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SCR Catalyst Selection Considerations

McIlvaine Hot Topic Hour

October 21st, 2010

Cormetech Approach

- **Understand the unique perspectives and challenges for individual utilities and/or plants**
  - Not all utilities/plants have the same drivers
- **Utilize strong experience and knowledge base in combination with strategic collaborations to provide full range of solution options**
  - Catalyst Technology Advancements
  - Optimization Tools
  - Strategic Collaboration

Integrated Management Considerations

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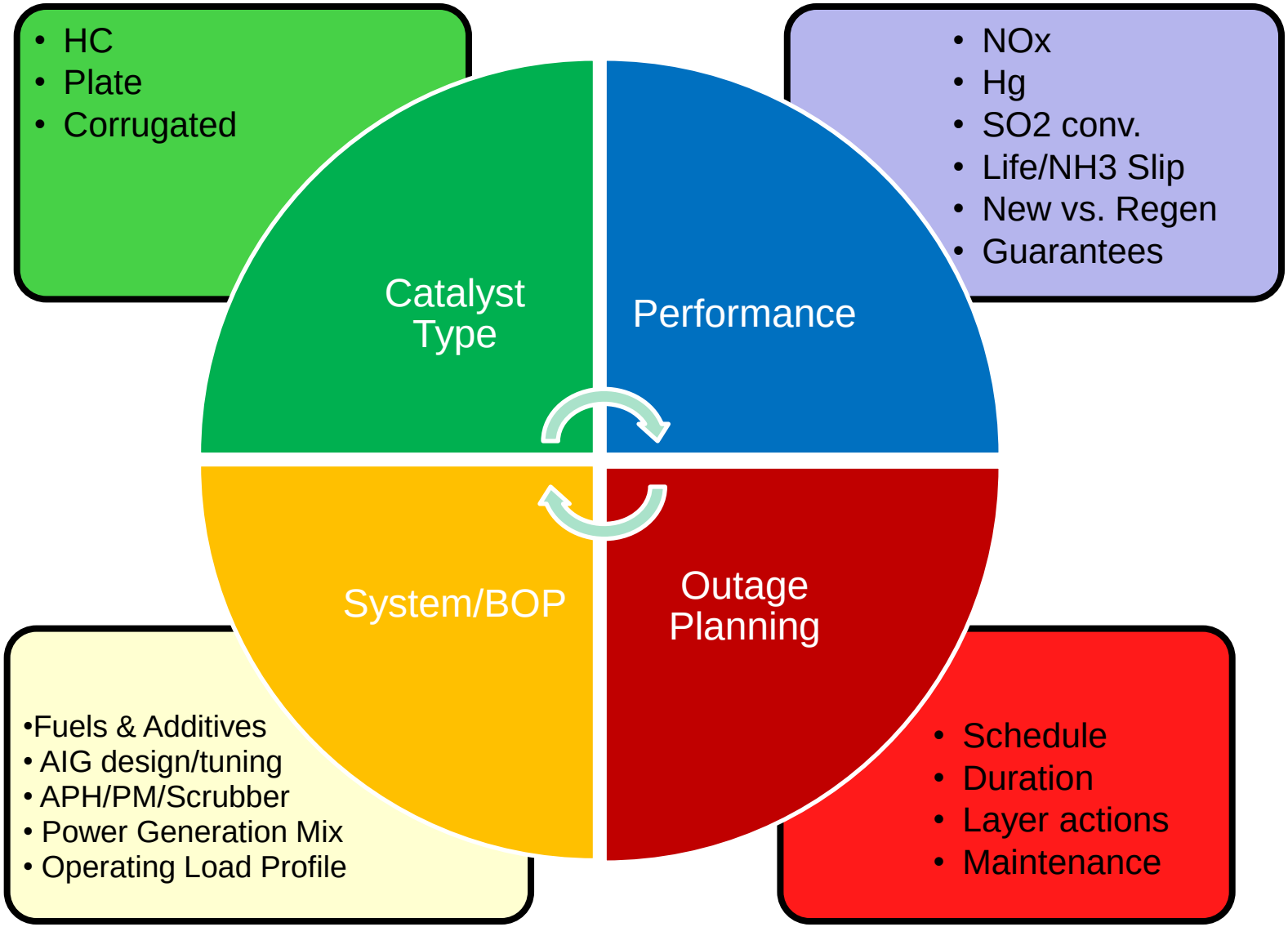

