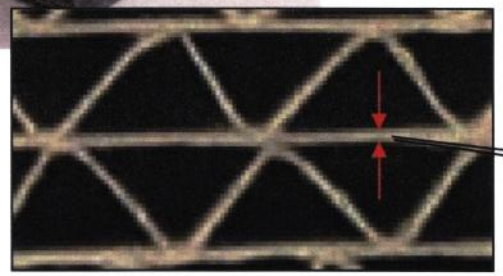
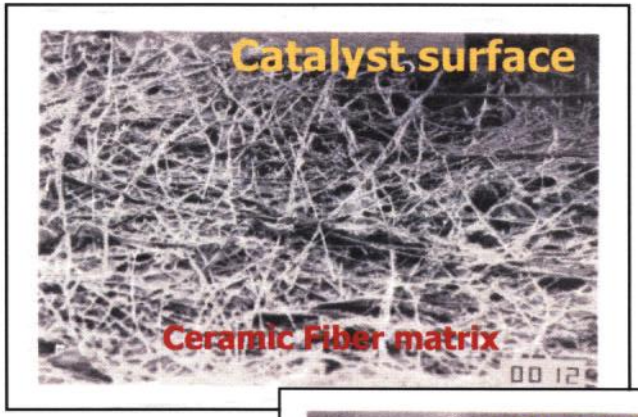
Catalyst Structure

