

# A SUMMARY OF EXPERIENCES RELATED TO COMBUSTION OPTIMIZATION

STEAG WORKSHOP=COMBUSTION  
OPTIMIZATION

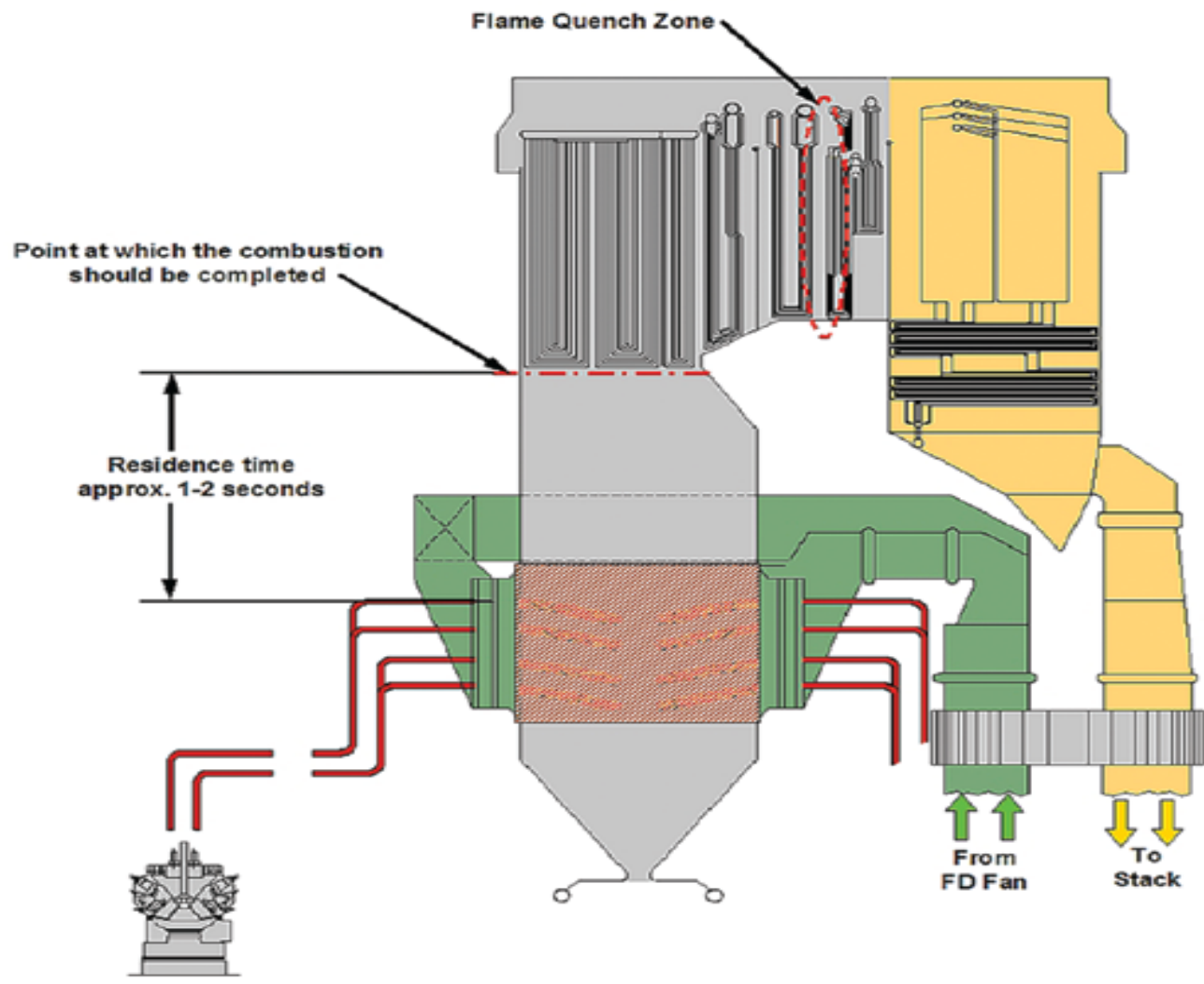
19.09.2013-20.09.2013

# Optimizing combustion in pulverized Coal fired Boilers

- **Optimizing combustion in pulverized Coal (PC)-fired** boilers today is more important than ever.
- The average PC plant is over 35 years old, however Nox reduction measures have been adopted only recently in different plants being installed in India
- Reduction of greenhouse gases is the need of the hour, CO<sub>2</sub> emissions could be lowered considerably by improving the efficiency of the existing coal fired plants.
- Tighter pollution controls have triggered major evolutionary development of coal-fired plants over the past 40 years:

# Residence time

- In a typical, 500-MW PC-fired boiler, the top of the burner belt is about 55 feet below the nose arch.
- To achieve optimal generation and environmental performance, combustion must be 99% complete by the time its products are passing over superheaters.
- The flue gases move swiftly; the residence time in the furnace of the primary air/coal mixture that entered the furnace at the top burner level is less than 2 seconds.
- As delayed combustion is fundamental to the design of all low-NO<sub>x</sub> burners and OFA systems, it is important to optimize pulverizer performance.



# TOOLS FOR COMBUSTION OPTIMIZATION

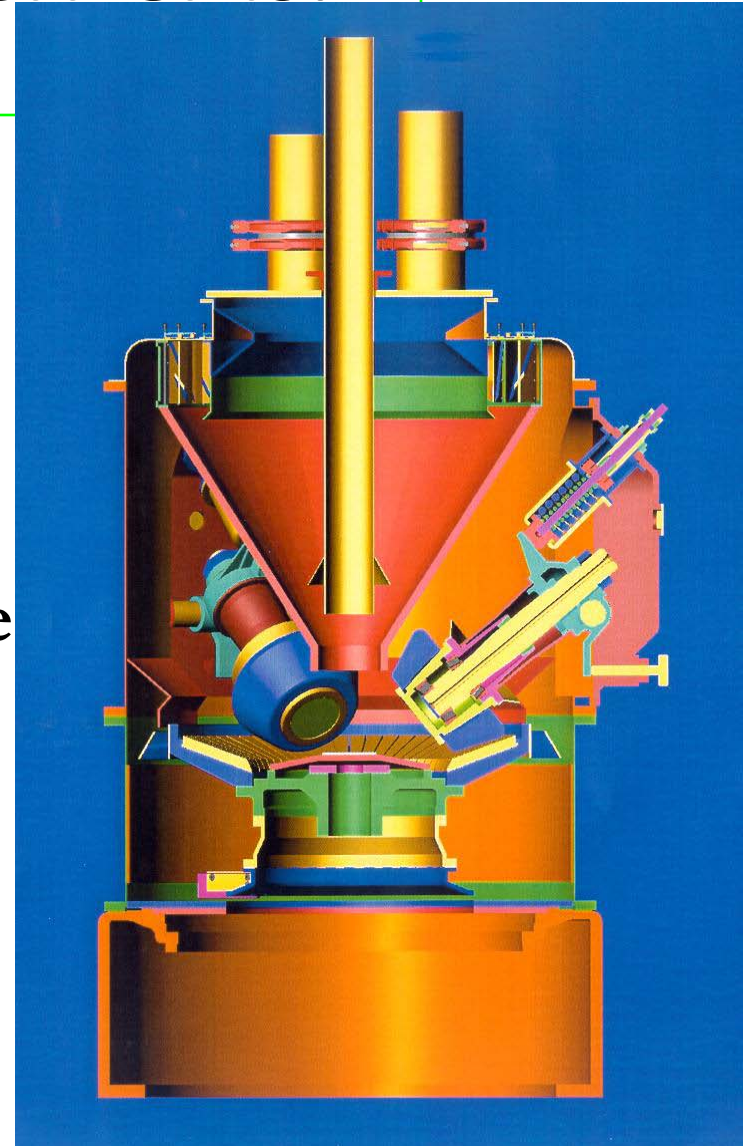
- On Line Instruments for Combustion Monitoring.
- Automatic Coal Sampler.
- Coal lab. for Coal analysis

- Modern utility boilers utilize many independent coal burners to deliver fuel to the furnace for combustion.
- **The number of burners in a boiler depends on the number of pulverizers and furnace configuration.**
- **To achieve optimum and efficient combustion of coal, equal quantities of fuel must be delivered to each of the separate burners.**
- These systems utilize a pulverizer or mill to grind coal to a desired fineness and subsequently transport the coal to the burners using air as a transport medium.
- Air utilized to transport coal to the burners is called “Primary Air”.

# The Purpose of a Pulverizer is:

- To Pulverize Coal to a Consistency Suitable for Proper Combustion in the Furnace And ;
- To Dry Incoming Coal
- For Pressurized Pulverizers, The Classifier's purpose is twofold:
  - Size Classification
  - Uniform Fuel Distribution to each Burner Line

The Pulverizer's are the HEART of a Pulverized Coal Fired Boiler!



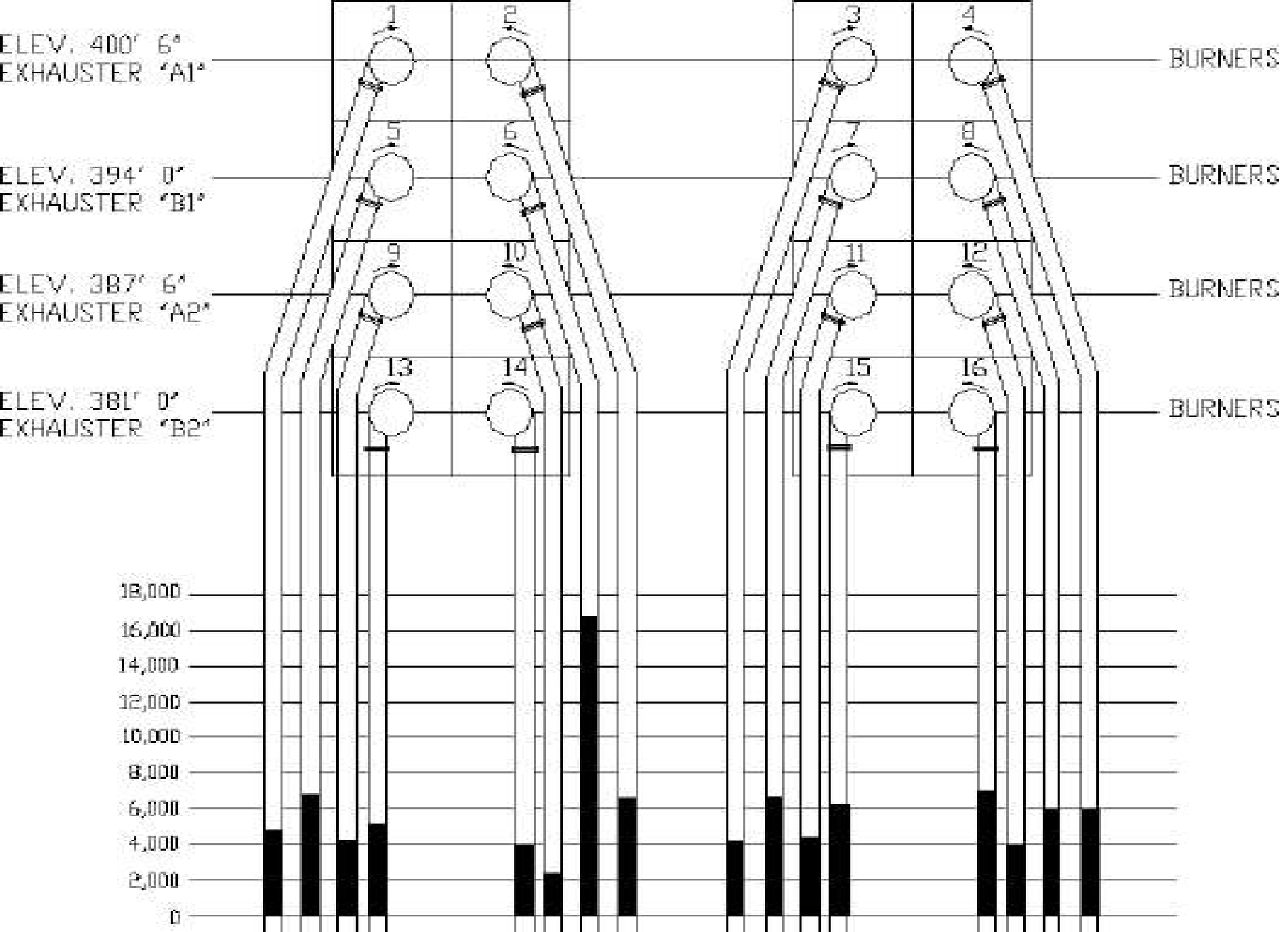
# The Purpose of a Primary Air

- **Primary air serves two purposes, these are:**
- **Transportation of pulverized coal from the pulverizer to the burner.**
- **Provides the necessary heat requirement to facilitate evaporation of surface and inherent moisture in the coal.**
- **After coal and air is mixed at the pulverizer the resulting mixture of air/coal is typically called dirty airflow.**
- **The use of air to transport coal to burner requires equal airflow through each fuel conduit supplying the burners.**
- **Imbalances in airflow through the fuel conduits can affect the quantity of fuel delivered to each burner.**