Catalyst Management

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Current Active Projects:

1. **Continuous Improvement**
   - Activity & SO_2 conversion → Improved $ per K/AV
2. **Advanced Hg Oxidation catalyst**
3. **Selective Decomposition of Ammonia**
4. **Proven Evaluation Tools**
5. **Strategic Collaboration**

Advanced Hg Oxidation catalyst

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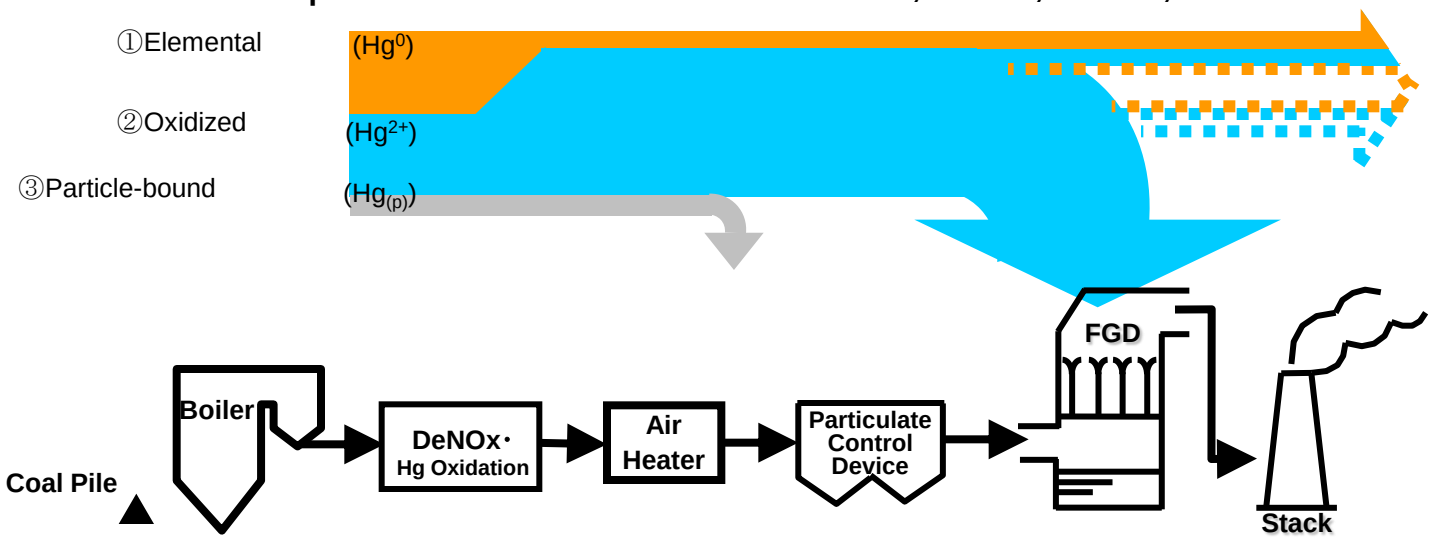
- **Drivers**
  - CAMR vacated but still anticipate Federal and State rules to require 90% reduction (basis coal pile to stack)
  - Will it be 90%? Will it be a rate? How does the requirement effect technology selection/applicability (fuel)/cost?
- **Timing**
  - Expected Rule 2011 → compliance 2014?
- **Market Needs**
  - What is anticipated oxidation need from SCR?
  - What is anticipated contribution from APH, ESP, FGD, etc.?



