

Reinhold Environmental Ltd.



2008 NOx-Combustion Round
Table & Expo Presentation

February 4-5, 2008 in Richmond, VA

Codan Development LLC



“Enhanced SCR/SNCR Performance via SO₃ Removal”

**NO_x Workshop
Reinhold Environmental
February 4-5, 2008**

**Jim Jarvis
URS Corporation**



Presentation Outline

- Impacts Created by Presence of SO₃
- Benefits of Effective SO₃ Removal
- SBS Injection™ Technology Description
- SBS Injection™ Development Programs
 - ✓ Reagent testing
 - ✓ Mercury testing
 - ✓ “Pre-SCR” testing
- Case Study: Pre-SCR Applications on Full-Scale Boilers
- Summary

Presentation Outline

- Impacts Created by Presence of SO₃
- Benefits of Effective SO₃ Removal
- SBS Injection™ Technology Description
- SBS Injection™ Development Programs
 - ✓ Reagent testing
 - ✓ Mercury testing
 - ✓ “Pre-SCR” testing
- Case Study: Pre-SCR Applications on Full-Scale Boilers
- Summary

Impacts Created by Presence of SO₃

- Plume Effects: Opacity & Buoyancy Issues
- Acid Dew Point: Corrosion, Heat Rate & Baghouse Impacts
- Reaction with NH₃: Air Heater Fouling
- SCR Operation: Minimum Operating Temperature Constraints
- Mercury Control: Reduced Mercury Retention by Fly Ash & Activated Carbon
- Improves ESP Particulate Removal Efficiency

Impacts Created by Presence of SO_3

- Plume Opacity Issue: Coloration of Plume from Optical Light Scattering Effects of Sulfuric Acid Aerosol Particles



Sulfuric acid opacity can be visible when $\text{SO}_3 > 5\text{ppm}$

Impacts Created by Presence of SO₃

- Plume Effects: Opacity & Buoyancy Issues
- Acid Dew Point: Corrosion, Heat Rate & Baghouse Impacts
- Reaction with NH₃: Air Heater Fouling
- SCR Operation: Minimum Operating Temperature Constraints
- Mercury Control: Reduced Mercury Retention by Fly Ash & Activated Carbon
- Improves ESP Particulate Removal Efficiency

What if SO₃ Could be Removed?

Direct Benefits:

- Elimination of Visual Opacity
- Reduction in Downstream Equipment Corrosion
- Fuel Flexibility

Potential Benefits:

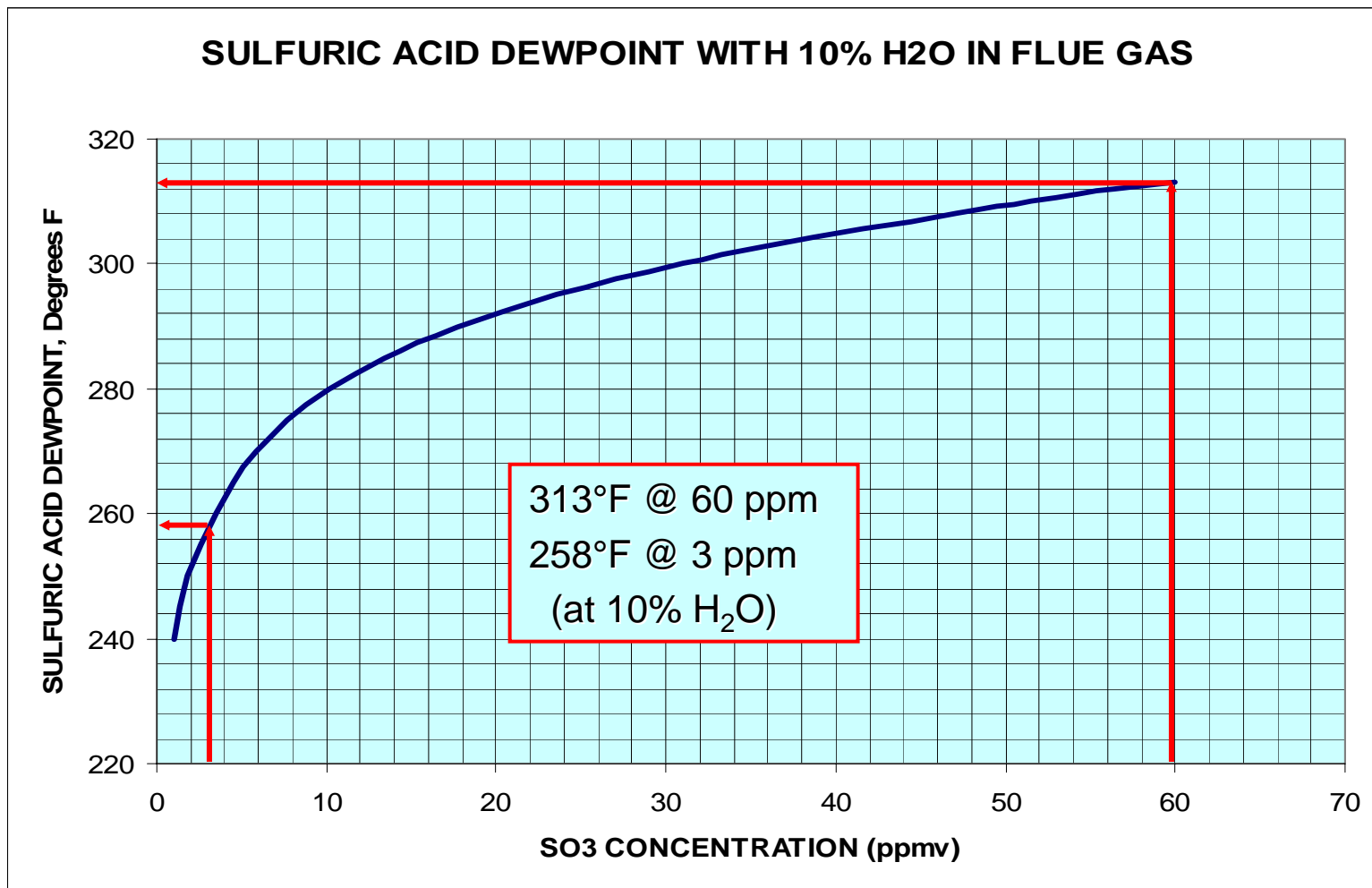
- Improvement in Unit Heat Rate (Efficiency)
- Optimization of Other Emission Control Processes
 - ✓ NO_x control (SCR, SNCR & combustion controls)
 - ✓ Particulate removal (ESP & fabric filter)
 - ✓ Hg control

