

REINHOLD ENVIRONMENTAL Ltd.



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Boiler Combustion / Boiler Tuning to Improve Emissions Control

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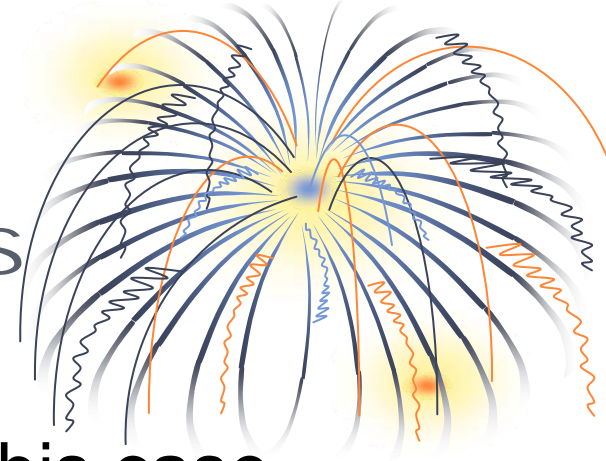


Outline



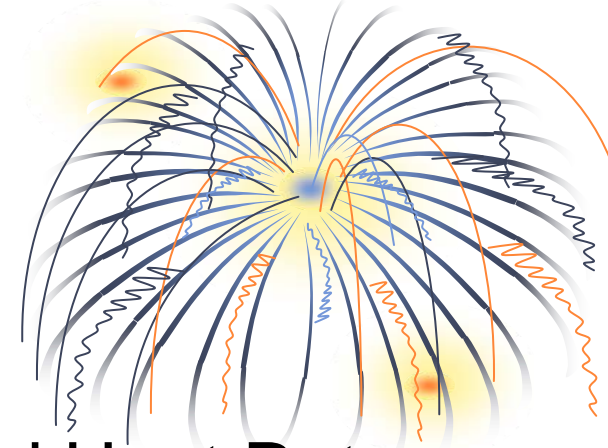
- Combustion Fundamentals
- NOx Formation
- Balancing NOx vs. Other Operational Goals
- Typical T-Fired Boiler Features
- Boiler Air Management and Guidelines
- Additional Strategies

Boiler Firing – The 3 Basics



- **Fuel:** Combustible material – in this case, Coal
- **Oxygen:** In sufficient quantity - from air delivered by FD Fans
- **Heat:** Ignition source – from the initial fuel oil fire

Boiler Firing – Pre NO_x



The 3 T's for Good Combustion and Heat Rate:

- **Time** for mixing and to complete the combustion
- **Temperature** above a minimum ignition temperature
- **Turbulence** for good mixing and good heat distribution





NO_x Formation



- NO_x – the name given for the various oxides of Nitrogen
- Nitrogen in air – 70%
- Oxygen in air – 21%
- Oxygen & Nitrogen mixing in high temperatures form NO_x

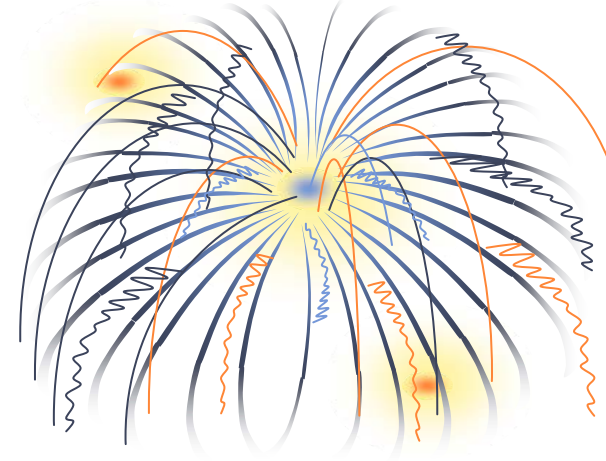
- The rate of Thermal NO_x formation is:
 - exponentially dependent on **temperature**
 - Proportional to the square root of **oxygen** concentration



NO_x, cont.



- Nitrogen in Fuel – Small %
- Fuel NO_x - basically formed with the oxidation of the organically bound **nitrogen in the fuel**.

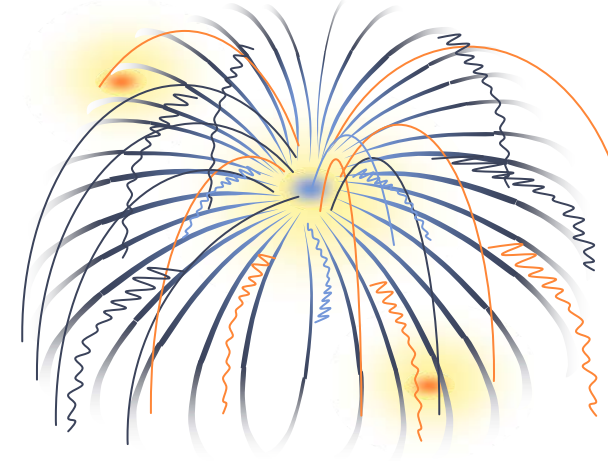


Boiler NO_x Reduction

To reduce Boiler NO_x formation:

- Reduce the amount of **oxygen** available to the fuel
- Reduce the combustion **temperature** by staging the combustion air
- Set up boiler to allow more **time** to complete the combustion process
- Set up boiler to produce a “lazy” fire which reduces **turbulence**

Boiler NOx Reduction – The Balancing Act



Goal is to:

- Minimize 1) NOx, 2) CO and 3) LOI

While:

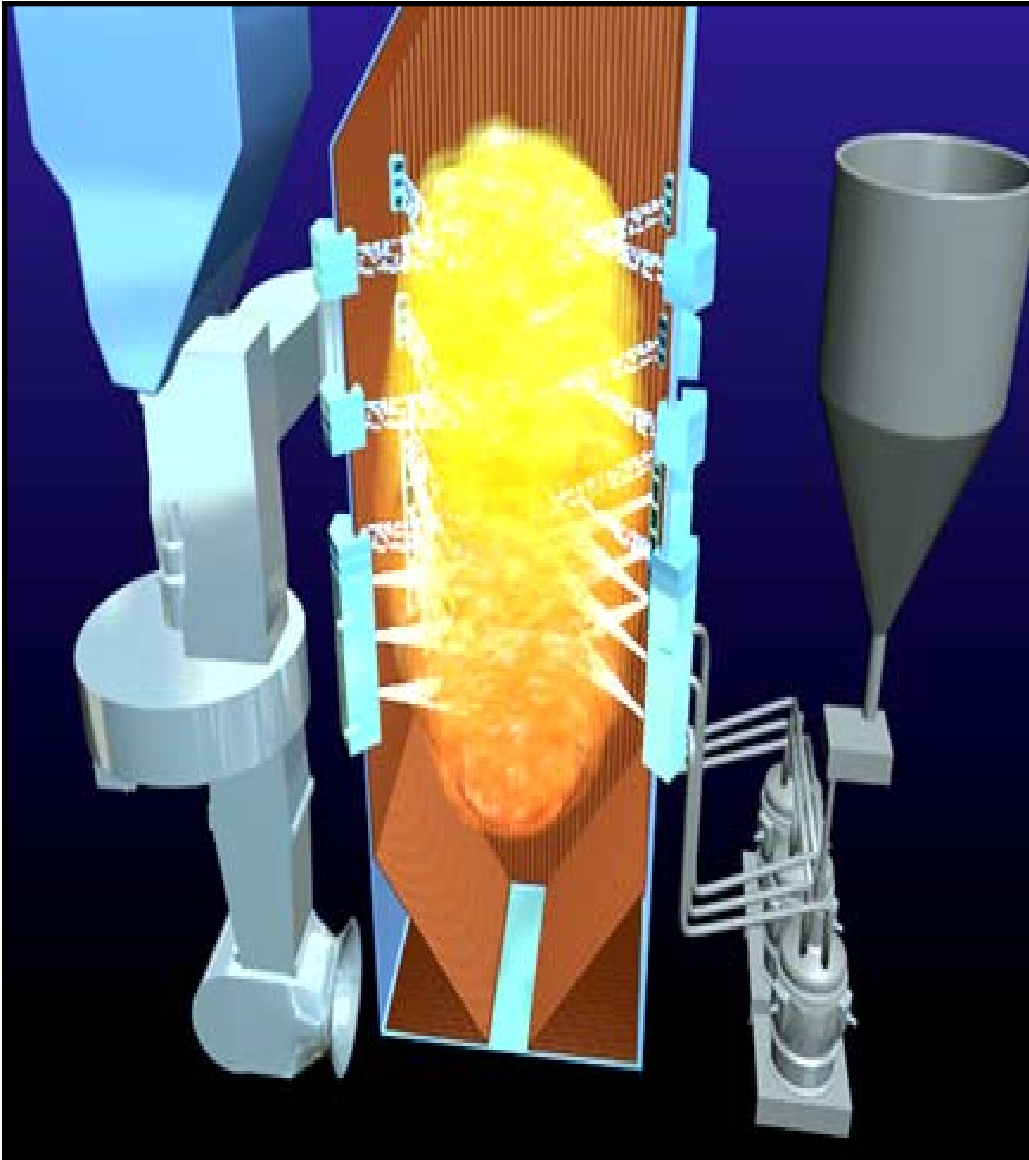
- Maximize 1) Steam Temperatures and 2) Boiler Efficiency
- Eliminate – or at least minimize - furnace reducing atmosphere

How to do this?

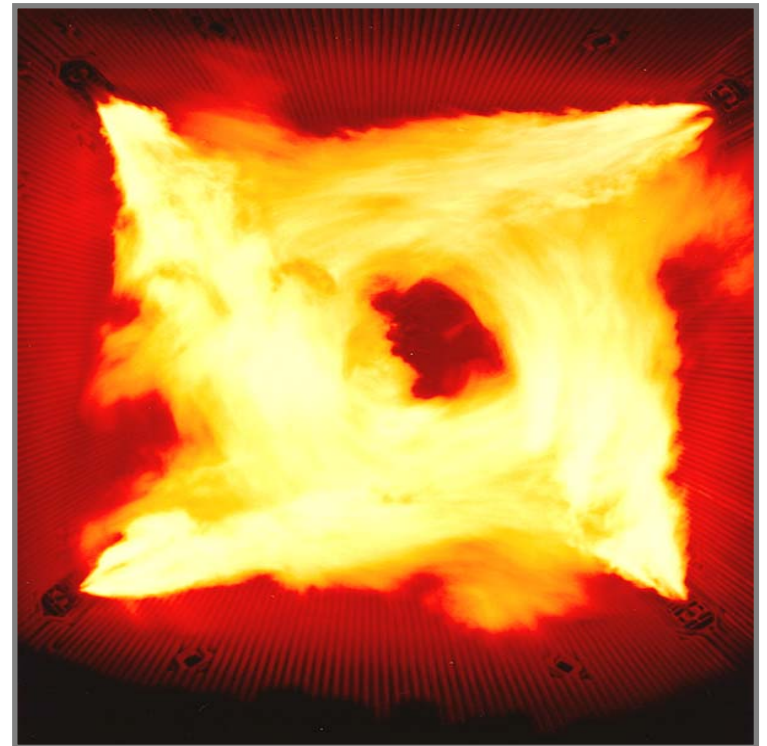
- Put Fuel in low, Air in high
- Optimize the **Total** amount of **Air**
- Optimize Secondary **Air Distribution**



