ULTRA™ PROCESS AND ITS EFFECTS ON ESP PERFORMANCE AND OPERATION IMPROVEMENTS

Fuel Tech, Inc.
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Ammonia Injection for Flue Gas Conditioning

- Ammonia injection at ESP inlet
  - Improves ESP performance
  - Particulate agglomeration
    - Reaction with SO$_3$ in the flue gas
    - Formation of ammonium bisulfate
    - Decreased particle re-entrainment
- Sometimes seen as a result of SNCR system
  - Ammonia slip
  - Increased flue gas moisture
James River Power Station
City Utilities of Springfield, Missouri
James River Power Station

- **Unit 1** – 22 MWg
  - Fires PRB coal
  - Four-field ESP
  - Shared stack with Unit 2

- **Installed SNCR system**
  - Simple single-zone urea system
  - Noticeable improvement in ESP performance
  - Decreased opacity at the shared stack

- **Willing to test a safe Urea-based FGC System**
  - Urea is used as reagent feed for ESP treatment
  - Direct control of NH$_3$ concentration at ESP inlet
- On-line urea decomposition for SCR feed

- Gas phase decomposition to NH$_3$ and HNCO
  \[ \text{NH}_2\text{-CO-NH}_2 \rightarrow \text{NH}_3 + \text{HNCO} \]
  \[ \text{HNCO} + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{CO}_2 \]

- Supplies reagent to injection grid for SCR

- ULTRA 5™ utilized for this small NH$_3$ demand
NOxOUT ULTRA® Layout

- Blower
- Urea
- Air
  - Air Heater
  - Air Pre-heater
- Natural Gas
- Fuel Oil
- Electric
- Urea Decomposition Chamber
- NH3 / HNCO to AIG
**HNCO – Isocyanic Acid**

- Urea (NH$_2$-CO-NH$_2$) $\Rightarrow$ NH$_3$ + HNCO
- Role in flue gas conditioning is uncertain
- Can precipitate urea at temperatures < 275 degF
- Will hydrolyze as:
  \[
  \text{HNCO} + \text{H}_2\text{O} \Rightarrow \text{NH}_3 + \text{CO}_2
  \]
- Hydrolysis can be catalyzed
Ultra™ Supplies NH₃ to the ESP

Hot Air

Urea

NH₃ HNCO

Catalyst Reactor

Flue Gas to ESP

Injection Lances

100% NH₃

Ultra™ Supplies NH₃ to the ESP
Ultra Chamber with Catalyst Reactor
Test Results

• Complete conversion of HNCO to NH$_3$

• ESP performance measures:
  – Data from transformer-rectifier (T/R) sets
  – Stack opacity measured at shared stack

• Short duration tests ( < 8 hours )
  – No discernable effect on performance
  – Primarily used to tune injection system

• 24 hour injection test
  – Measureable effect at the T/R Sets
  – Apparent improvement in unit opacity
Spark Rate Improvement

ESP Total Spark Rates

Decreased spark rate in ESP fields #3 and #4
Infers improved capture in previous ESP fields
Secondary Power Improvement

ESP Secondary Power Levels

Increased power in field #2 (and #3) Infers improved performance in field #2
ESP Performance Improvement

- Evident after overnight ammonia injection
- Improved further with water injection
  - SNCR system run in water-only mode
  - ESP performance upset when injection terminated
- Stack opacity improvement
  - Measured opacity uncharacteristically low
  - Summer operation
  - Full load
- Extended testing recommended
Implications for ULTRA

- Hydrolysis catalyst removes temperature limit
  - No re-formation of urea products at low-temperature
  - Decreased insulation on AIG
- Applicable to low-temperature SCR processes
- Reduced energy cost:
  - Less gas, oil or electric power
- No change to ULTRA decomposition
  - Commercial grade urea is acceptable
  - Formaldehyde is not a problem
  - No chemical residuals in reactor
Conclusions

• ULTRA system utilized to generate NH₃ for FGC
  - System converts all HNCO to NH₃

• Successful improvement to ESP performance
  - Decreased sparking
  - Increased secondary power
  - Improved opacity

• Improved ULTRA design for low-temperatures
  - Operating cost decreased
  - Robust operation for any NH₃ supply need
  - Simple decomposition without complications