Capital & Operating Cost Reductions

Heat Rate Improvement

- Impact:
 - ✓ Acid deposition & corrosion in the APH requires higher back-end temperatures with reduced unit efficiency
- Approach:
 - ✓ Reduce SO₃ at APH inlet
 - ✓ Operate with a lower AH outlet temperature or offset increases in the outlet temperature due to SCR
 - ✓ Eliminate combustion air “pre-heat” (i.e., steam coils)
 - ✓ APH basket replacement may be necessary
- Benefits:
 - ✓ Improved unit heat rate (efficiency)
 - ✓ Reduced flue gas volume
 - ✗ Reduced ID fan energy consumption
 - ✗ Improved ESP collection efficiency
 - ✓ Reduced CO₂ emissions

Sulfuric Acid Dewpoint vs SO₃



SCR/SNCR Optimization

- Impact:
 - ✓ Presence of SO_3 requires low ammonia slip to avoid APH fouling
- Approach:
 - ✓ Reduce SO_3 at APH inlet
 - ✓ Operate with a modest increase in ammonia slip
- Benefits:
 - ✓ Reduced ABS deposition in the APH
 - ✗ If SO_3 is low, elevating the ammonia produces ammonium sulfate instead of ammonium bisulfate (ABS)
 - ✓ Increased NO_x removal & credit generation
 - ✗ Up to 10 percentage points for SCR
 - ✗ Up to 30 percentage points for SNCR
 - ✓ Optimize boiler operation (less staging with reduced LOI)
 - ✗ Let SCR treat inlet gas with a higher NO_x concentration

