Reinhold Environmental Ltd.

2010 NOx-Combustion Round Table & Expo Presentation

February 8 & 9, 2010 Chattanooga, TN

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Boiler Control Challenges

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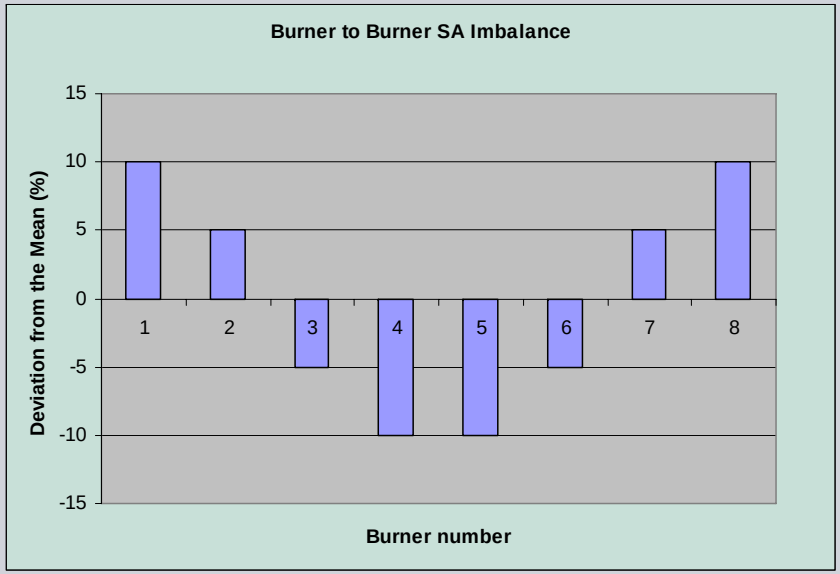
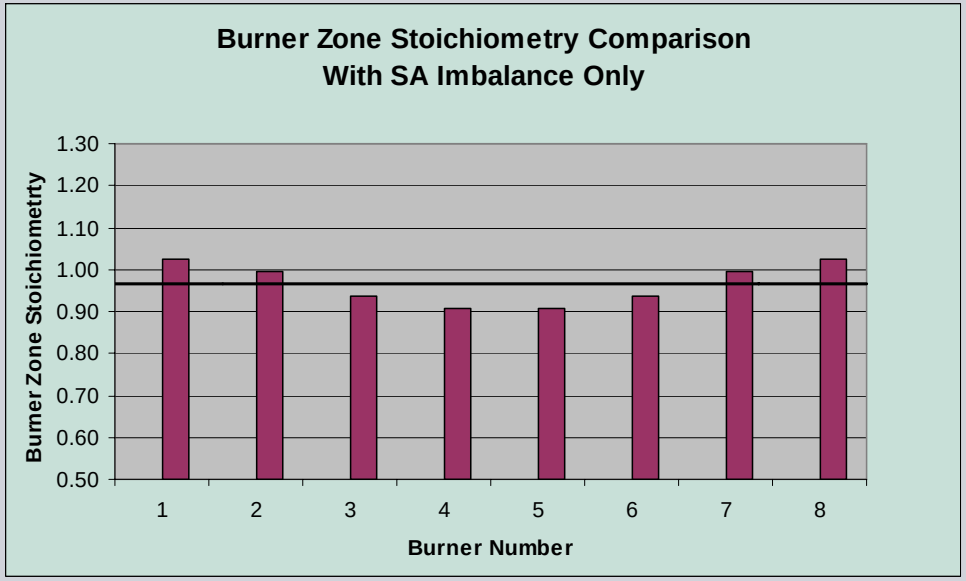
SECONDARY AIR FLOW

Poor Air Flow Distribution in the Burner Windboxes Effect On NO_x





The chart on the left shows a secondary air flow imbalance with more air flow to the outboard burners, typical of a side fed windbox.

The chart on the right shows the variation in the stoichiometric ratio between burners, assuming an equal coal flow to all burners.

When combined with coal flow imbalances, the effect is much greater.