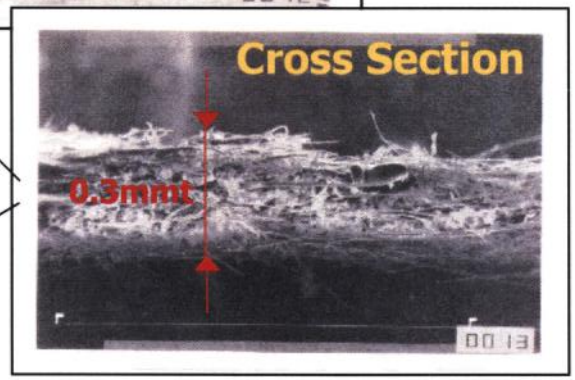
Ceramic fiber matrix structure





Hitz New Catalyst

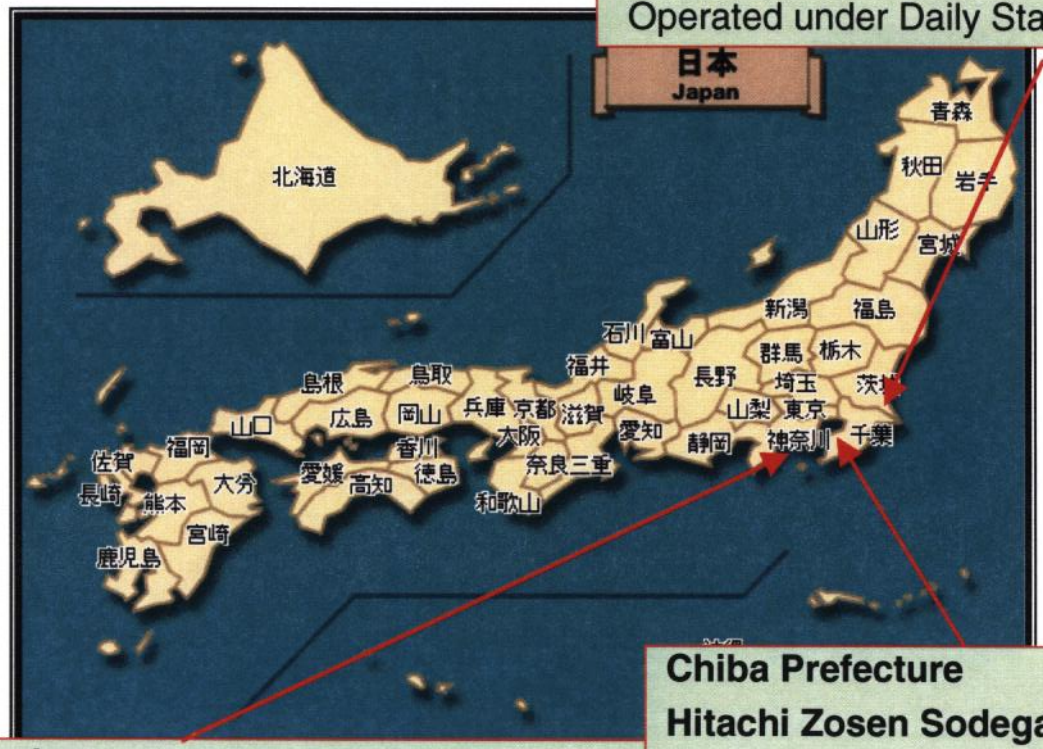




SEM of Catalyst surface/cross section

Location of Plant

Ibaraki Prefecture
Hitachi Zosen Ibaraki-City Power Plant
NOXNON700-HT Now being Tested in GE-F6A
Operated under Daily Stat-Up /Down at 1094F



Chiba Prefecture
Hitachi Zosen Sodegaura-City Power Plant
GE-F9 x14trains. Tested NOXNON700-HT for 4 years

Kanagawa Prefecture
Hitachi Zosen Kawasaki-City Manufacturing Plant
First Commercial Application of NOXNON700-HT Now Operational.

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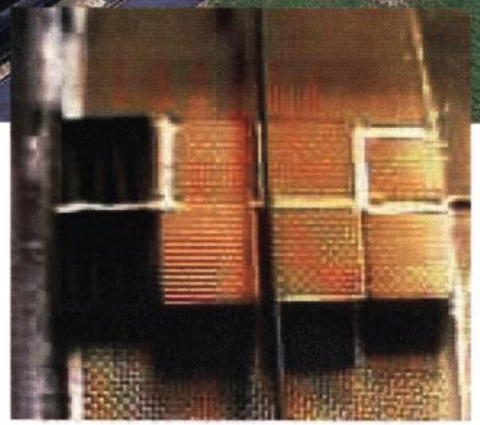
Commercial Plant



Location : Ibaraki, Japan

Gas Turbine : GE F6FA

Gas Temp. : 1094 ° F

Operation Mode : DSS

Operation Period : 1year

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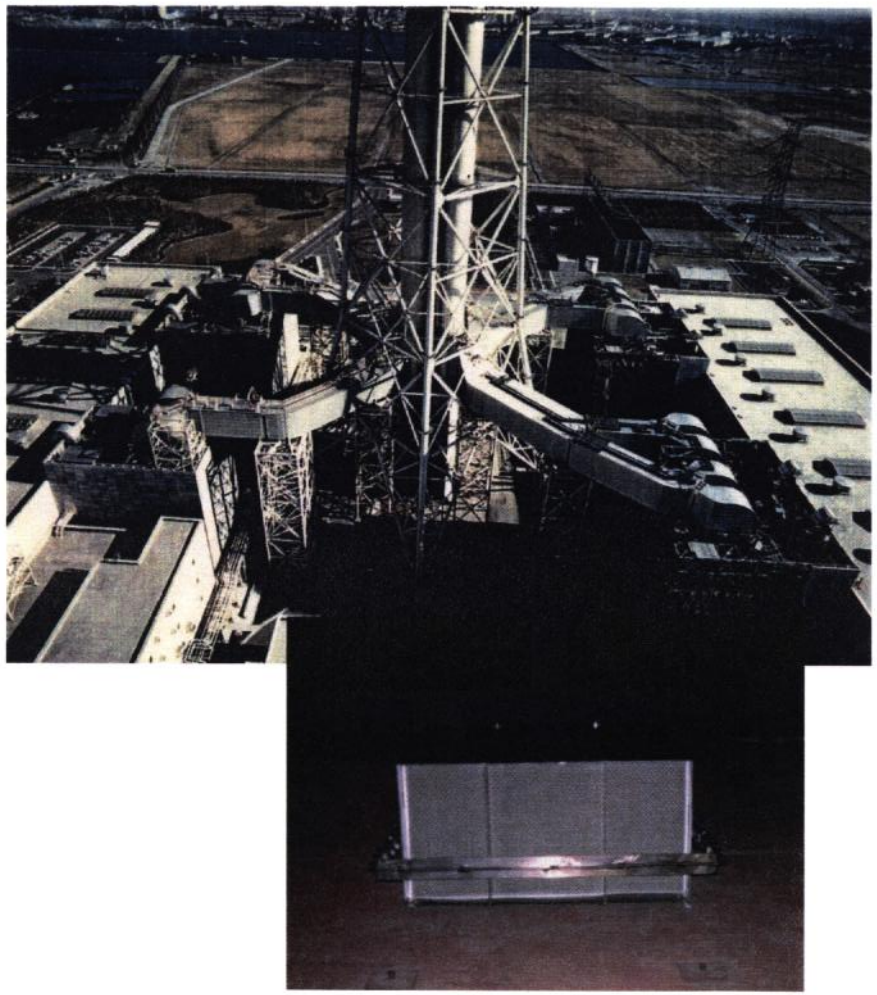
Commercial Plant



