FUEL TECH
Technologies to enable clean efficient energy





Mitigation of SCR Impacts on Fuel Flexibility Using Targeted In Furnace Injection (TIFI)

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McIlvaine Hot Topic
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Agenda

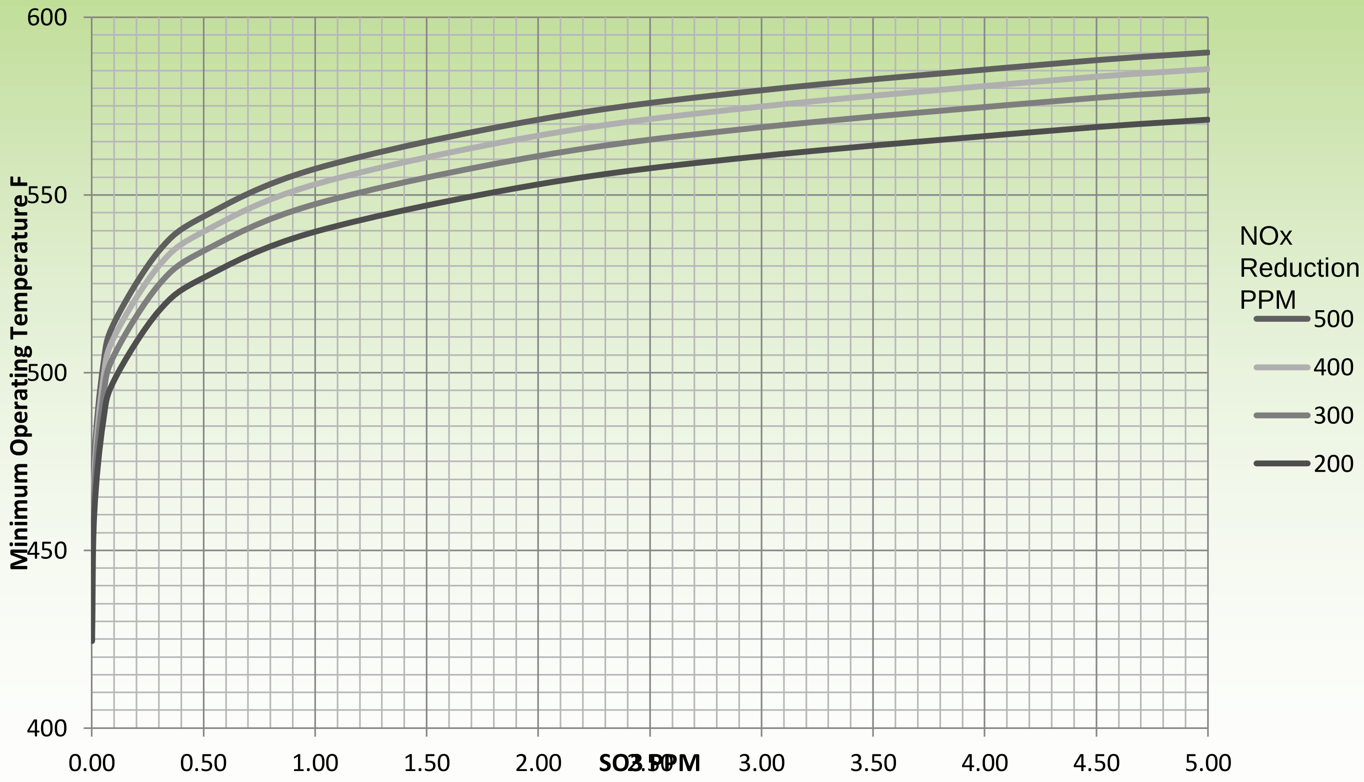
- Impact of catalyst technology on fuel flexibility
- Overview of Targeted In Furnace Injection TIFI®
- Demonstrated Benefits of TIFI® on boiler and SCR operation
- Conclusions

Impact of SCR on Boiler Operation and Fuel Flexibility

- Minimum Operating Temperature MOT
  - Determined by ABS formation temperature (to protect catalyst from masking)
  - MOT may impose restrictions on unit minimum load, NOx removal efficiency (NH_3 injection rate) and fuel quality (Sulfur content)
- Downstream impacts of Ammonia Slip and SO_3
  - Fouling (delta-P), Corrosion, Byproduct Quality ($), Visible Emissions (Environmental)
- Catalyst poisons
  - Fuel flexibility and Catalyst life ($)

