Reinhold Environmental Ltd.

2007 NOx Round Table & Expo Presentation

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2007 NOx Round Table & Expo

FUEL IMPACTS ON CATALYST

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Key SCR Design Parameters

- Required NOx Removal
- SO_2 to SO_3 Conversion Limit
- Ammonia Slip Specification
- Operating Temperature
- Fuel Type

Catalyst Design

- Geometric and Internal Surface Area
- Support Materials: TiO_2
- Catalytic Activity: V,W,Mo

Honeycomb Catalyst

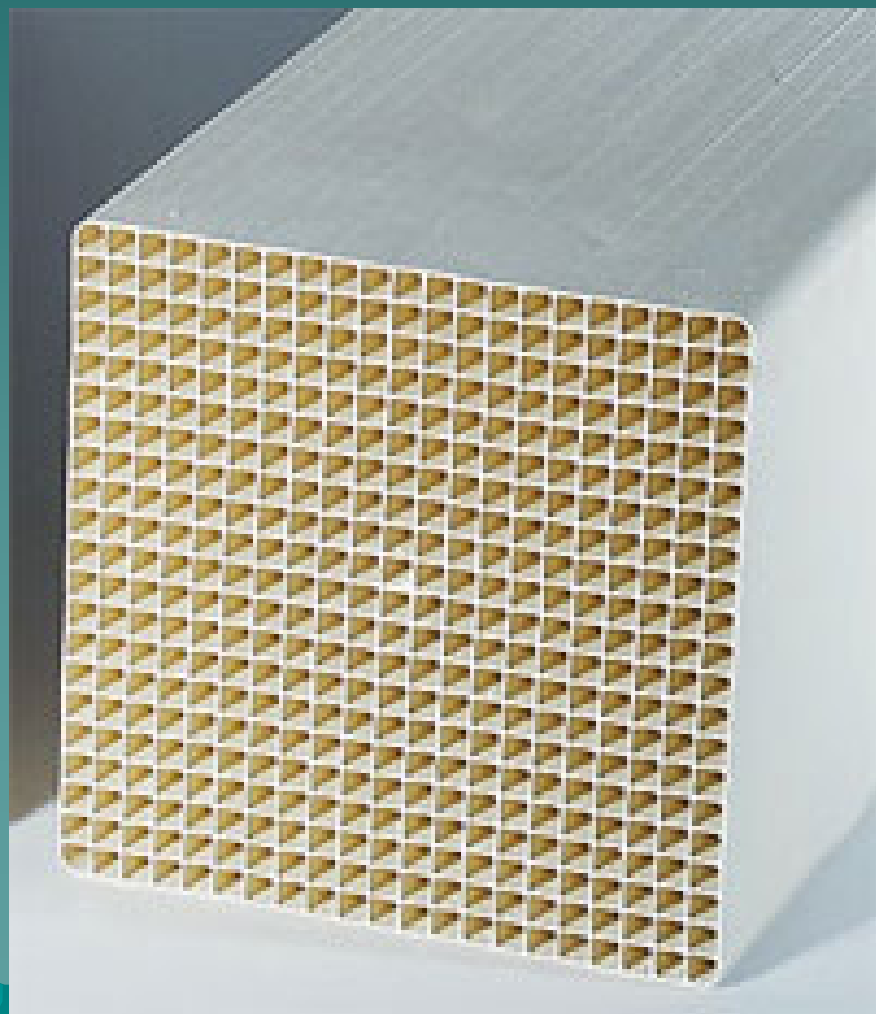
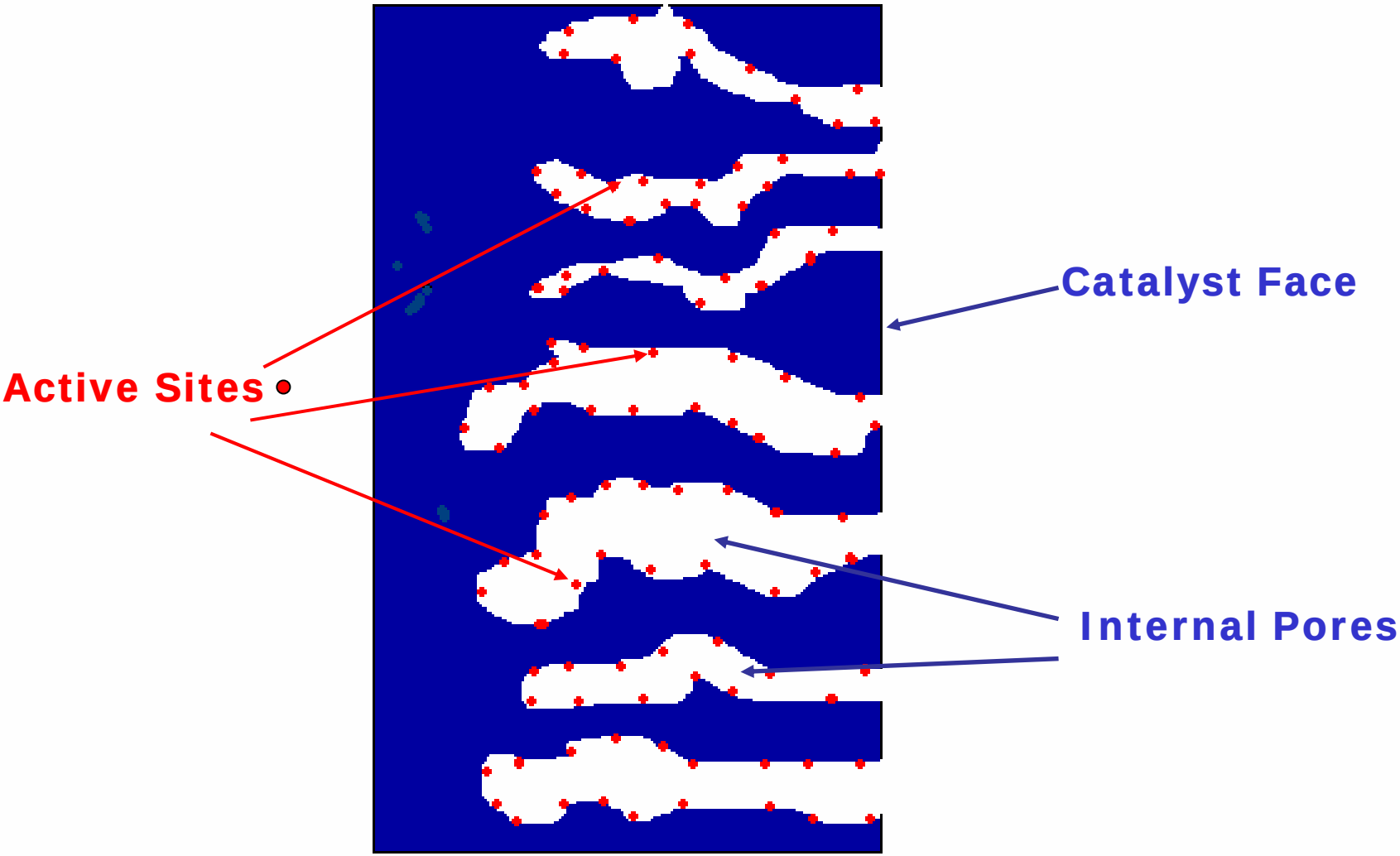
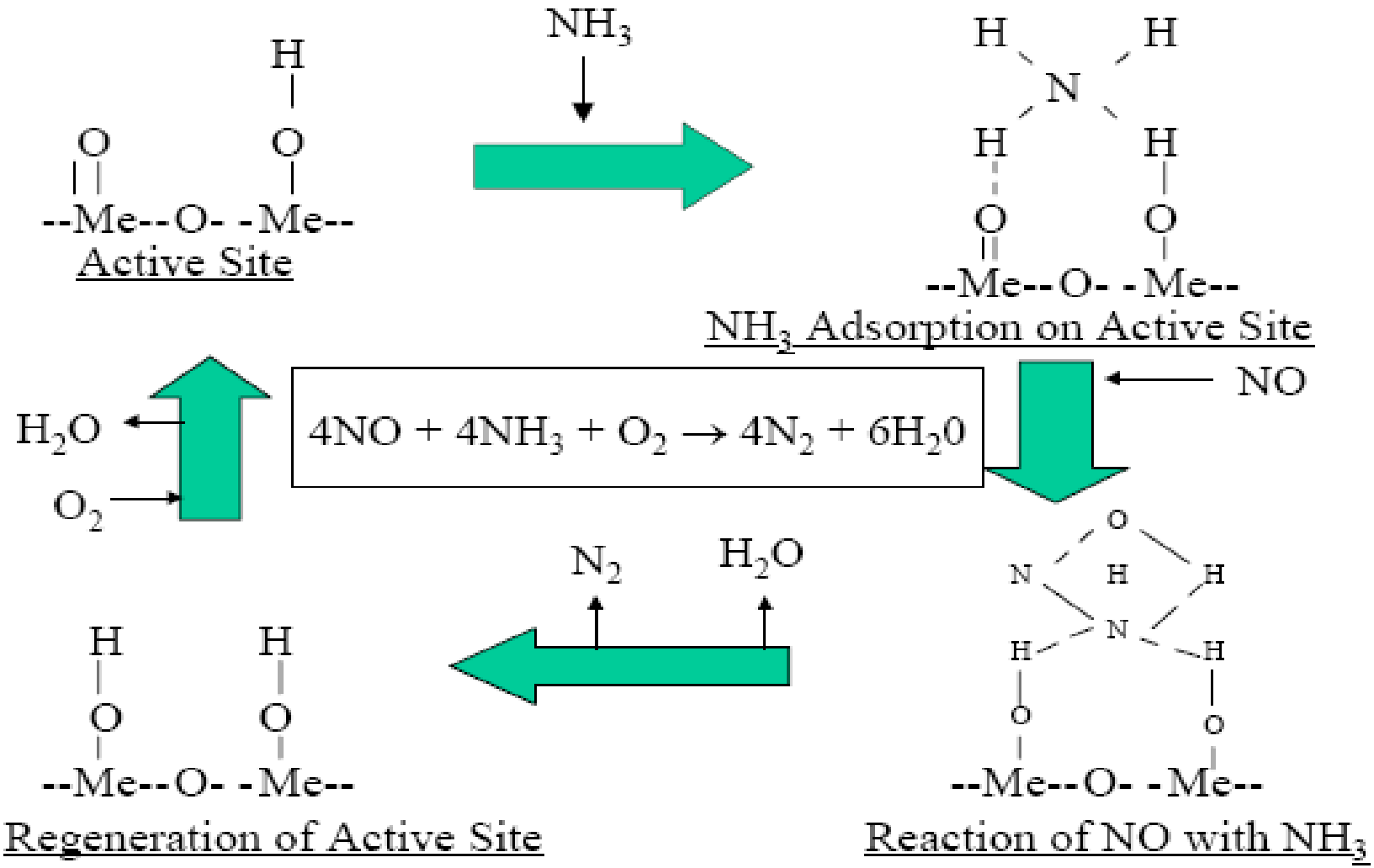