Tangential Fired (T-Fired) System



**Flame Pattern of
Tangential Firing
System – Acts
Like One Big
Burner**

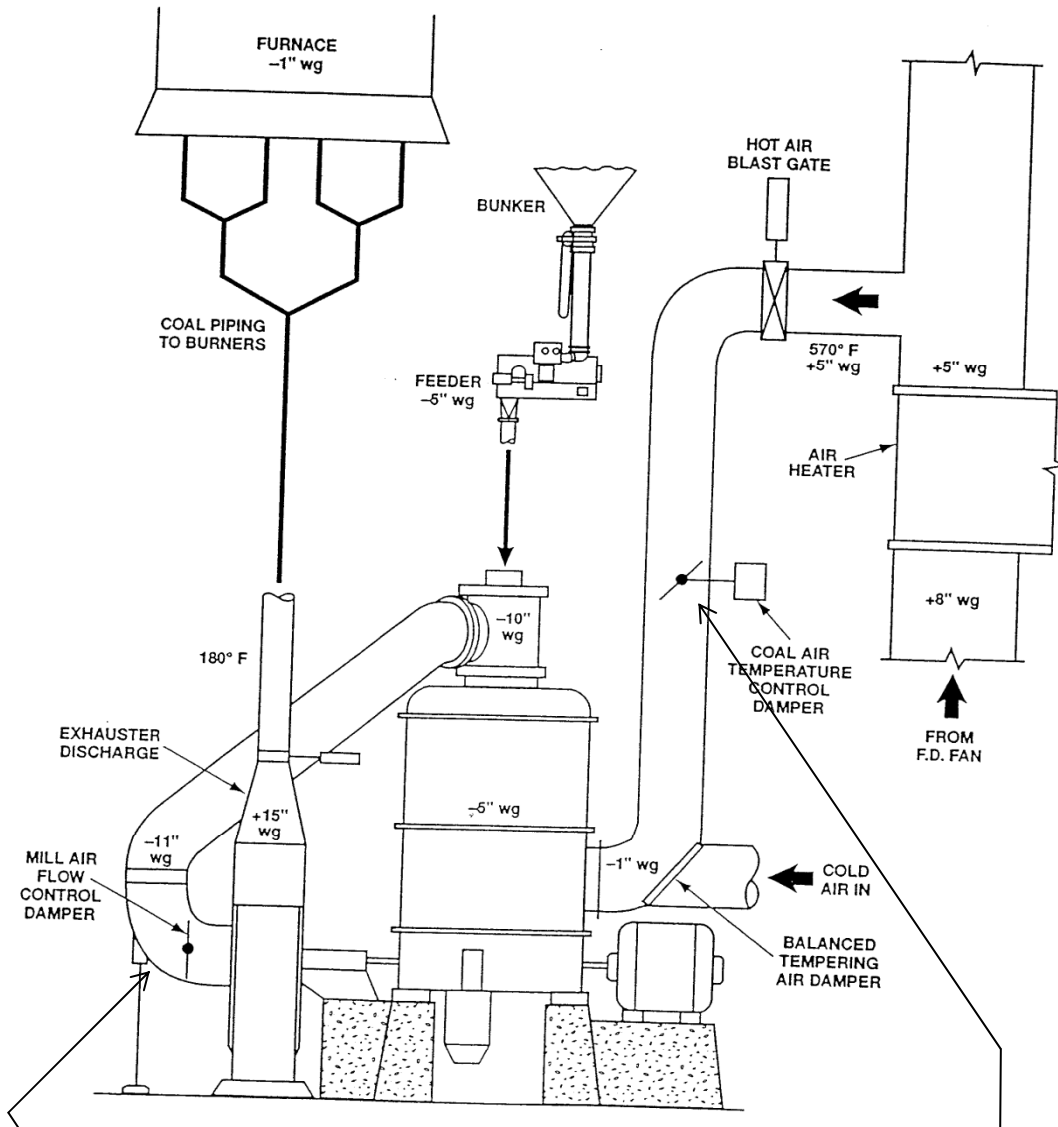


Pulverizer Mill

2 Key Purposes:

1) Dry Incoming Coal – with Primary Air