# Balance of fuel and air

- Burners from each pulverizer are usually grouped or paired for combustion stability in the furnace.
- **Usually burners of given elevation or group originate from a single pulverizer. This enables “biasing” of total fuel to a given elevation to control steam temperatures and furnace combustion characteristics.**
- Each pulverizer is an independent system that delivers fuel to the burners originating from the given pulverizer. **For this reason, the balance of fuel and air is typically addressed on an individual pulverizer basis.**
- Fuel and air is balanced between all burner lines leaving a specific pulverizer. **This will result in uniform air to fuel ratios for all burners.**
- **This is critical for combustion performance and control of emissions.**



# TOOLS FOR COMBUSTION OPTIMIZATION

- On Line Instruments for Combustion Monitoring.
- Automatic Coal Sampler.
- Coal lab. for Coal analysis
- Classifier on top of Mills.
- Fuel Piping Orifice for coal balancing

# Tolerances for fuel and air balance

- ***±2% balance in clean airflow between each pulverizer's fuel lines.***
- ***±5% balance in dirty airflow between each pulverizer's fuel lines.***
- ***±10% balance in fuel between each pulverizer's separate fuel lines.***
- Maintaining optimum fuel and air balance is critical to the following items:
- **Obtaining acceptable levels on unburned Carbon in Fly ash.**
- **Uniform release and absorption of heat across of the furnace.**

# Tolerances for fuel and air balance

- **Reduction in furnace slagging and fouling propensities.**
- **Maintaining boiler exit gas temperatures within design tolerances.**
- **Prevention of water-wall wastage and tube metal overheating .**
- The actual test data indicates a gross imbalance in fuel to burners. Poor fuel balance is commonly observed on utility boilers.
- One of the primary reasons for this is the difficulty in balancing two phase mixtures.
- The reduced emphasis on fuel and air balancing at the burners has been promoted in the past by boiler manufacturers that depended on mixing by the furnace

# Factors affecting Coal balancing

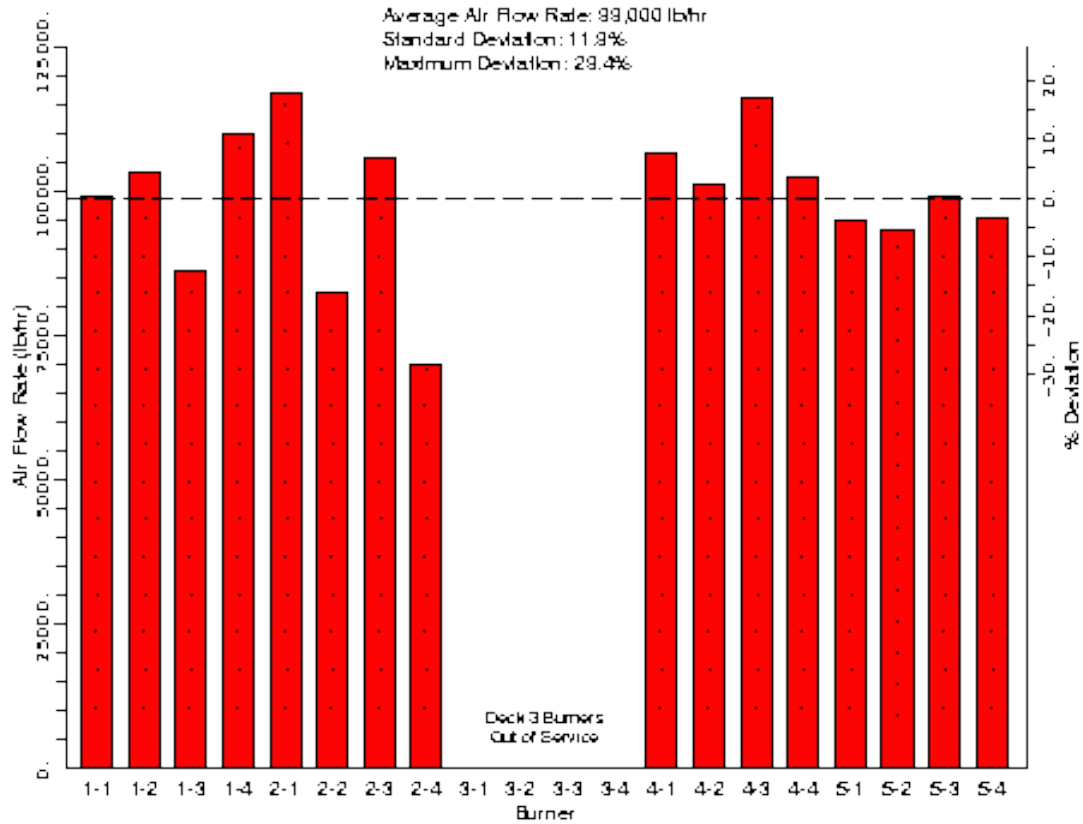
- Numerous controllable variables affect the distribution of air and fuel between a pulverizer's separate fuel lines. These variables are as follows:
- **Size of coal particles leaving the pulverizer (*Fineness*).**
- **System resistance of each individual fuel conduit.**
- **Total airflow through the pulverizer that is controlled on a ratio of weight of air to fuel.**
- **Velocity of air/coal mixture passing through each burner line.**
- **Maintenance of critical components such as classifiers, classifier cones riffles, orifices and burner components.**

# TOOLS FOR COMBUSTION OPTIMIZATION

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- Classifier on top of Mills.
- Fuel Piping Orifice for coal balancing
- Iso Kinetic PF Sampler Kit
- Coal Fineness - Particle Classification Sieves.

# Comparison Before and After Balancing

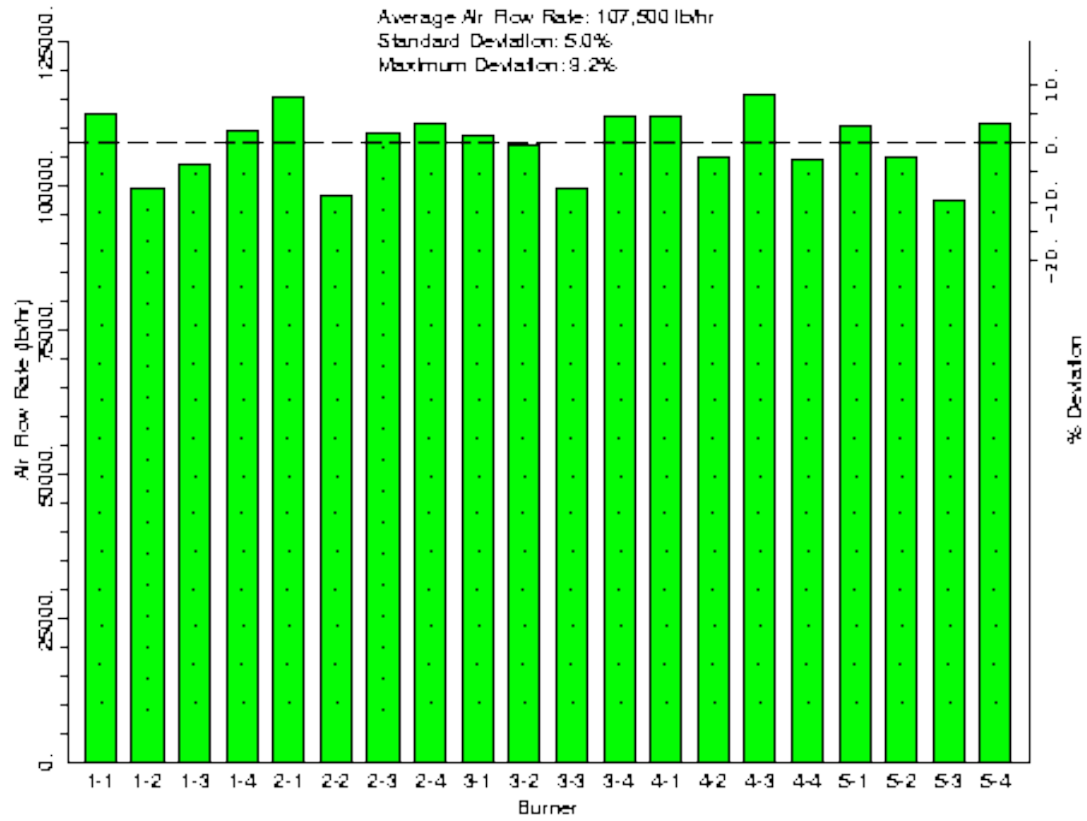
## Initial Burner Flow Rates (Before Balancing)



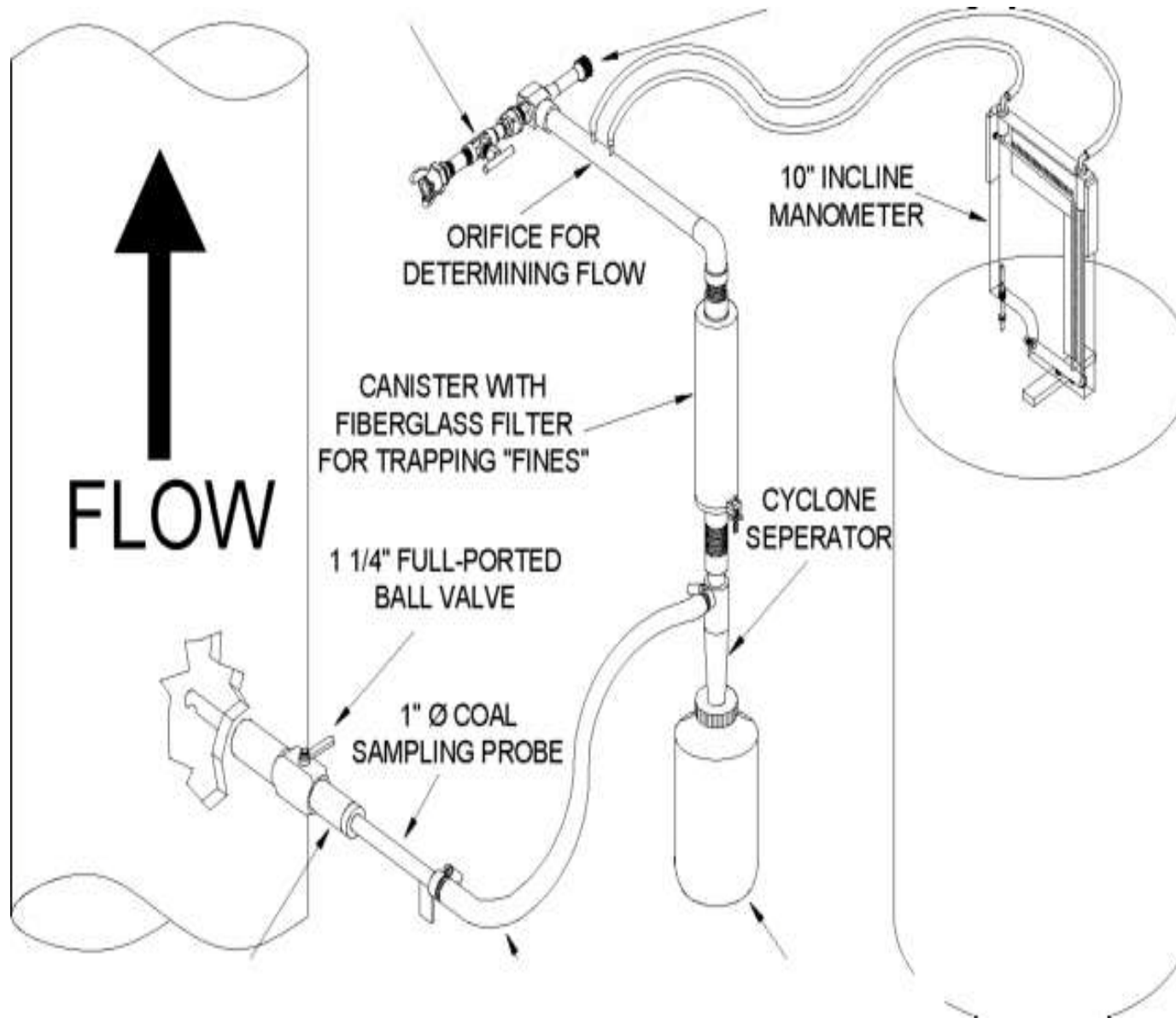
## Final Burner Flow Rates (After Balancing)

