

SCR DENOX SYSTEMS FOR THE MCILVAINE COMPANY

A short overview of SCR NO_x Emission Control Systems for Gas Turbines

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MITSUBISHI HEAVY INDUSTRIES

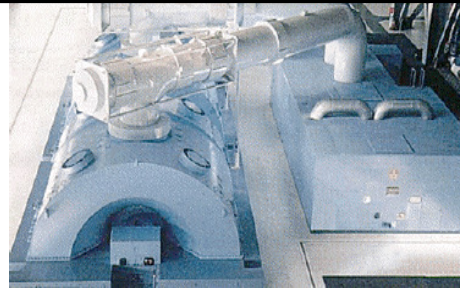
- Founded 1884, Headquarters – Tokyo, Japan
- 1969 Merger of three heavy industries – MHI Ltd.
 - 1979 Formed MHIA - US Headquarters New York, NY
 - 2001 Formed MPS – US Headquarters Lake Mary, FL
 - 2006 Name changed to MPSA
- Global Manufacturer:
 - Shipbuilding & Ocean Development
 - Power systems – Thermal, Renewable, Nuclear
 - Machinery & Steel Structures – Environment, Transportation, Medical, Industrial
 - Aerospace – Space Systems, Aviation
 - General Machinery & Special Vehicles
 - Other – Air Conditioners, Industrial Machine Tools
- 34,000 Employees manufacturing 700 products worldwide
- Sales in excess of \$31 billion USD
- A “Mitsubishi Group” core company