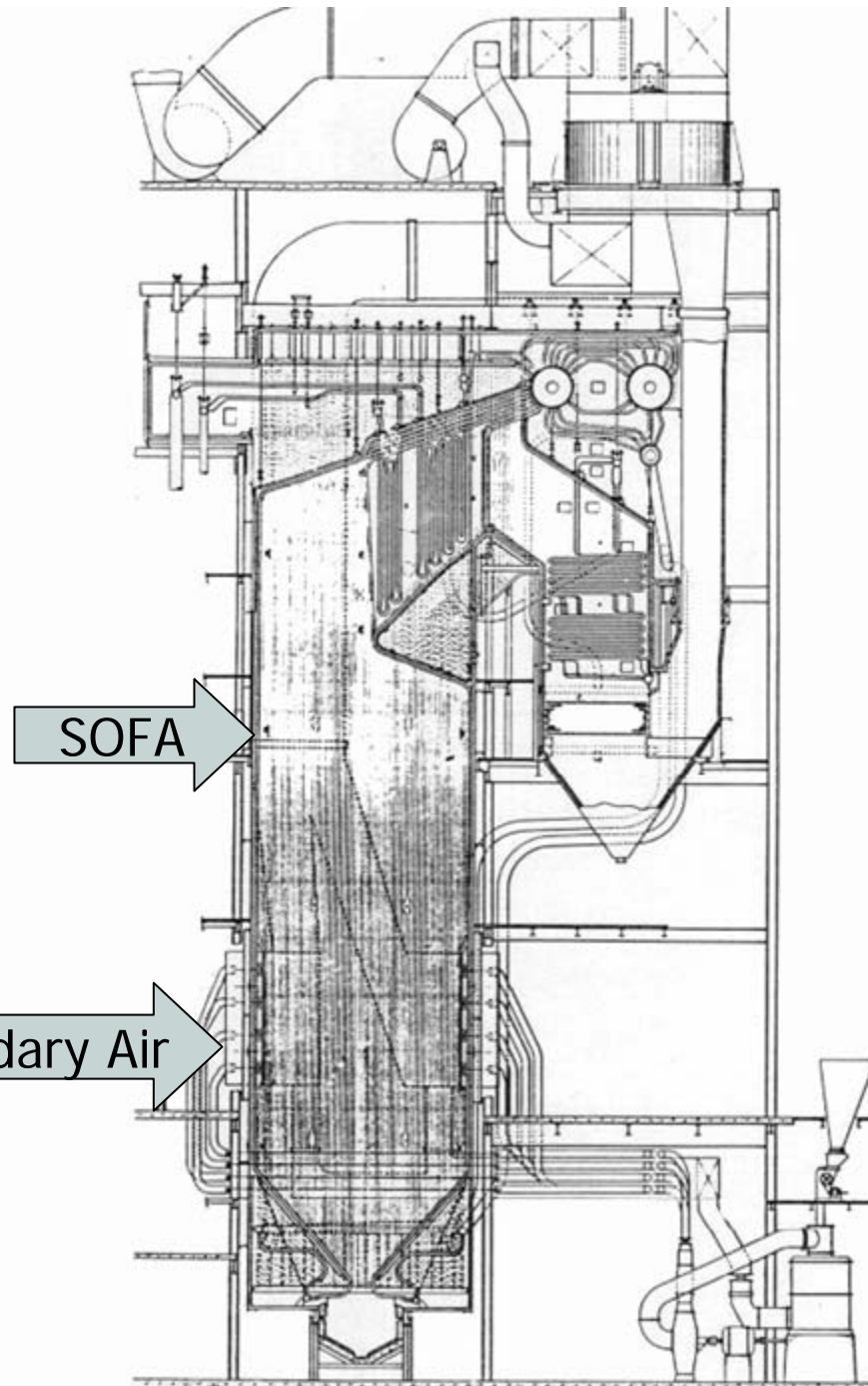
2) Pulverize Coal to a consistency suitable for proper combustion in the furnace



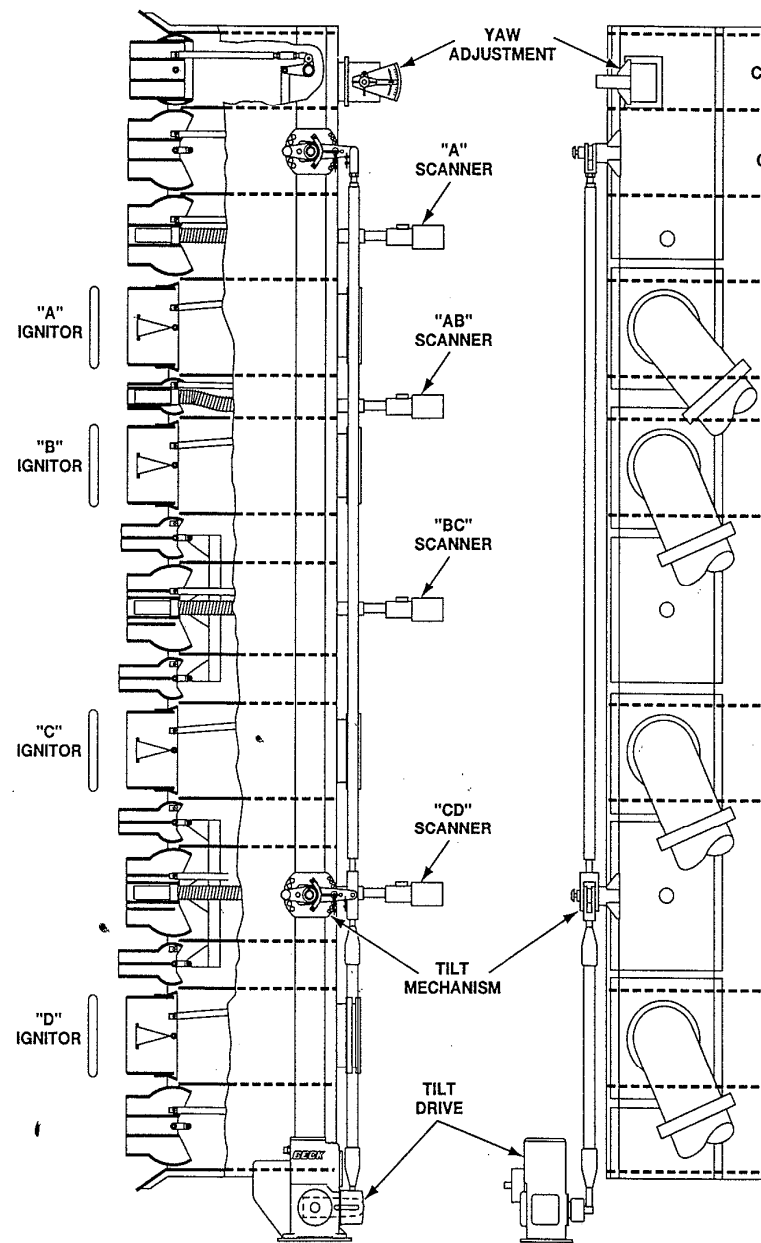
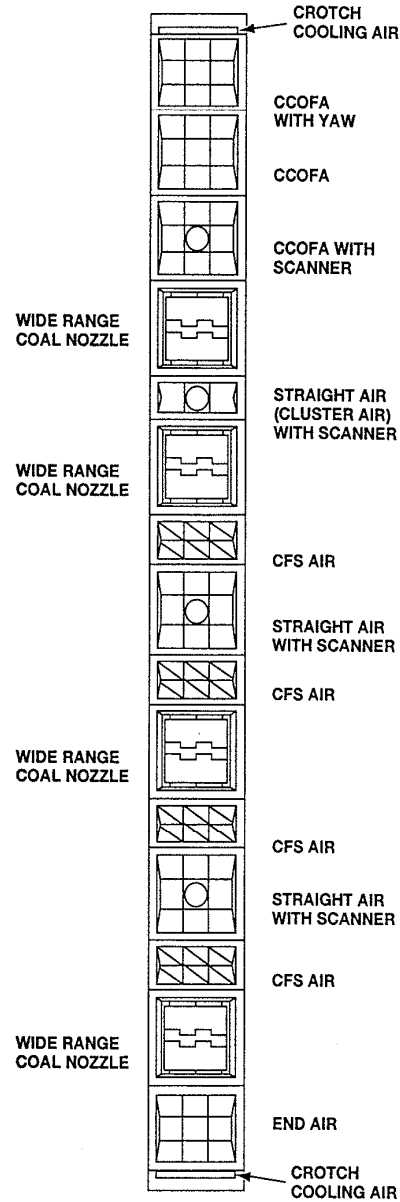
Controls Exhauster Discharge Pressure

