SNCR Experience on Large Coal-Fired Boilers with Difficult Operating Conditions

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Westar Energy

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Technologies to enable clean efficient energy

JEFFREY ENERGY CENTER

ST. MARYS, KANSAS

- Three (3) eight-corner, tangentially-fired units designed for PRB coal
  - Units 1, 2, and 3 commissioned in 1978, 1980, & 1983, respectively
  - CE subcritical drum boilers – 5,050,000 lb/hr capacity
  - 800 MWg nameplate
- Dispatched as part of the Southwest Power Pool (SPP)

PROJECT OVERVIEW

- 2010 Consent Decree required JEC NOx emissions upgrades
  - Coordinated effort with the Environmental Protection Agency (EPA) and the State of Kansas
    - SCR required to be installed on one unit at a minimum – selected Unit 1
    - Option to build a second SCR or comply with a 0.10 lb/mmbtu site-wide NOx limit
  - Stacked technologies to achieve site-wide NOx limit without an additional SCR
    - Neural network combustion and sootblowing optimizers on all three units
    - Boiler modifications on Units 2 & 3
      - Additional elevation of over-fire air (tertiary over-fire air, TOFAs)
      - New low-NOx burners with horizontally biased combustion
    - SNCRs on Units 2 & 3

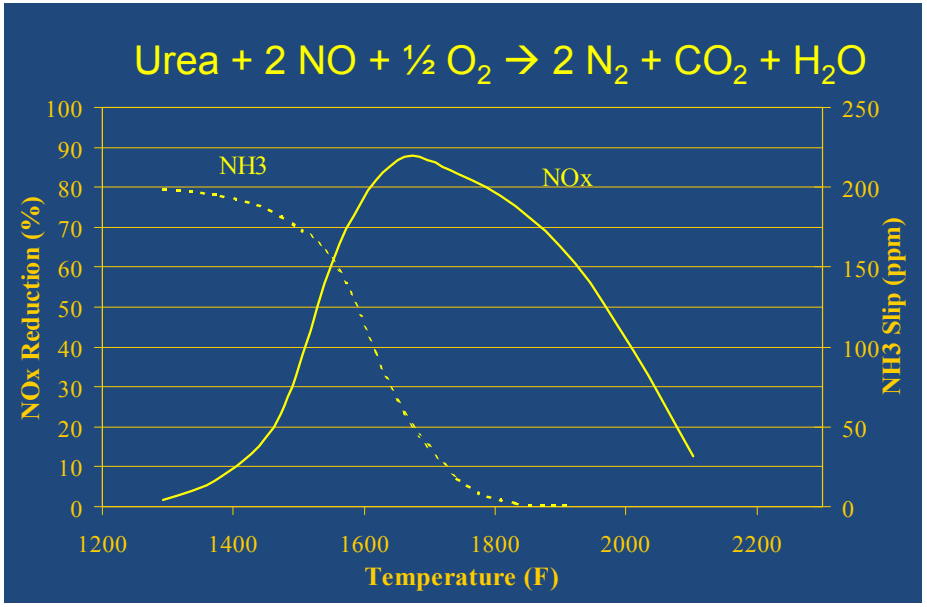
PERFORMANCE OBJECTIVES & SCHEDULE

- Control NOx emissions over large load range (39-100% MCR)
  - Reduce NOx from ~0.17 to <0.125 lb/mmbtu with combustion modifications
  - Reduce NOx from 0.125 to <0.115 lb/mmbtu with SNCRs on Units 2 & 3
  - Reduce NOx from 0.17 to 0.04 lb/mmbtu with SCR on Unit 1
- Ammonia slip <10 ppm for SNCRs
- Maintain CO and other unit performance metrics

Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012	Spring 2014	Fall 2014	Spring 2015
• Enter Consent Decree	• Research NOx reduction options • Conduct combustion tuning	• Decide to proceed with boiler mods and SNCR on J3	• Install SNCR and boiler mods on J3 • Install optimizers on all units	• Decide to proceed with boiler mods and SNCR on J2	• Install SNCR and boiler mods on J2	• SCR tie-in on Unit 1	• In compliance with 0.10 lb/mmbtu site-wide 30-day NOx average

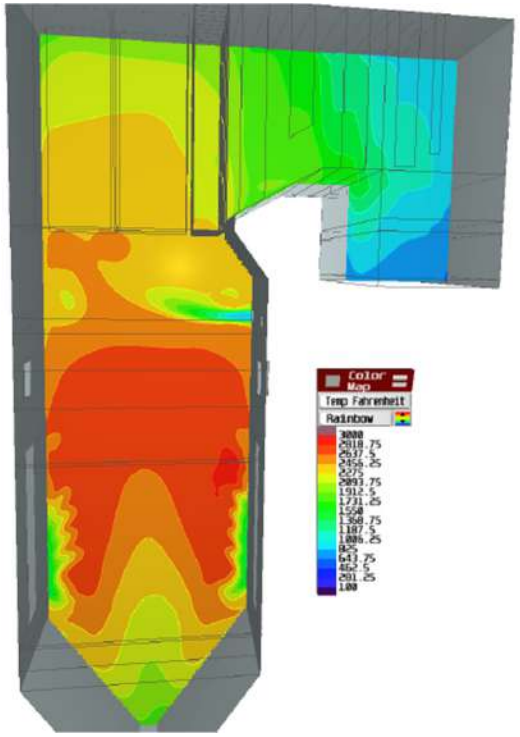
DESIGN CHALLENGES

- Limited time
- High FEGT due to high net heat input per plan area and PRB coal
- Challenging SNCR reagent distribution due to large furnace cross-sectional area and superheat pendants in upper furnace
- Boiler combustion modifications completed simultaneously with SNCR install, resulting in:
  - Very low baseline NOx (~0.125 lb/mmbtu)
  - High CO concentration at the point of urea injection (~1600 ppm)
  - Even higher FEGT
  - Need for modeling of both the boiler modifications and the SNCR