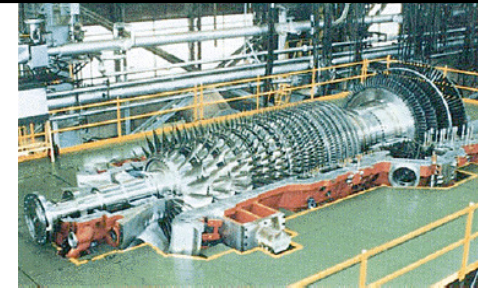
MHI, YOUR PARTNER IN POWER GENERATION DEVELOPMENT



Combined Cycle Power Plant



Large Steam Turbine



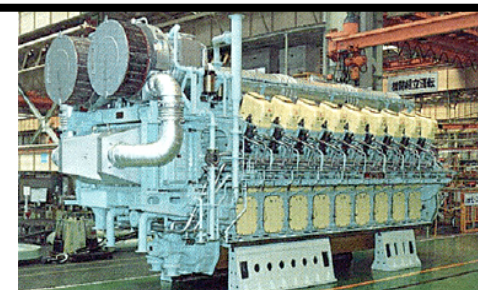
Gas Turbine



Geothermal Power Plant



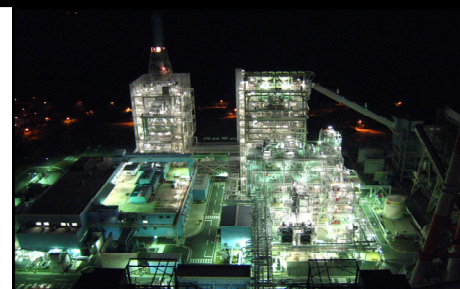
Small / Medium Steam Turbine



Reciprocating Power Plant



Wind Turbine

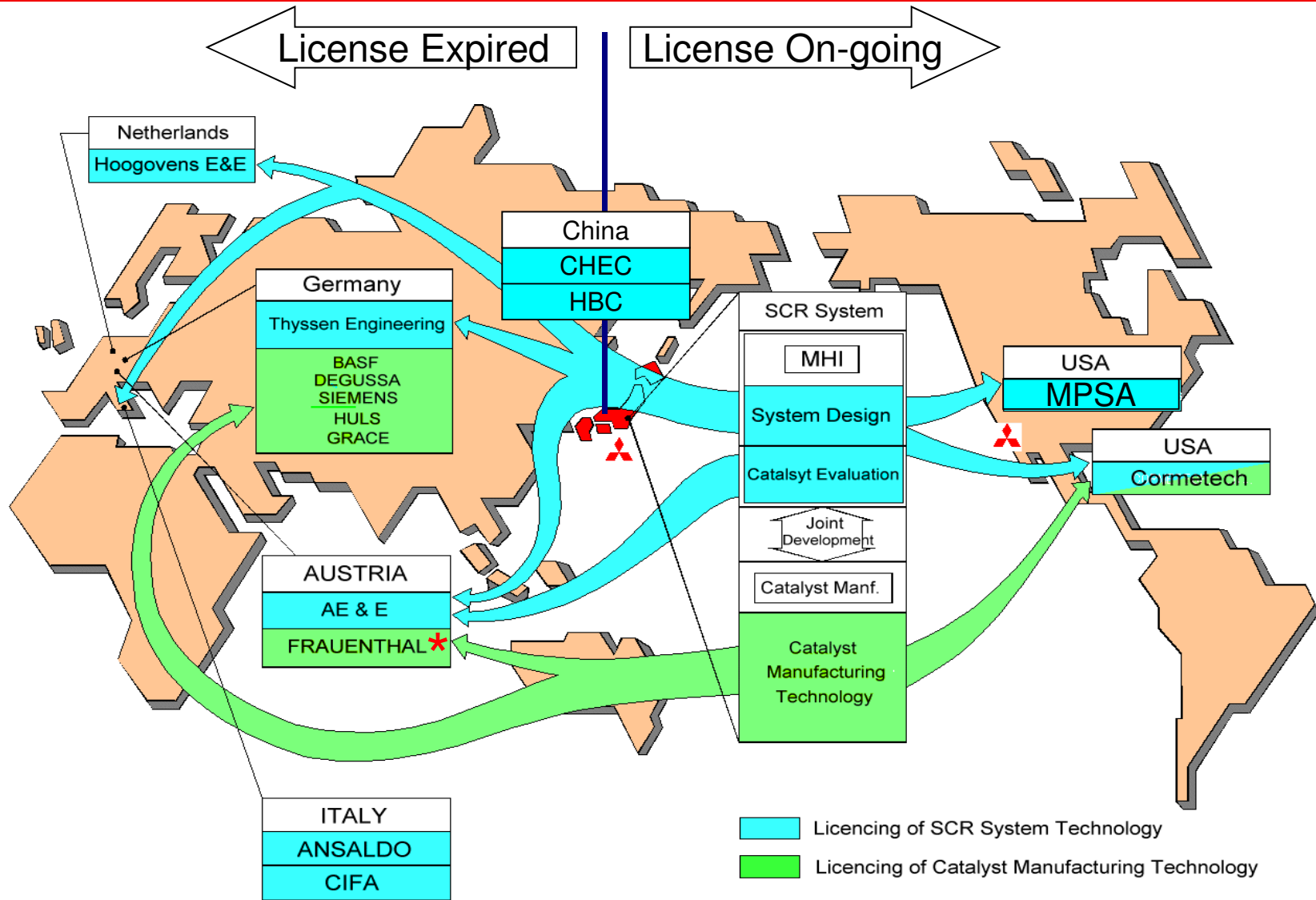


IGCC



**SCR DeNOx Systems
Gas Turbines, Coal Fired Boilers
Refinery Heaters**

MITSUBISHI WORLD WIDE LICENSING



* Frauenthal now operates as Ceram after licensing agreement expired

MPSA EXPERIENCED TEAM

- US based team drawing on 40 years R&D in Japan
- MPSA Capabilities:
 - SCR process design
 - Feasibility study and detailed engineering (*incl. 3D*)
 - Project execution / management
 - Fabrication in North America only (*sub-contract*)
 - Shop preassembly of components (wherever possible) -> helps to minimize field changes and associated cost
 - CFD and Cold Flow Model Test (*designed and controlled by Mitsubishi / executed at local facilities*)
 - Quality control and inspection (*ISO 9001 Certified*)
 - Commissioning and start-up

mitsubishi SCR Supply List

as of 10/2012

		<u>Japan & Others</u>	<u>USA</u>
Boiler	Coal	49	2
	Oil	64	0
	Gas	27	15
Gas Turbine		95	154
Diesel Engine		153	0
FCC & Refinery Heater		22	27
Total		410	198

