Reinhold Environmental Ltd.

2008 NOx-Combustion Round Table & Expo Presentation

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Waterwall Wastage From Low NOx Systems

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NOx-Combustion Round Table

February 5th, 2008

Waterwall Corrosion from Low NOx Systems

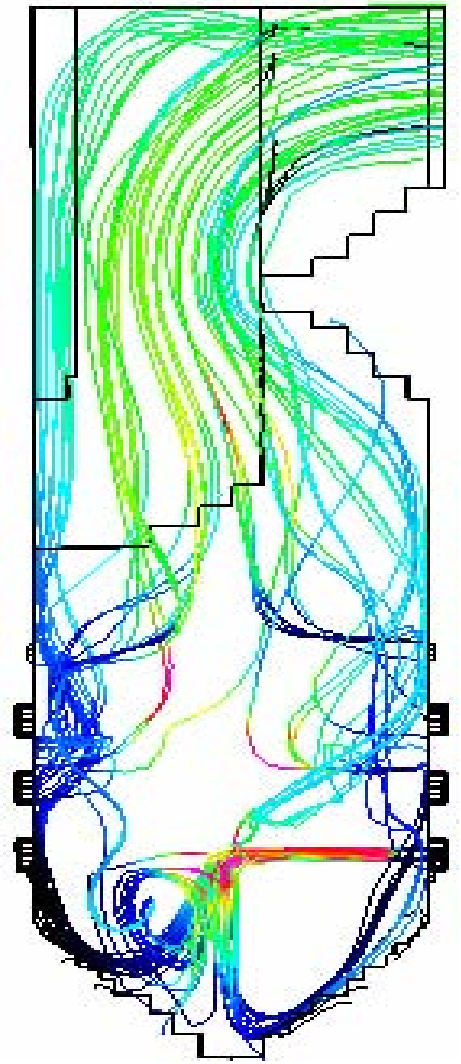
- **General topics:**
  - **Why it occurs, where it occurs, when it occurs**
  - **Prevention methods**
  - **Group Discussion**

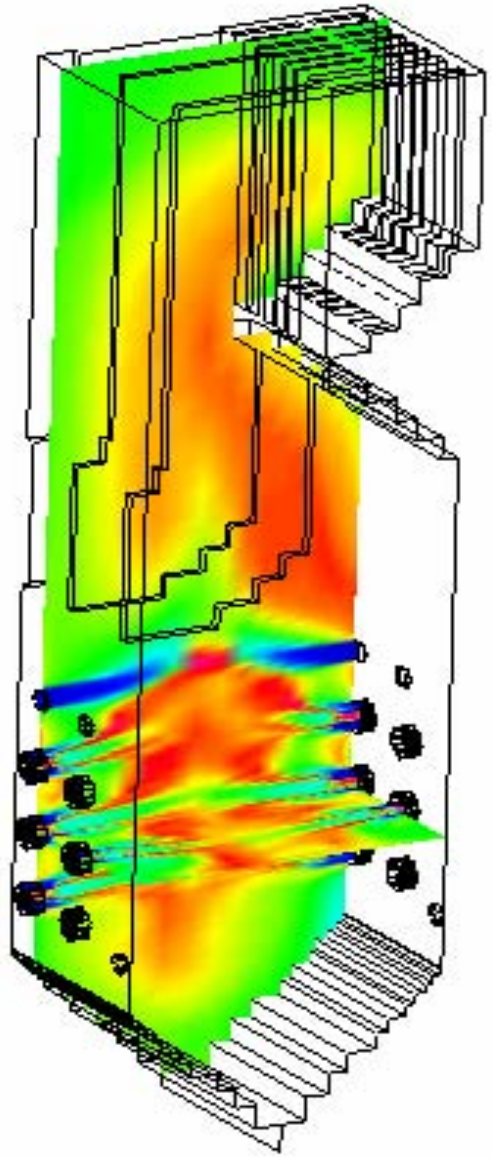
Combustion Systems Overview

Coal Particle and Gas Species

Increased Staging:

- **Lowers NOx** 
- **Increases reducing S, Cl, ash and gaseous species impinging on waterwalls** 





Fireside Corrosion – Why it Occurs

- ***Problem occurs when coals high in S and/ or Cl are utilized with OFA***
  - **Primary Culprit is deposition of reduced ash species**
    - **Pyrites (FeS_2) and other Sulfur Species in coal particles**
    - **Results in FeS deposition on furnace walls**
    - **Formation of alkali chlorides on furnace walls**
  - **Secondary culprits are reducing gases (H_2S, HCl)**