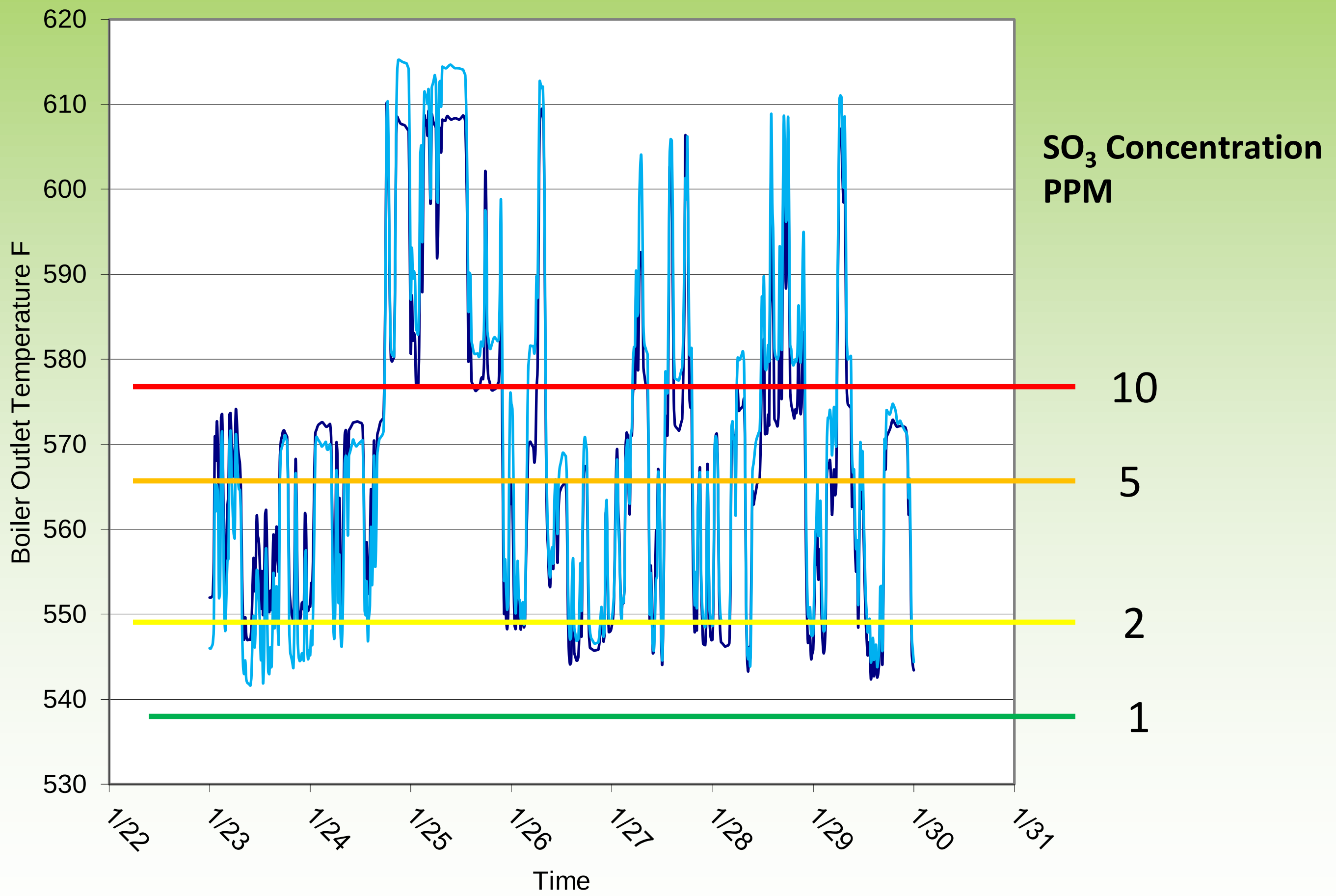
Minimum Operating Temperature

- The MOT of the catalyst depends on the SO_3 and ammonia concentration in the flue gas
- The ammonia concentration is a function of the NO_x removal