Grand Total: **608** units

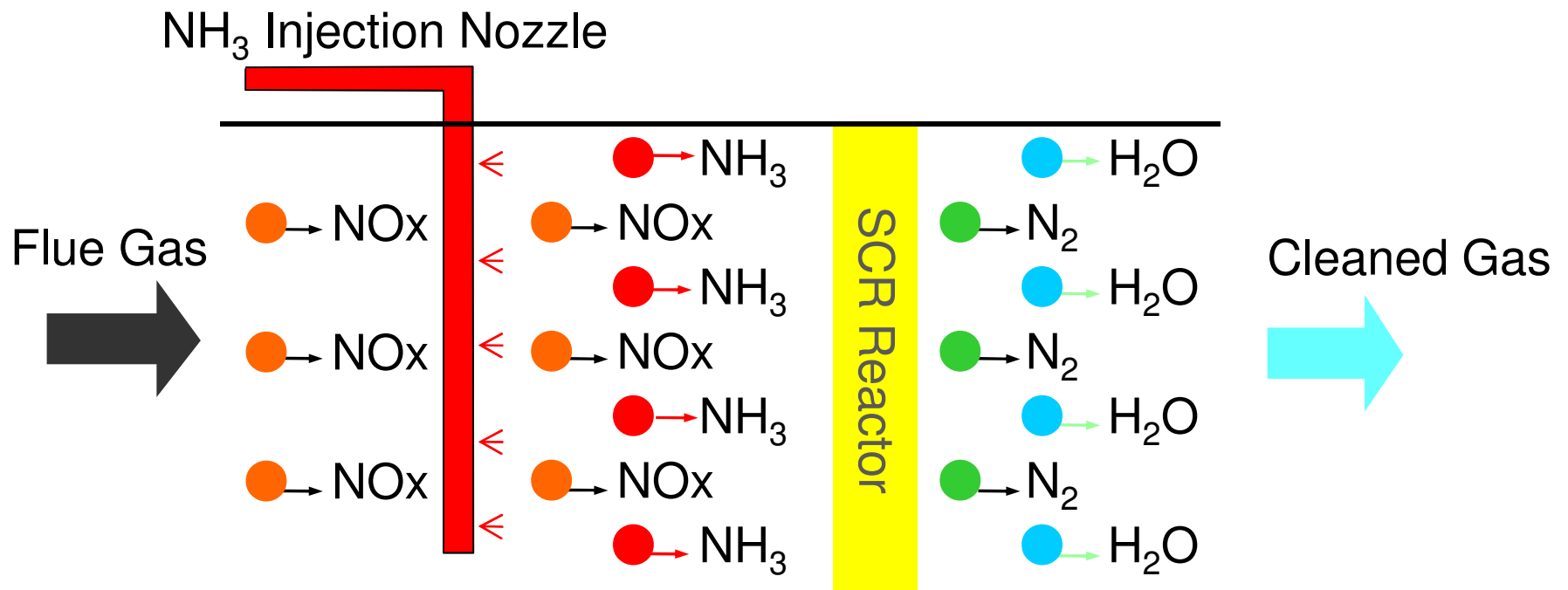
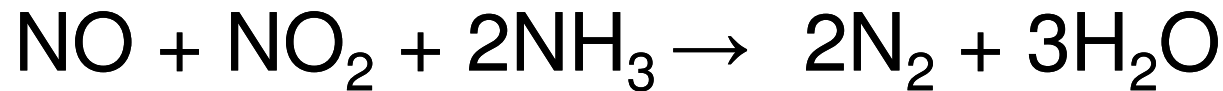
PRINCIPLE OF SCR REACTION

(DENITRIFICATION PROCESS)