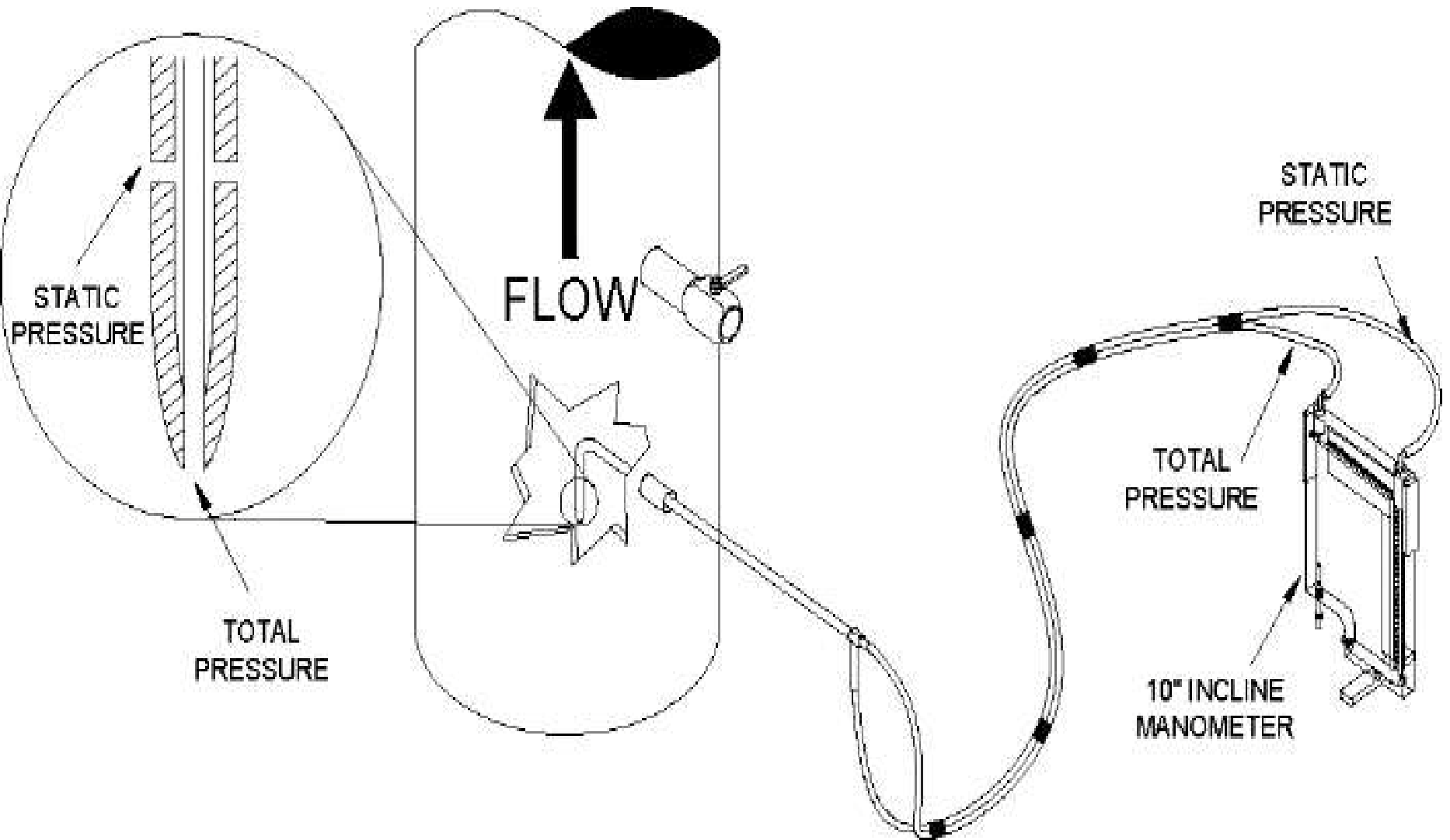


### Final Burner Flow Rates (After Balancing)



- The dirty air probe is used in conjunction with the air/fuel sampler and the Rotorprobe® to measure fuel line airflow and to determine Isokinetic sampling rates .
- The quantity of coal passing each sieve is used to determine coal particle sizing. Sieves utilized are ASTM 50, 100, 140 and 200 Mesh.
- The numeric designation on ASTM sieves specifies the number of openings in screen or mesh per linear inch. For example, a 200 Mesh sieve would have 200 openings per inch.
- Coal fineness levels of 75% passing 200 Mesh and 99.5% passing 50 Mesh are generally considered acceptable.
- Boiler manufacturers (*OEM*) have typically specified coal fineness to be no less than 70% passing 200 Mesh with 99% passing 50 Mesh.





# Clean Air Balancing, A Vital First Step to Fuel Line Balancing

Fuel lines balanced to each burner by "Clean Air" test  $\pm 2\%$  or better.



## ***Dirty Pitot Survey - Summary Data (Mill X)***

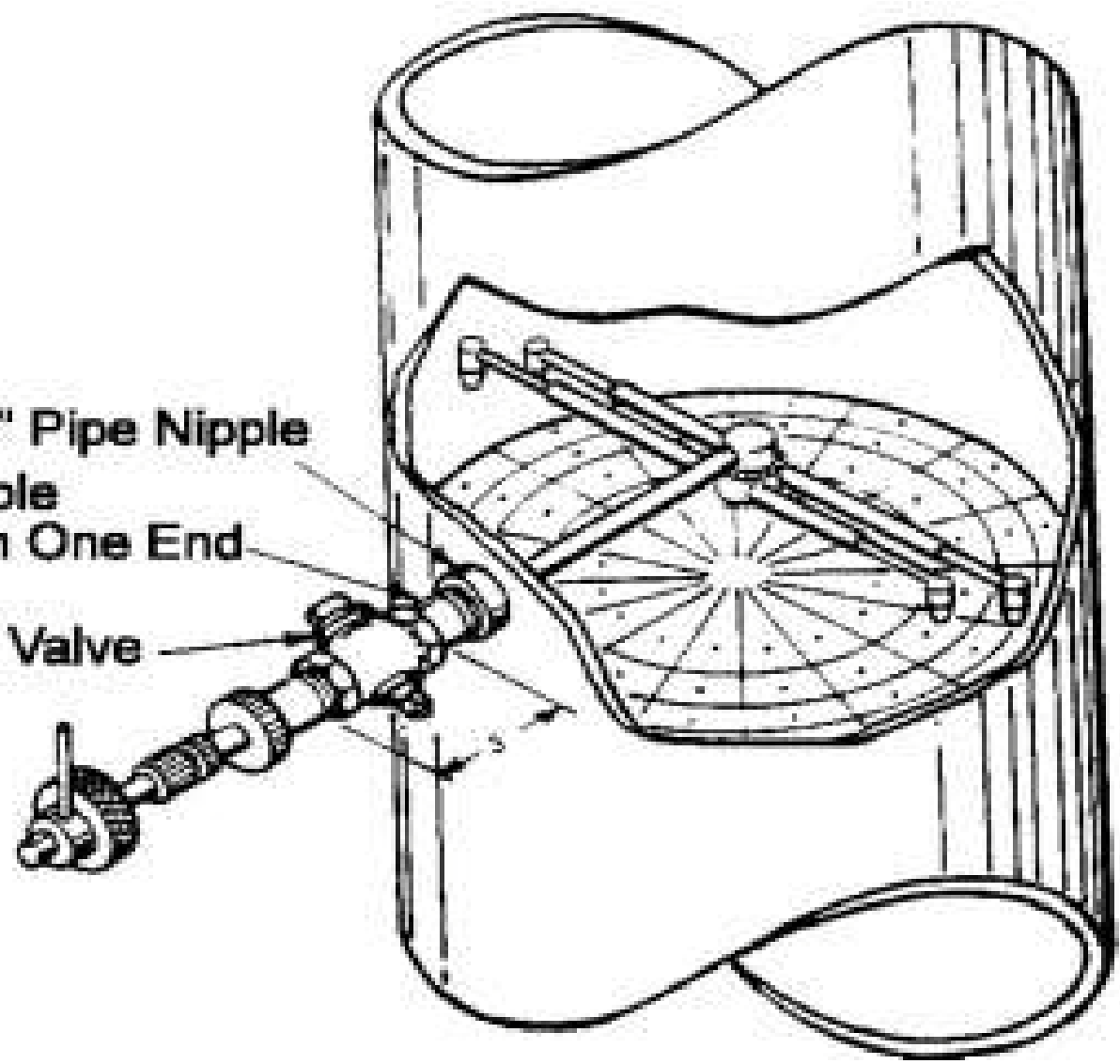
	UCB	Measured
Air Flow T/hr	40	43.6
Mill Outlet Temp C	65	54.8
Coal Flow T/hr	-	26.2

Description	Corner				Mean	Desired
	1	2	3	4		
Velocity m/s	24.3	22.9	16.0	17.4	20.2	> 18 m/sec
Air Flow T/hr	13.1	12.4	8.7	9.4	10.9	----
Dev. From Mean %	20.2	13.8	-20.2	-13.8	---	< +/- 5%
Mill Out Temp °C	56.0	55.0	53.0	55.0	54.8	~ 85°C
Coal Flow T/hr	7.9	5.8	5.6	6.9	6.6	< +/- 10%
A/F Ratio	1.7	2.1	1.0	1.4	1.6	1.8 to 2.5