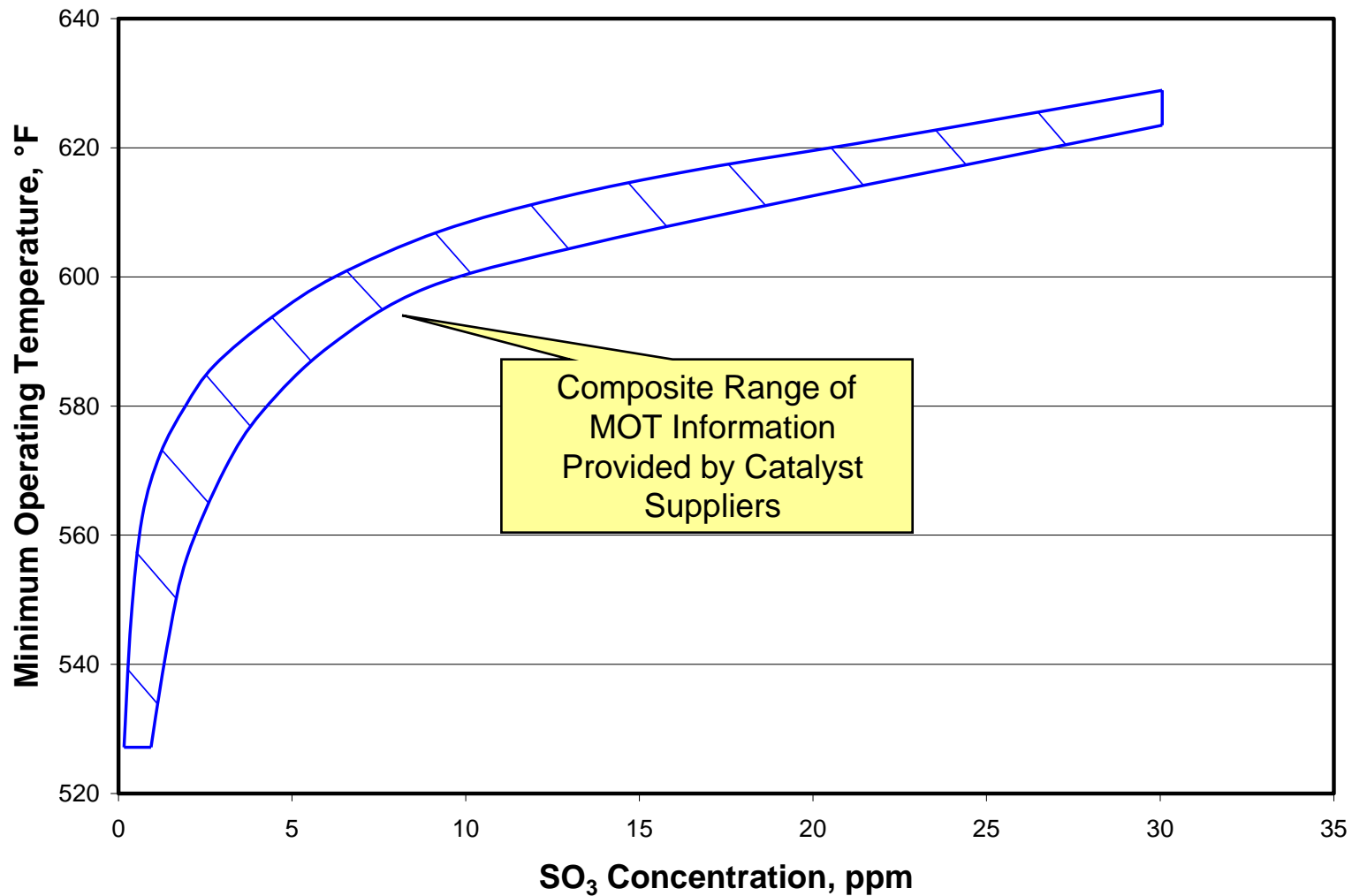
SCR/SNCR Optimization (Continued)

- More Benefits:
 - ✓ Additional catalyst management options
 - ✗ Extend effective catalyst life
 - ✗ Extend operating times between outages
 - ✓ Employ SNCR on boilers firing medium to high sulfur coal
 - ✗ Limited number of applications on medium/high sulfur units
 - ✗ NO_x removal limited due to APH fouling
 - ✗ SO₃ removal extends applicability of relatively low capital cost SNCR to a wider population of boilers
 - ✓ Optimize catalyst design for NO_x removal & Hg oxidation
 - ✗ Increase catalyst activity, then remove the higher SO₃
 - ✓ Optimization concepts can be employed during SCR reactor design
 - ✗ Design with one less catalyst layer
 - ✗ Include modifications to facilitate SO₃ removal