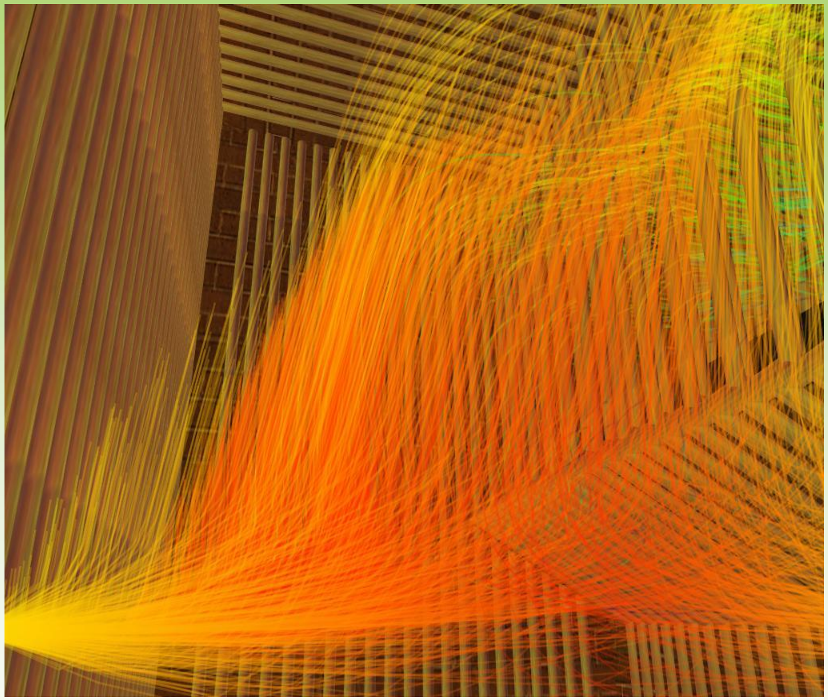
Impact of SO_3 on NO_x Reduction

- **MOT impact at 200 PPM NO_x Reduction**



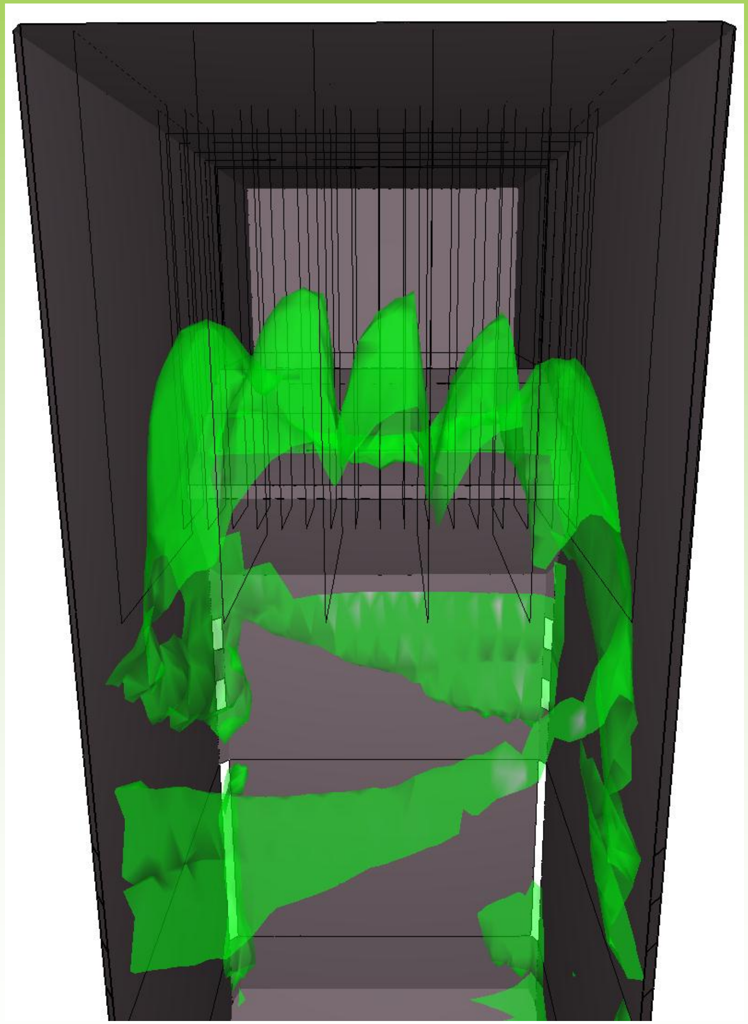
TIFI® Targeted In-Furnace Injection™

- **Highly reactive magnesium hydroxide $Mg(OH)_2$**
- **Patented process using Computational Fluid Dynamic Modeling**
- **Critical Design Criteria**
  - Furnace gas flows and temperatures
  - Chemical distribution, particle size and feed rate