Simultaneous SCR Reactions:

$DeNO_x$ - Hg Oxidation and Reduction – SO2 oxidation

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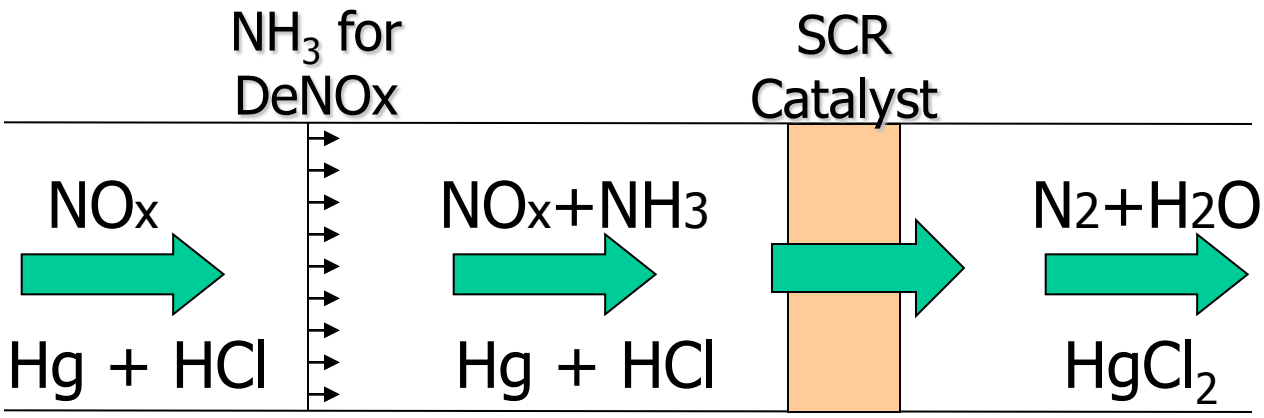
Desired Reactions:

$NO + NH_3 + 1/4\ O_2 \rightarrow N_2 + 3/2\ H_2O$ (NO_x Reduction)

$Hg + 2\ HCl + ½\ O_2 \rightarrow HgCl_2 + H_2O$ (Hg Oxidation)



Undesired Reactions:

$HgCl_2 + NH_3 + ¼\ O_2 \rightarrow Hg + 2\ HCl + ½\ N_2 + ½\ H_2O$ ($HgCl_2$ Reduction by NH_3)

$HgCl_2 + SO_2 + H_2O \rightarrow Hg + 2\ HCl + SO_3$ ($HgCl_2$ Reduction by SO_2)

$SO_2 + ½\ O_2 \rightarrow SO_3$ (SO_2 Oxidation)

Co-Benefit Improvement Strategy

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Increase Rate of Desired Reactions:

$NO + NH_3 + 1/4\ O_2 \rightarrow N_2 + 3/2\ H_2O$ (NO_x Reduction)

$Hg + 2\ HCl + ½\ O_2 \rightarrow HgCl_2 + H_2O$ (Hg Oxidation)

- Advanced SCR Catalyst!

Decrease Rate of Undesired Reactions:

$HgCl_2 + NH_3 + ¼\ O_2 \rightarrow Hg + 2\ HCl + ½\ N_2 + ½\ H_2O$ ($HgCl_2$ Reduction by NH_3)

$HgCl_2 + SO_2 + H_2O \rightarrow Hg + 2\ HCl + SO_3$ ($HgCl_2$ Reduction by SO_2)

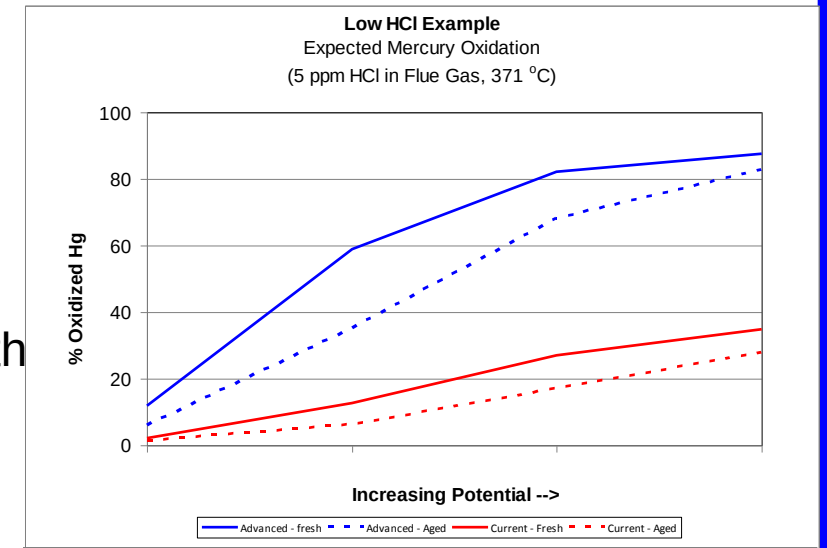
$SO_2 + ½\ O_2 \rightarrow SO_3$ (SO_2 Oxidation)