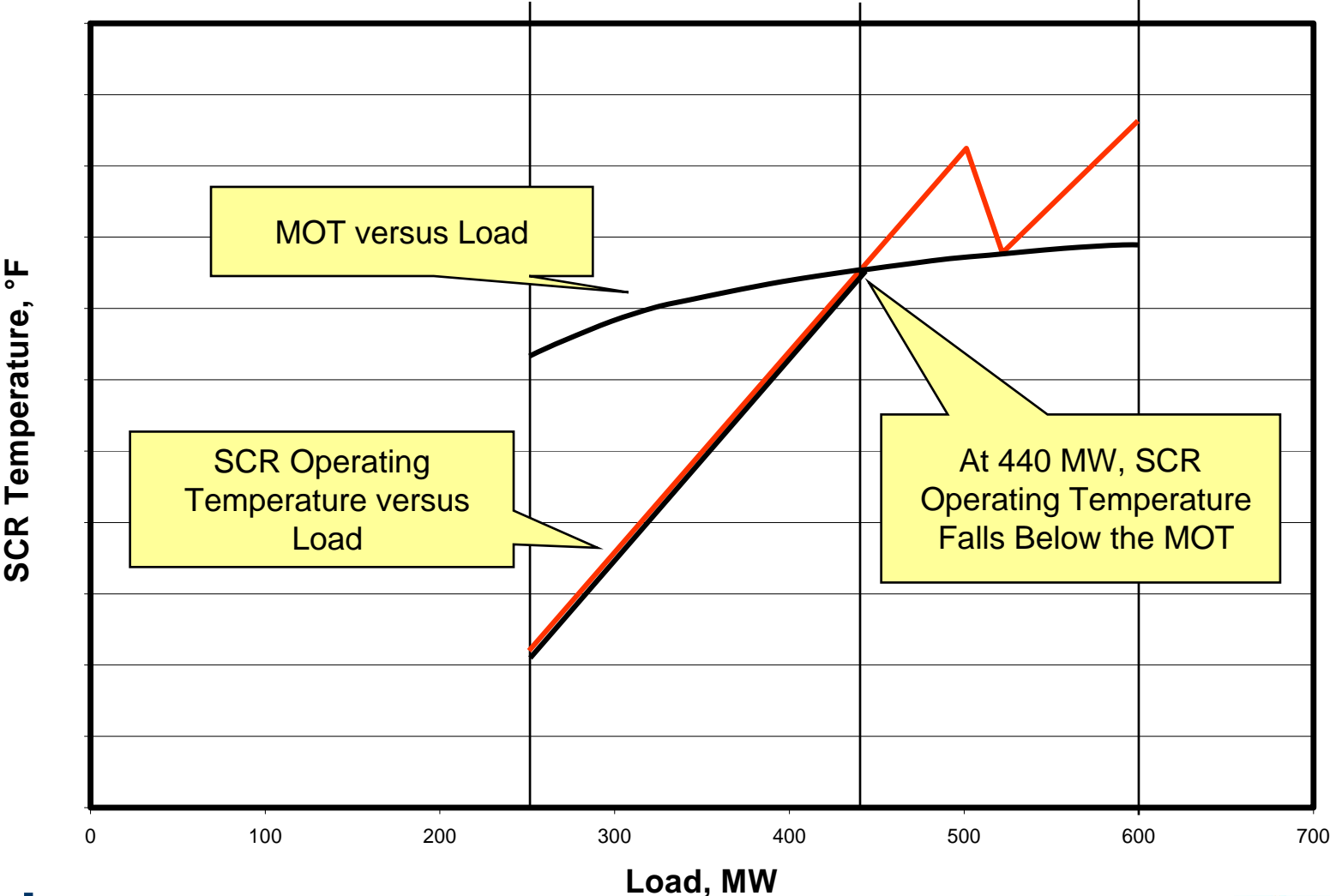
SCR Operation & Performance

- Impact:
 - ✓ Presence of SO_3 increases the SCR's Minimum Operating Temperature (MOT) due to formation of ABS within the catalyst pores (capillary condensation)
 - ✓ Direct impact is a reduction in NO_x removal efficiency to avoid operation below the MOT
 - ✓ MOT issue affects plants switching to higher-sulfur coals
- Approach:
 - ✓ Remove combustion-formed SO_3 upstream of the SCR along with SO_3 produced by the catalyst to reduce MOT
- Benefits:
 - ✓ Increased NO_x reduction efficiency at reduced loads
 - ✓ Reduced reliance on economizer bypass with its associated maintenance & heat rate impacts
 - ✓ Avoid more costly means of increasing SCR operating temperatures (e.g., duct burners)

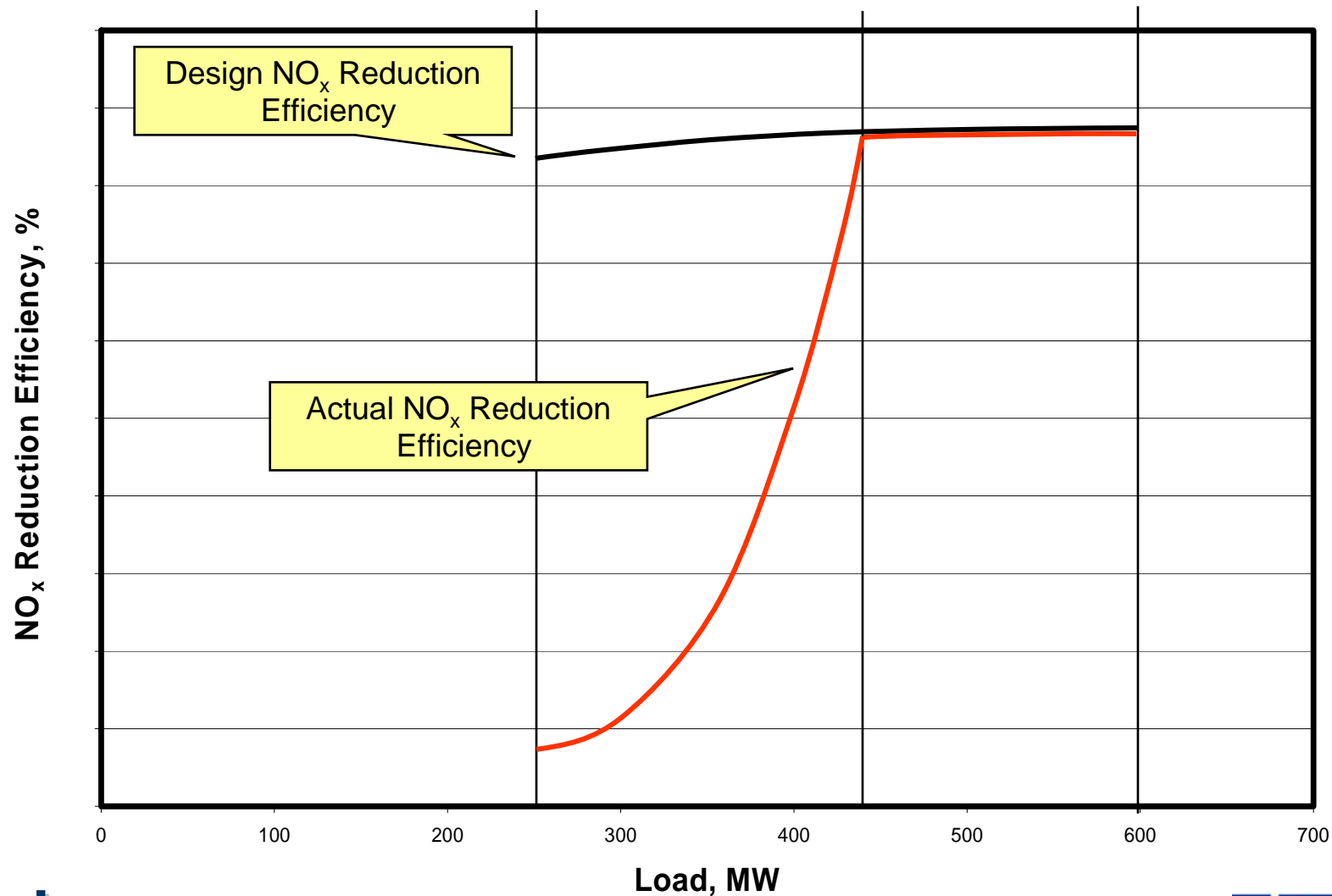
Minimum Operating Temperature versus SO₃