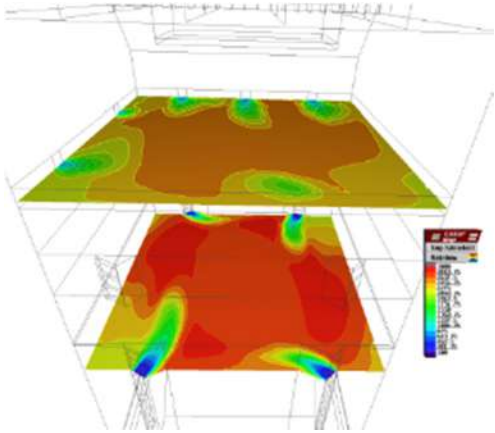


HIGH UPPER FURNACE TEMPERATURE

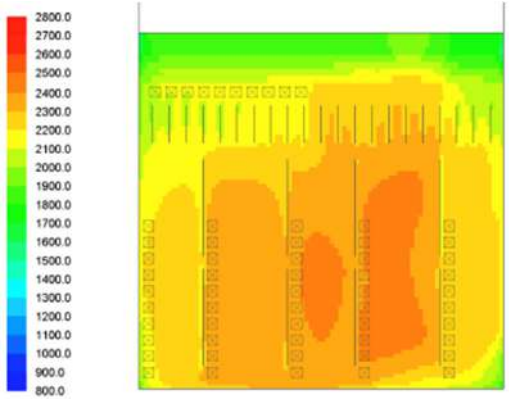
FULL LOAD - CFD MODEL



Furnace Centerline Temperature



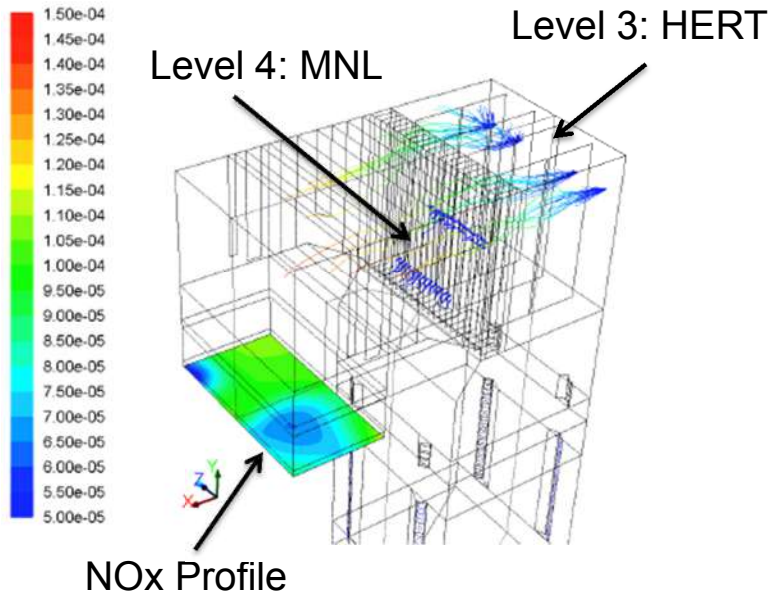
TOFA and Lower Windbox Elevations

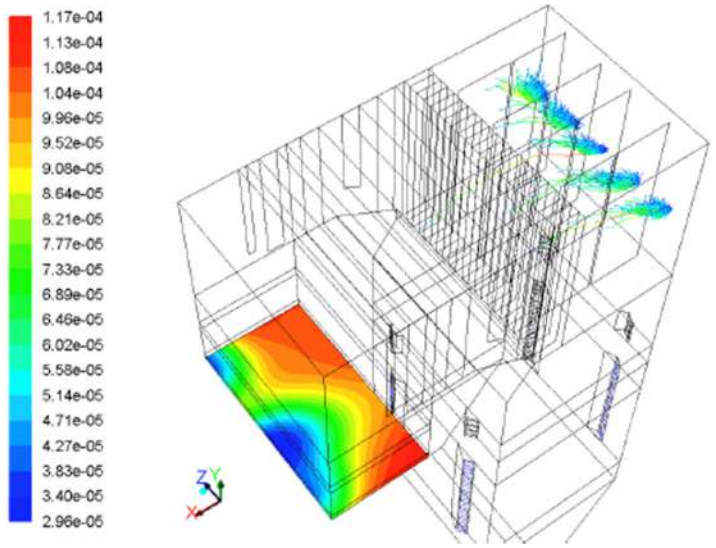


Superheater Platens Elevation 1464’

