

SCR and Zero-Slip™ Technology

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Turbo Expo - Atlanta, GA



Mitsubishi Heavy Industries, Ltd.

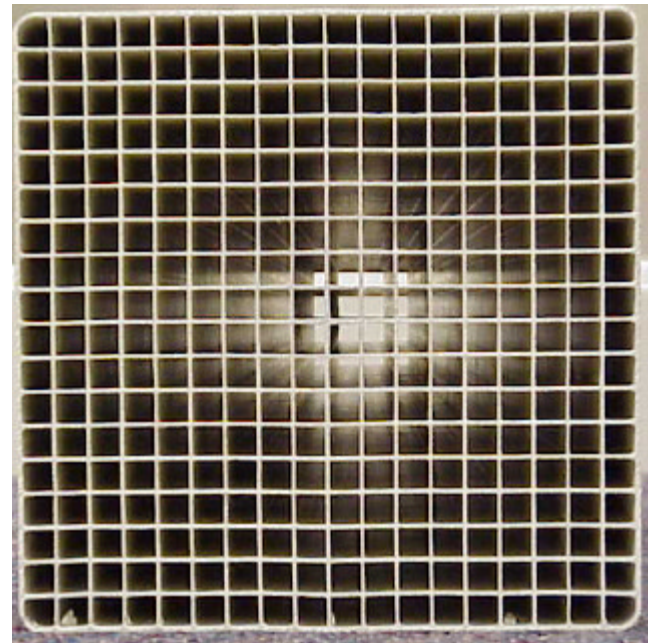


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Presentation Outline

- ❖ **Mitsubishi/Cormetech Background**
- ❖ **SCR Experience**
- ❖ **Zero-Slip™ Technology**
- ❖ **Zero-Slip™ Commercial Status**

Mitsubishi Experience

- ❖ Leading SCR System Supplier in the World
 - Pioneered SCR Systems in Japan in 1970's
 - Delivered/Installed > 500 units
 - Various Applications:
 - Boiler, GT, Diesel Engine, FCC, Process Heater
 - Various Fuels:
 - Coal, Oil, Natural Gas, Orimulsion, BFG, COG and etc.
- ❖ Examples
 - Highest NOx Removal (>95%) at T-Point 330MW GTCC, which is Mitsubishi's 501G verification power plant since 1997 at Takasago Machinery Works in Japan
 - Lowest Emissions (< 2 ppm NOx and NH3) at ANP/Blackstone GTCC
 - High Temperature Applications
 - 1000 °F class GT simple cycle (2 units in Kanagawa, Japan)

Cormetech Experience – SCR Catalysts

- ❖ #1 SCR catalyst supplier: > 700 Units
 - Gas Turbines: 437 units
 - Gas Boilers: 56 units
 - Utility Coal Boilers: 67 units
 - Refining & Industrial: 126 units
 - Stationary Diesel Engines: 17 units
- ❖ 100% Performance Warranty Compliance
- ❖ 100% On-Time Deliveries
- ❖ Highest NOx Removal Efficiencies
 - > 95% at SCE Mandalay (Gas-Fired Boiler)
 - > 93% at AECI New Madrid 2 (PRB Coal-Fired Boiler)
- ❖ Lowest NOx emissions
 - Ten units with less than 2 ppm NOx and 2 ppm NH3 Slip

Innovation in SCR Systems & Catalysts

- ❖ High Performance SCR for Gas Turbines and Coal-Fired Boilers
- ❖ High Temperature (1,000°F Class) SCR for Simple Cycle Gas-Fired Plants
- ❖ Ultra-Low Emission SCR for Combined Cycle Plants
- ❖ Zero-Slip™ Technology for GT's