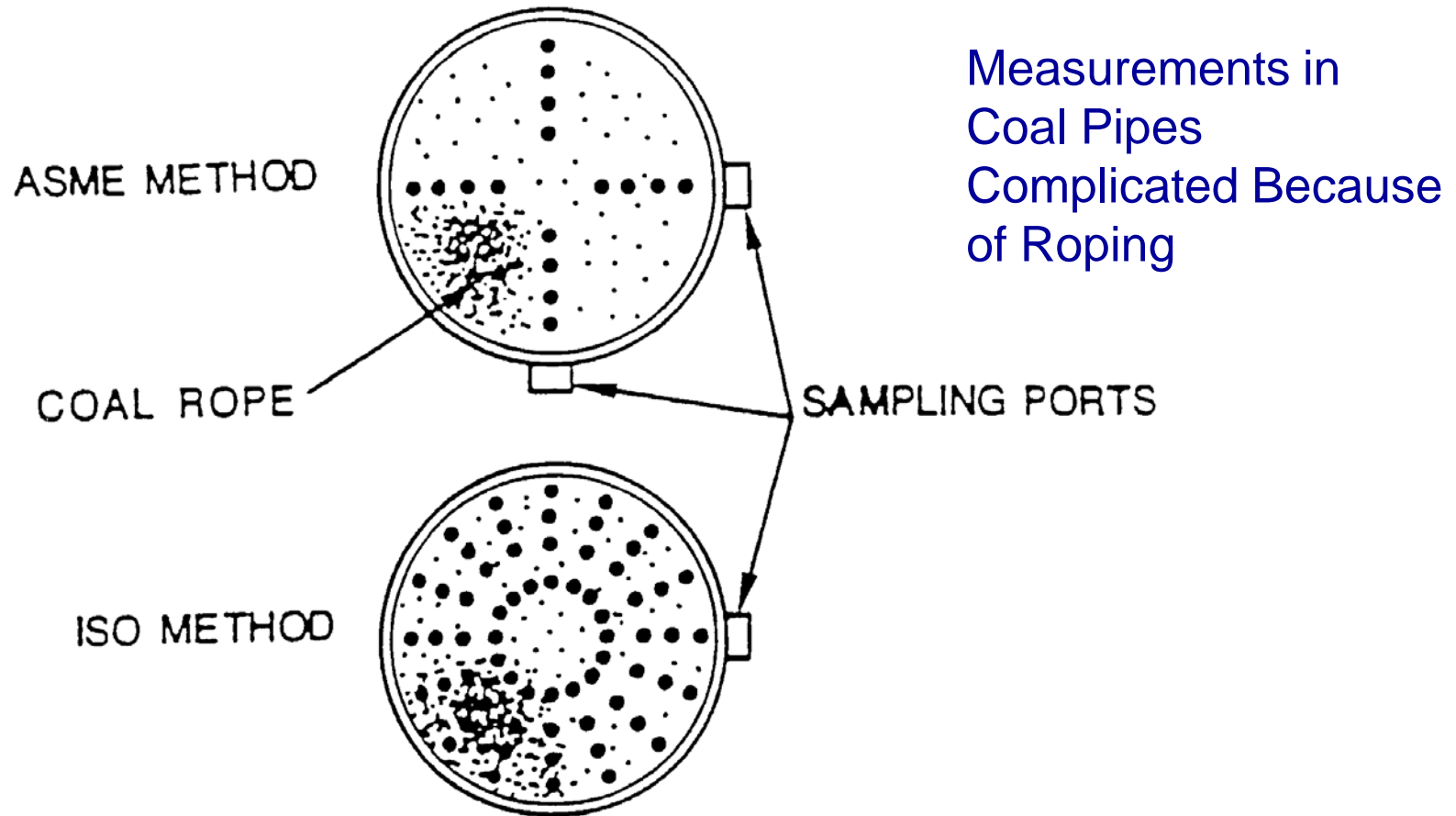
- ***Operating PA flow through the mill is lower by almost 13 T/hr than design***
- ***Mill Outlet temperature is low in all the pipes.***
- ***Low mill outlet temperature coupled with low PA flow could be the reason for the choking observed in Pipes 3 & 4.***

**1½" Pipe Nipple**  
**3" Long Nipple**  
**Threaded on One End**

**1½" Ball Valve**



# COAL PIPE INSTRUMENTS AND MEASUREMENT ACCURACY

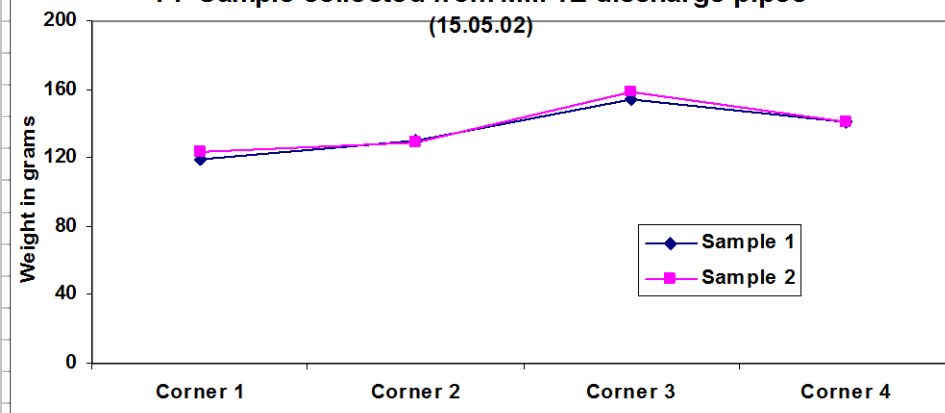


Comparison of Sampling Grids



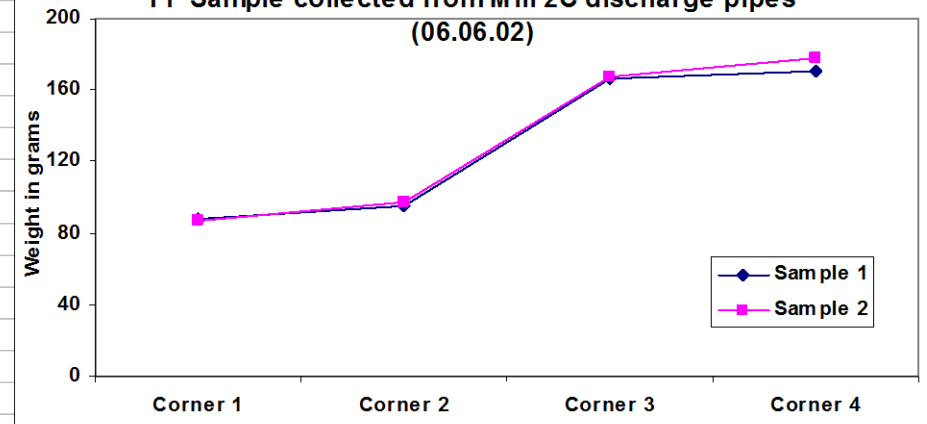
**PF Sample collected from Mill 1E discharge pipes**

(15.05.02)



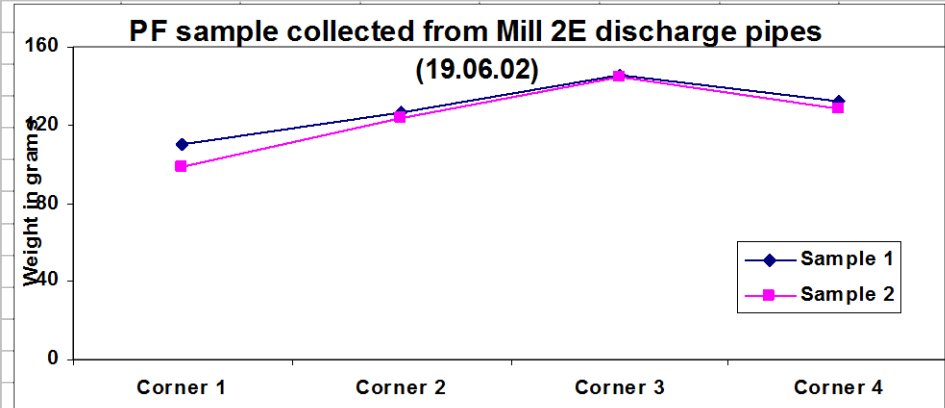
**PF Sample collected from Mill 2C discharge pipes**

(06.06.02)



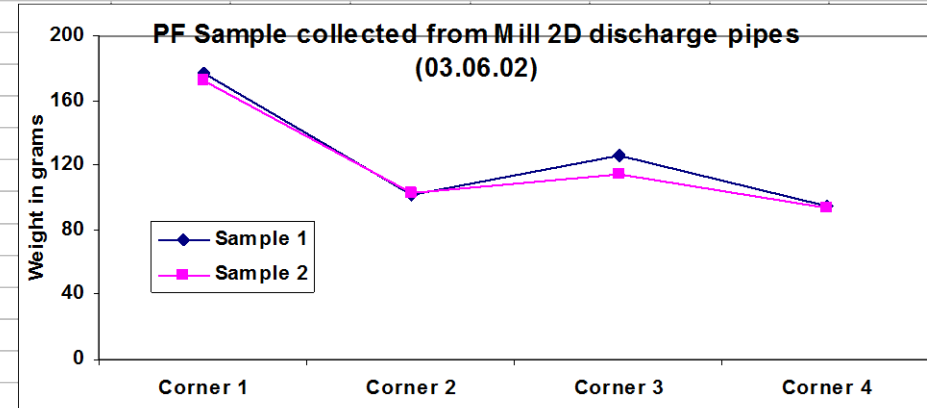
**PF sample collected from Mill 2E discharge pipes**

(19.06.02)



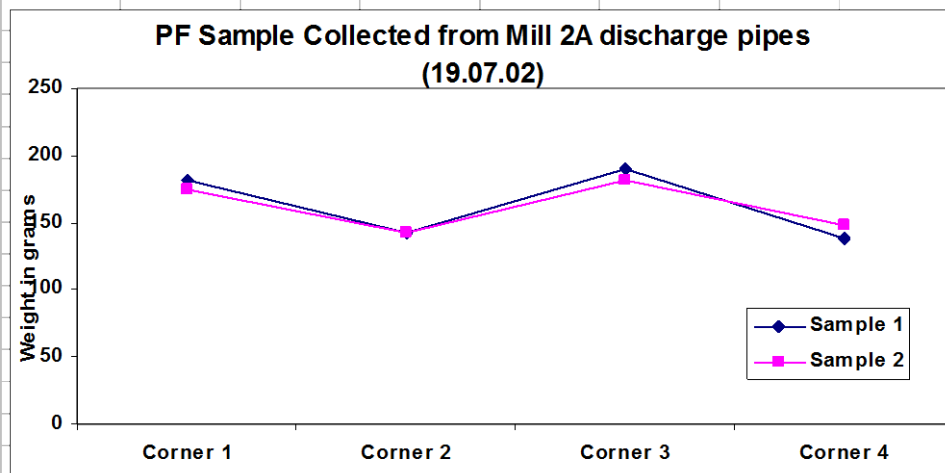
**PF Sample collected from Mill 2D discharge pipes**

(03.06.02)



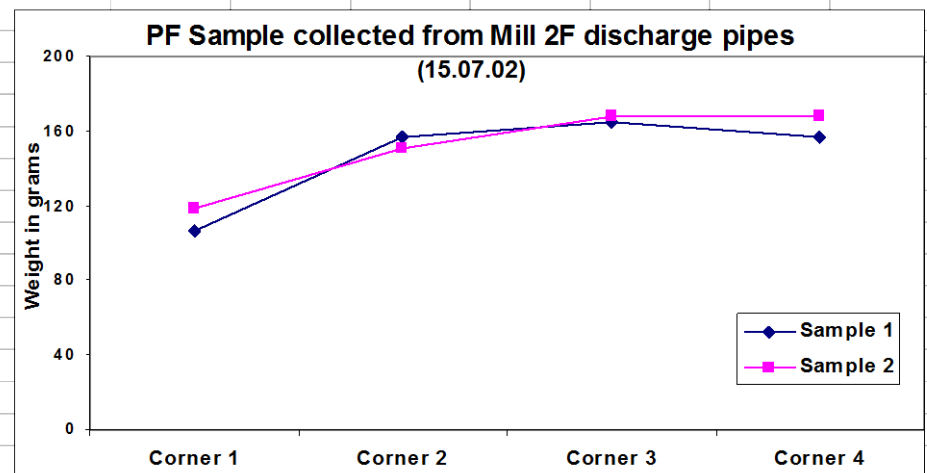
**PF Sample Collected from Mill 2A discharge pipes**

(19.07.02)