For 100% PRB, not an issue, although blends of (high alkali) PRBs with high Cl coals, containing pyrites, is problematic

Original Design Conditions (Pre-low NOx)

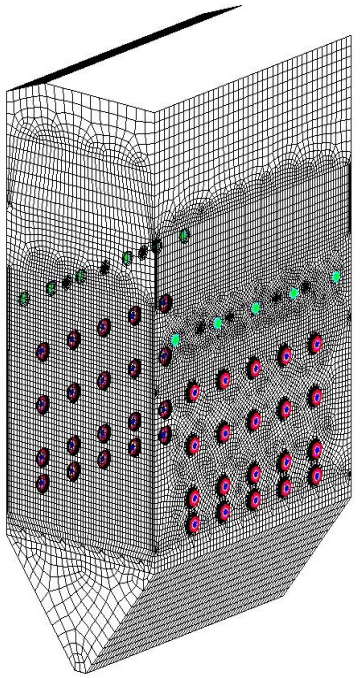
- **Oxidizing Environment**
  - **Pyrite in coal oxidizes to FeO before impinging on wall, Protective Fe_30_4 scale forms**
  - **Minimum formation / deposition of alkali chlorides**
  - **Shorter flames (no impingement)**
- **In most instances:**
  - **Wastage rates are minimal**
  - **Boiler tubes should last >20 years**

Staged Combustion (low NOx operation)

- **Reducing Environment**
  - **Pyrite in coal impinging on wall as FeS**
  - **Formation / deposition of alkali chlorides occurs**
  - **Longer flames (impingement in some instances)**

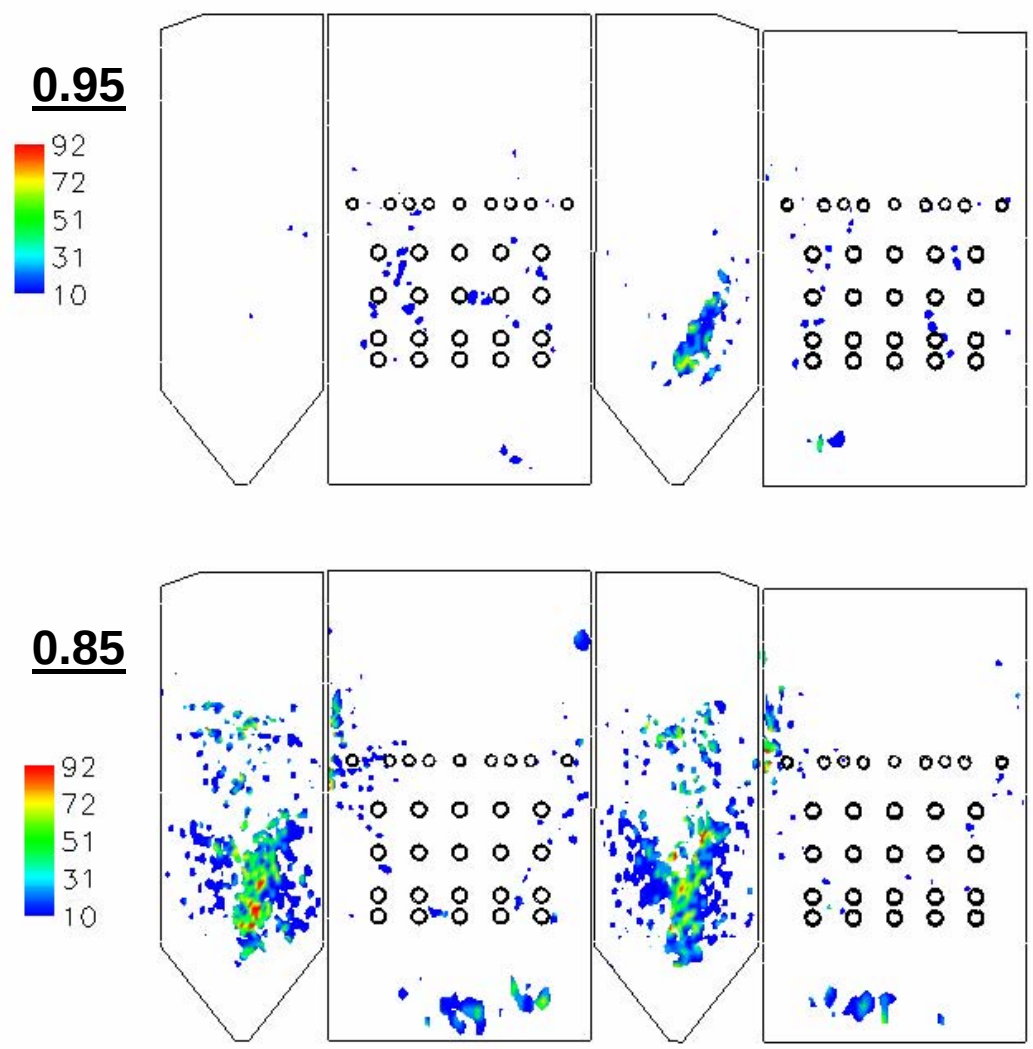
- **In many instances:**
  - **Wastage rates are accelerated**
  - **Forced outages may occur due to tube failures**