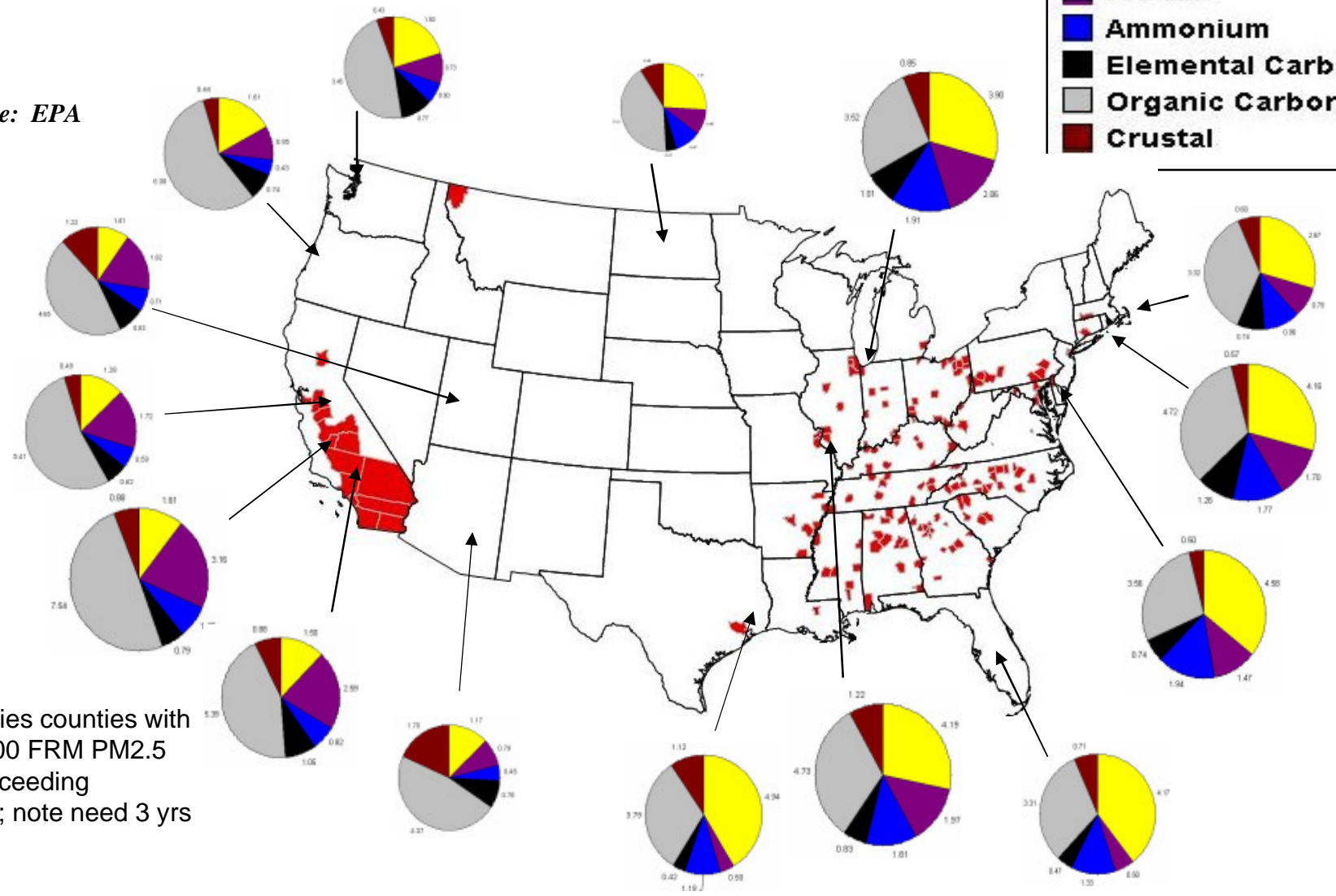
Zero-Slip™ Technology - Purpose

- ❖ Tighter Regulations (e.g. Southern CA, Mass.)
 - $\text{NO}_x < 2 - 5 \text{ ppm}$
 - $\text{NH}_3 \text{ Slip} < 2 - 3.5 \text{ ppm}$
- ❖ Upcoming Particulate Matter (PM) Regulations
 - NH_3 is Constituent of PM
- ❖ Mitsubishi/Cormetech Technology Development
 - "Zero" Ammonia Slip Technology
- ❖ Applicability of Zero-Slip™ Technology
 - Gas-Fired Combined Cycle De- NO_x – New or Retrofit
- ❖ Future: $< 1 \text{ ppm NO}_x$ Versions

Chemical Composition of PM2.5 in 2000

(EPA preliminary analysis)

Source: EPA



Red implies counties with 1999/2000 FRM PM2.5 levels exceeding standard; note need 3 yrs of data