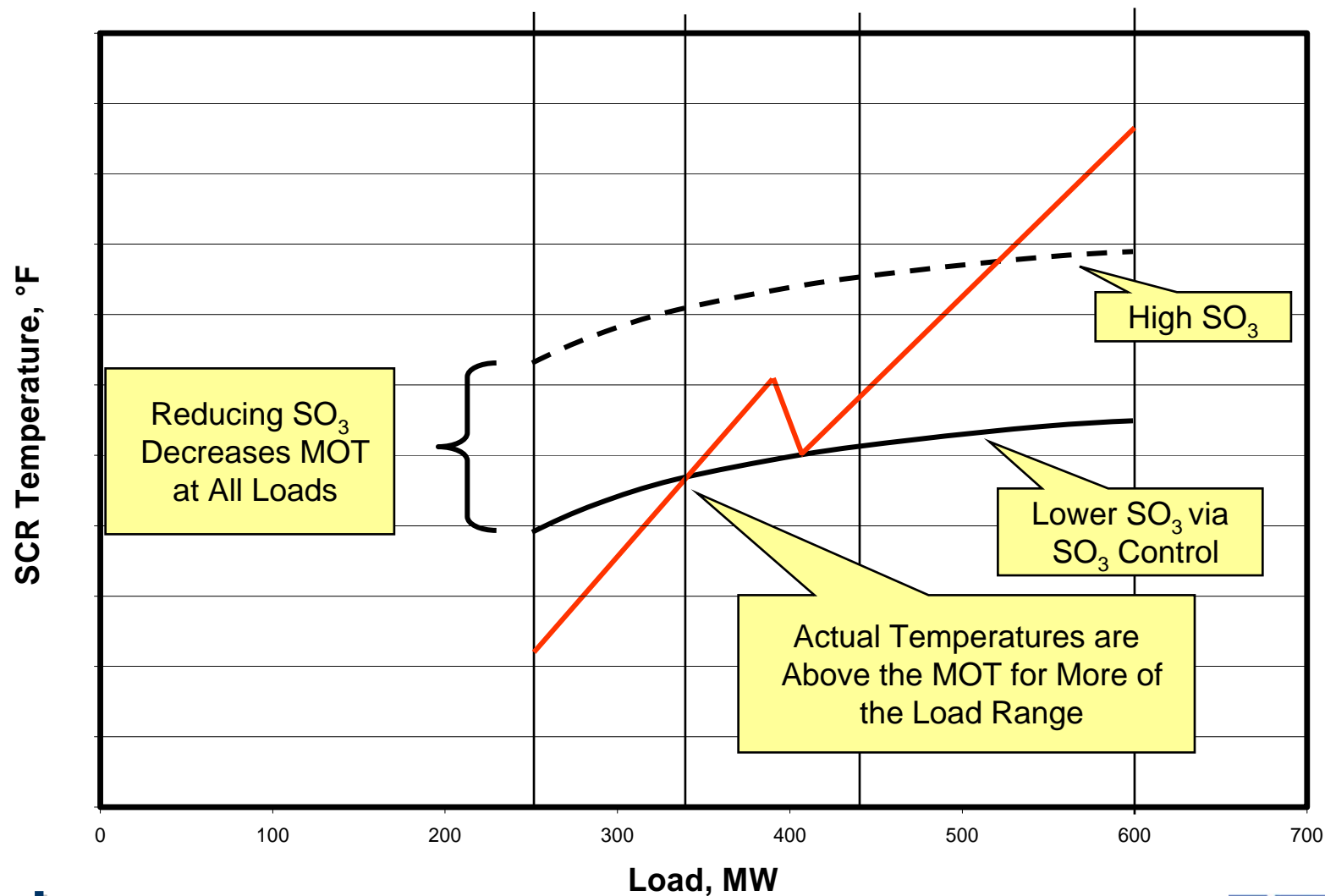
Example – Impact of MOT on SCR Performance