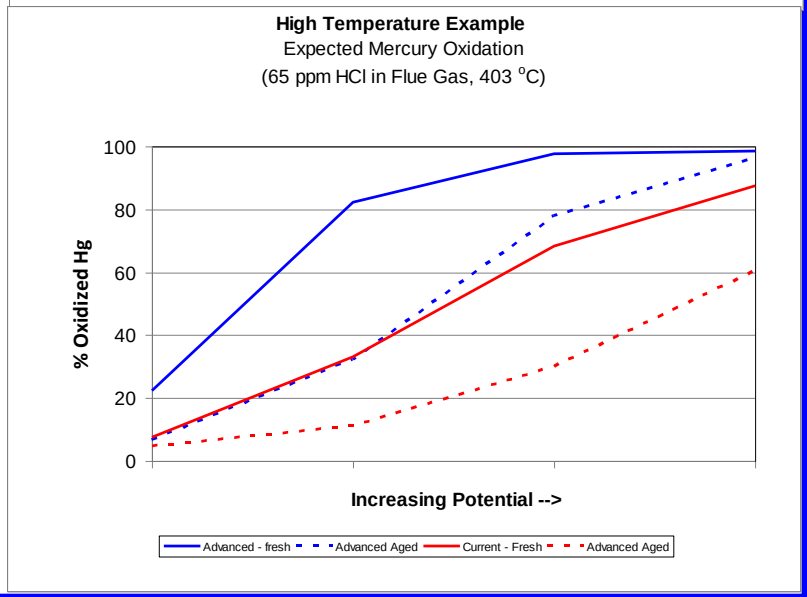
- Advanced SCR Catalyst!

Advanced Hg Oxidation

MHI/Cormetech Joint Development

- **Additional Features**
  - Much lower negative impact from reducing species
  - Designed for high durability over time
  - Can be used alone or in combination with existing catalyst
  - Reduced total compliance cost





Selective Decomposition of Ammonia

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- **Drivers:**
  - NH3/NOx maldistribution requires periodic tuning and limits NOx reduction achievable
    - NH3 in excess in some areas due to maldistribution can lead to downstream equipment fouling
  - Continued pressures on total NOx emissions
- **What is value of:**
  - Reduced tuning costs
  - DP savings
  - Reduced fouling
  - High NOx Reduction (95%+)

SDA Catalyst

- **US Patent 7658898 (joint Cormetech–MHI patent)**
- **Reaction network for SDA catalyst:**

Reaction equations for standard SCR catalyst

DeNOx:

$NO + NH_3 + 1/4O_2 \rightarrow N_2 + 3/2H_2O$

SO_2 oxidation:

$SO_2 + 1/2O_2 \rightarrow SO_3$

SDA catalyst incorporates NH_3 oxidation functionality (without increasing SO_2 oxidation)

NH_3 oxidation:

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

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

Dominant NH_3 oxidation reactions

$4NH_3 + 7O_2 \rightarrow 4NO_2 + 6H_2O$ ← **Not active**

$2NH_3 + 2O_2 \rightarrow N_2O + 3H_2O$ ← **Low activity (1-2 ppm)**

SO_3 reduction:

$SO_3 + 2NH_3 + O_2 \rightarrow SO_2 + N_2 + 3H_2O$

Simulations: Case Studies

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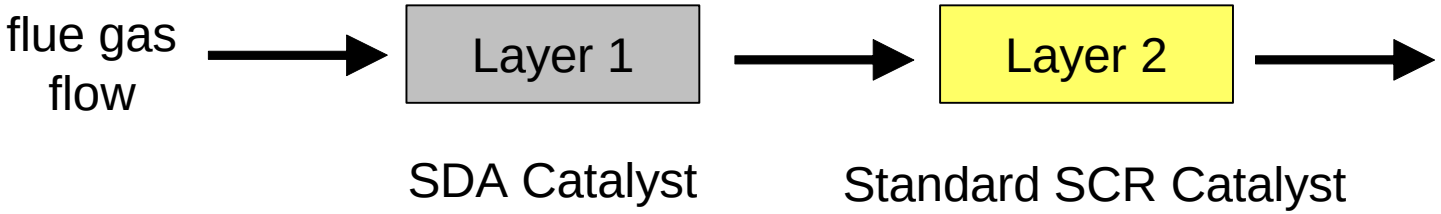
- ***Developed kinetic model for SDA catalyst***
  - *Predict DeNOx, NH_3 oxidation, and SO_2 oxidation activity*
  - *Utilized 15 sets of fresh performance data*
- ***Proposed system layer arrangement:***



- ***Ran simulations:***
  - *Catalyst surface area vs. RMS at 90%, 95%, and 99% DeNOx*
  - *Two case studies (compare SDA system vs. standard catalyst):*
    - *90% DeNOx and 99% DeNOx*

Impact of NH_3/NO_x RMS on Catalyst Surface Area (or Catalyst Volume for Constant Pitch)