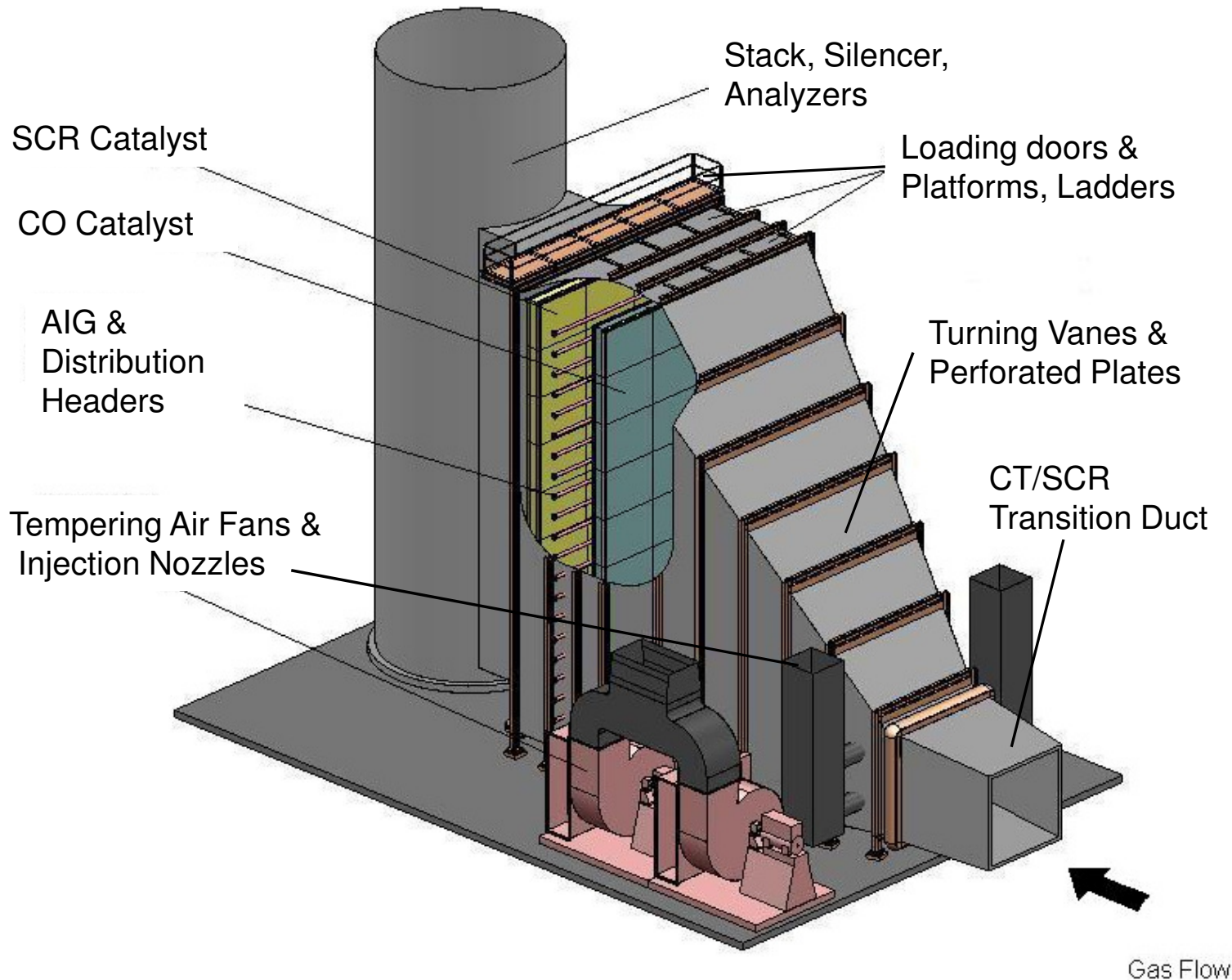
Catalyst



Catalyst



SCR FOR SIMPLE CYCLE GT (TYPICAL SCOPE)



Add'l Scope

- AFCU
- PLC
- Tech Advisor
- Training

Options

- Ammonia Tank
- Pump Skid

Guarantee

- NO_x; CO; VOC
- Utility
- dP
- Noise
- Catalyst Life

SCR SYSTEM DESIGN

- Standardized design
 - Operational philosophy
 - Modular design
 - Catalyst modules and loading system
 - Skid design (optimized to match site requirements)
- Flexibility to design around plant specific restrictions and needs. Carry out flow studies, as necessary, to determine best layout and configuration