Boiler Locations where Wastage will Most Likely be Noticed First



- **Tangentially fired Boilers**
  - Front and rear walls
  - Between upper burner rows and OFA locations
- **Wall fired Boilers**
  - Side walls
  - Between upper burner rows and OFA locations
- **For all Boilers**
  - In cases of severe corrosion wastage may occur on all 4 walls
  - Once wastage has been found in the above locations, wastage may spread to surrounding areas

Wastage Rate Maps from CFD Model (mpy)



- Impact of lower furnace degree of staging
- Note accentuated areas on sidewalls for this opposide fired unit
- Lower staging translates to higher probability of corrosive species deposition

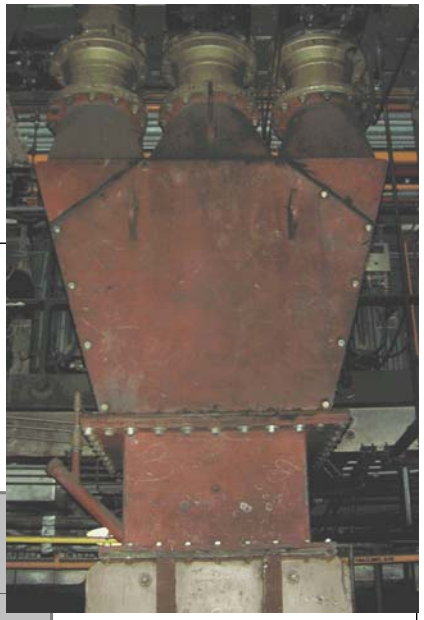
Fireside Corrosion Prevention

- **Fuel Switching**
  - Select coals with low pyrite and Cl content
  - Controlling blend ratios (e.g., Cl w/alkali)
- **Combustion Modifications**
  - Reduced staging
  - Improved mill performance
  - Improved coal / air distribution
  - Burner tuning
- **Protective Coatings**
  - Thermal spray coatings
  - Weld overlays

Possible Combustion Based Solutions
Improved Particle Size Distribution

- Lower deposition of reducing particles (lower particle momentum)
- Less staging needed (enhanced mixing in near burner zone)
- Shorter flame length (enhanced mixing in near burner zone)