Location : Chiba, Japan

Gas Turbine : GE F9E

Gas Temp. : 1022° F

Operation Mode : DSS

Operation Period : 4 years

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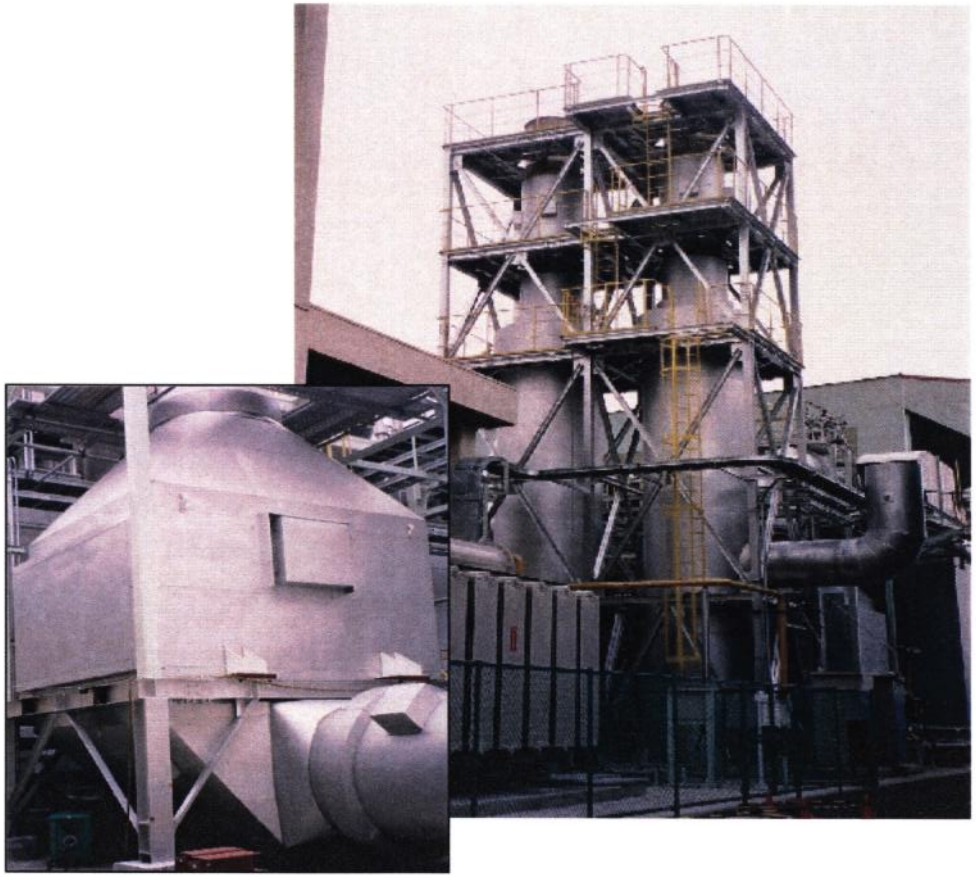
For various application