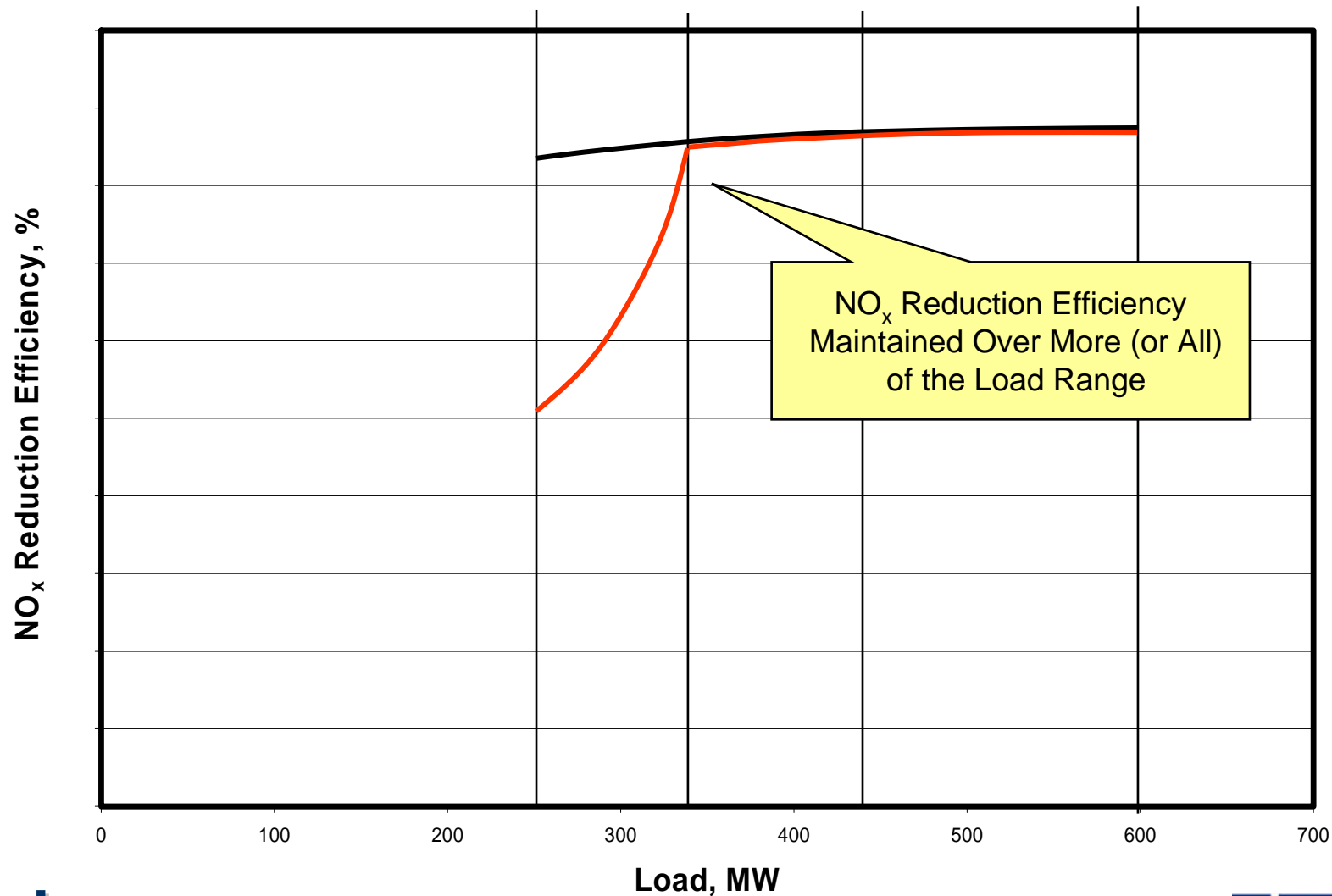
Example – Impact of MOT on SCR Performance



Example – Impact of MOT on SCR Performance



Example – Impact of MOT on SCR Performance



Mercury Control

- Impact:
 - ✓ SO₃ competes with mercury for carbon absorption sites
 - ✓ Reduces mercury co-removal on activated carbon & flyash
- Approach:
 - ✓ Remove SO₃ upstream or just downstream of the APH
- Benefits:
 - ✓ Overall decrease in mercury emissions
 - ✓ Potential reduction in activated carbon injection rates
 - ✓ Avoid activated carbon injection entirely
 - ✓ Reduced mercury content in the gypsum
 - ✓ Beneficial for boilers that don't have SCR or FGD
 - ✓ Beneficial for boilers with both SCR/FGD if mercury emission reductions are below 90%