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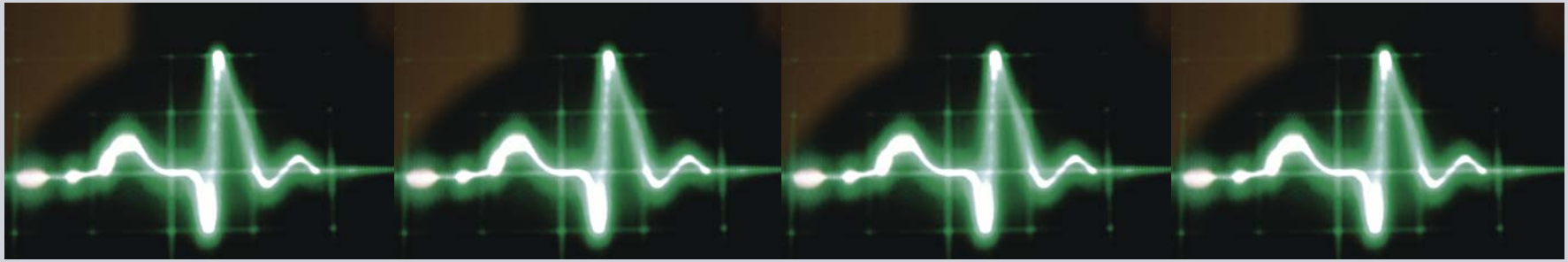
What do a heartbeat and secondary air flow control have in common?



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NOTHING

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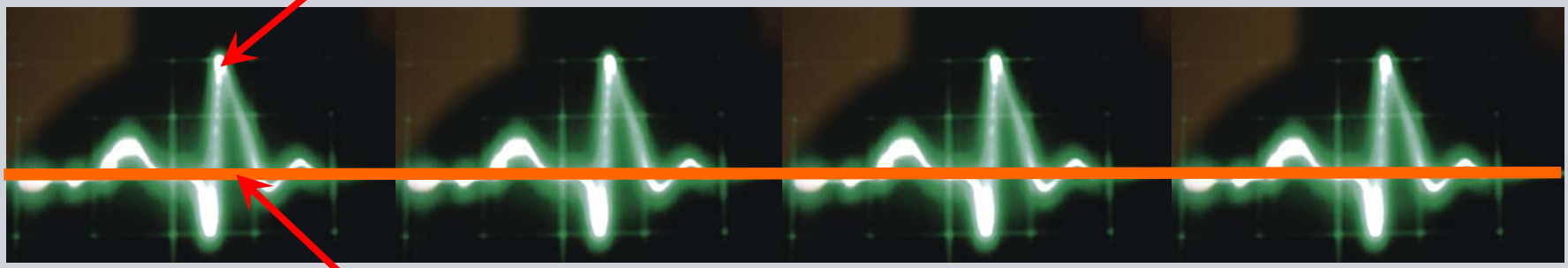
Good heartbeat

Bad secondary air flow control



Bad heartbeat

Good secondary air flow control

Random Plugged Air Heater Baskets
Effect on NO_x

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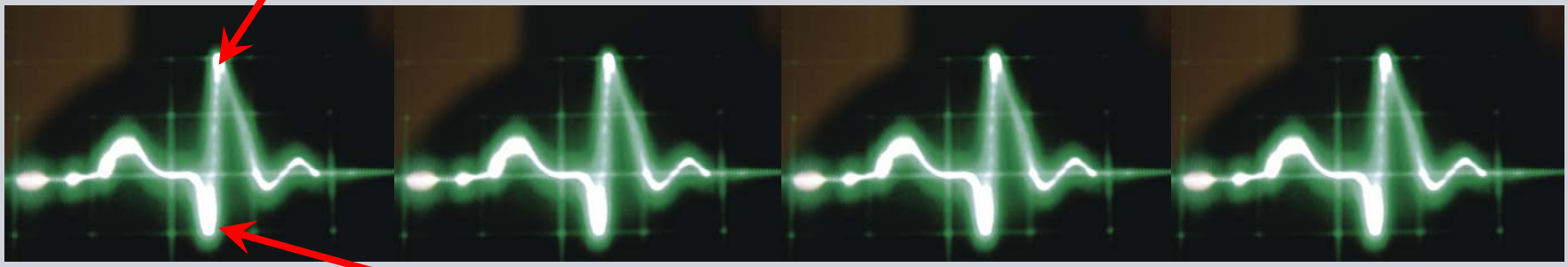
<u>High secondary air flow:</u>
Higher NO_x levels
Lower CO levels
Lower UBC levels
Lower potential corrosion rates
Lower potential slagging rates



<u>Low secondary air flow:</u>
Lower NO_x levels
Higher CO levels
Higher UBC levels
Higher potential corrosion rates
Higher potential slagging rates

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COAL FLOW BALANCING

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Coal Flow Balance

Typical coal flow balance between coal pipes on each mill are ± 10%.