HOT SCR FOR SIMPLE CYCLE GT NO TEMPERING AIR SYSTEM



SCR SYSTEM DESIGN

Design Considerations:

- Seismic and Wind Loads
- Thermal Growth
- Catalyst Support & Sealing
- Accessibility (Internal and external components)
- Thermal Insulation & Liner System
- Extent of Prefabrication – Panel & Modular
- Constructability – Lowest Installed Cost
- Operation & Maintenance

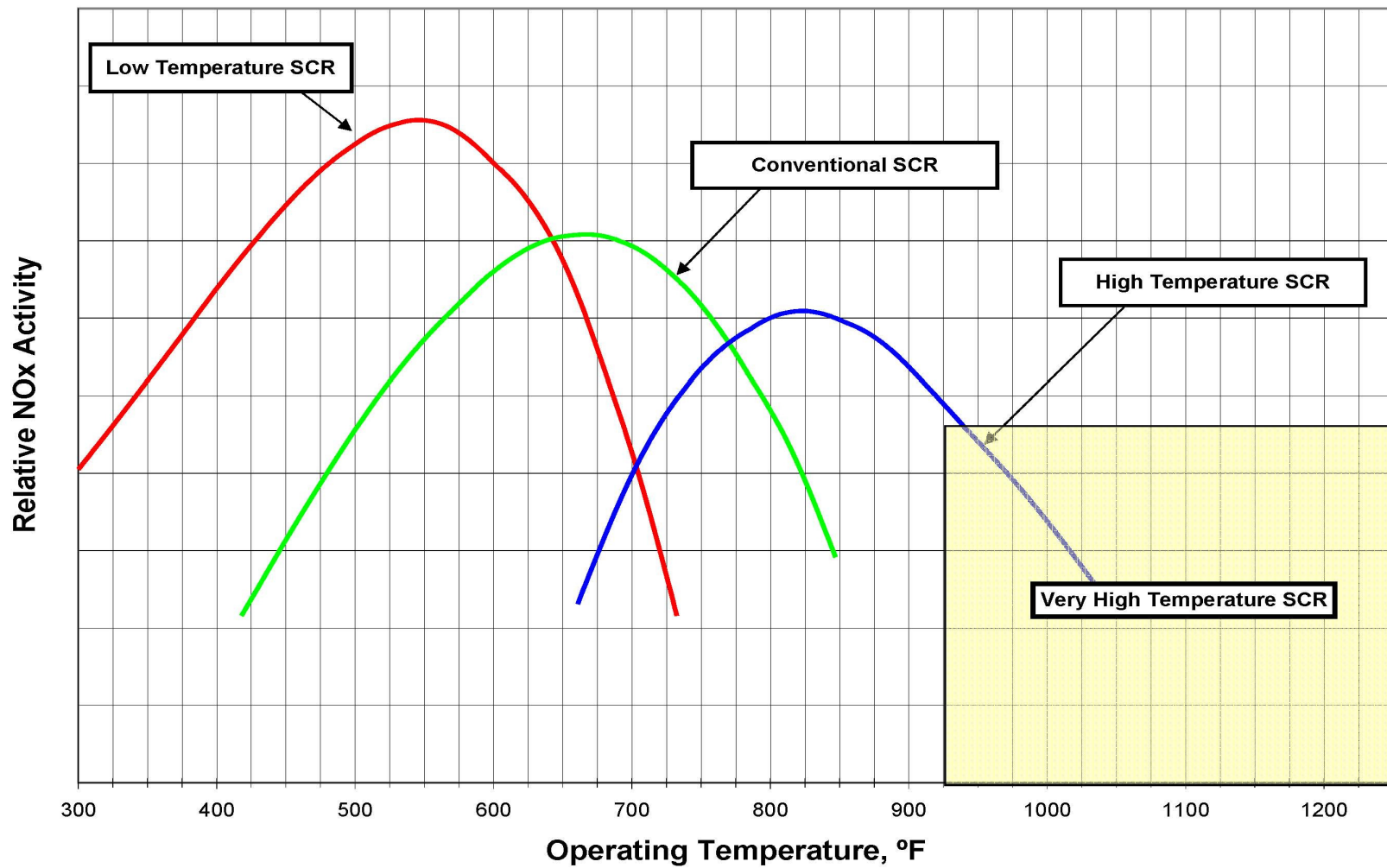
SIMPLE CYCLE MODULAR INSTALLED SCR



CATALYST SELECTION CONSIDERATION

Service life (customer requirement)	Ammonia slip
Exhaust gas temperature	Catalyst temperature