Controls Mill Outlet Temp

Typical T- Fired Boiler Features



Typical T-Fired Corner Layout



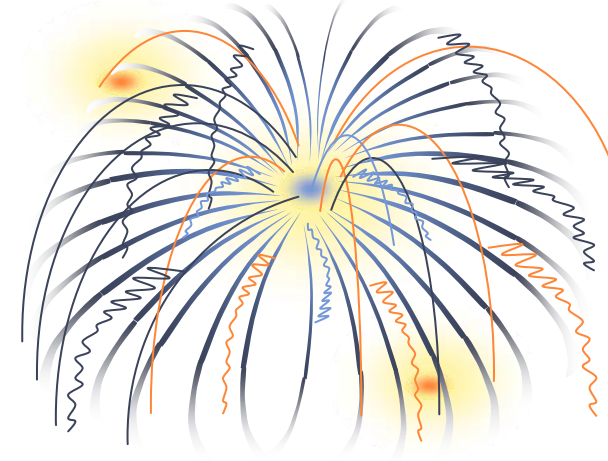


SOFA Design



- SOFA Area
 - 10-20% larger than existing large auxiliary air compartment.
 - Throttled with Automatic Dampers
- SOFA Elevation -
 - higher is better
 - About 50% of distance from top coal to arch
 - need to weigh against LOI & Opacity
- This allows about 20 – 30% of the secondary air to move higher in the furnace – to complete combustion where the furnace is even cooler.