Gas Engine Power Plant



Location : Kawasaki, Japan

Gas Engine : WARTSILA

18V34SG

6000kW x2

Gas Temp. : 878 °F

Operation Mode : DSS

Operation Period : 6 months

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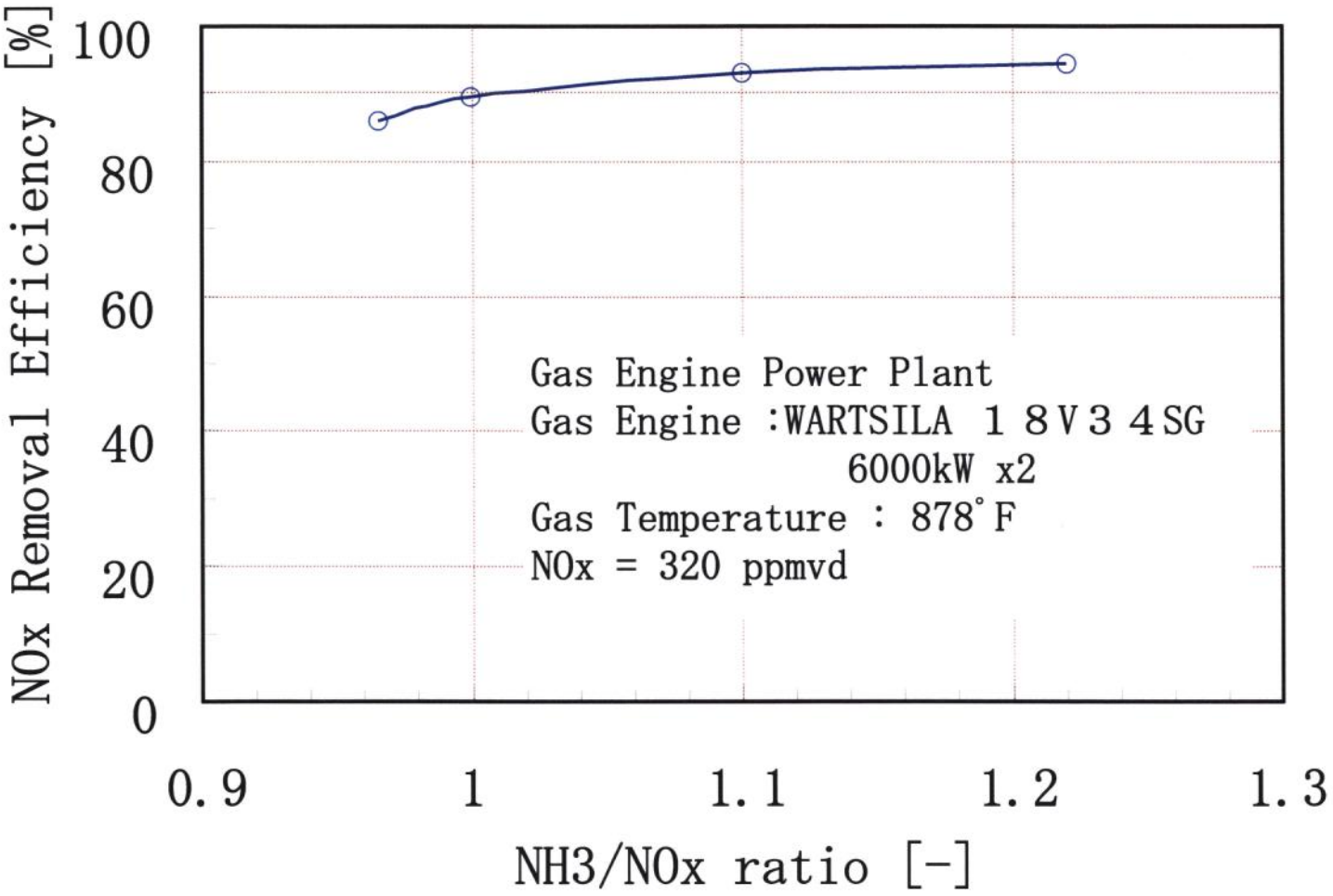
Performance of Gas Engine Power Plant



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Summary （1）

Hitachi Zosen has developed a high temperature SCR catalyst for use in Simple Cycle applications.

The new catalyst, called NOXNON 700-HT has minimal high temperature NH3 oxidation and an increased affinity for NH3 over standard medium temperature catalysts.

Summary （2）

Extensive field testing at 3 different locations in Japan indicates the following:

The DeNOx efficiency of the NOXNON 700-HT is over 90% efficiency for NH3/NOx mole ratios >1.0.

Catalyst durability testing performed over 3 years indicates the NOXNON 700-HT has the capability to withstand thermal stress of high temperature operation and cyclic stresses of startup and shutdown in simple cycle application as proven in material strength testing.

The decrease in catalyst efficiency measured at a gas temperature of 1022 °F is < 4% for 8,000 hrs operation.