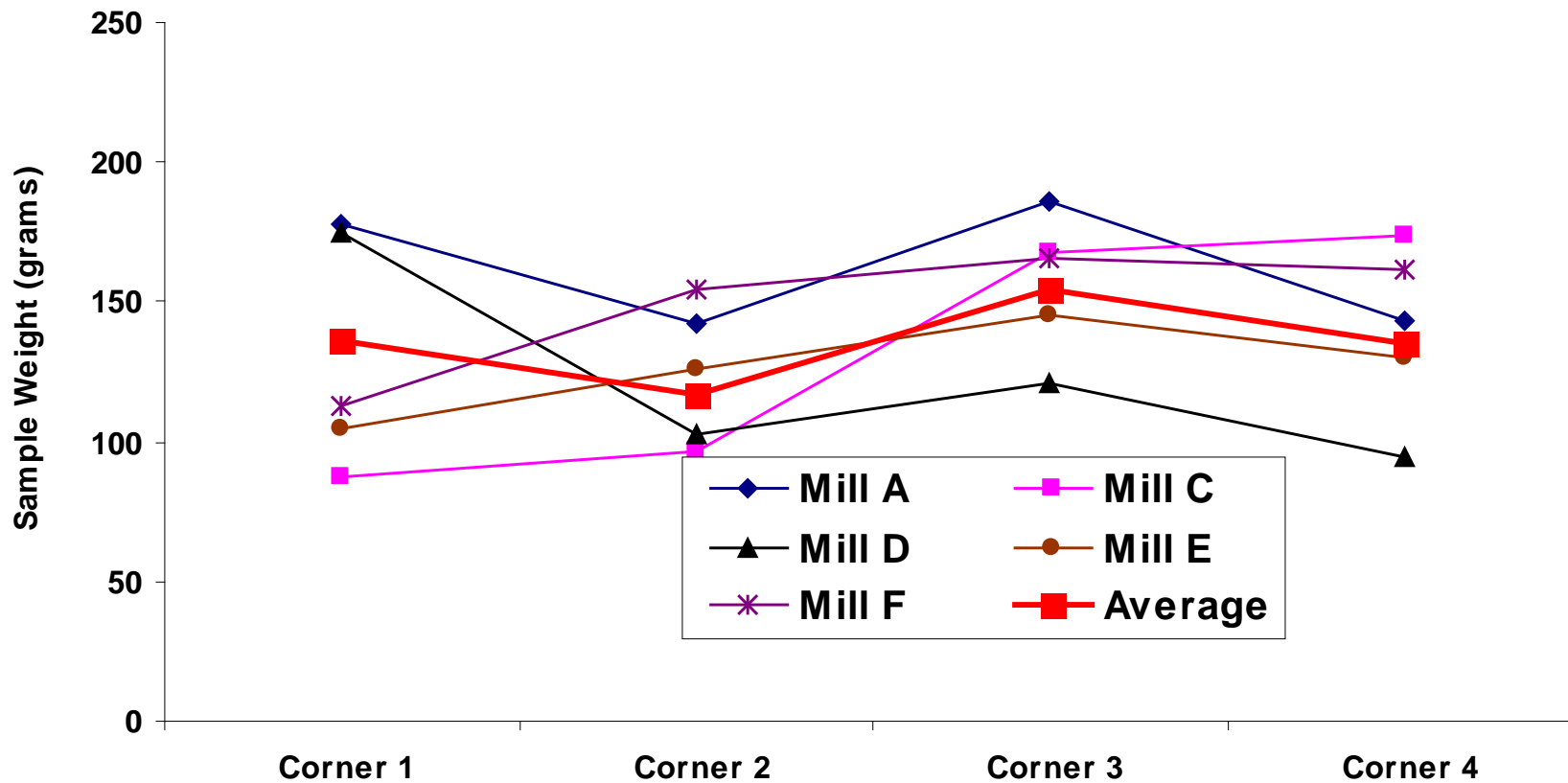


**PF Sample collected from Mill 2F discharge pipes**

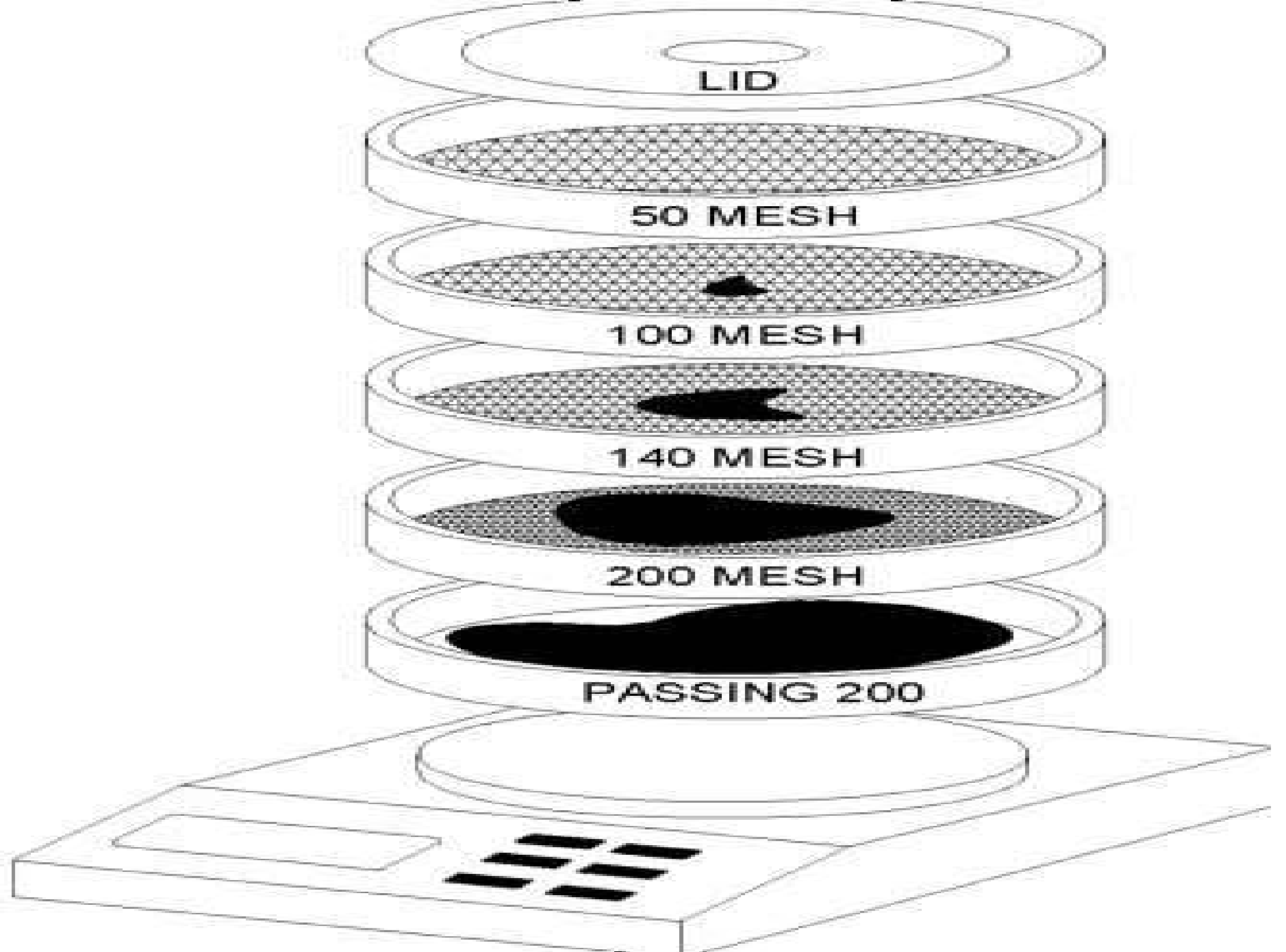
(15.07.02)



## Variation of coal flows in the four corners in Unit 2



- Coal fineness is ascertained by collecting a representative coal sample from each burner line and shaking the sample through a series of sieves.
- Coal fineness samples should be collected from all fuel lines of a specific pulverizer. The pulverizer fineness is considered the weighted average of all fineness samples collected.
- To obtain a representative coal sample an Isokinetic sampler must be utilized.
- The Air/Fuel Sampler or Rotorprobe<sup>®</sup>.are two types of samplers that have been successfully utilized.



- However, when optimum combustion and flyash of  $<1\%$  unburned Carbon is desired, then improved fineness is required. Fineness levels of 75% passing 200 Mesh and 99.9% passing 200 Mesh improves fuel distribution as well as unburned Carbon in flyash.
- After coal fineness is determined by sieving, fineness data should be plotted against the Rosin and Rammler formula.
- This plot is utilized to verify the representativeness of the coal sample and sieving.
- A representative sample will plot as a straight line on a Rosin and Rammler Log chart.

FINENESS, PERCENT PASSING

99.00  
95.00  
90.00  
80.00  
70.00  
63.21  
60.00



# Coal Fineness and Fuel Balance

- Fineness specifications were devised in the 1960's when boiler designs were very conservative and **based on single stage combustion theory.**
- ***NO<sub>x</sub> emissions are usually reduced by staging combustion to lower the air/fuel stoichiometry in the burner zones where temperatures are sufficient to facilitate formation of NO<sub>x</sub>.***
- ***Due to this, a higher degree of precision in delivery of fuel and air to the furnace is required. To compensate for imbalances in fuel and air and lower exposure time of fuel carbon to free Oxygen at temperatures above ignition points, Coal fineness standard required reevaluation.***
- ***Low NO<sub>x</sub> firing configurations require no less than 75% passing 200 Mesh with 99.9% passing 50 Mesh. This fineness is not always required for acceptable NO<sub>x</sub> emissions, as some burners have performed with poor coal fineness.***

# Coal Fineness and Fuel Balance

- ***As fineness increases (reduction in coal particle sizing), fuel balance improves. The finer the coal, the more the two-phase mixture (coal and air) behaves like a fluid than a solid in suspension.***
- ***The more homogenous mixture of air and coal results in more even distribution between the separate burner lines.***
- ***Pulverizers usually utilize classifiers, which employ the principles of centrifugal separation to reject coarse coal particles back to the pulverizer for regrinding. The “Swirl” imparted by centrifugal classification facilities separation of coarse and fine particles.***
- ***Poor fineness results in a very stratified mixture leaving the classifier due to wide variation in particle sizing.***
- ***The more massive coal particles (lower fineness) have more momentum when entrained in air at a certain velocity and are more easily stratified than finer coal particles that have less mass, thus lower momentum.***
- ***After coarse and fine coal particles are separated fuel and air balance is further aggravated by imbalances in airflow.***
- ***Typically, burner lines that receive the largest quantity of coarse coal particles have the lowest air velocities***



# *Clean Air Balancing*

- Balancing system resistance of fuel lines on clean air is the first step of an empirically approach to balancing pulverizer fuel and air. **Clean air balance is defined as balance of airflow between a pulverizer's fuel lines in the absence of fuel.**
- This is achieved by forcing air through the pulverizer at normal operating mill outlet temperatures with primary air fans while the feeder remains off-line. Clean air balance is determined by measuring the velocity of air flowing through each individual fuel line with a standard Pitot tube.
- **In most cases, primary airflow is higher than desired and will be reduced to optimize performance.**
- **Prior to optimization of primary airflow it is prudent to perform clean air balancing.** This will insure minimum fuel line velocities in all fuel lines must exceed 3,300 feet/minute (*Fpm*). *Fuel line velocities above 3,300 Fpm are to insure coal entrainment in primary air.*
- ***Air velocities below 3,000 Fpm allow coal to fall out, accumulate or "dune" in horizontal runs of fuel lines. The 3,300 Fpm minimum velocity includes a 10% safety margin above the absolute minimum line velocity of 3,000 Fpm.***