Plate Catalyst

Catalyst Design



Reaction Mechanism



Courtesy - Cormetech

General Fuel Types

- Natural gas, process gas
- Fuel Oils – low to high sulfur refined petroleum
- Residual refinery products – distillate bottoms
- Refinery Solids – Petroleum Coke
- Coal – bituminous, PRB, lignite, anthracite

Natural Gas

- Easiest Fuel for SCR Applications
- No Particulate, No Sulfur
- No sootblowing !
- No SO2 Conv. Limits !
- High activity, small pitch, horizontal and in-duct arrangements
- Long guarantee life
- Slip a function of regulations

Process Gas

- Often very similar to natural gas
- May contain sulfur, fine particulate
- May have poisons – silica, sodium, potassium, other upstream catalysts
- Unknown/trace components can be problematic
- Highly site specific
- May have little industry experience

Low-Sulfur Fuel Oil

- Similar to natural gas if high-grade oil is used
- SO_2 conversion can be relaxed if low-sulfur oil is used exclusively
- Sootblowing may not be required
- Horizontal and vertical applications – little or no HRSG or APH modifications needed
- Long catalyst lives, small pitch, high activity – slip can be relatively high

Medium to High-Sulfur Fuel Oil

- Significant sulfur will limit allowable SO_2 conversion
- Sootblowers are generally required, often preferred over sonic horns
- Horizontal configuration possible with low particulate
- Vanadium in fuel may cause increase in SO2 conversion over time
- Significant ABS corrosion may occur
- Possible acid plumes depending on SO2 conversion rate and sulfur level

Refinery Residuals

Refinery Residuals

- Distillate bottoms, heavy oils
- Typically high sulfur, high particulate, high contaminants; vanadium and others
- May need sootblowing/ vertical configuration
- Strong limits on SO_2 conversion or mitigation of conversion assoc. with vanadium deposition
- Strong potential for ABS formation
- Stringent limits on ammonia slip
- Highly Fuel Specific

Pet Coke

Pet Coke

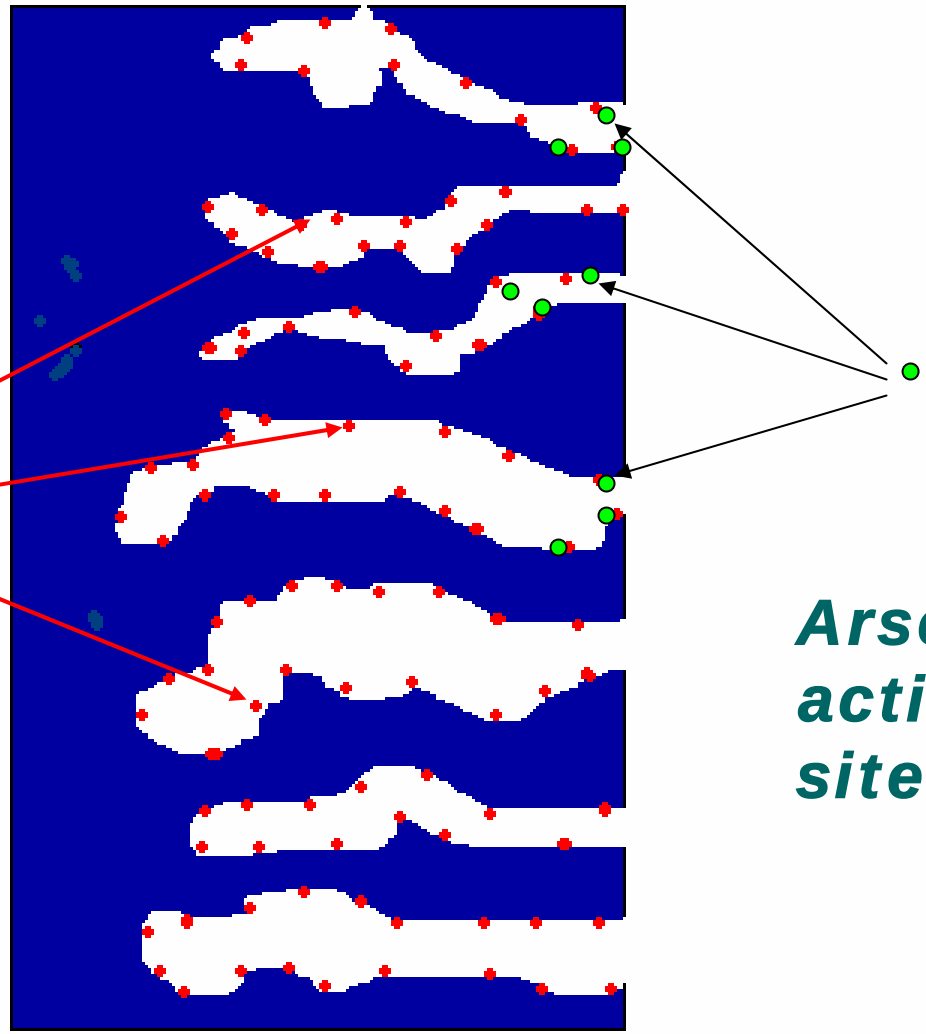
- High sulfur, high particulate, high contaminants - vanadium
- Sootblowers or sonic horns required, vertical configuration preferred
- Strong limits on SO2 conversion and mitigation of impacts of vanadium deposition
- Strong impact on downstream equipment due to ABS, sulfuric acid
- Ammonia slip typically low, similar to coal
- Large catalyst pitch

Bituminous Coal

Bituminous Coal

- Extensive industry experience
- Poisoned by Arsenic
- Medium to high sulfur levels, variable ash loading
- Sootblowing required
- Strong limits on SO2 conversion
- Strong impact on downstream equipment due to ABS, sulfuric acid – APH mods. common
- Ammonia slip typically < 2 ppm
- Life Strongly impacted by calcium and arsenic levels