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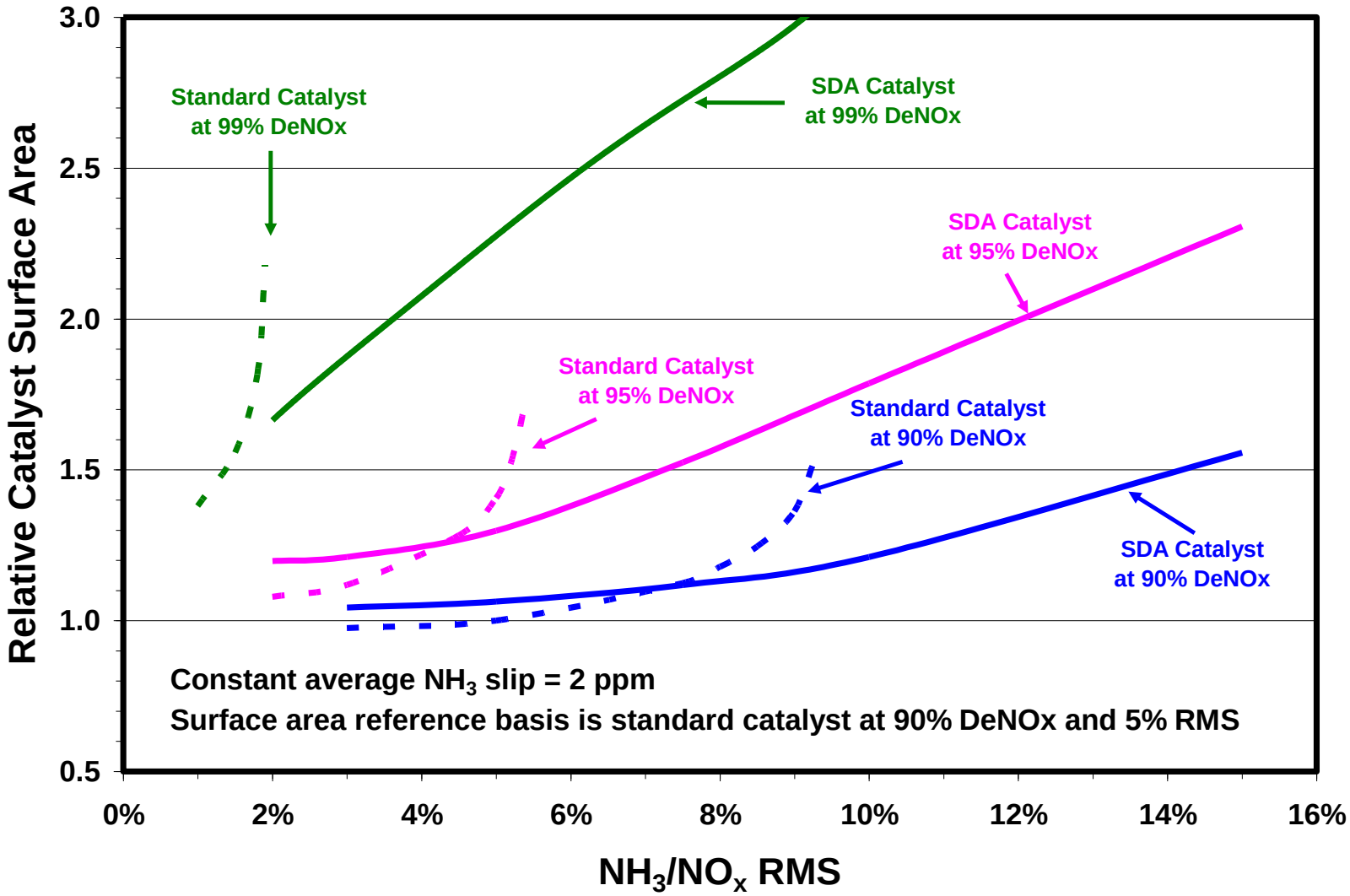
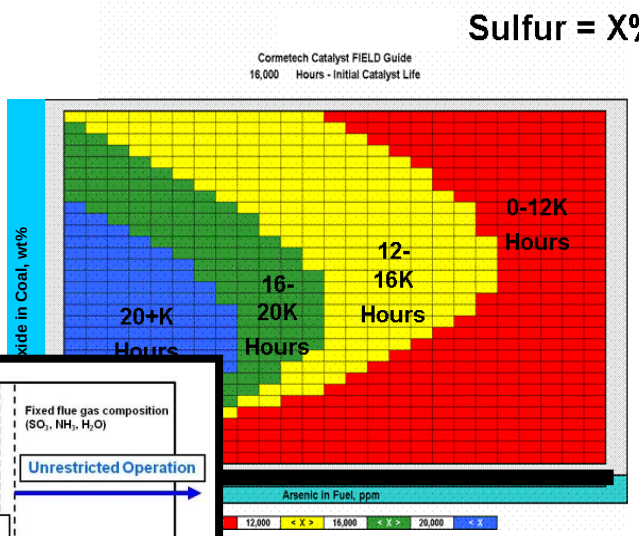
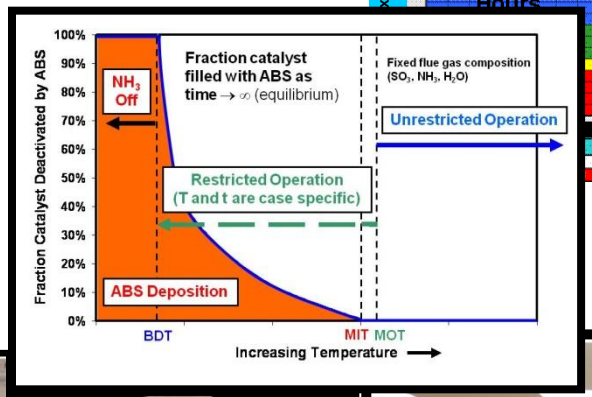
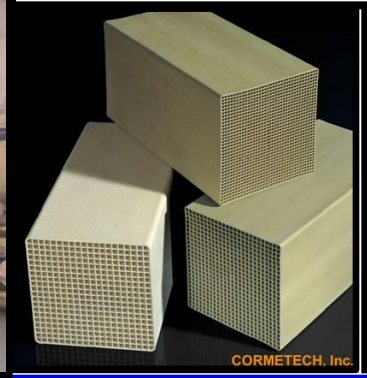


Evaluation Tools

- **Multiple Tools/Capabilities Including:**
  - Fuels management tool
  - Additives Analysis
  - Laboratory Analysis
  - AIG Design/Tuning
  - Lifecycle management economic evaluation tool
  - Expanded operating temperature range