# *Pulverizer Airflow*

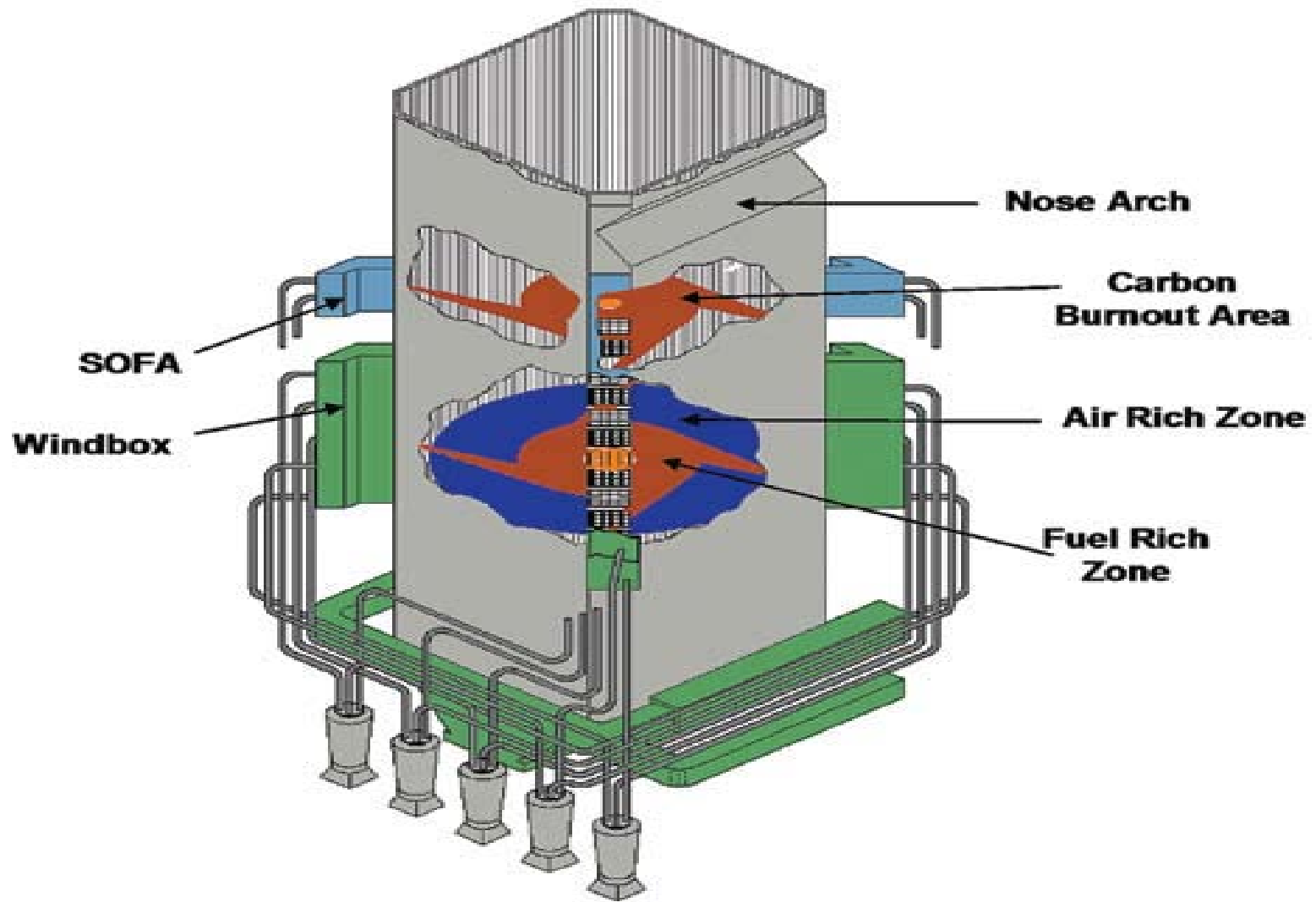
- **Coal line accumulations may cause burner pulsation's, flame instabilities and possible stoppages. Fuel lines are balanced by an iterative process utilizing 10 Gauge carbon steel trial orifices.**
- Clean air balance with a maximum of  $\pm 2\%$  deviation from the mean between all fuel lines on a pulverizer must be achieved. After optimum orifice configuration is determined, permanent hardened 400 Series stainless orifices are installed.
- **Computer modeling is sometimes performed to determine orifice sizing. Following installation of orifices, clean air balance should always been verified by Pitot traverse of fuel lines.**
- Clean air tests by Pitot traverse is also required to ascertain if any fuel line resistance's not shown by drawings are present.
- **High primary airflow can cause poor coal fineness as well as poor fuel balance. Optimum primary airflow depends on the type of pulverizer.**
- Primary airflow should be ramped or ratio ed against fuel flow. Optimum pulverizer airflow in most cases is as follows:

# *Pulverizer Airflow*

- To characterize primary airflow, accurate control and measurement of primary air and fuel must be facilitated. **Load cell gravimetric feeders is the preferred method of fuel flow control.**
- Flow nozzles or venturis usually provide the most accurate and reliable means to measure and control primary airflow. **The venturi and flow nozzle that are frequently recommended .**
- **High primary airflow contributes to poor coal fineness by increasing air velocities in the classifier and reducing overall retention time of coal in the grinding zones.**
- **Increases in primary airflow correlate to an increase in velocities at the classifier outlet of the pulverizer.** Higher velocity air at the classifier outlet has sufficient energy to entrap larger more massive coal particles.
- **Lower velocities allow larger particles to be returned to the grinding zones. Inverted cone clearances, if so equipped, must be correct before optimizing primary airflow.**
- Non-optimum inverted cone clearance can result in pulverizer swings that can cause high motor amperage trips and poor 50 Mesh fineness.

## Additional adverse effects of high primary airflow on unit performance are as follows:

- **Poor flame stability at lower loads and flame ignition points unattached to burner nozzles.** Optimized primary airflow will maintain velocities at the coal nozzle tip within the best range of flame propagation speed for flame stability and improved combustion efficiency.
- **Higher dry gas losses are the result of increased tempering air usage.** Higher air to fuel ratios require lower temperature at the pulverizer inlet to maintain outlet temperature, decreasing the quantity of hot air from Airheaters.
- Increased furnace exit gas temperatures. High primary airflow increases the differential in velocity between the primary air/fuel mixture and the secondary (combustion) air. **This stages or delays combustion that allows a large percentage of heat to be released above the burner belt .**



# Slagging promoted by Low NO x Burners

- It has been observed that when coal with high sulfur and high iron content is fired with non-optimized inputs, excessive slagging occurs in the furnace due to the combination of coal chemistry and secondary combustion.
- The key point to be understood here is that the effect of chemistry kicks in when the ash becomes “sticky” or molten and that happens at a lower temperature with high iron in ash.
- Low-NOx combustion deliberately consumes some of the furnace residence time for staging combustion .
- Consequently, soot blowing is done to remove the slag, which reduces heat transfer. Increased soot blowing increases tube erosion and shortens tube life, suboptimal combustion contributes to reduced plant reliability and availability.

# Impact of High FGET on Combustion

- In units retrofitted with low-NO<sub>x</sub> burners or an OFA system, combustion may be actively occurring higher in the furnace, creating secondary combustion.
- This elevated center of combustion will decrease water wall heat absorption, elevating the peak furnace exit gas temperature (FEGT). High FEGTs lower combustion efficiency .
- Short furnace residence times and the staging of combustion to reduce NO<sub>x</sub> formation at the source, it is clear that combustion efficiency must be maximized in the burner belt.
- High FEGTs can overheat super heater and reheater metals and cause higher-than-optimal de superheating spray water flows (imposing a sizable heat rate penalty).
- Optimizing burner belt performance requires more precise measurement of key boiler performance variables and tighter control of the fuel :air ratio.

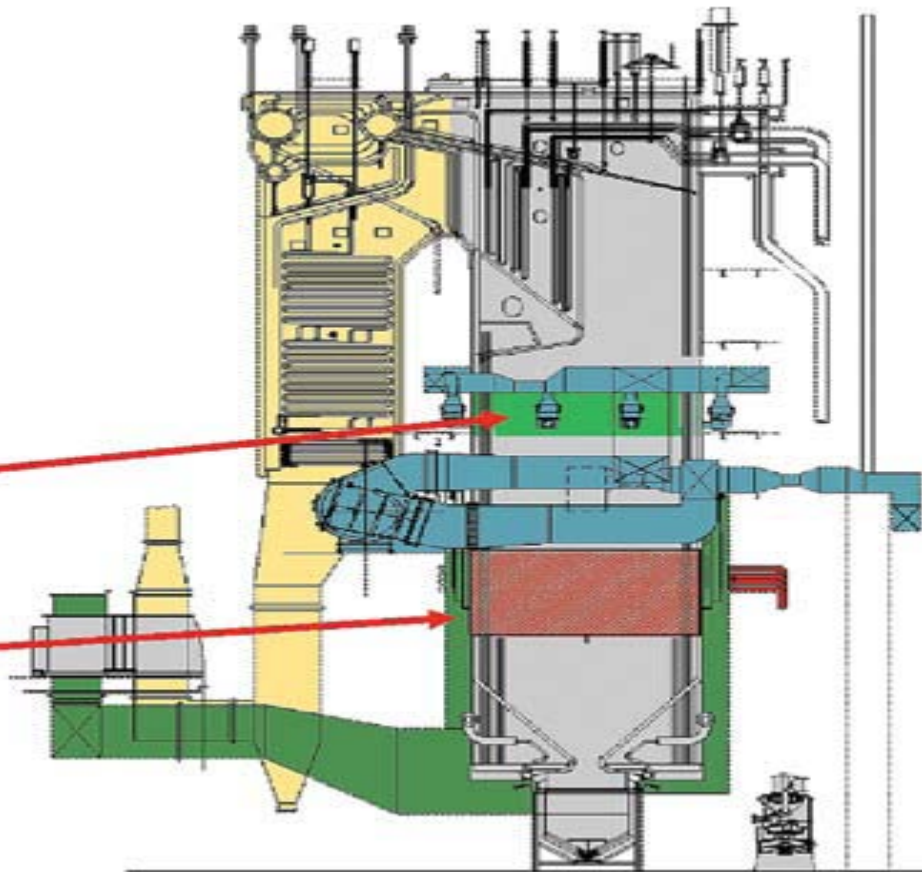
# Focus on firing

- Several significant factors involved in optimizing combustion with low-NO<sub>x</sub> burners are equally applicable to corner-fired and wall-fired boilers.
- In corner-fired boilers, the entire furnace volume can be considered a single burner into which fuel and air are injected from the corners, creating a burning mass in the center.
- The burning mass serves to reduce peak temperatures. Meanwhile, tangential injections from the corners impart “swirl” to the fuel and combustion air at all burners; that creates a more homogeneous mix of the products of combustion for fuel-rich and fuel-lean burners.
- The tangential admission of the fuel and air also slightly increases the residence time of a coal particle, from its introduction into the furnace until its conversion to a burning carbon char particle that is quenched to below 1,400F in the convection pass.
- The “burning mass” principle also reduces the intensity of combustion in the burner belt, lowering “natural” NO<sub>x</sub> levels in the process. Before low-NO<sub>x</sub> burner technology was perfected, corner-fired boilers inherently produced less NO<sub>x</sub> than wall-fired boilers.



*OFA Zone to Complete  
Combustion*  
Stoichiometry = 1.15

*Burner Zone*  
Stoichiometry  $\leq 1.00$



# Wall Fired Boilers

- Wall-fired unit—which has an unforgiving furnace arrangement (furnace division panels and wall-mounted burners) and a relatively short residence time (1 second from the top burners to the nose arch)— validates the potential of using the tenets of combustion optimization .
- Improved fuel fineness, fuel distribution, and combustion air distribution also have contributed to greater unit availability.
- One less well-documented advantage of greater fuel fineness (75% of coal particles pass a 200-mesh screen, and none pass one of 50 mesh) is reduced water wall wastage.
- This type of corrosion becomes more severe on boilers operating at supercritical pressure and firing fuels with high sulfur and iron content.
- Even boilers running at 1,600 to 1,800 psi can have their useful life shortened considerably if their water walls are exposed to highly aggressive fireside corrodents of sulfur and iron in a reducing environment.