Typical Coal Distribution from a 3-way Splitter



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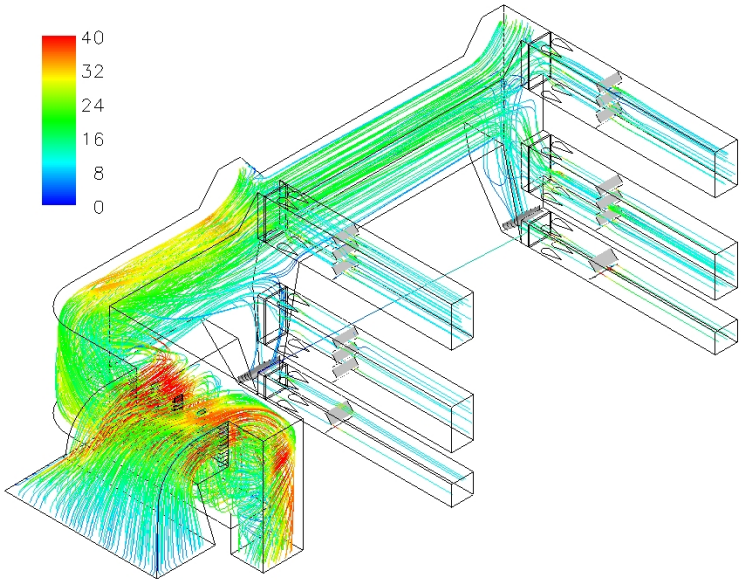
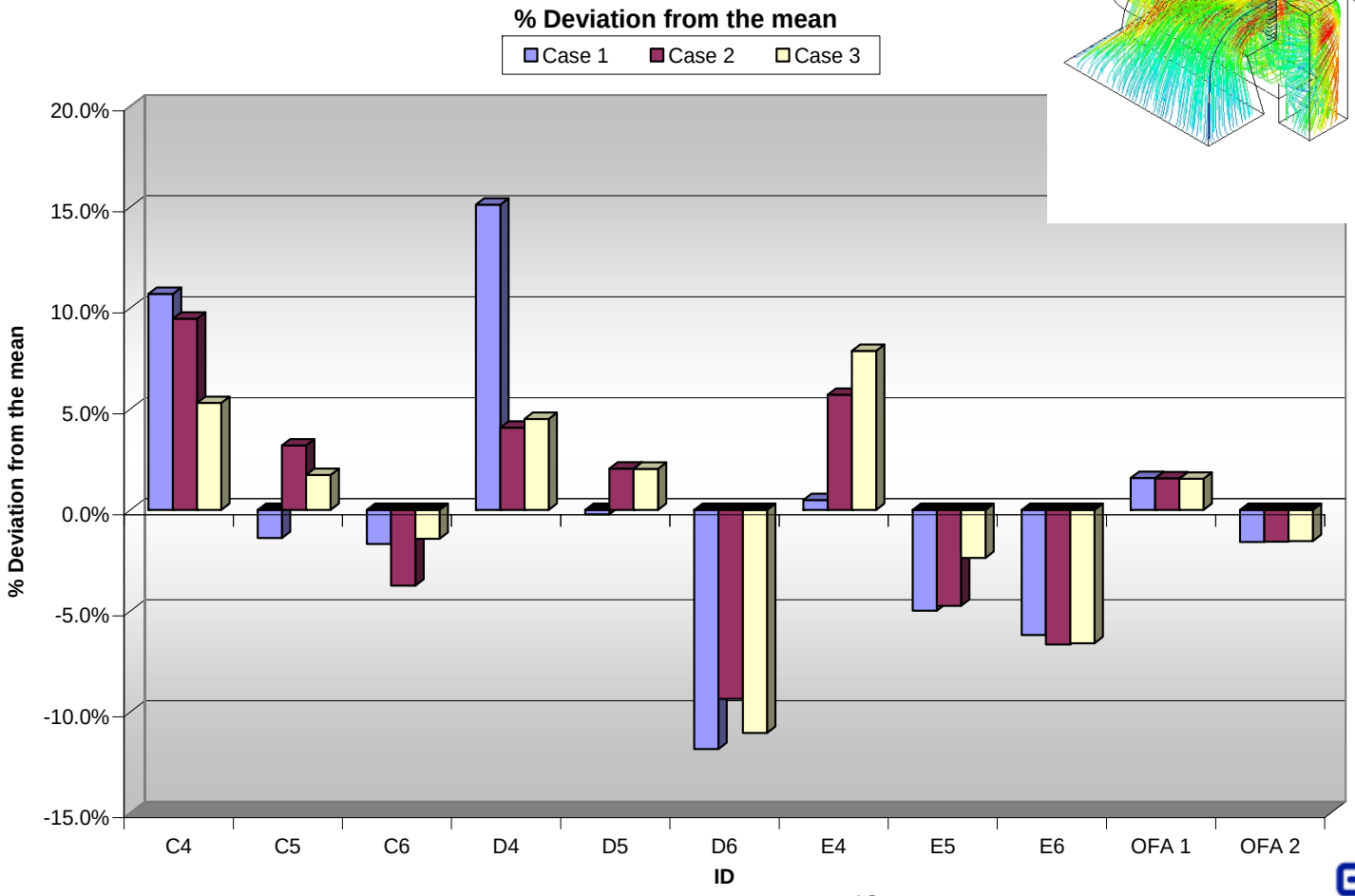
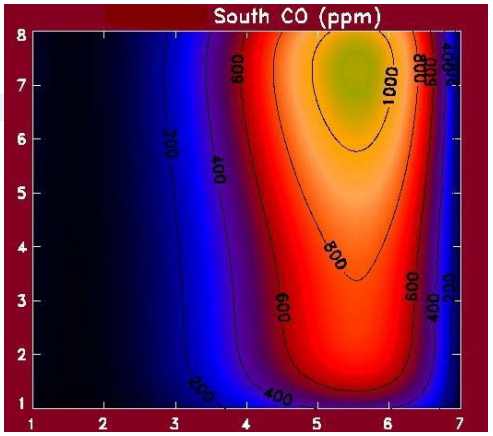
Impact of Air Distribution