Arsenic Poisoning

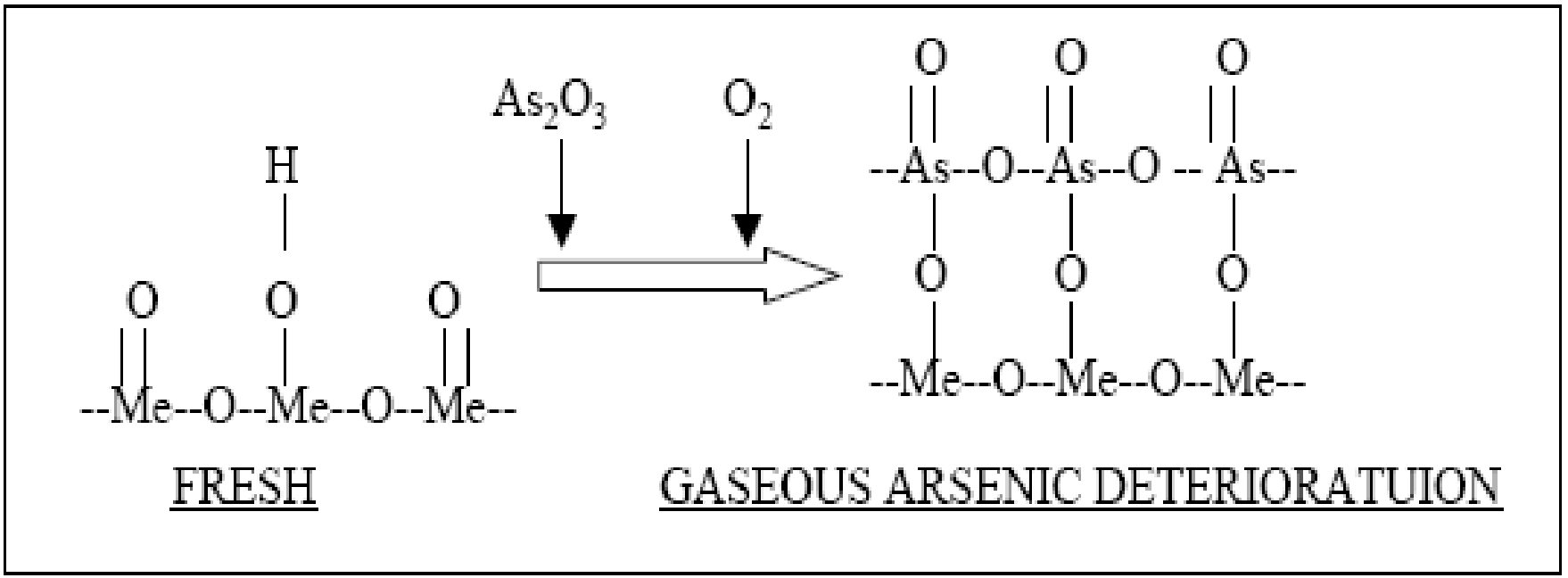


Active Sites

Gaseous Arsenic

Arsenic attacks active vanadium sites

Chemical Mechanism of Arsenic Poisoning