In some cases one mill may be out by a bit more than this.

It is also relatively important to have all mills operating at similar coal flow levels to each other.

Biasing of the coal flow between mills can raise or lower the overall NOx in the furnace (depending on which mills have more or less coal flow). In addition, it is then also important to bias the secondary air flow to maintain the proper stoichiometry at all of the burners. This condition also limits the operational flexibility of the unit.

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Coal Flow Balance Optimization

There are a number of things that affect the coal flow balance between coal pipes on a mill. Coal flow imbalances are somewhat influenced by imbalanced primary air flows (but not always). The following are potential sources of coal flow imbalances in the coal pipes:

- Length and geometry (bends) of the individual coal pipes
- Coal pipe velocities
- Condition of any existing coal flow devices (orifices, etc.)
- Air flow maldistribution in the mills
- Coal Roping at mill outlets and in coal pipes

Coal Flow Imbalance Effect On NO_x

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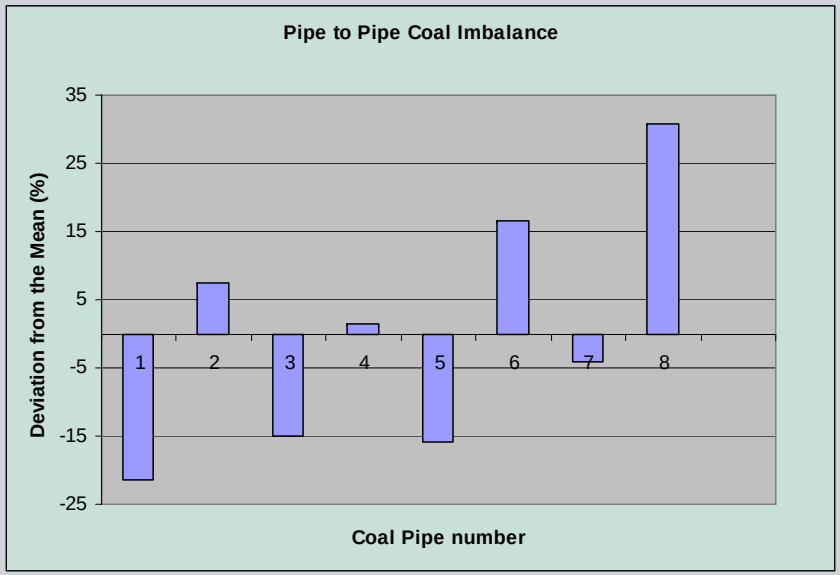

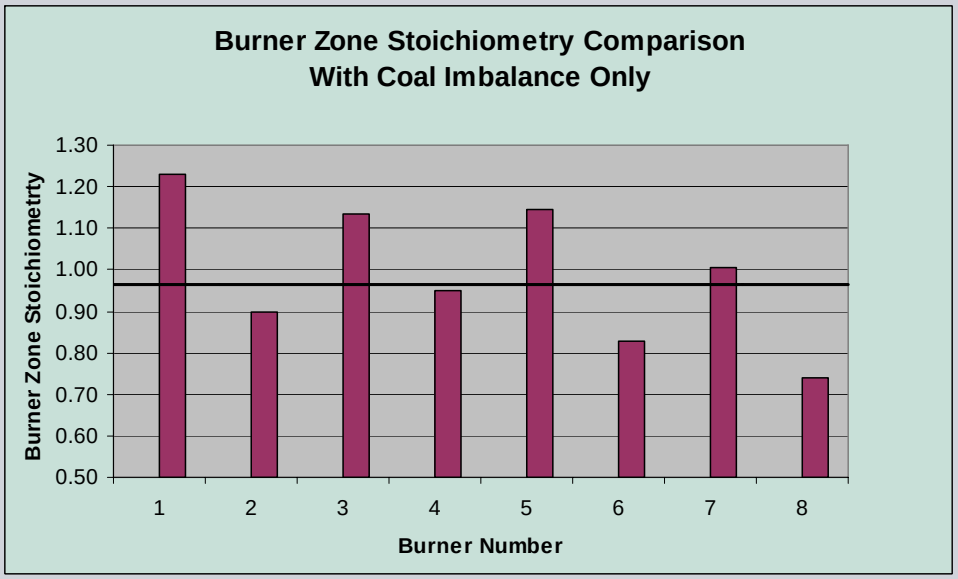

The chart on the left shows a test case burner to burner coal flow imbalance.

