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I-NOx™ Integrated NOx Reduction Technology



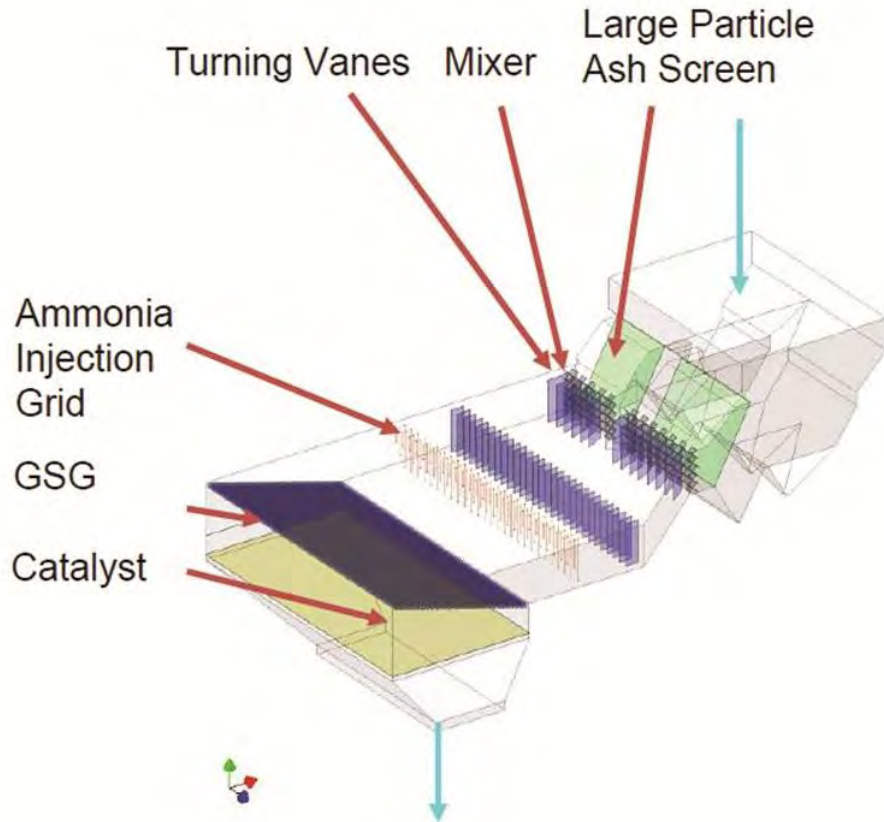
McIlvaine PacifiCorp Webinar No. 3



FUEL TECH'S I-NO_x TECHNOLOGY

- Combustion Modifications
 - Low NO_x Burners and Over Fire Air for Wall Fired Units
 - Combustion Modifications and Separated Over Fire Air for T-Fired Units
 - Additional Modifications and Combustion Tuning to Reduce NO_x Further
- Selective Non-Catalytic Reduction of NO_x (SNCR)
 - In-Furnace Injection – Furnace is Reactor
 - Low Capital Cost
 - Additional NO_x Reduction / Optimized Reagent Consumption when Combined w/ASCR
- ASCR™ Advanced Selective Catalytic Reduction of NO_x
 - Single Layer of Catalyst Where Applicable
 - In-Duct Arrangement with Proper Flow and Ash Distribution
- Combining Multiple Technologies Requires Technical “Know-How” and Commercial Experience

ADVANCED SCR (ASCR™)



- Combination of SNCR and “High Performance” SCR
- Optimized SNCR
 - Better Reagent Utilization
 - Higher Removal Efficiency
 - Higher NH₃ Slip
- Optimized SCR Utilizing Less Catalyst than Traditional SCR
 - Single Layer
 - Maintain the proper flue gas flow criteria
- Overall Reductions in Excess of 80%
- 60 – 85% NO_x Reduction at 40 to 70% of Full Scale SCR Cost
- *Site Specific Application*

I-NO_x CHALLENGES AND BENEFITS

- **Design Must Be Truly Integrated:**
 - SNCR Design Must Account for Combustion Output and Varying Operational Conditions of Typical Boiler
 - SCR Design Must Account for SNCR Output and Varying Operational Conditions of the In-Furnace Combustion and SNCR Systems as Boiler Conditions Fluctuate
- **Challenges:**
 - Physical Space Limitations for In-Duct Reactor
 - Highly Maldistributed NO_x and NH₃ from Boiler
 - Increased SCR Velocity Due to Restrictions in Catalyst Installation Space
 - Both Require Expert Knowledge in the Design of All of the Technologies being combined
 - Computational and Experimental Fluid Dynamics Modeling Coupled with Flow Distribution Device Optimization
- **Benefits:**
 - Integrated Technologies Provide Lower Capital Cost w/ NO_x Reductions Ranging from 50 – 80%
 - Optimized Reagent Consumption, Lower dP, Reduced Catalyst Replacement, Lower SO₂-SO₃ Oxidation, Lower Minimum Operating Temperatures, Etc.

FUEL TECH I-NO_x COMMERCIAL EXPERIENCE

- Reliant Energy Seward Station (1999)
 - 147 MW T-Fired Unit
 - SNCR + SCR, 55% NO_x Reduction
- AES Greenidge (2005)
 - 115 MW T-Fired
 - Significantly Improved Chemical Utilization w/ASCR
 - Combustion Modifications + SNCR + ASCR, >60% NO_x Reduction
- China Light and Power Castle Peak (2010)
 - Four (4) 680 MW Wall Fired Units
 - Boosted OFA, ASCR, and ULTRA Urea Conversion
 - ASCR Provided 40% NO_x Reduction
- China Steel Corporation, Taiwan (2014)
 - Three (3) 80 MW T-Fired Units
 - Four (4) Sub-Systems Deployed – Combustion Modifications, New SOFA System, SNCR, and ASCR
 - > 78% Total NO_x Reduction