Burner-to-burner air mal-distribution

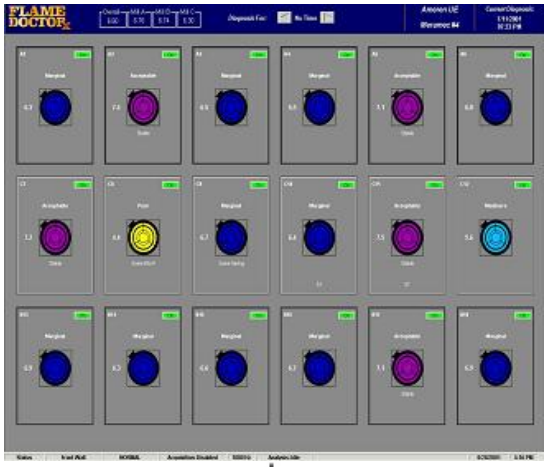




Possible Combustion Based Solutions
Burner Tuning



- **How it Helps:**
  - **Shorter flames, elimination of impingement**
  - **Lessens staging for a given NOx level**
  - **Lower particle deposition**
- **Advanced system tuning tools (covered in other W/S sessions):**
  - **Combustion diagnostics (Flame Doctor)**
  - **Tunable diode lasers**
  - **Commercial optimizers**
  - **CFD modeling**



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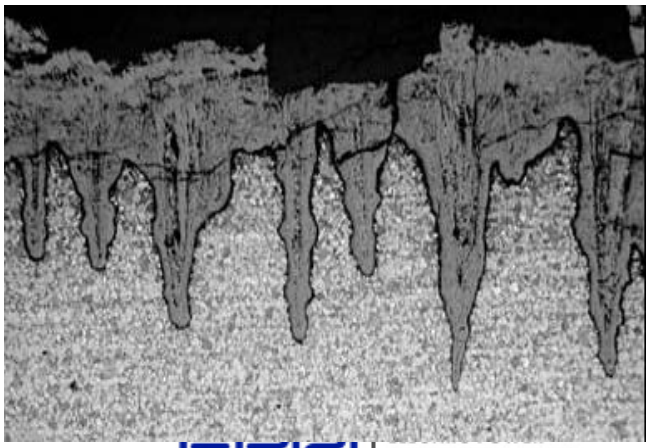
Weld Overlays

Field Experience

- **Weld overlays now preferred method to reduce waterwall wastage. Large number of installations.**
- **Alloys 622 and 309 now most widely used weld overlays.**
- **Major failure mechanism of weld overlays is *circumferential cracking*, but cracks usually detected prior to tube failure. Cracks detectable by sand blasting plus visual inspection.**

Circumferential Cracking of Weld Overlays

- Increases with temperature
- Highly dependent on deposit corrosivity (chlorides, sulfides)
- Highly dependent on weld overlay type (esp. @ lower temps)
- Results impacted by surface roughness (e.g., application method) and surface defects



Conclusions

- Low NOx operation, especially staged combustion results in reducing conditions in the lower furnace.
- Reducing conditions will cause FeS and chloride deposition on the walls, mainly in and around flame impingement areas.
- FeS deposition is dependent on the level of staging, amount of Pyrite and its particle size distribution.
- Weld overlays provide the best protection against wastage, but *circumferential cracking* may be an issue.
- Thermal spray coatings may be adequate and cost effective for areas with low wastage rates. Chloride deposition is dependent on chlorine and alkali content

Waterwall Wastage
For Discussion

Although deep staging for low NOx often leads to corrosion and cracking issues, associated costs are often not considered in NOx compliance strategies.

Is this the case at your organization and if so, what can be done to improve awareness of this relationship? Has consideration been given to implementation of alt. strategies (e.g., SNCR).