Secondary Benefits Overview & Economics

Area	Mechanism	Performance Improvement	Economic Benefit*
Heat Rate	Operate at lower AH exit temperature due to lower sulfuric acid dewpoint	1-2%	~ \$1 M/yr
NO _x - SCR	Operate at high NH ₃ slip without ABS fouling of AH	2-10%	~ \$1 M/yr
NO _x - SNCR	Operate at high NH ₃ slip without ABS fouling of AH	10-30%	~ \$3 M/yr
Hg	Eliminate competing SO ₃ adsorption on native ash or activated carbon	10-80%	~ \$2 M/yr
CO ₂	Improve unit efficiency by operating at lower AH exit temperature	1-2%	~ \$1 M/yr
Opacity	Eliminate sulfuric acid opacity and enhance ESP collection efficiency	10-40%	Priceless

* Typical 500 MW plant

Presentation Outline

- Impacts Created by Presence of SO₃
- Benefits of Effective SO₃ Removal
- **SBS Injection™ Technology Description**
- SBS Injection™ Development Programs
 - ✓ Reagent testing
 - ✓ Mercury testing
 - ✓ “Pre-SCR” testing
- Case Study: Pre-SCR Applications on Full-Scale Boilers
- Summary

SBS Injection™ Technology

Features

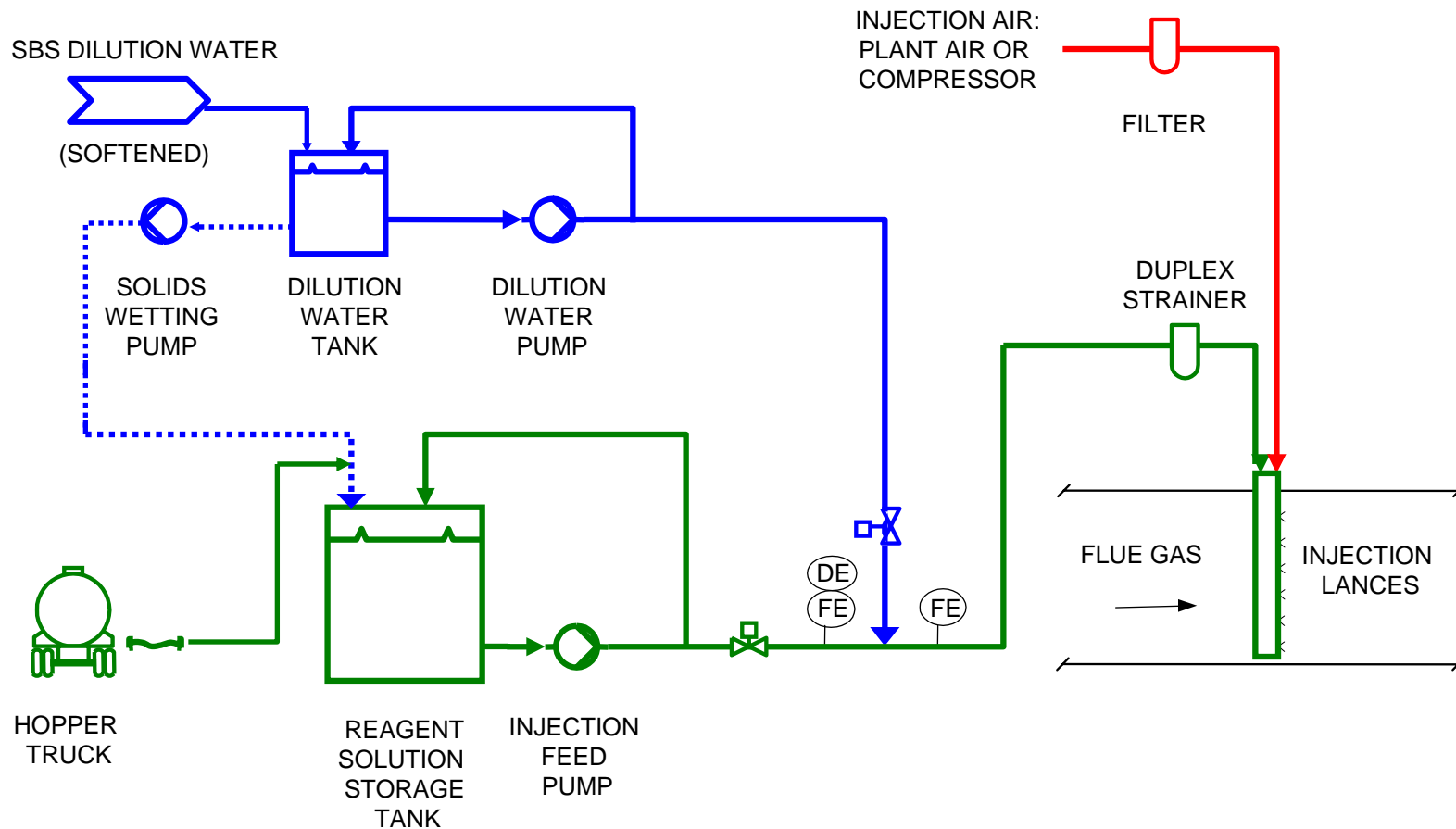
- Patented Technology
- Clear Solution Injection
- Sodium-Based Reagent
- Dual-Fluid Atomization
- Selective Reactions
- High SO₃ Removal
- Low Injection Rate
- Product Collected in ESP