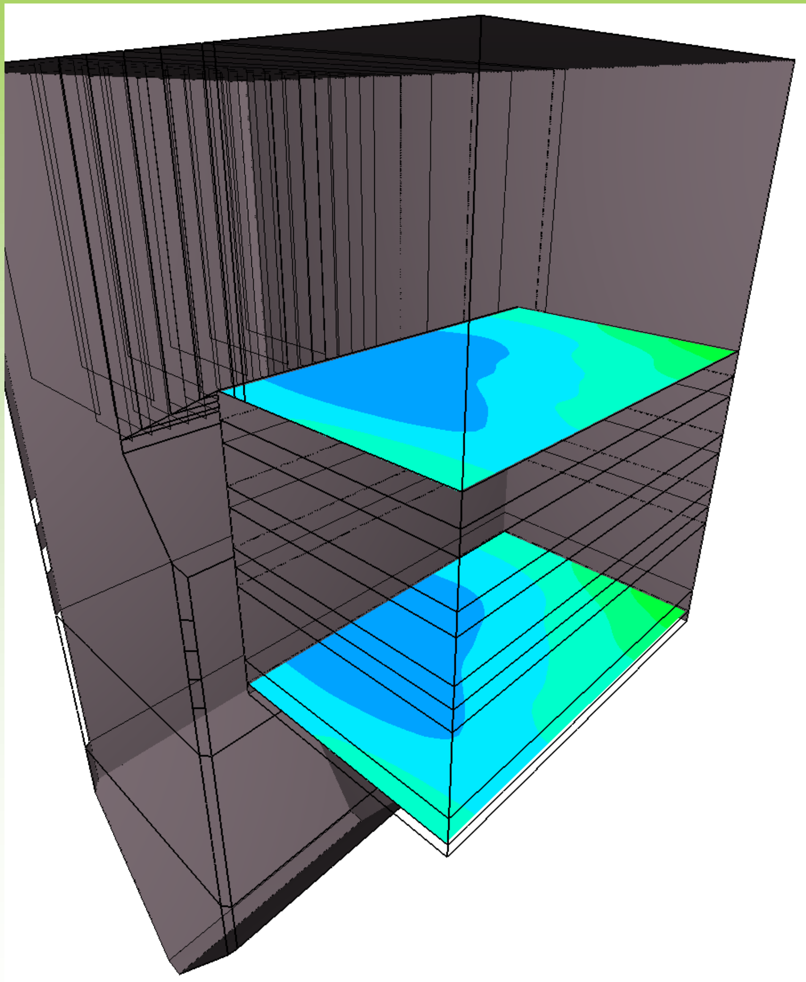


CFD Modeling of Injection Strategy includes both Furnace and Backend

TIFI Injection Model

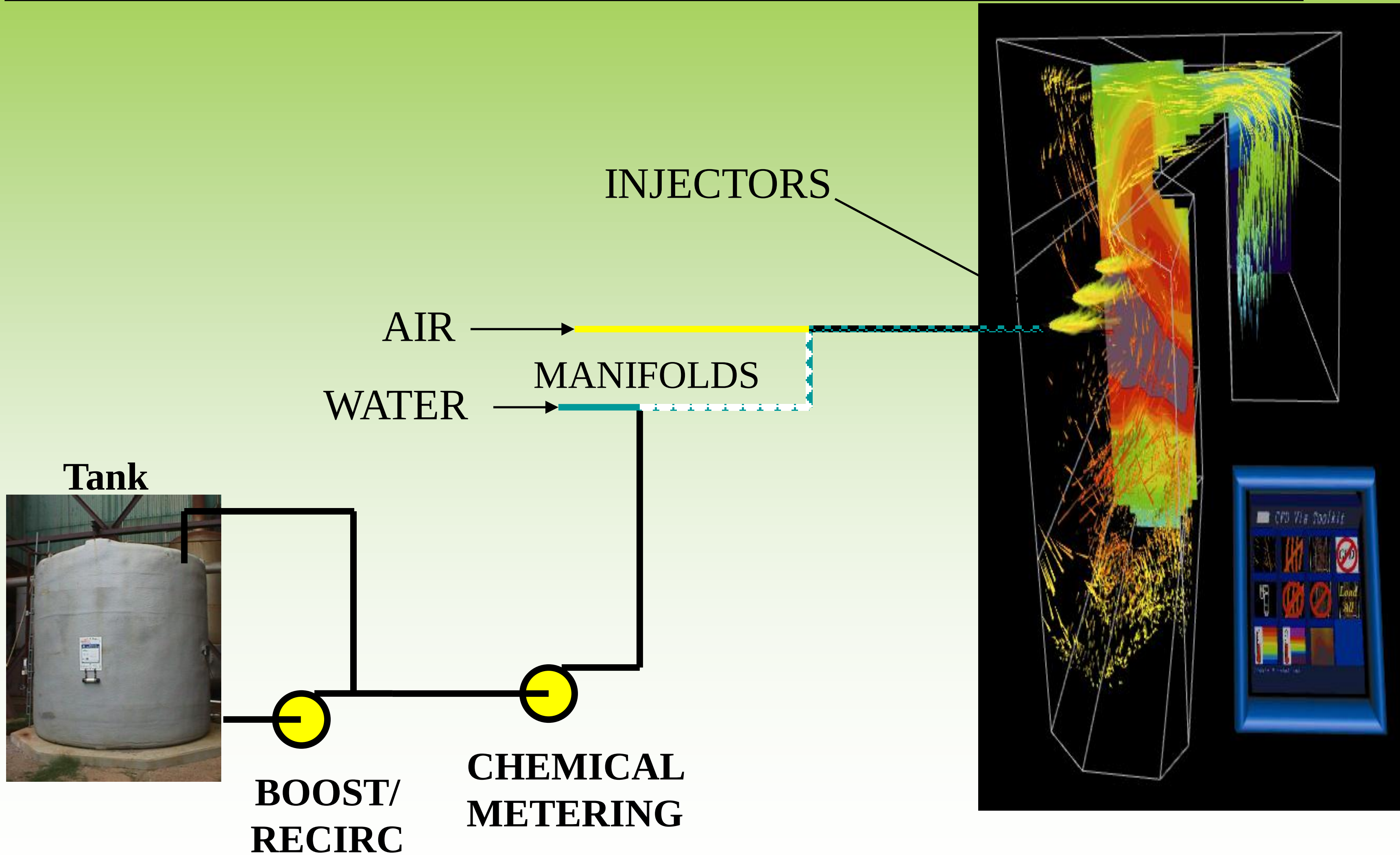


SO_3 Distribution Map



TIFI® Targeted In-Furnace Injection™

<u>ANATOMY OF A TYPICAL INJECTION SYSTEM</u>



TIFI reduces ABS, SO_3 and H_2SO_4

- **Lower Furnace Temperature**
  - Decreased SO_2 Oxidation Rate
- **More Balanced Furnace**
  - Reduced Excess Oxygen
- **Reduced Slag and Iron Deposits**
  - Less Catalytic Oxidation of SO_2
- **Direct Reaction with MgO**
  - $MgO + SO_3 \Rightarrow MgSO_4$
  - $MgO + NH_4HSO_4 \Rightarrow MgSO_4 + NH_3 + H_2O$