The chart on the right shows the variation in the stoichiometric ratio between burners, asssuming an equal secondary air flow to all burners.

When combined with secondary air flow imbalances, the effect is much greater.

Coal and Secondary Air Flow Imbalance Effect On NO_x

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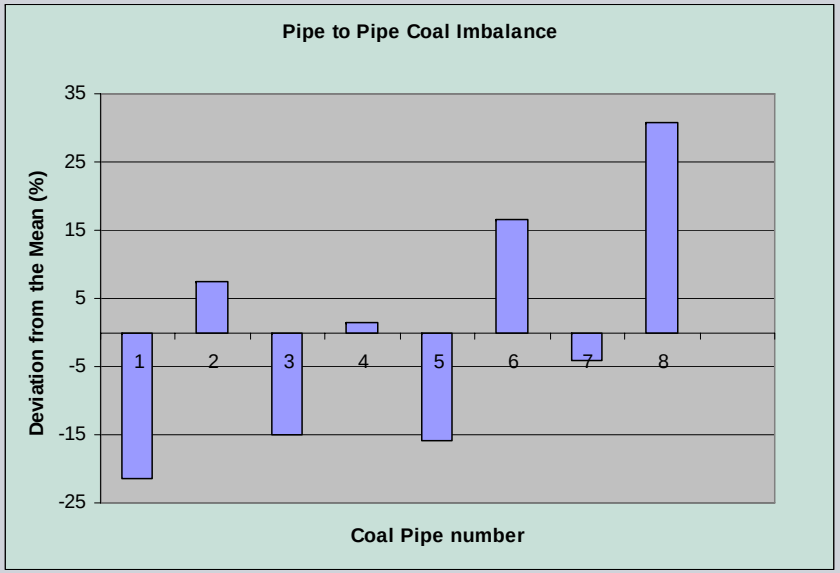

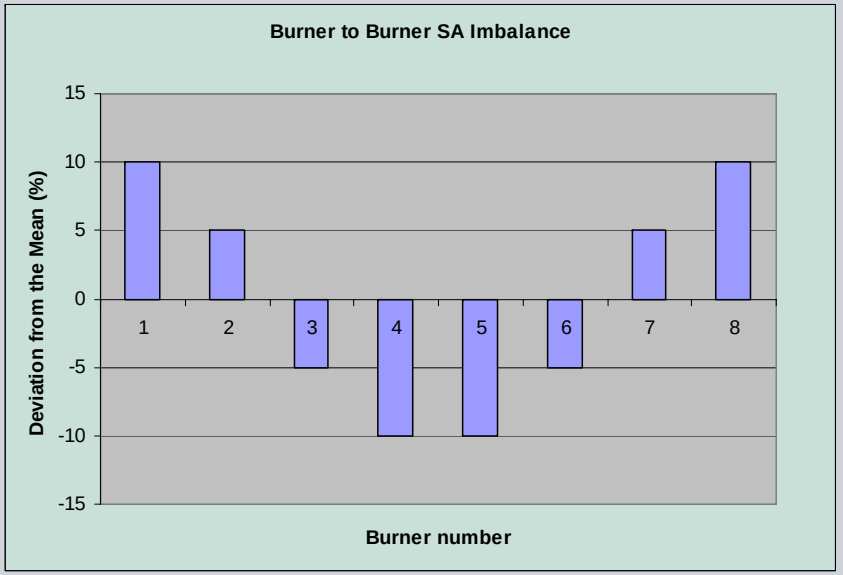

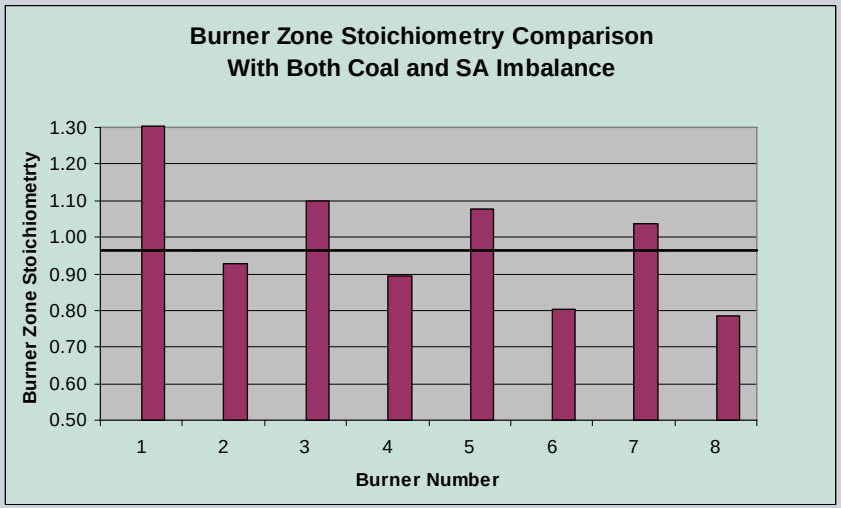

The charts above show burner to burner coal and secondary air flow imbalance.