Turbine exhaust NO _x levels	Reactor duct configuration
Required NO _x removal	Flue gas flow distribution
Pressure loss allowance	Flue gas temperature distribution
Volumetric flow rate	NH ₃ /NO _x distribution

TEMPERATURE VS. CATALYST ACTIVITY



CATALYST MODULES & TEST DEVICES



Typical Sampling Basket



Typical Sampling Coupon

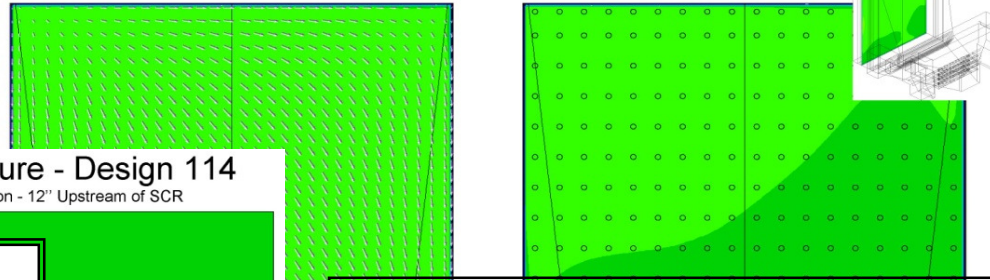


SCR MODELING SIMPLE CYCLE GT

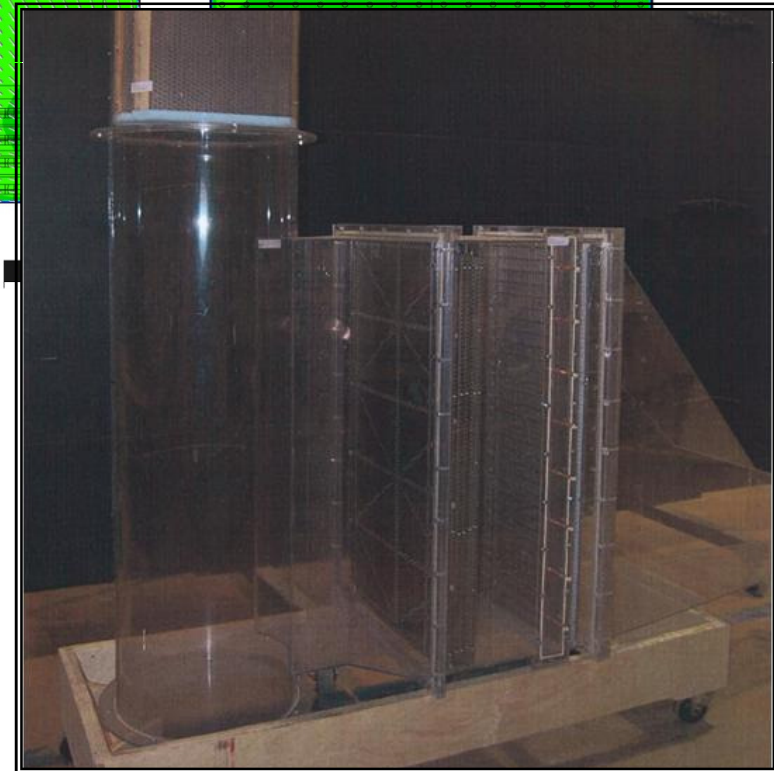
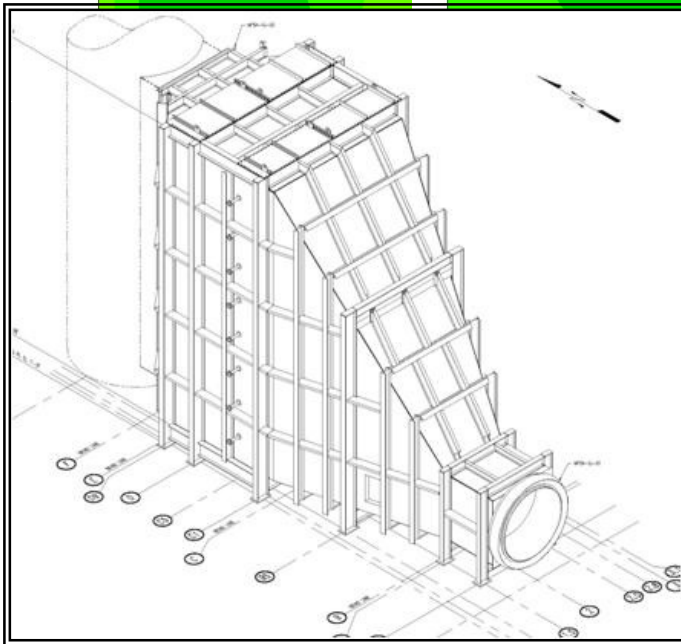
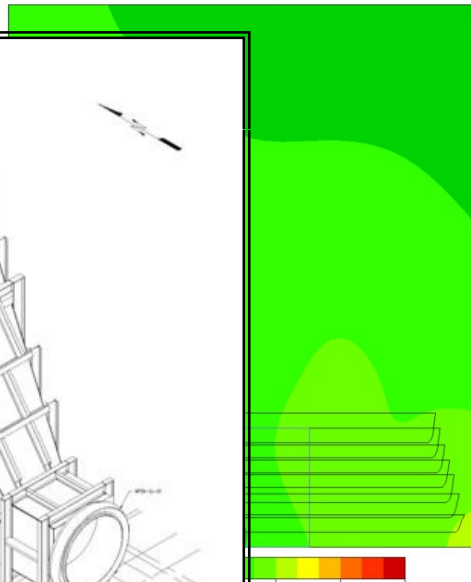
Temperature - Design 114
End Elevation - 12" Upstream of CO Catalyst