Case Studies

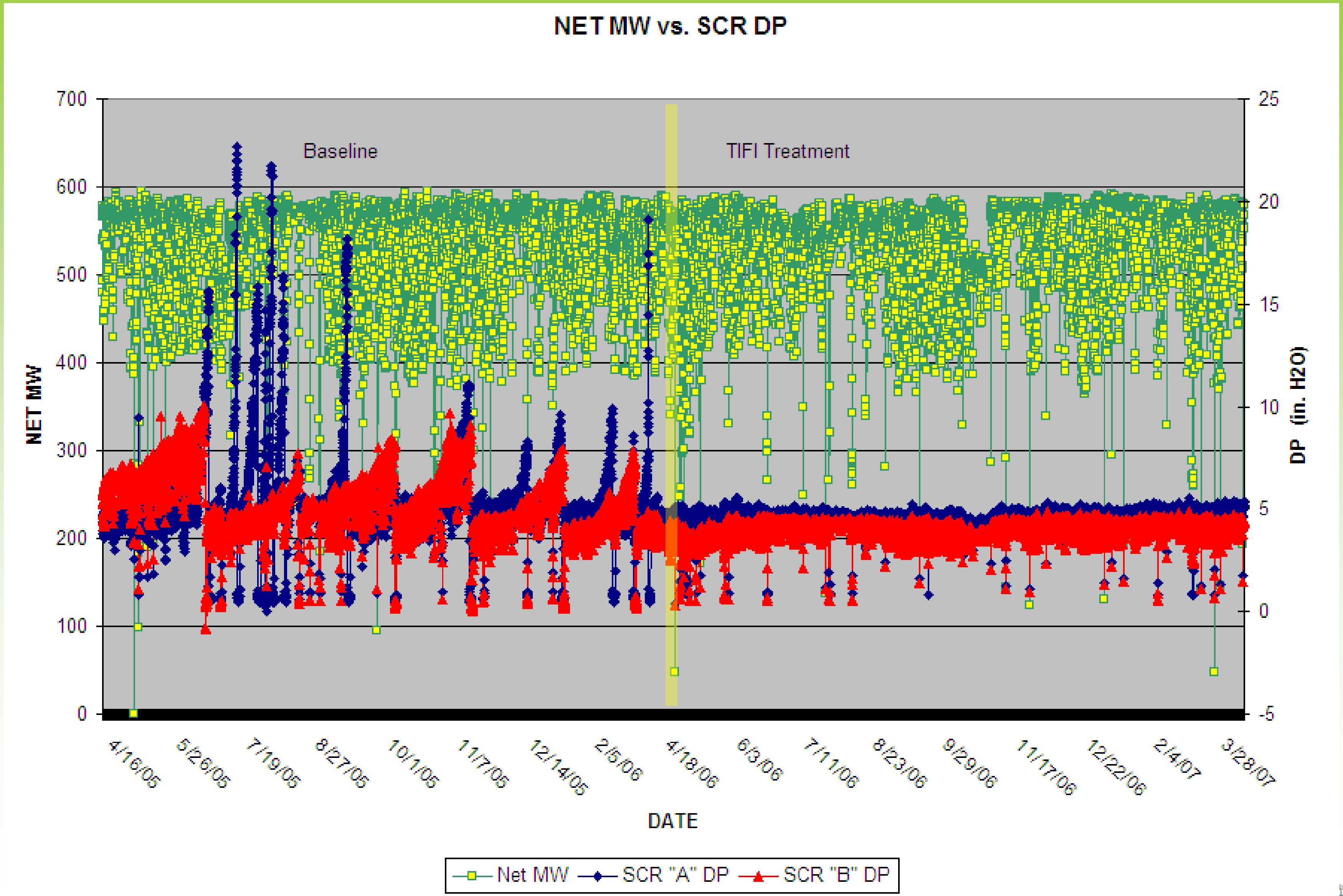
Demonstration of TIFI with SCR

Control of Hard Slag Formation

Fuel Characteristics – SO2 3.3-4.5 #mmBtu; Iron Content (in ash) 23-25%

- Treated slag material is more friable
  - More easily and thoroughly removed with existing soot blowing
  - Mitigates formation of Large Particle Ash/Popcorn Ash