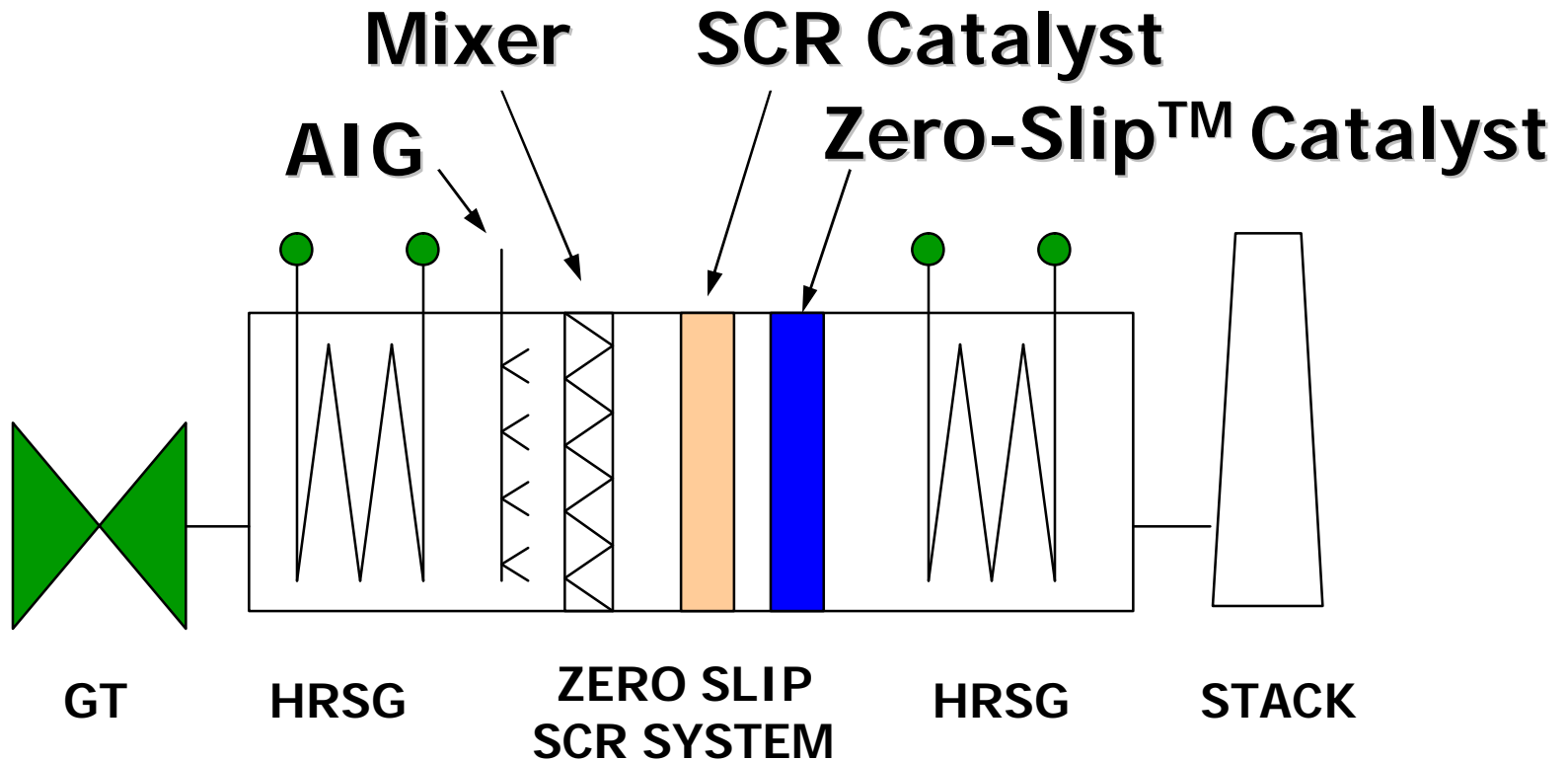
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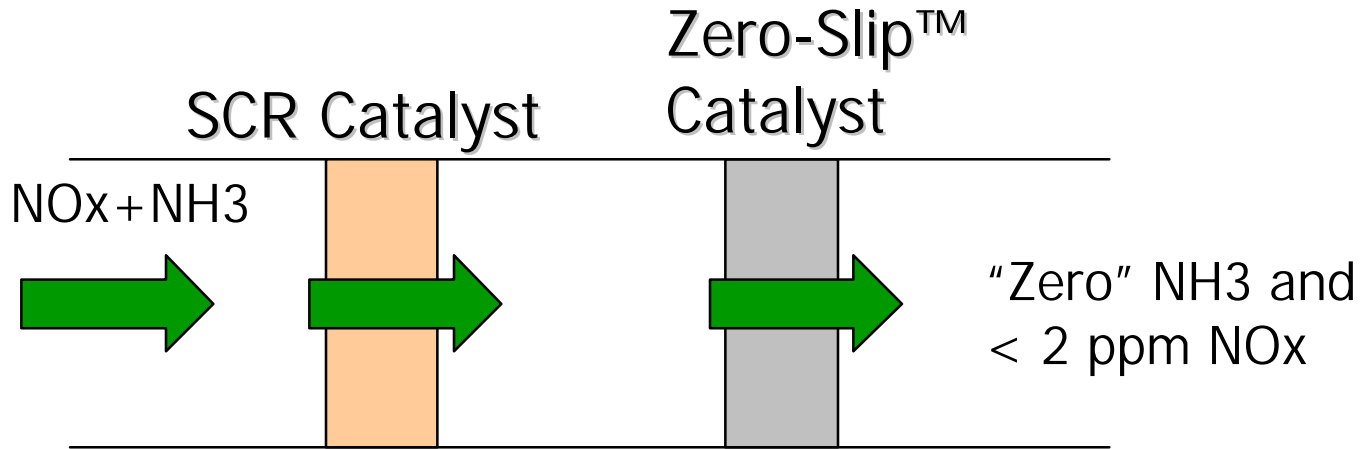
Zero-Slip™ Technology