Benefits

- Opacity Elimination
- Corrosion Reduction
- ESP Enhancement
- Potential Heat Recovery
- CO₂ Reduction
- SCR/SNCR Flexibility
- Hg Capture Enhancement
- Fuel Flexibility

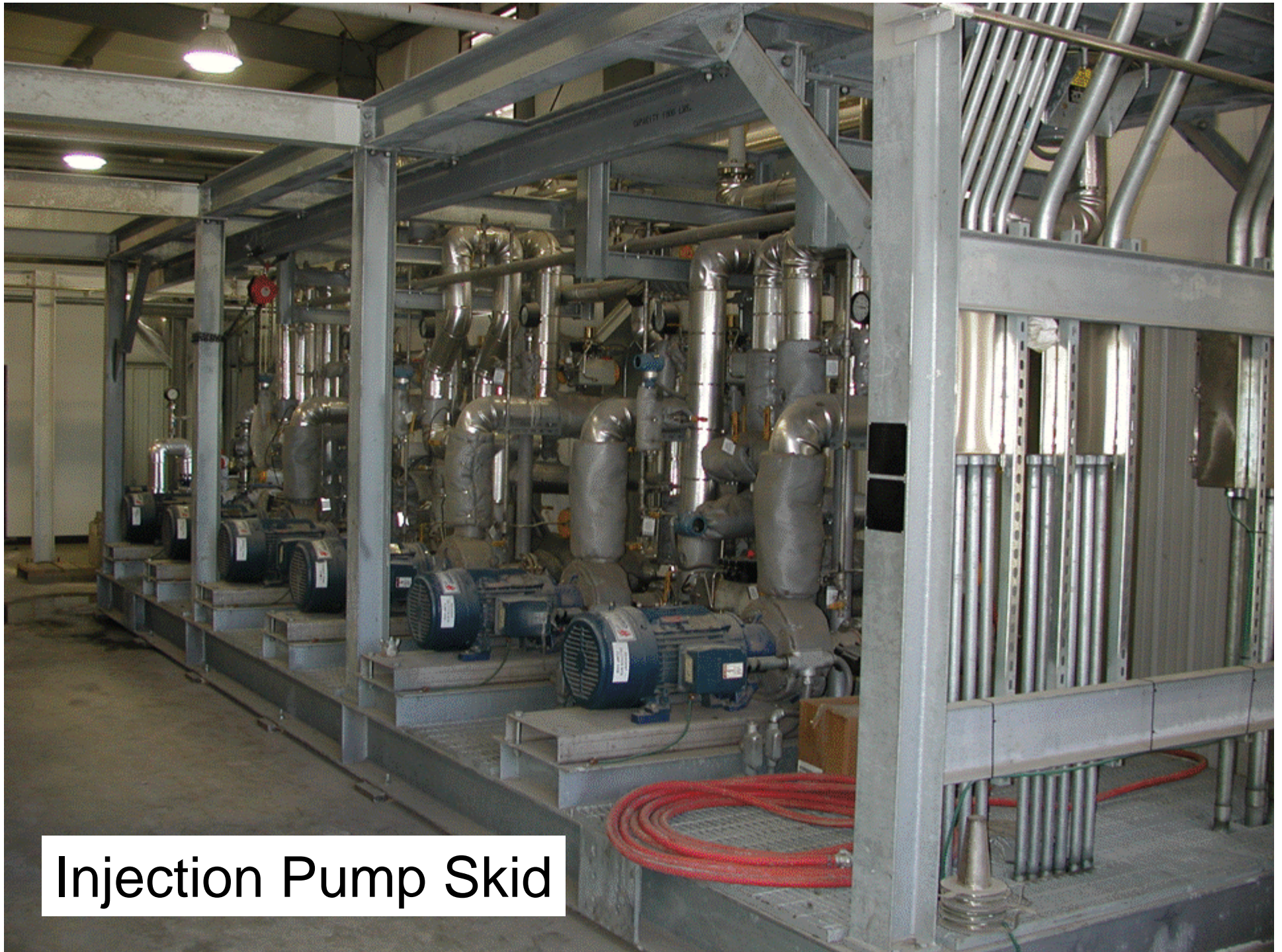
Maximum Benefits with “Upstream” Injection

Simplified Process Flow Diagram



Duke Energy Gibson Generating Station





Injection Pump Skid

The image shows a complex industrial facility with multiple injection metering skids. Each skid is a large, rectangular metal structure supported by a grid of steel beams. The skids are filled with a dense network of stainless steel pipes, valves, and flow meters. Some pipes are wrapped in grey insulation. The facility is well-lit, and the overall appearance is that of a modern, high-capacity industrial plant. The caption 'Injection Metering Skids' is positioned at the bottom right of the image.

Injection Metering Skids



Injection Lance System



Gibson June 2004 – No Treatment



Gibson June 2005 – SBS Injection



Gibson April 2005 – No Treatment 14