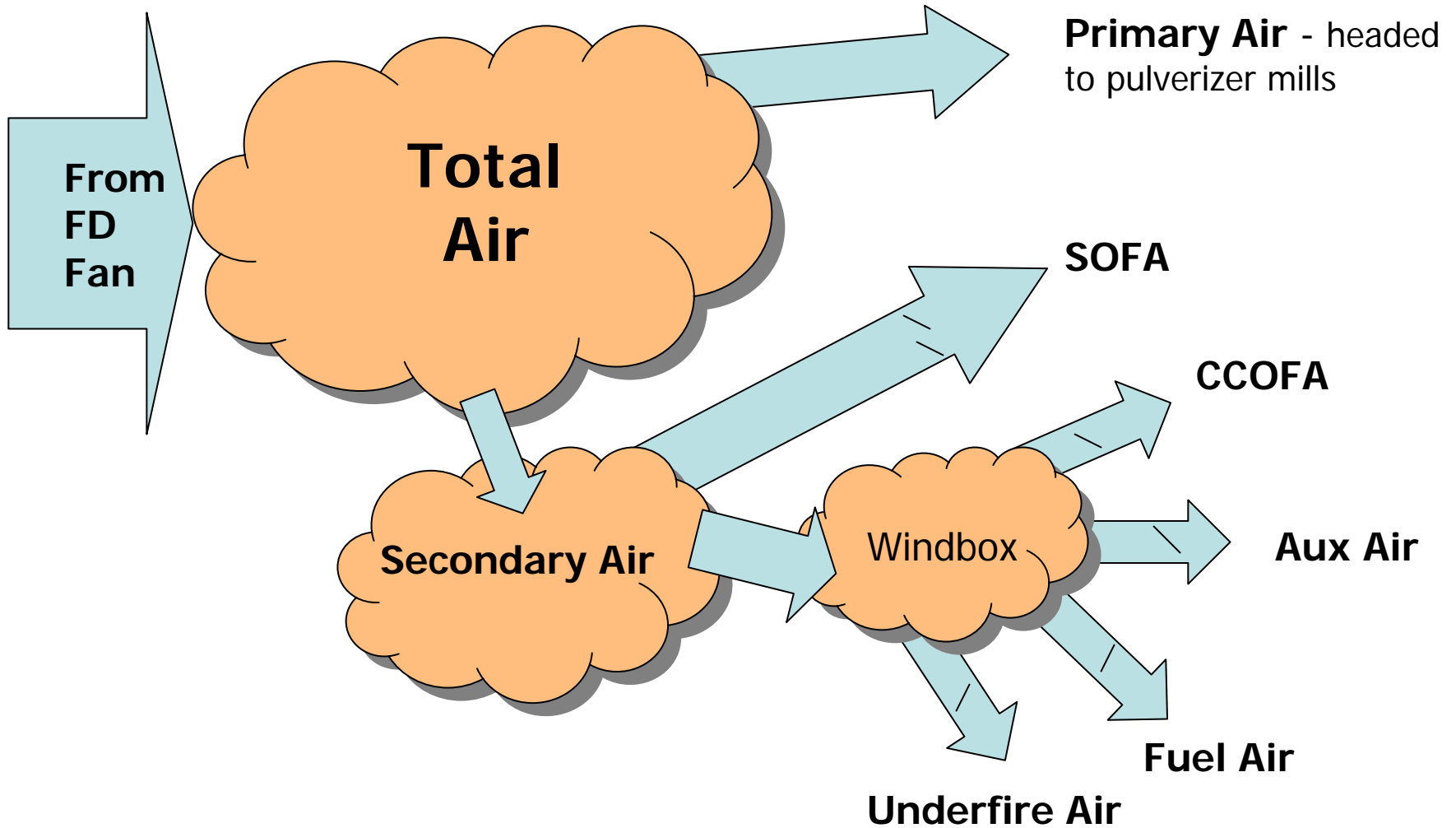
Boiler NOx Reduction – Air Management



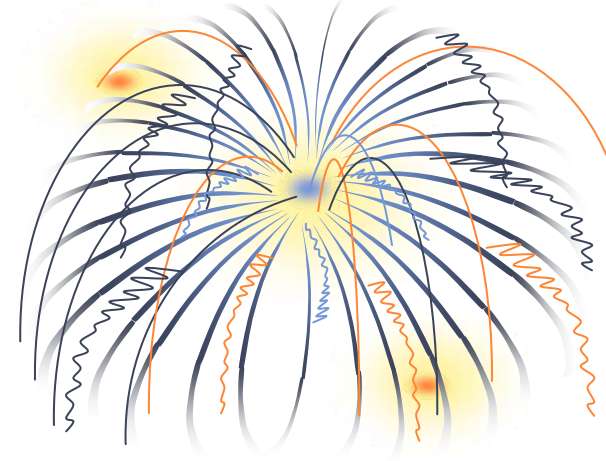
Distribution of Secondary Air is accomplished via dampers associated with:

- Fuel Air
- Auxillary Air
- Under Fire Air (UFA) – Lowest Aux Air
- Close Coupled Overfire Air (CCOFA)
- Separated Overfire Air (SOFA)

Total Air Management

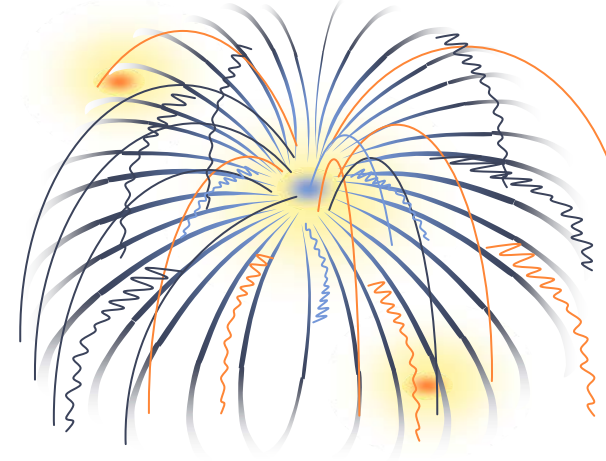


Burner Tilts



- Lowering tilts reduces NO_x; Raising Tilts increases Steam Temperatures
- Burner tilts raise or lower the fire ball in the furnace
- Burner tilts should typically be between +/- 10% and lower is generally better.
- Lower burner tilt produces more residence time (Fuel in low)
- Horizontal burner tilt produces more mixing

O₂ Bias - Excess Air



Reducing Excess Air (or Lowering O₂) reduces NO_x

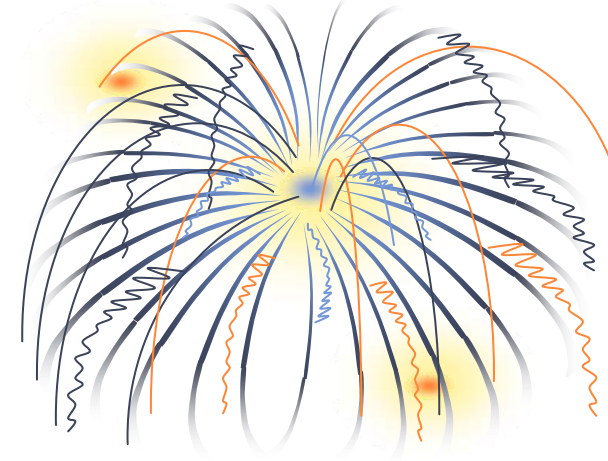
BUT.....