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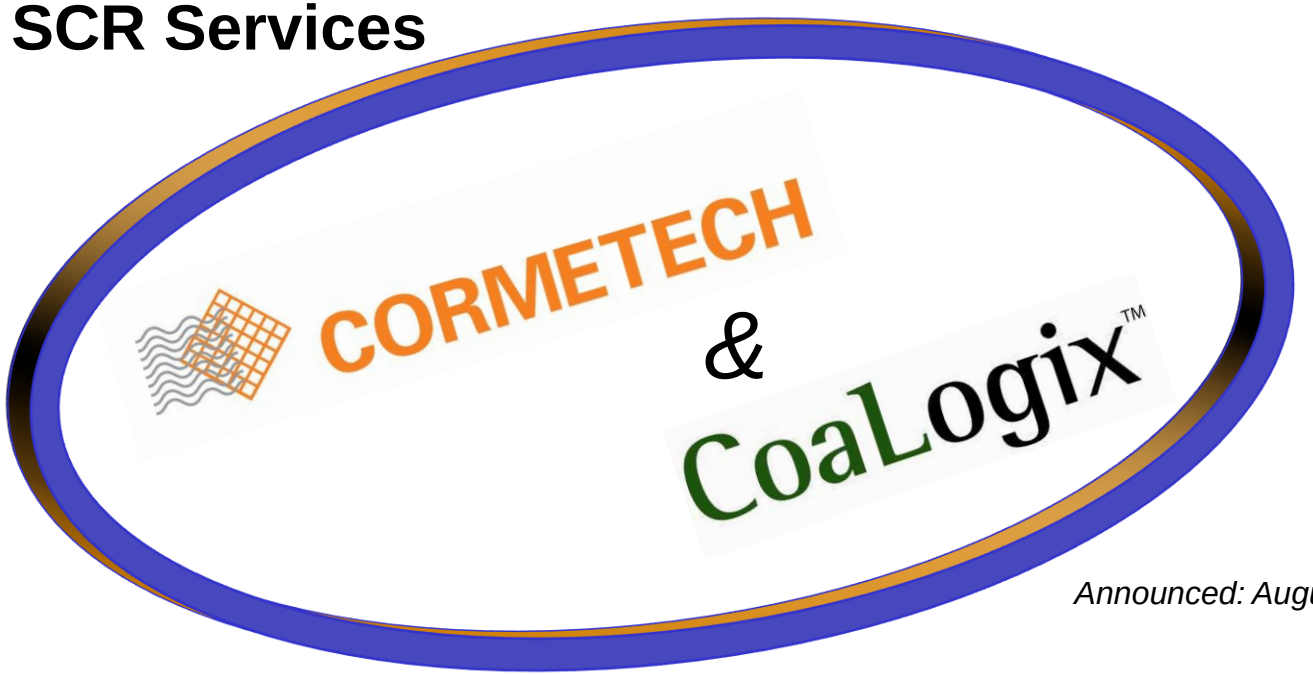
Strategic Collaboration

- **Cormetech and CoaLogix are pleased to announce the collaboration of the two of the leading Supply and Technology Companies for SCR Services**



Announced: August 10, 2010

Cormetech & CoaLogix

Core Competencies & Capabilities

- **Cormetech**
  - SCR Catalyst Manufacturing
  - SCR System Application/Management Experience
  - Technology Advancements in Hg oxidation, SDA, SO_3 mit., etc.

- **CoaLogix**
  - Regeneration Technology/Experience
  - SCR Management Experience
  - SO_3 and Hg mitigation (FLSmidth Agreement)

Cormetech & CoaLogix

- **Key Benefits of Cormetech Certification**
  - Combination brings 360° Catalyst Mgmt Service
  - Integrated performance solutions and warranties
  - Simplified and consolidated purchasing and inventory management & supply assurances
  - Long-term SCR catalyst management commitment
  - Integrated technology to assure lowest compliance cost

Future will be focused on Implementation of Regeneration & Advanced Technologies to meet New Air Emissions Challenges