  - Reduces build up of catalytic metals in the furnace
  - Generous improvement of boiler efficiency

Control of LPA/SCR Pressure Drop



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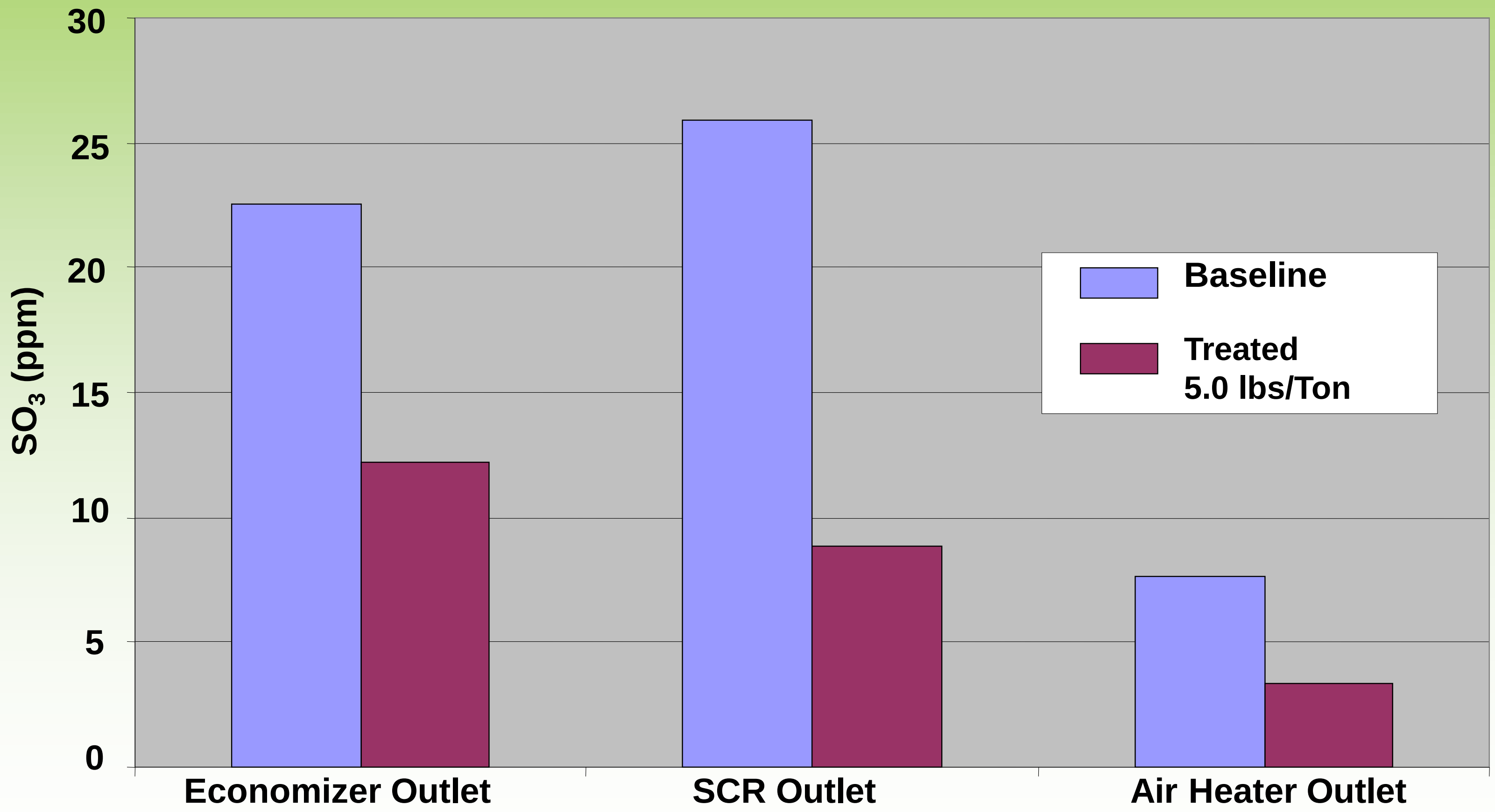
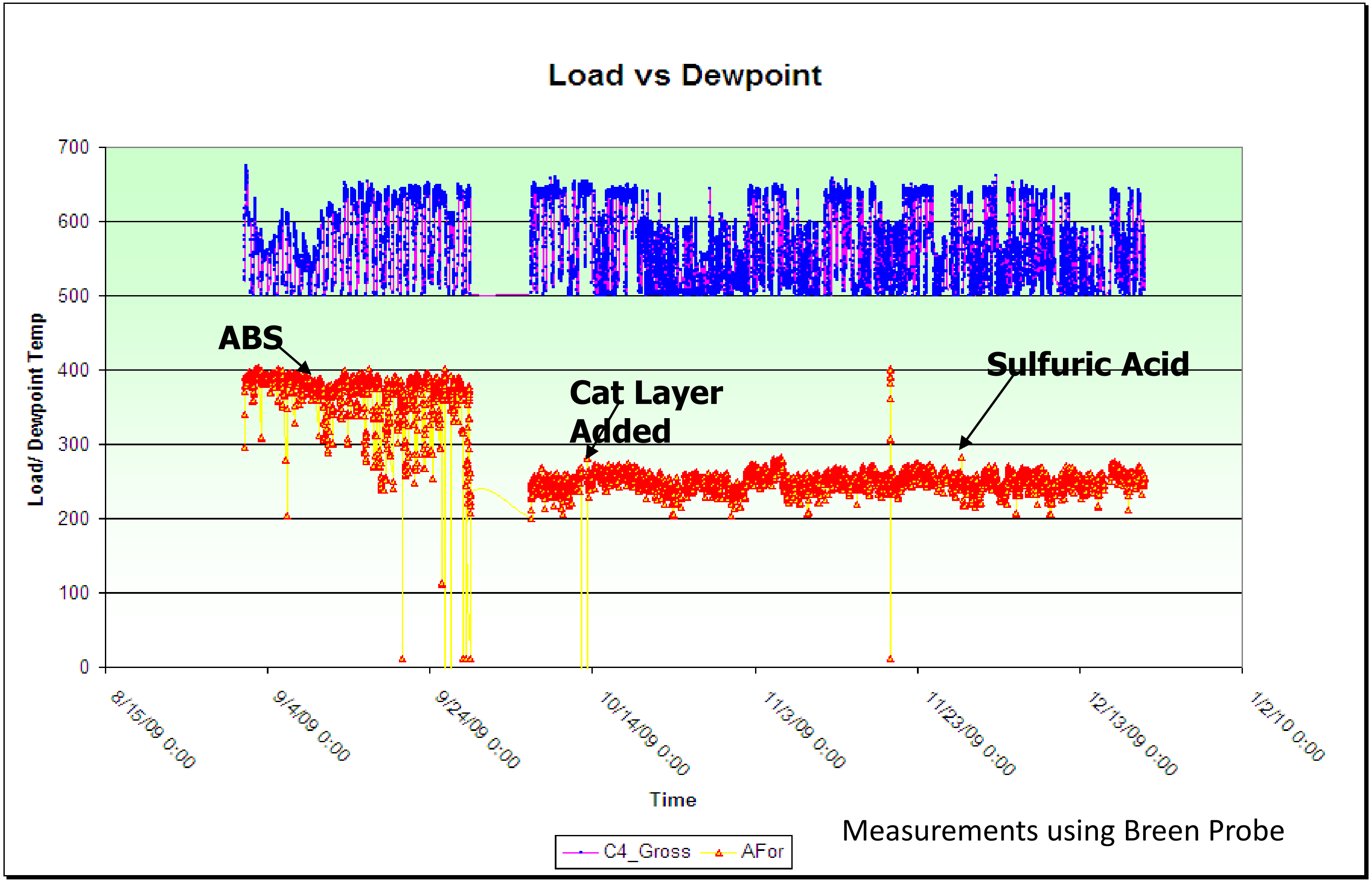
SO_3 Mitigation with TIFI