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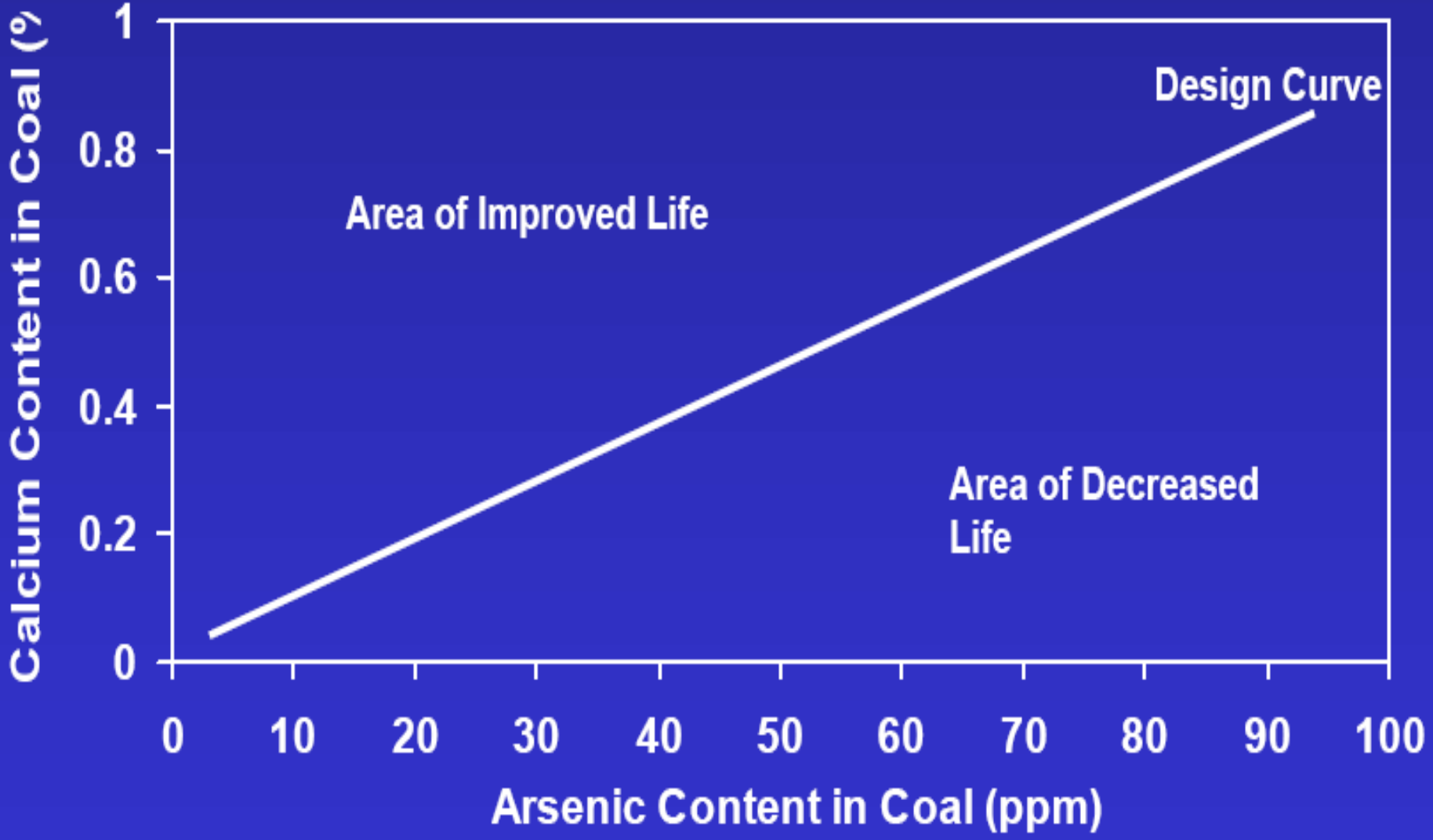
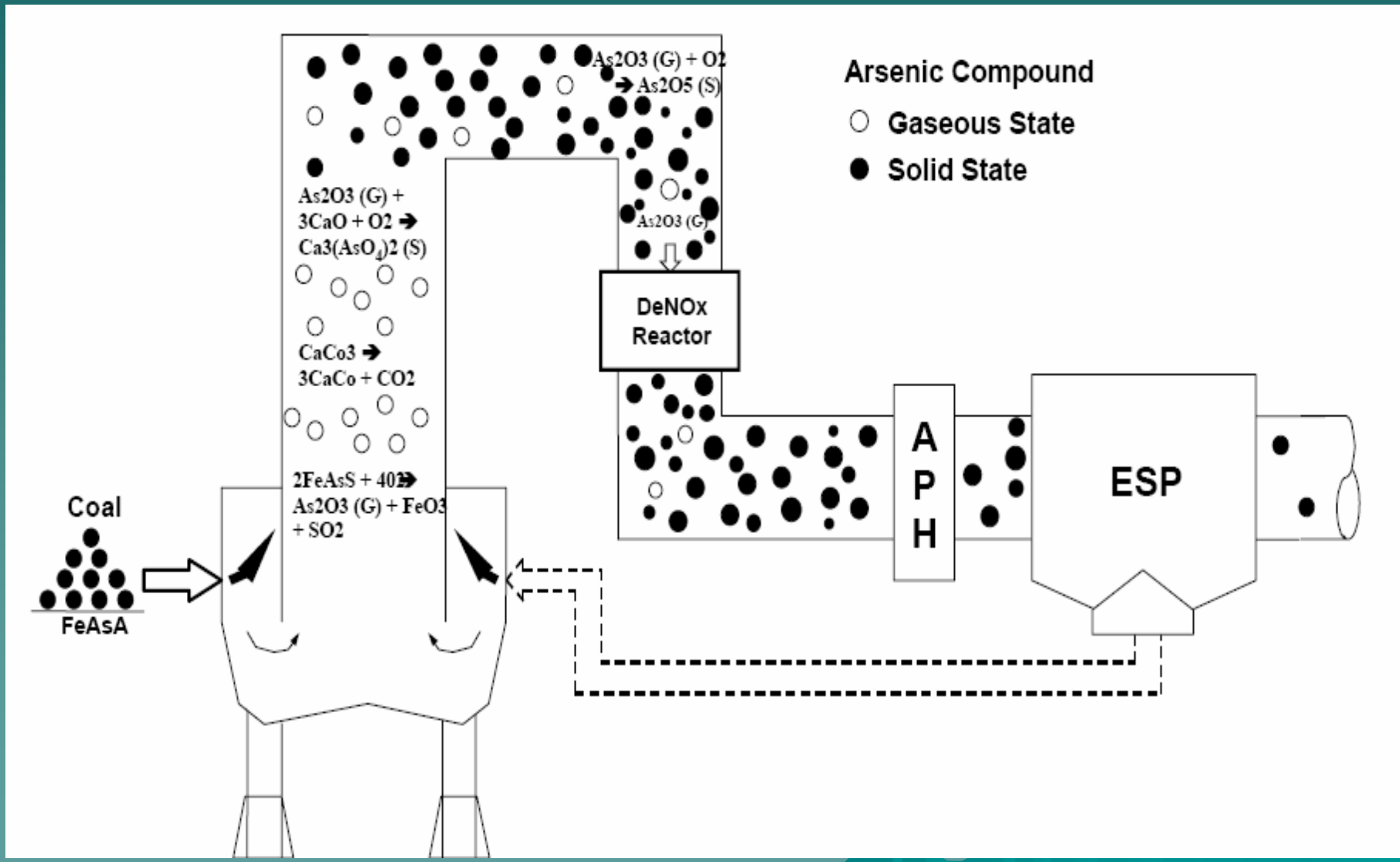
Catalyst Life vs. Arsenic and Calcium in Fuel