Velocity - Design 114
End Elevation - 12" Upstream of SCR



Temperature - Design 114
End Elevation - 12" Upstream of SCR



TYPICAL AMMONIA SKIDS(AFCU)

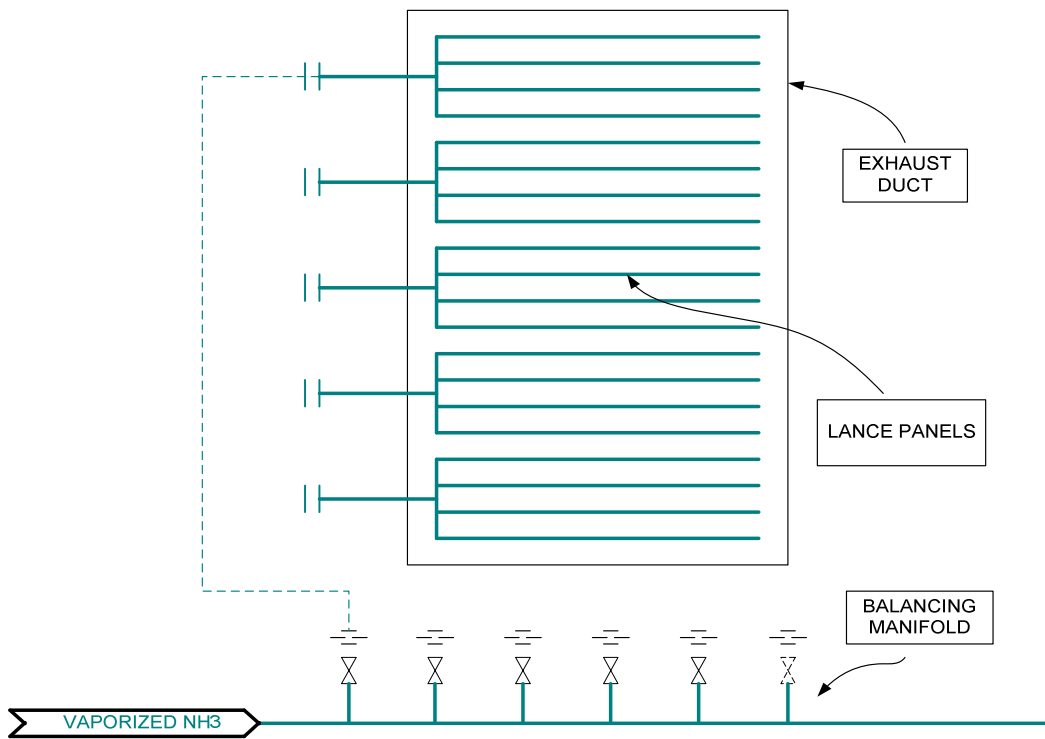


AMMONIA SYSTEM COST COMPARISON

	Anhydrous	Aqueous (19%)	Urea
Equipment Cost	100%	125%	160%
Reagent Cost	100%	145%	105%
Utility Consumption	100%	650%	400%

- Estimation per 150 kg/hr as Anhydrous Ammonia in USA.
- Equipment cost is for the ammonia vaporization skid only (vaporizer system, dilution air system and flow control unit).
- Utility consumption is based on electricity use.
- Urea system becomes competitive if the unit capacity is small.

HOT GAS VAPORIZER & AIG



COMBINED CYCLE SCR RETROFIT



TEMPERING AIR SYSTEMS (1,2,3, x 100%?)



HIGH VOLUME TEMPERING AIR SYSTEMS

- Major Design Concern;

a) Short Distance Available to Mix the Air

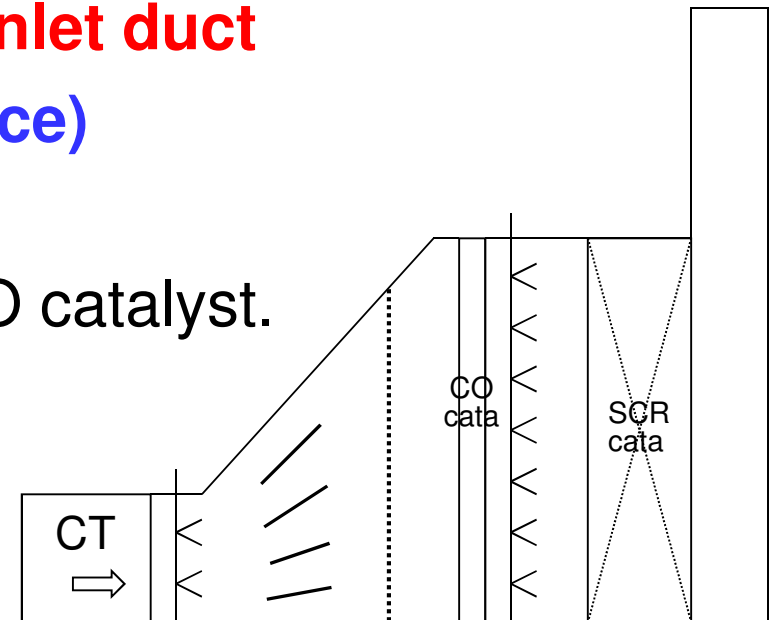
b) Conflicting requirement at the inlet duct

Mix the air into flue gas (**Turbulence**)

v.s.

Uniform gas flow necessary for CO catalyst.

(**Straightening**)



SCR FOR SIMPLE CYCLE GT



Project Features

- Frame SCGT x 4 units
- Max operating temp: ~1200F
- Tempering Air
- Outlet NOx: 2.5 ppmvd
- Online January 2013

SUMMARY

- MPSA has established SCR design considerations for gas turbine fired applications and can ensure long-term and continuous system operation.
- Mitsubishi has supplied SCR systems for combined cycle and simple cycle gas turbines globally, and is a “Proven” technology provider.
- MPSA has a team of qualified experts in Newport Beach and Lake Mary Office with access to more experts at MHI Nagasaki and MHI R&D. We can offer support with feasibility studies, with project execution, and with long term maintenance of your valuable investment.

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