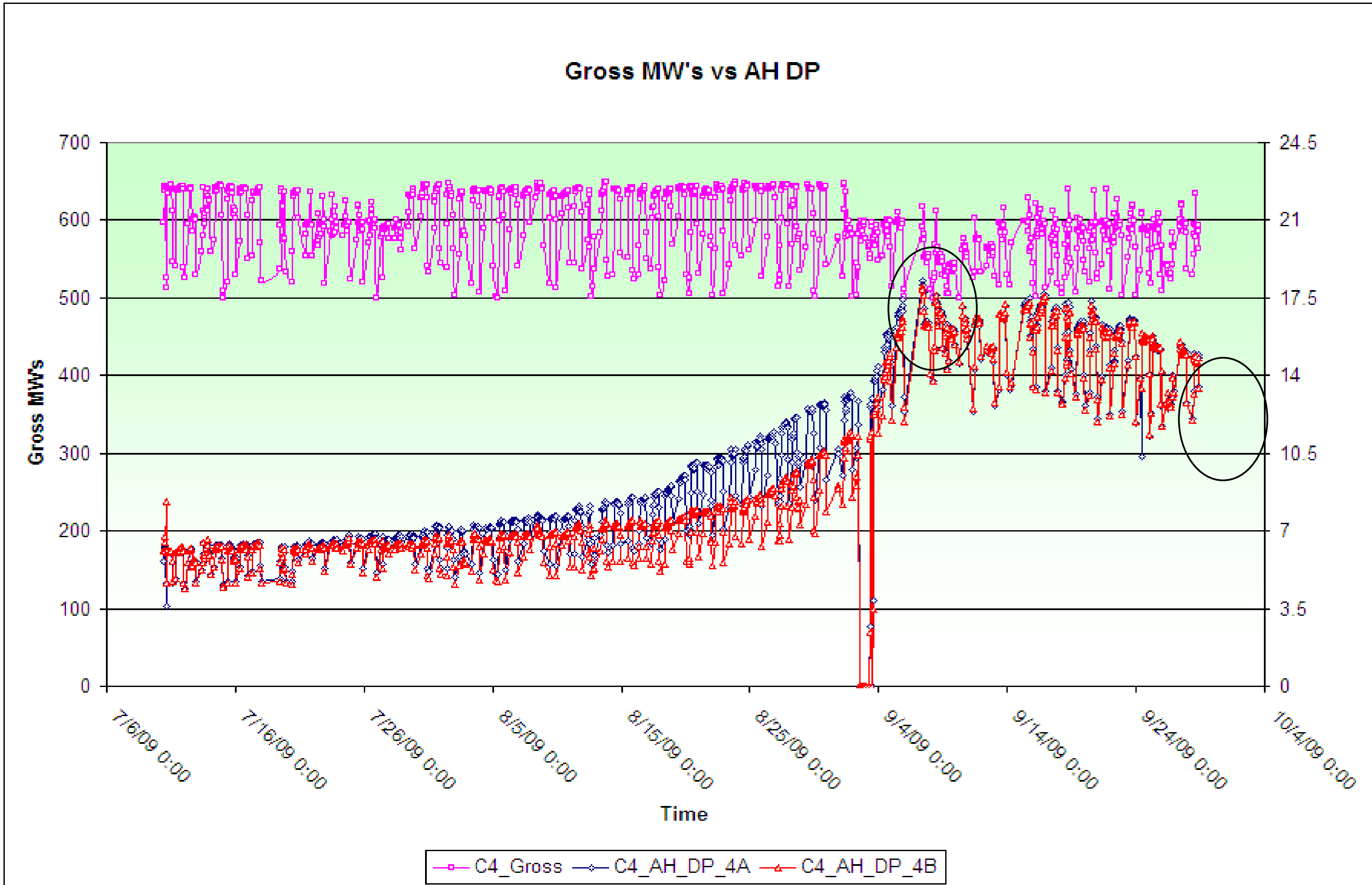


TIFI Clean up Of Air Heater



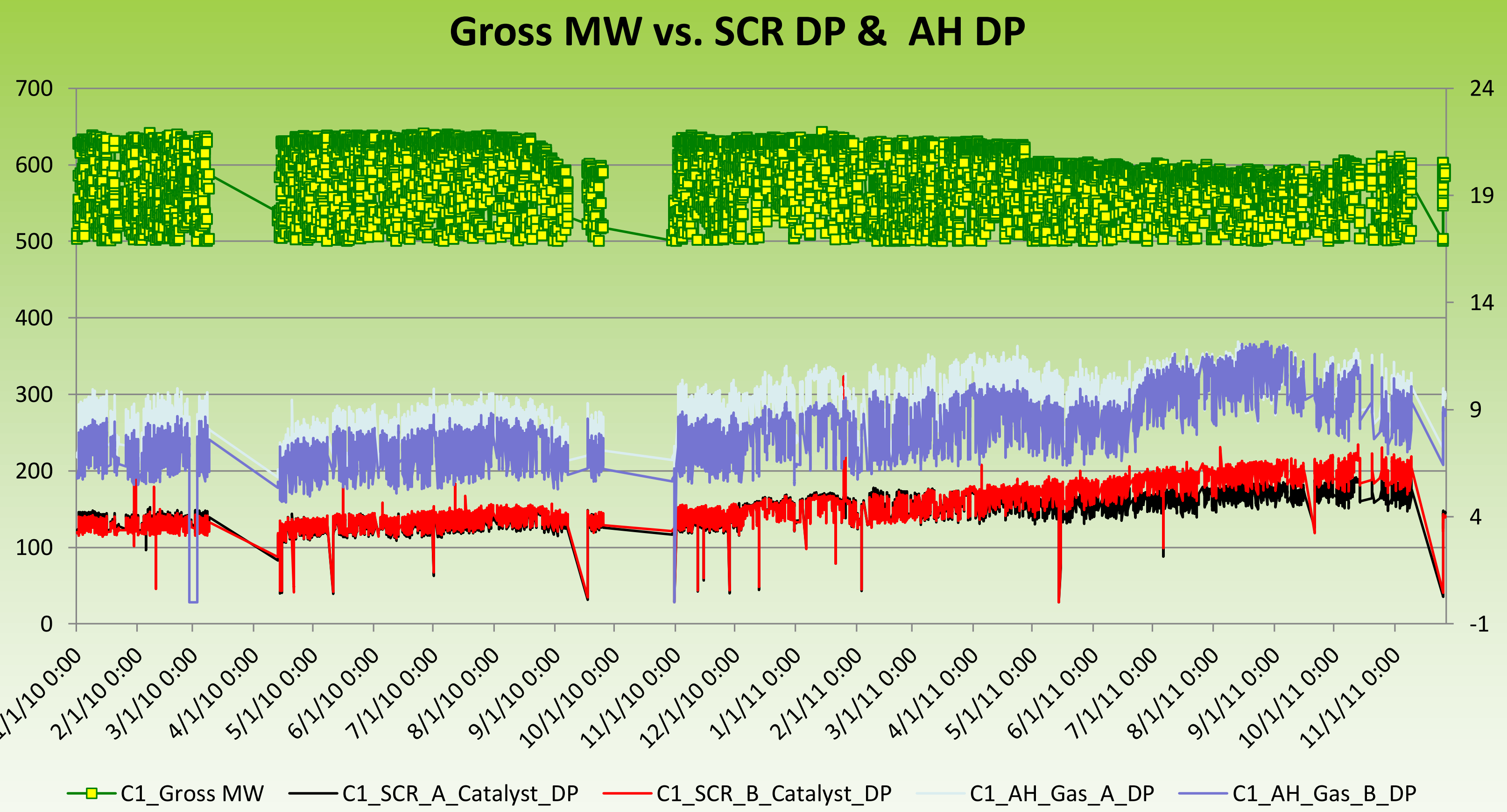
- TIFI virtually eliminates precipitation of ABS in the AH

Online ABS Removal from Air Heater



- AH pressure drop decreased from 17.8” to 14.7”

Catalyst Operating Life Extension



- **Ammonia Slip ranged from 3-15 ppm**
- **SCR dP and Air Heater dP controlled for 19 months**

Arsenic Poisoning Mitigation

Gaseous Arsenic is a predominant deactivation mechanism for SCR catalyst in coal fired applications (source E-ON 2010)

Low concentration of alkaline metals in the fuel can exacerbate deactivation by Arsenic.