Limestone Injection



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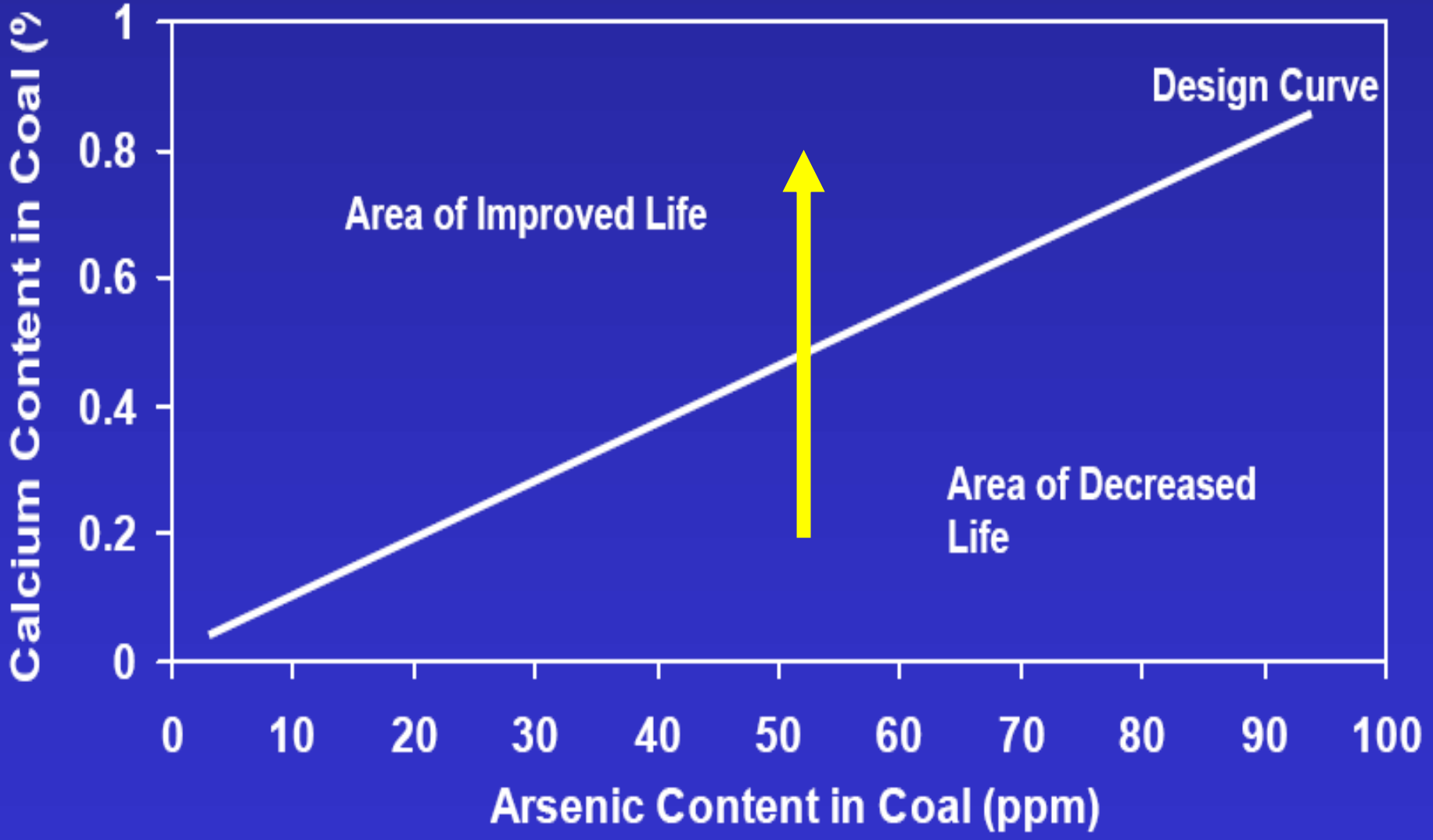
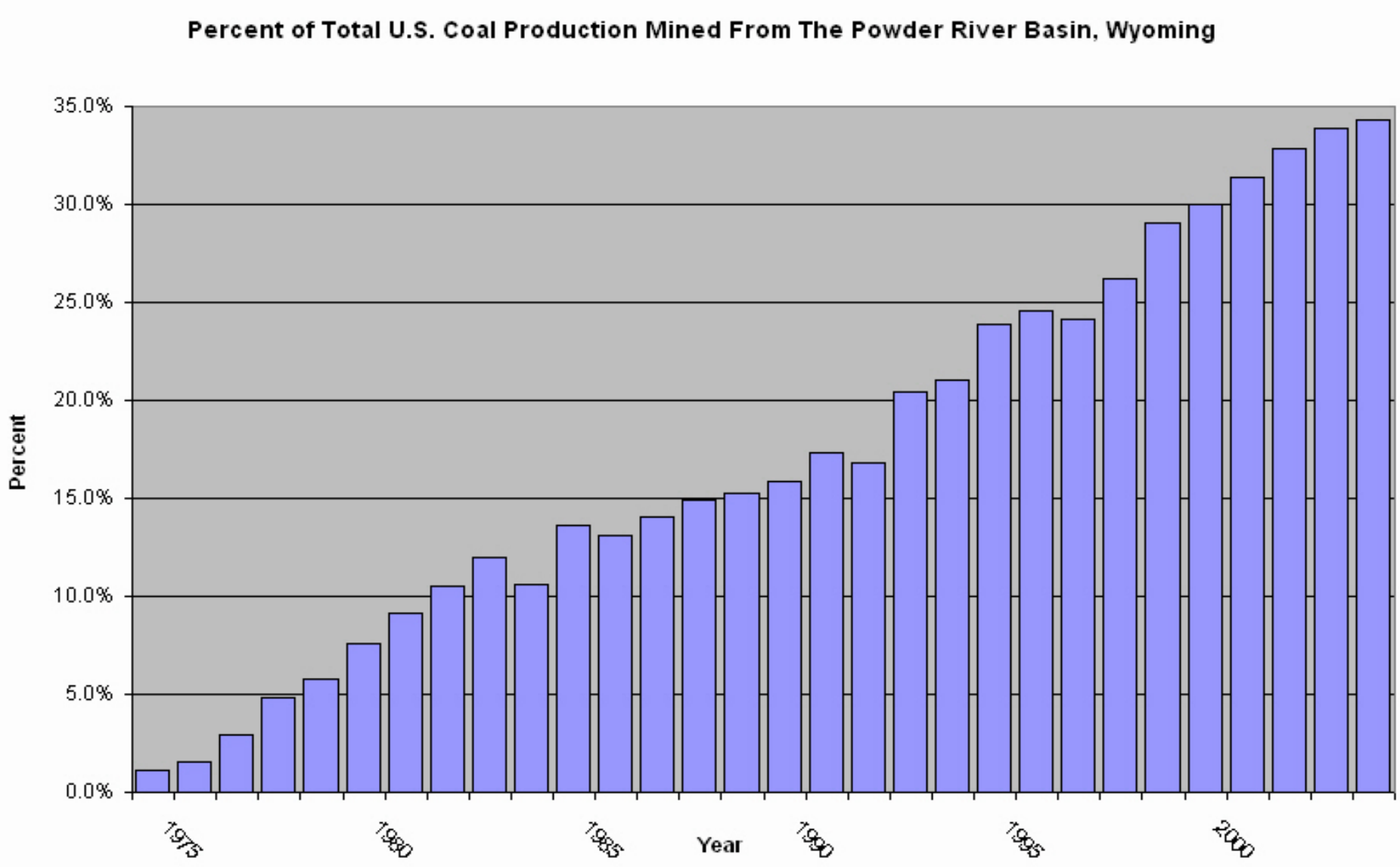
Effect of Limestone Addition