The chart on the left shows the variation in the stoichiometric ratio between burners, based on the above imbalances.

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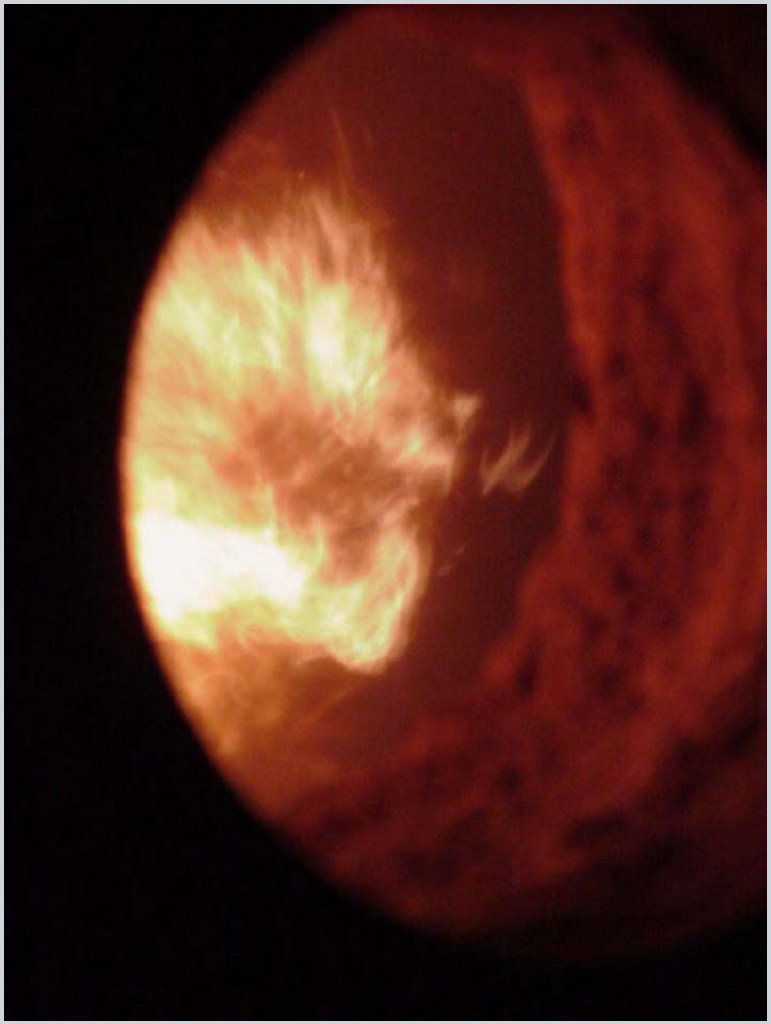
Burner Flame Shape Generated From Poor Burner Nozzle Fuel Distribution



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Burner Flame Shape Generated With Good Burner Nozzle Fuel Distribution

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PRIMARY AIR FLOW

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Primary Air Flow Issues

There are a number of issues that can affect the ability to operate the combustion system at the lowest possible NO_x levels. Some of these issues are as follows:

- Poor air flow distribution in the coal pipes
- Poor air flow distribution through the mill
- Incorrect air flow indication

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Effect of Incorrect Primary Air Flow

All burners are nothing more than flow device “orifices”. As such, they operate best at the design air flow and associated pressure drop.

Pressure drop is known to vary as the square of the velocity.

To illustrate how increased primary air flow affects the pressure drop, the following two examples are offered:

Primary air flow 10% high
Pressure drop = $(1.10)^2 = 1.21$

Primary air flow 15% high
Pressure drop = $(1.15)^2 = 1.32$

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Primary Air Flow

Identified sources of primary air flow measurement are:

- The measuring devices have not been calibrated.
- The measurement devices are in a poor location for measurement
- The flow measurement is not temperature compensated.
- The primary air flow is biased in the control system