- TIFI provides alkaline metal (Mg) to mitigate

Higher flue gas temperatures can exacerbate deactivation by Arsenic.

- TIFI improves furnace heat recovery and allows lower MOT

Higher concentrations of SO_3 can exacerbate deactivation by Arsenic.

- TIFI effectively reduces SO_3

Conclusions

- TIFI® Targeted In-Furnace Injection™ Successfully controlled slag, fouling, SO_3, & ABS
- Prevented ABS Formation, and removed ABS from a Fouled Air Heater
- Catalyst Life Significantly Extended by maintaining low SCR & AH dP
- Ammonia slip is managed - preventing need to buy new catalyst prematurely
- TIFI mitigates several contributors to catalyst deactivation by gaseous Arsenic

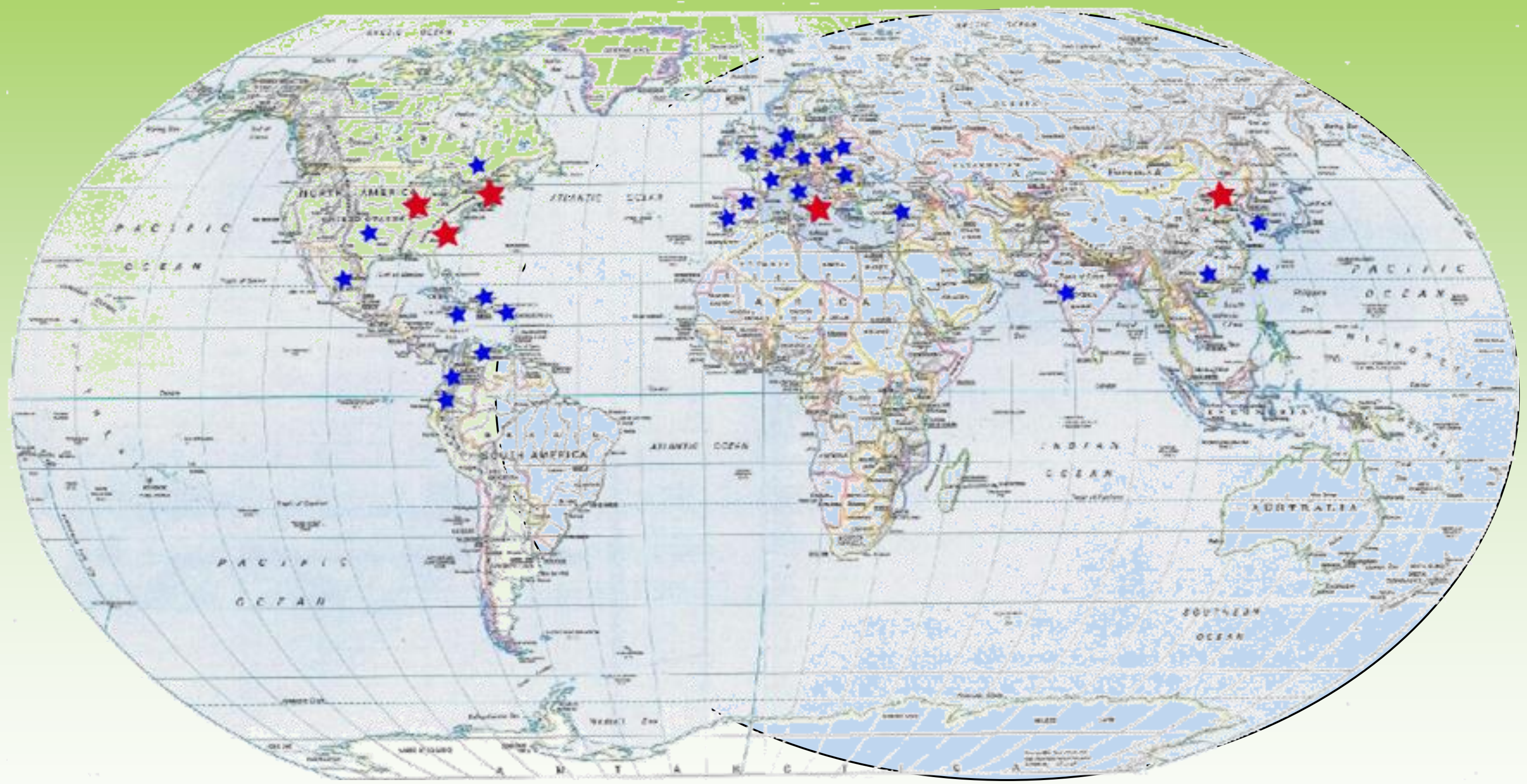
Fuel Tech Inc (FTEK)

NOx Reduction Technology Suite

- Advanced Combustion Technologies
  - Combustion Modifications: LNB, ULNB, FGR and OFA Systems
- Selective Non-Catalytic Reduction
  - RRI (Rich Reagent Injection)
  - NOxOUT® SNCR
  - HERT (High Energy Reagent Technology)
- Catalyst Technologies
  - Urea-based and NH3-based* SCR for Industrial Applications
  - NOxOUT CASCADE®: SNCR + SCR Hybrids
  - Advanced SCR Systems
  - NOxOUT ULTRA®: Thermal Decomposition of Urea
  - SCR Design and Application Consulting, Catalyst Mgmt Services

*Note: Recent development for small NH_3 flow SCRs under 10,000 pounds of reagent storage.

Fuel Tech's Global Presence



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