DROPLET TRAJECTORIES AND NOX PROFILE

INJECTION MODELING



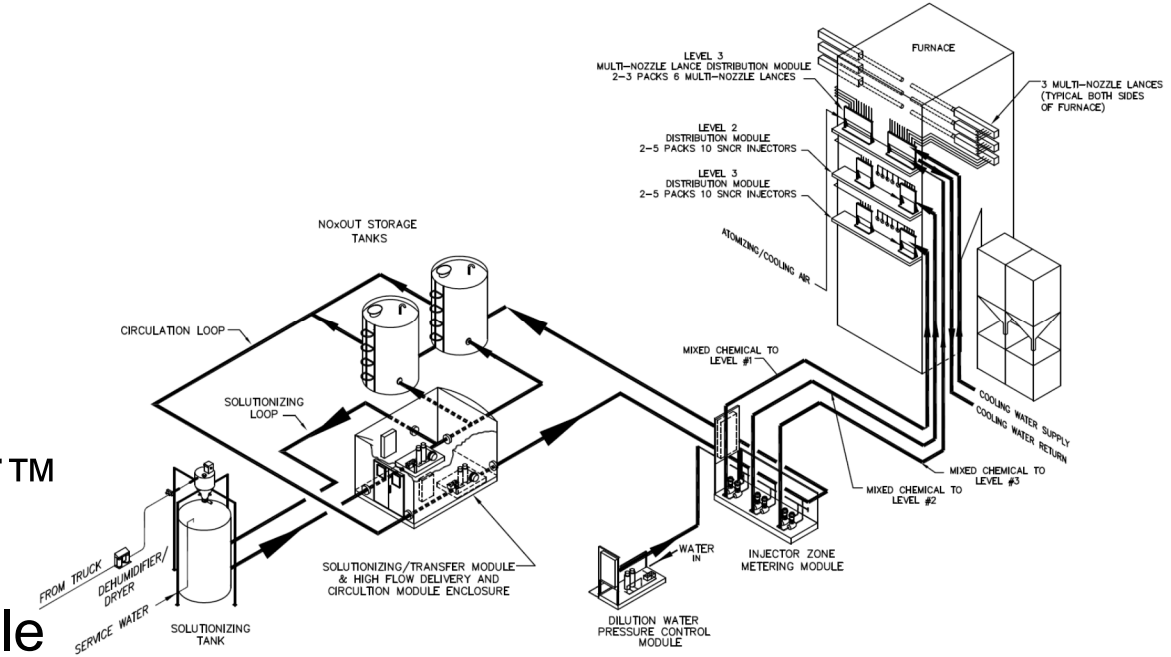


Full Load:
Wall Injectors and Multiple Nozzle Lances (MNLs)

65% Load: Wall Injectors Only

SYSTEM SUMMARY

- Fuel Tech's injection strategy
  - Three (3) zones of wall injectors
  - One (1) zone of MNLs
- Zones 1 and 2 consist of NOxOUT® wall injectors
- Zone 3 consists of HERT™ wall injectors
- Zone 4 consists of multiple nozzle lances (MNLs)