Reducing O₂ may increase Opacity, LOI and CO

- Monitor side to side O₂ (using O₂ Probes) to observe potential “poor combustion”
- Typically, operate by the controls curves and use discretion



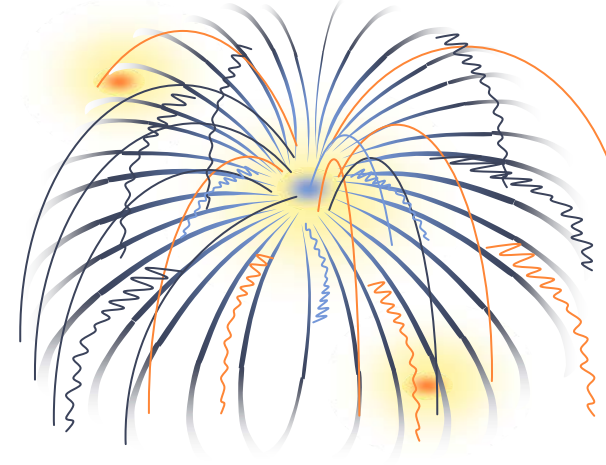
SOFA Dampers



- SOFA opened more (air in high): Increases Steam Temperatures and reduces NOx
- The Curves (based on unit load) will open dampers to reach the desired NOx setpoint
- Typically, operate with SOFA Damper control in automatic
- However, consider manually opening SOFA even more to increase steam temperatures – which lowers burner tilts – which lowers NOx

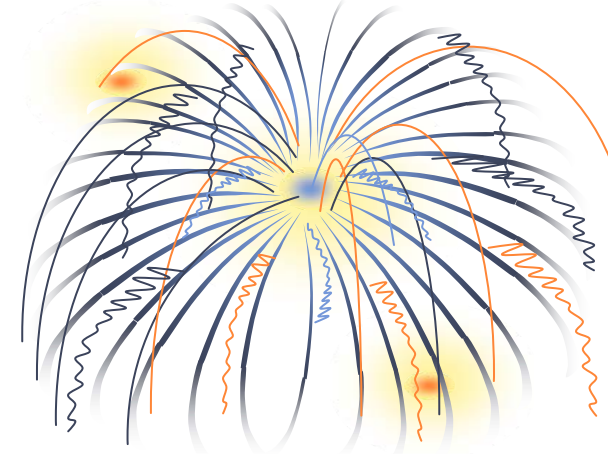


Windbox to Furnace ΔP



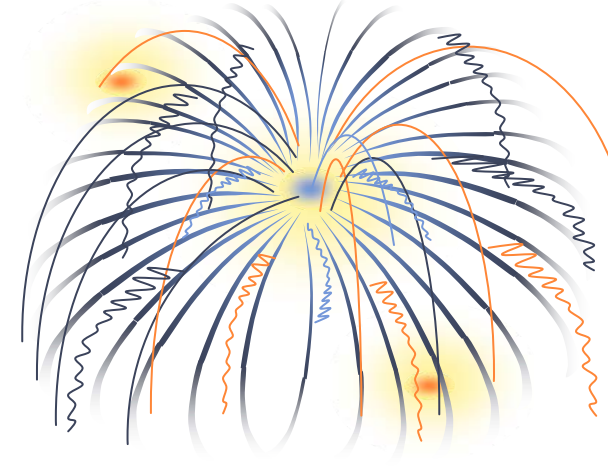
- Increase ΔP to reduce NOx
- Boilers depend on ΔP to push out coal ignition point
- This closes the auxiliary air dampers and reduces airflow in the main windbox (primary combustion zone)
- This forces more air up to the SOFA
- Increased velocity and turbulence in the combustion zone
- Turbulence can be good, however too much turbulence can increase NOx

Aux Air Dampers



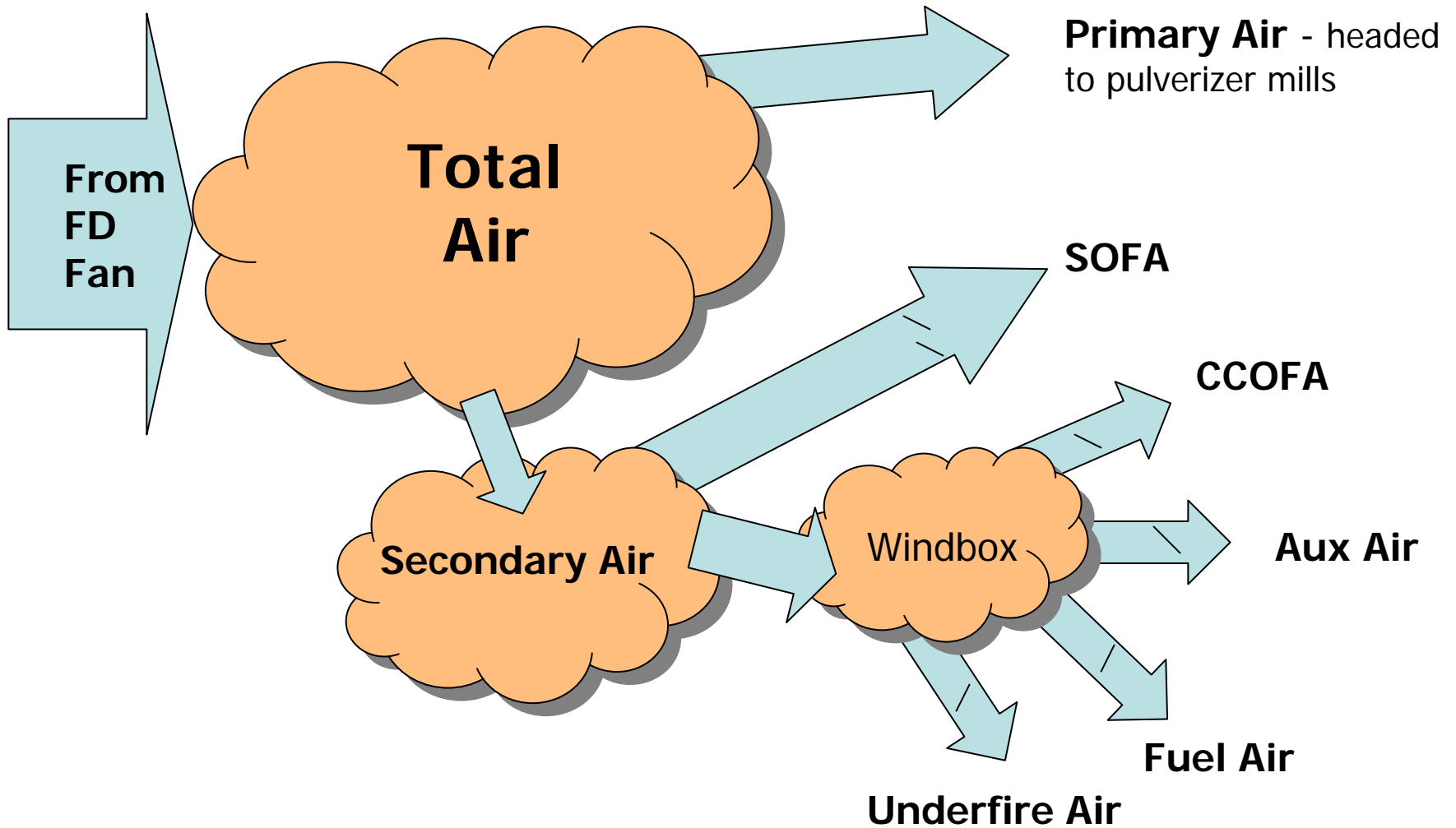
- Aux Air Dampers modulate automatically to satisfy the Windbox to Furnace ΔP
- Knowing position of Aux Air Dampers allows an understanding of the quantity of air entering the furnace at other locations
- Keep in mind:
 - Just because a damper – any damper - is open, does not necessarily mean that more air will go there
 - If Aux Air Dampers are closed too much, The coal ignition point may get too close to the burner (flame attachment) causing potential concerns with burner fires.
- Incorporate override logic to maintain Windbox to Furnace DP