PRB Coal

PRB Coal Utilization



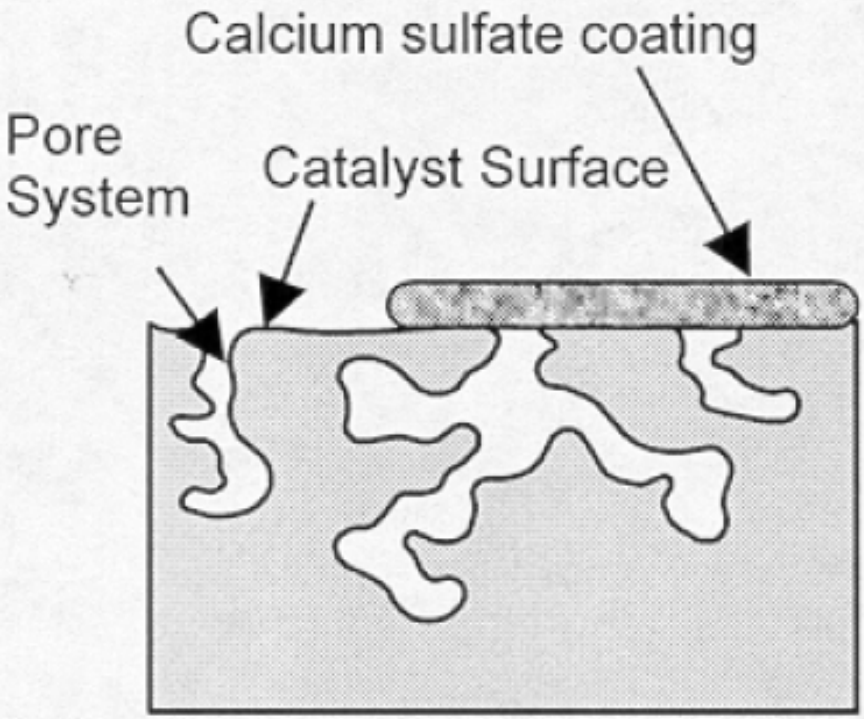
Sources: Energy Information Administration/AnnualEnergy Review, State Inspector of Mines of WY., & D.O.I. Federal Coal Management Report

PRB Coal

- Experience more recent than Bituminous, but still large
- Poisoned by calcium (calcium sulfate)
- Typically low sulfur levels, variable ash loading
- Sootblowing required
- Relaxed limits on SO_2 conversion (sometimes)
- Effects on downstream equipment variable
- Ammonia slip typically < 2 ppm, but not as critical as bituminous