SOLUTIONIZING SYSTEM

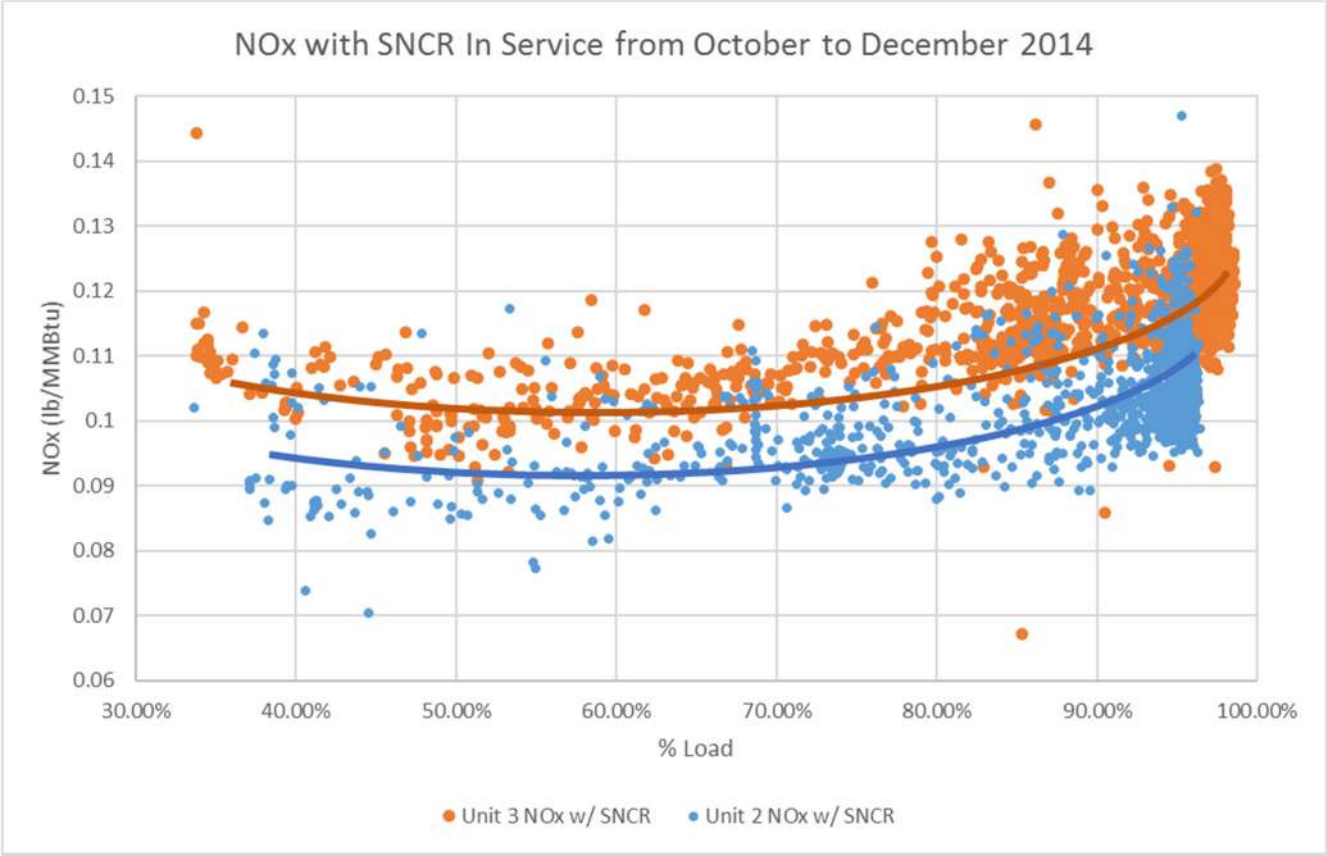
- JEC has ability to receive both dry and aqueous urea
- Solutionizing system scope of supply
  - 3,100 ft^3 dry urea silo
  - 10,000 gallon solutionizing tank w/ mixer, heaters, and load cells
  - Solutionizing module with density meter and strainer
  - Dehumidification unit
  - Redundancy in heating and mixing
  - Remote I/O panels controlled by DCS
  - Treated water system
- Significant reagent cost savings with dry urea solutionizing system vs. 50% aqueous urea delivery