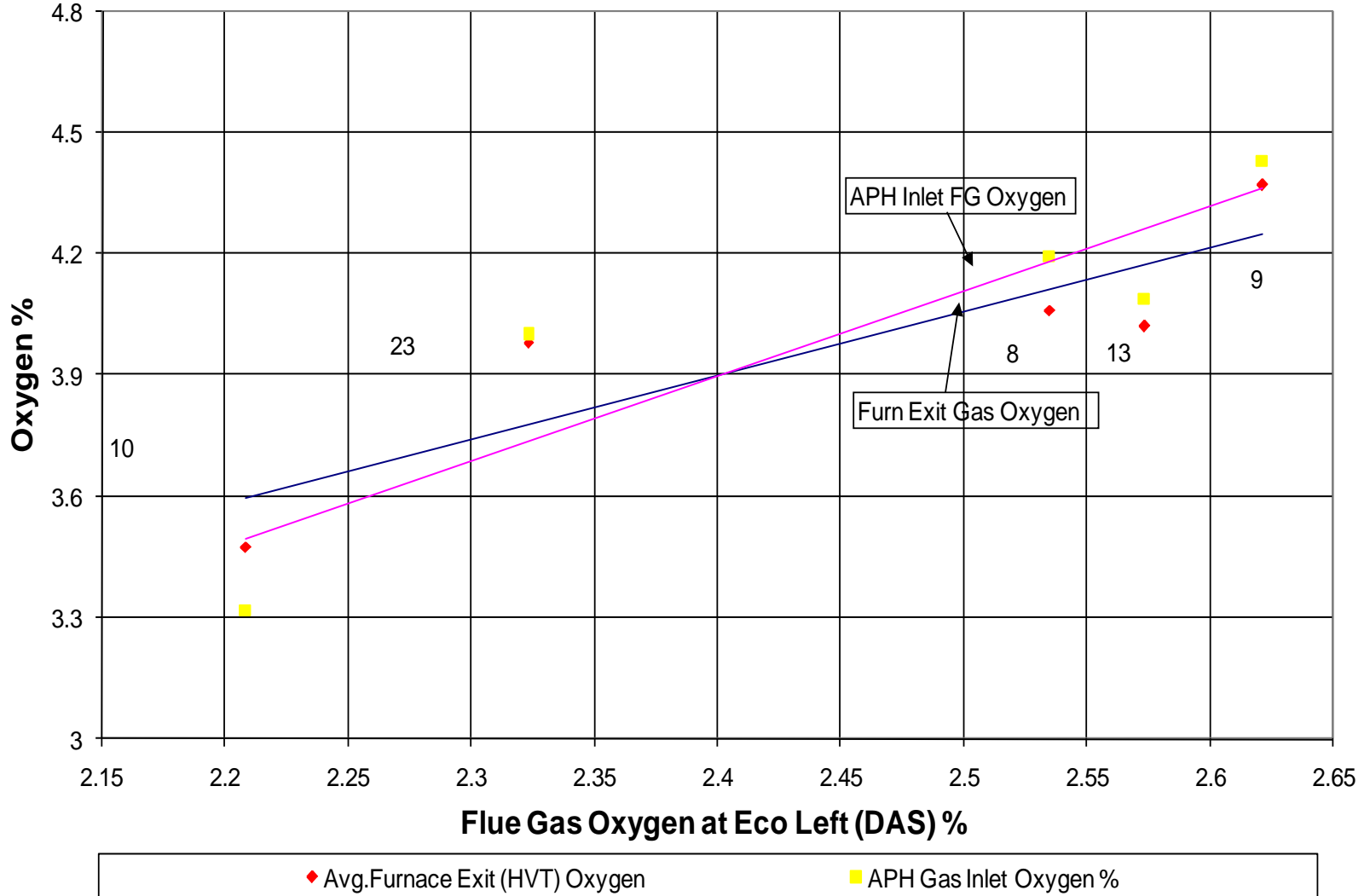
**Reduce Slag Generation.** Flux sensors provide good information about soot and slag buildup, but close attention to combustion analyzers can provide another indication of slag formation. Fly ash fusion temperatures are usually affected by the amount of excess  $O_2$  in the flue gases for a particular coal, and some operators run with an  $O_2$  setpoint that has been established to prevent slag (Figure 5).

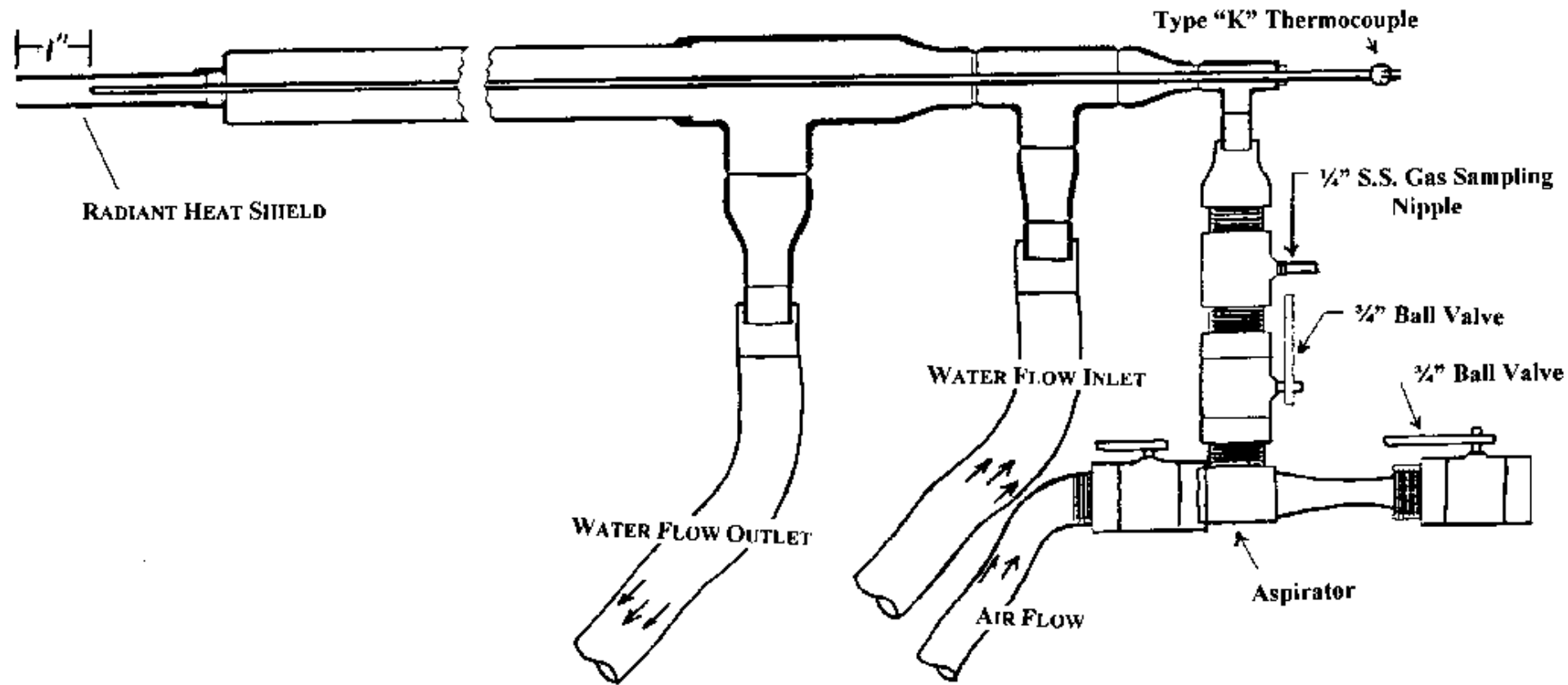


# Instruments for Combustion Optimization

- Plant operators have used combustion flue gas analysis for decades as a method of optimizing boiler combustion fuel/air ratios.
- By measuring the amount of excess oxygen and/or carbon monoxide (CO) in the flue gases, the plant can be tuned to operate at the best heat rate and lowest nitrogen oxide (NO<sub>x</sub>) levels.
- Operation at best efficiency also inherently produces the least amount of carbon dioxide (CO<sub>2</sub>).
- This Power Point presentation covers considerations for sensor selection and placement in the furnace to maximize performance and balance furnace operation.
- The theoretical ideal, or stoichiometric combustion, occurs when all of the fuel is reacted with just the right amount of oxygen in the combustion air so that no fuel is left unburned and no oxygen (O<sub>2</sub>) remains in the flue gas .
- Any air that is not used to combust the fuel is called "excess air."

## Comparision of Flue Gas Oxygen Levels at APH Inlet/HVT with Oxygen at Eco Outlet from DAS (500 MW Unit)





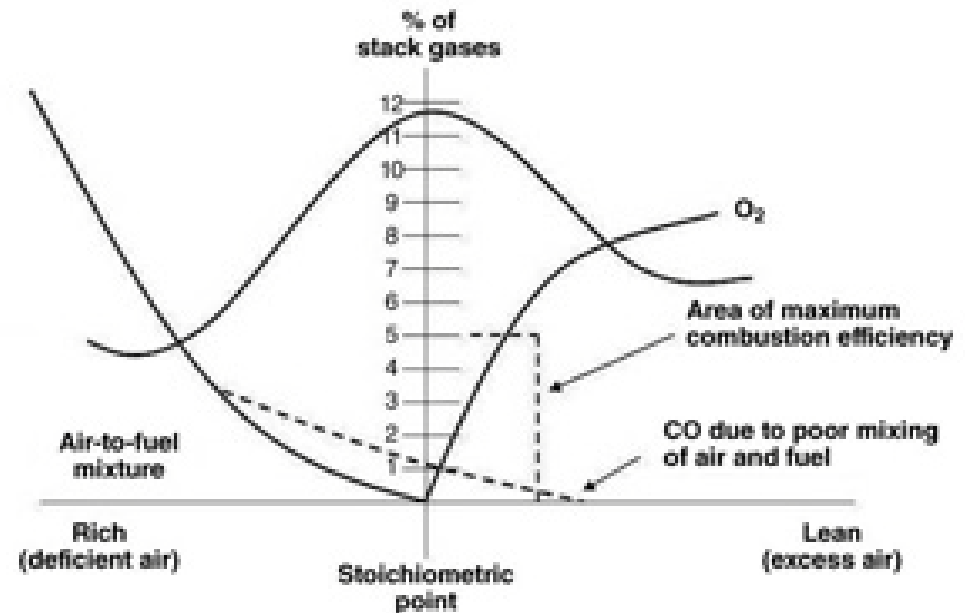
HVT - High Velocity Thermocouple Probe

Operating furnaces never attain this stoichiometric ideal due to the practical limitations of continuously mixing large quantities of fuel and air and burning the mixture to completion .

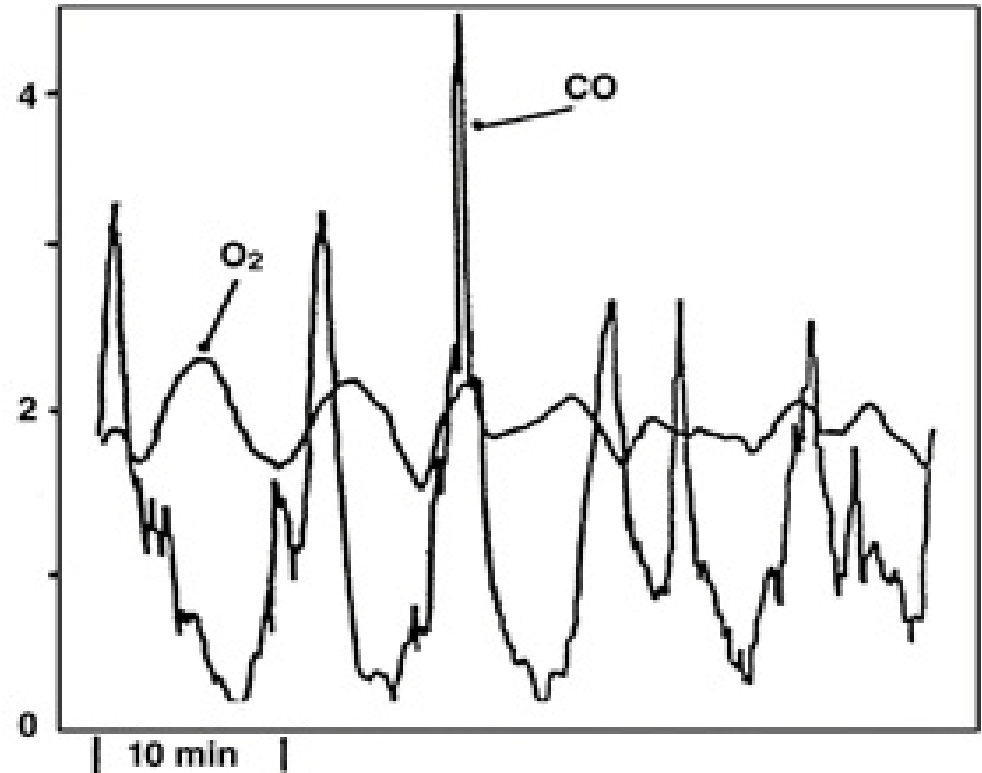
Operators usually find that the best operating point lands in the 1% to 4% excess air range with zero to 200 ppm of CO formed. This optimum operating point is different for every furnace and changes with differing boiler loads and firing rates.