Under Fire Air (UFA) – Lowest Aux Air Location



- Opened more improves steam temps by “pushing” the fireball higher– which allows the burner tilts to be lowered – which reduces NOx
- Allows air into the bottom of the furnace for better combustion to lower LOI
- Too much UFA can increase NOx by making the fire hotter

Total Air Management





Typical Controls Curves



- Primary Air controlled by needs of Pulverizer Mill to dry and transport coal
- Aux Air – controlled by “windbox to furnace”
- SOFA Master - 2 elevations of SOFA Dampers will regulate based on load
- Under Fire Aux Air –controlled by “windbox to furnace” however, operator can bias more open
- Fuel Air Dampers controlled by feeder speed – typically open 20-30%
- Steam Temperatures – controlled in automatic by raising / lowering burner tilts

Boiler Combustion Critical Process Parameters

- ❑ **O2 Setting**
 - ❑ **Burner Tilt Setting:** Near horizontal or lower
 - ❑ **SOFA Dampers:** Open as much as Opacity will allow
 - ❑ **Secondary Air Damper setup:** Windbox air managed properly (Aux Air, UFA, Windbox ΔP)
 - ❑ **Proper Selection of Mills:** upper mills in service to gain temperature; lower mills in service to reduce NOx

 - ❑ **Parameters to Monitor**
 - NOx
 - Opacity
 - Furnace Exit Gas Temperature (FEGT)
 - Steam Temperatures
 - Burner Tilts when in automatic
 - Aux Air Dampers
 - Physical observation of burner ignition points
 - CO Monitors
-



Additional Combustion Strategies



Mill Levels in Service / Mill Sequencing

- Use this strategy to increase separation between air and fuel
- Top mill out is best overall for NOx reduction
- Steam temperatures also need to be considered.
- Keep burner tilts at or below horizontal and meet steam temperatures



Additional Combustion Strategies



BOOS (Burners Out Of Service)

- Operate with the fewest mills in service whenever possible to reduce NOx. This is referred to as BOOS (Burners Out Of Service)
- Adding a mill adds fuel, but also adds air in the windbox area
- Steam temperatures also need to be considered.
- Keep burner tilts at or below horizontal and meet steam temperatures



Additional Combustion Strategies



Mill Feeder Biasing

- Bias fuel out of the upper mill or mills and into the lower mills
- With more fuel lower, the separation between air and fuel is increased



Additional Combustion Strategies



CO Monitoring

- An indicator of good furnace combustion
- Improves LOI
- Assists in ash collection in the Precipitator (less carbon) – which helps lower opacity
- An indicator of a mill with poor fineness



Additional Combustion Strategies



Sootblowing

- IK's typically increase SH temperatures by increasing heat absorption in the convection sections. This results in decreased tilt demand which is generally beneficial to NO_x.
- Blow IK's rear to front to clear a path (less potential for puffs)
- Develop an IK sequence and interval plan

- IR's (wall blowers) lower steam temperatures by increasing heat absorption in the waterwalls. This results in increased tilt demand which could adversely affect NO_x.

Final Thoughts

- ❑ Utilize the ability to move secondary air around to optimize the boiler combustion
 - ❑ There is always a balancing act for NO_x vs. Temperature vs. LOI vs. Opacity vs.
 - ❑ Fuel is always changing - and a lot of time, so is load
 - ❑ Consider how a change will affect the 3 T's: Time, Temperature, Turbulence
 - ❑ As part of the final steps of troubleshooting, need to consider that the equipment (dampers, drives, etc.) may not be operating properly.
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- ❑ **Questions?**
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