PERFORMANCE TEST RESULTS

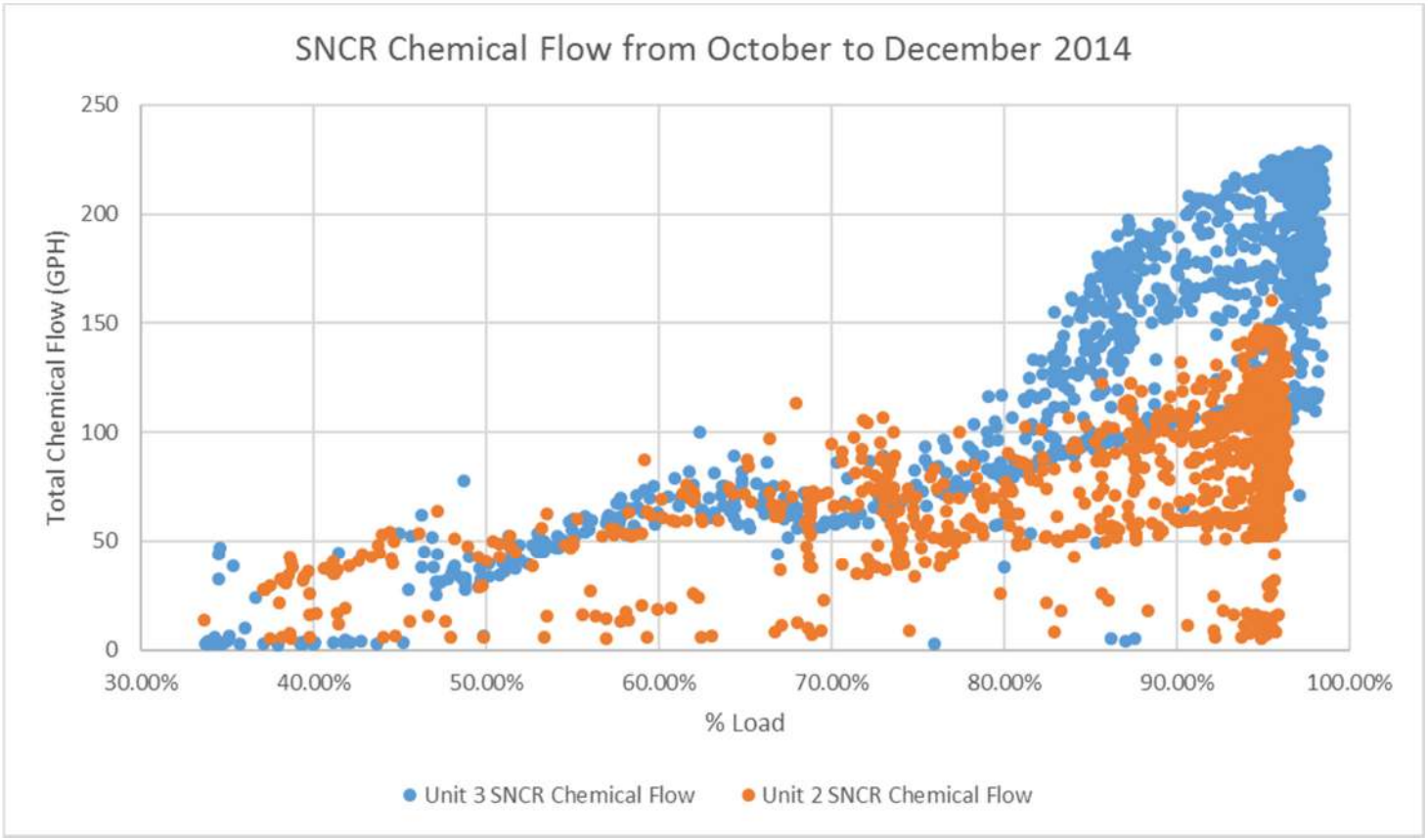
Unit	Unit 3		Unit 2	
Load Condition	Full Load	Mid Load	Full Load	Mid Load
NOx after Combustion Mods (lb/mmbtu)	0.125	0.108	0.120	0.104
NOx with SNCR (lb/mmbtu)	0.112	0.101	0.107	0.098
NH3 slip (ppm)	8.8	6.9	7.8	5.8

- Met or exceeded performance objectives
- Overall NOx performance on Unit 2 with SNCR in service is approximately 5%-7% better than Unit 3
  - Benefits include flexibility in compliance with site-wide NOx limit and annual urea cost savings

JEC 2 AND 3 HOURLY NO_X



JEC 2 AND 3 SNCR CHEMICAL FLOW



BUMPS ALONG THE WAY & LESSONS LEARNED

- Short timeline resulted in oversights and rework.
  - Freeze protection
  - Water pretreatment system
  - Air compressors
- Simultaneous install of combustion modifications and SNCR produced challenges in predicting performance and establishing guarantees.
- Coordination among all involved parties was key.
- Learned from Unit 3 and made the most of the opportunity to improve on Unit 2.

PROJECT SUMMARY

- Jeffrey Energy Center is able to comply with the Consent Decree
  - Flexible emission compliance plan
  - Significant capital savings
  - Reduced consumption of urea from lower baseline NOx
  - Operating cost savings from SNCR operating at low loads
- Units control NOx emissions over wide load range offering operating flexibility
- Flexibility with reagent supply options
- SNCRs have been in normal operation since fall 2014
  - NOx remains well controlled

Questions?

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