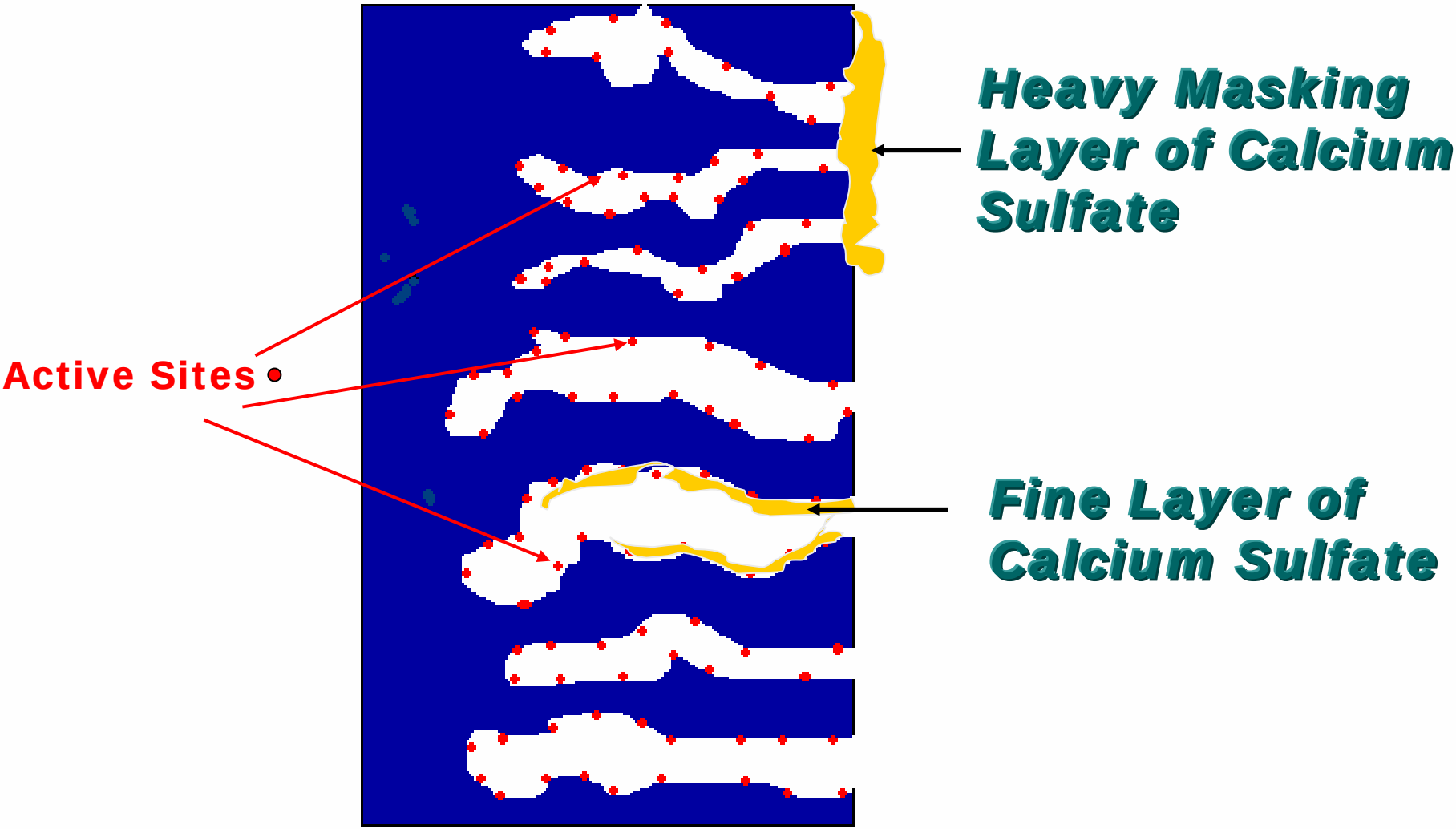
Mechanism of PRB Poisoning

PRB deactivation mechanism:
Macroscopic blockage of catalyst surface by calcium sulfate coating



Courtesy – Siemens

PRB Poisoning



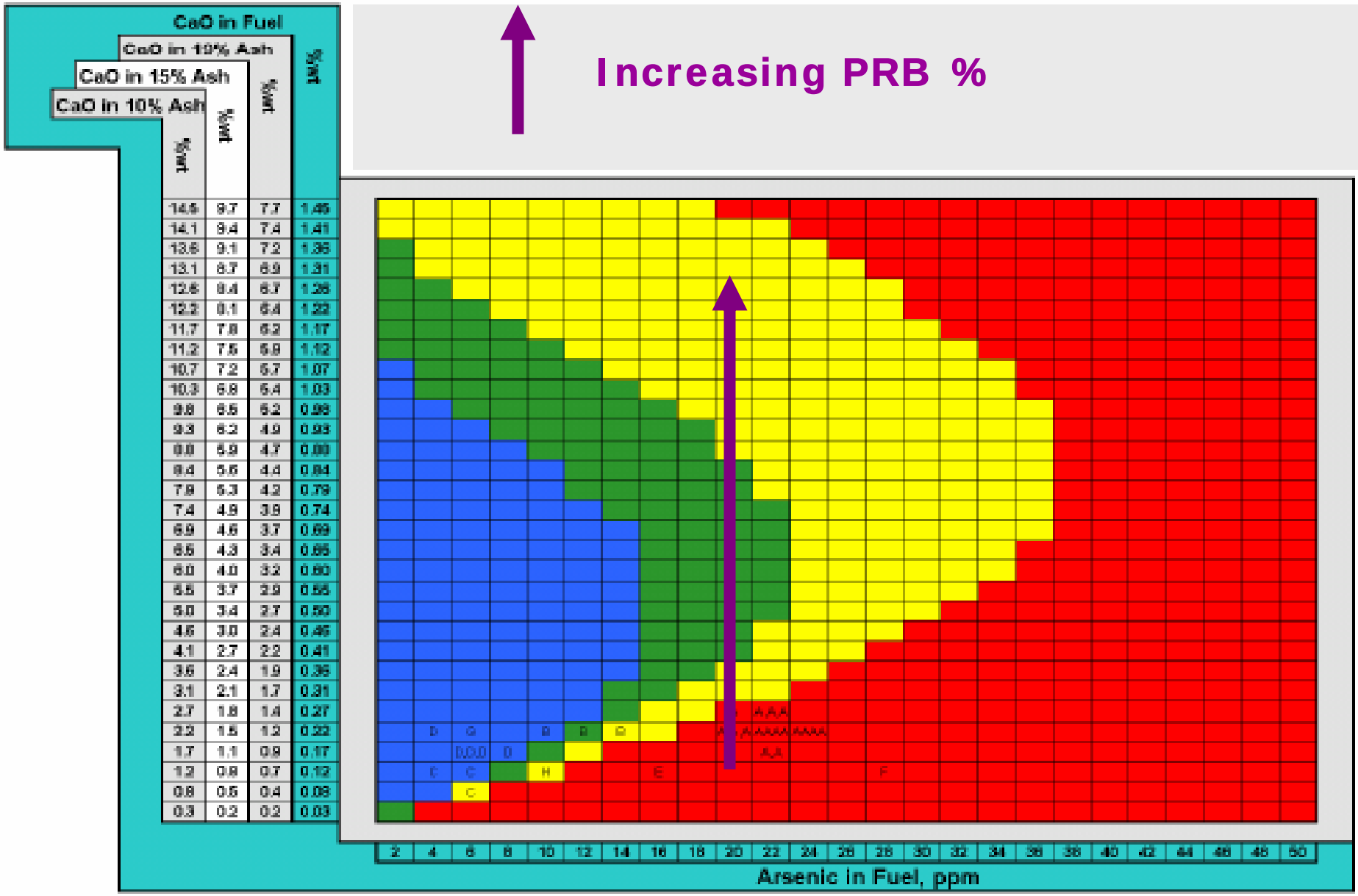
Mitigating PRB Poisoning

- Catalyst Design
- Good sootblowing, cleaning practices
- Good catalyst management plan

Coal Blends

- Can have arsenic poisoning or calcium poisoning, depending on %
- Can produce wide range of flue gas/ash characteristics
- Can be used as poison mitigation

Coal Blending Effect on Catalyst Life



Courtesy Cormetech

Guaranteed Catalyst Life

Too Long

- Tied-up capital
- Can't take advantage of Catalyst Improvements
- Catalyst exposed needlessly to flue gas – deactivation
- Extra Pressure Drop

Too Short

- Costly outages
- Logistics and purchasing costs

QUESTIONS ?