- ❖ Enhanced SCR Technology for Gas Turbines to Achieve “Zero” Ammonia Slip
- ❖ Zero-Slip™ System Consists of Typical SCR System, Plus the Zero-Slip™ Catalyst:
 - SCR and Zero-Slip™ Catalysts
 - Reactor Housing
 - Ammonia Injection Grid (AIG) & NH₃ Skid
 - Static Mixer (if needed)

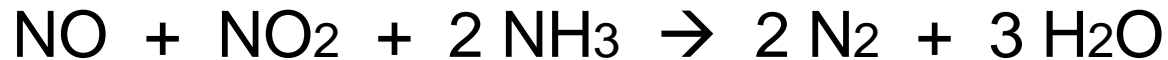
Zero-Slip™ System Configuration



Reactions



DeNO_x Reactions Over SCR Catalyst



Zero-Slip Reactions Over Zero-Slip™ Catalyst



Durability Tests

- ❖ Lab-Scale Test
 - 1,800 Hrs in the Presence of 100 ppm SO_x
 - Result: Negligible Change in Catalyst Activity
- ❖ Samples in Full-Scale Commercial Unit
 - Operating Time > 3,000 Hours
 - Results:
 - ❖ Meets Expected Outlet NO_x and NH₃ Slip
 - ❖ Small Activity Decline per Expectation

Full-Scale Commercial Demonstration

- ❖ Host: Paramount Petroleum Corp.
- ❖ Location: Los Angeles Basin
- ❖ Unit: 7 MW Cogeneration
- ❖ Startup: January 2003



Full-Scale Commercial Demonstration

- ❖ Startup: January 2003
- ❖ Operating Time: 3,000 Hours
- ❖ Result: Meeting Performance Targets
 - < 0.1 ppm NH₃ Slip
 - < 2 ppm NO_x

Conclusions – Zero-Slip™ Technology

- ❖ Zero-Slip™ Technology has been Demonstrated Commercially
 - Guaranteed Performance: < 0.1 ppm NH₃ and < 2.0 ppm NO_x
 - Actual Performance: Much Lower NH₃ and NO_x
- ❖ Zero-Slip™ Systems are being Offered for CC Units
- ❖ System Design is Flexible to Meet Customer Needs
 - Extremely Low NO_x Levels, and/or
 - Extremely Low Ammonia Slip
- ❖ Handles Backup Oil Firing with Low Sulfur Oil