A higher firing rate induces greater turbulence through the burner(s), providing better mixing of fuel and air, thereby leaving less excess air (or  $O_2$ ) before unburned fuel (represented by CO) appears or "breaks through" (Figure 3).

A curve, or function generator is typically developed from test data to assign the ideal  $O_2$  control point based upon an index of firing rate, such as fuel flow or steam flow, which is usually determined during tuning of the boiler controls.



A typical distributed control system (DCS) trend report depicts the relationship of O<sub>2</sub> and CO and indicates a CO breakthrough point.





# Reevaluate Your Combustion Goals

- This ideal curve should be reestablished from time to time as burners wear and other furnace conditions change over time. The curve for burners using natural gas and light oil fuels will tend to remain valid for long periods of time—even years.
- Burners firing solid fuels such as coal, petroleum coke, or pelletized biofuels will experience more frequent plugage and other degradation of the burners and fuel delivery systems and will benefit from more frequent testing to confirm the firing rate/O<sub>2</sub> curve.
- Large furnace operators will typically dynamically control excess oxygen to the optimal level using the plant distributed control system (DCS). Control of CO is more difficult because target levels are usually in the parts per million range, and making fan or damper adjustments small enough to control at these low levels is difficult.
- Many operators will make manual adjustments based upon the CO signal or use the measurement as a feed forward signal to adjust the O<sub>2</sub> control set point upward or downward.
- The traditional goal of striving for the best boiler combustion efficiency often must be reevaluated when NO<sub>x</sub> production rises and slag begins to form on the boiler tubes.

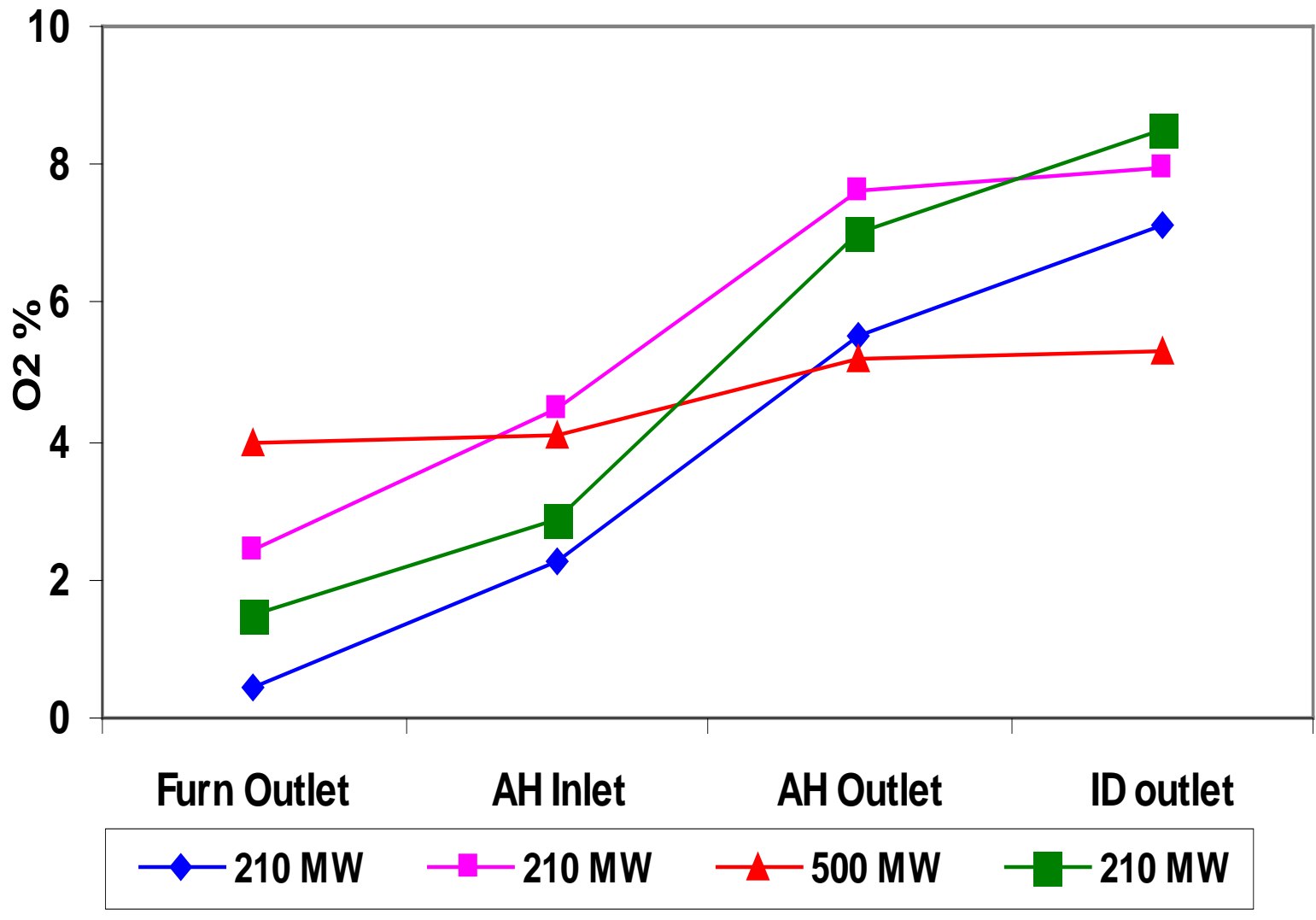
# Boiler Furnace Performance assessment using HVT probe

Boiler Furnace Performance assessed using HVT probe to diagnose heat transfer degradation, excess air levels and slagging propensity.

Oxygen Values at some stations:

	<u>Furnace outlet</u>	<u>AH Inlet UCB Test Grid</u>	<u>Diff. between AH Inlet HVT/AH Inlet</u>	
500 MW	4.0 %	4.0%	2.5 %	0.0
200 MW	2.0 %	3.5 %	3.5 %	1.5
210MW-WR	2.5 %	2.5 %	2.5 %	0.0
210 MW-NR	2.45%	4.45%	3.8 %	-2.0
210 MW-SR	3.35%	4.5 %	4.35 %	-1.50

# Oxygen % at various locations in boiler



## BOILER TUNING AND COMBUSTION OPTIMIZATION

Many boilers are simply not equipped with monitoring and control systems capable of achieving optimum operation. An array of operational tests are conducted to establish spatial [gaseous analysis](#) to flyash carbon analysis in order to closely monitor boiler operation. A test matrix varying applicable operating parameters such as primary air , Fuel air damper, burner tilt, excess O<sub>2</sub>, and burners in service, is devised and performed.

Through analysis of the collected data, we can determine settings for optimum operation under various conditions.

## **Correcting Existing Final Stoichiometric Imbalances**

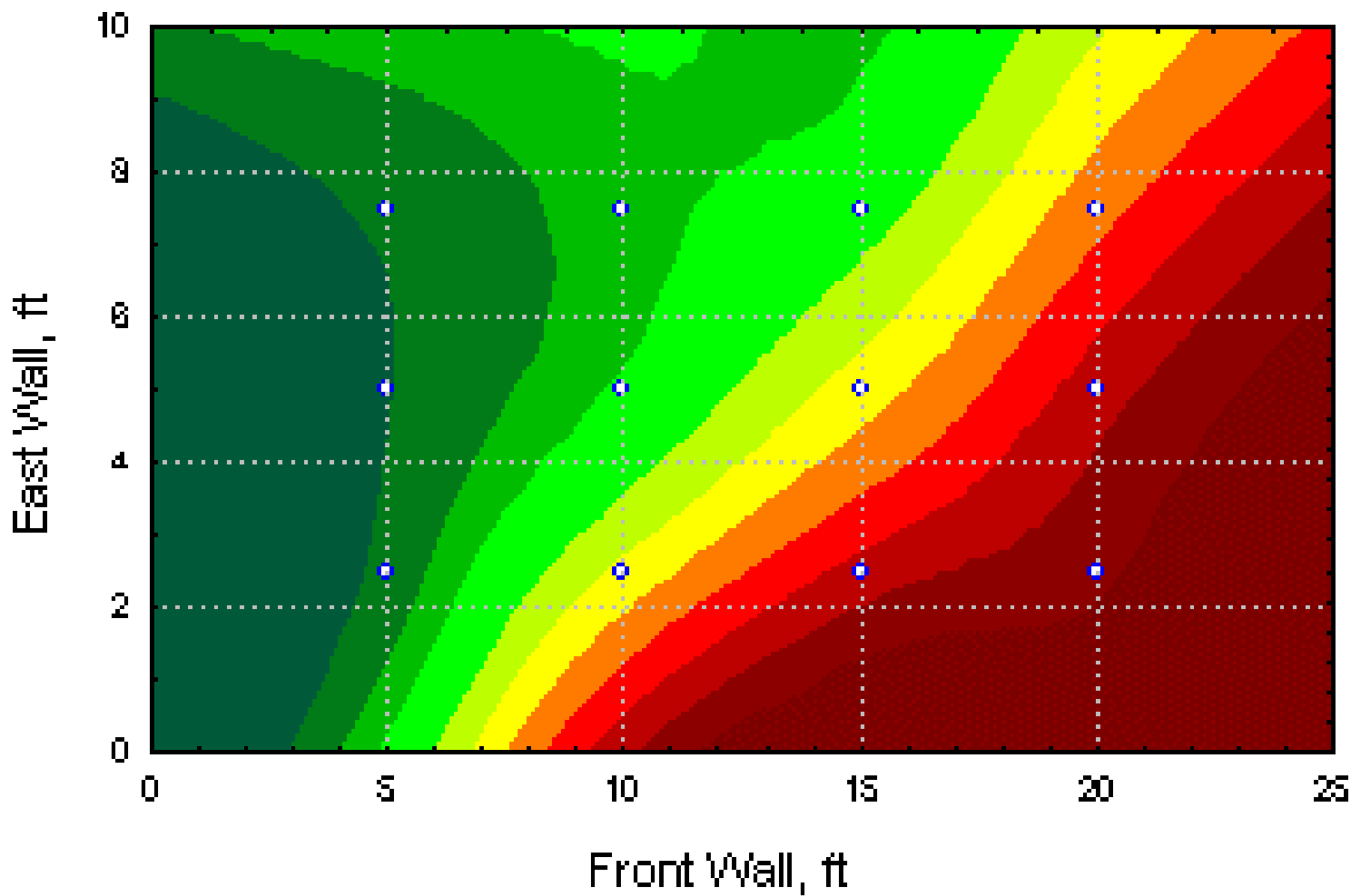
Local fuel-air imbalances can occur for a number of reasons including windbox restrictions, overfire air duct restrictions or limited port placement, and fuel distribution problems.

When operating with reduced excess air these imbalances are revealed by local carbon monoxide (CO) formation.

These local CO areas can be significant and affect the average of the entire furnace. A correction in combustion of these local CO spikes can allow reduction of excess air improving emissions and efficiency.

The graphics below show an example of data collected from the economizer outlet plane of a wall-fired unit. The grid measurement shows how the a pocket of high CO effected the overall unit emissions and how elimination of the localized imbalanced improved overall unit emissions.

CO (ppm 3% O<sub>2</sub>) at Economizer Exit



## Typical % Oxygen / CO in flue gas across AH Inlet ducts (Test 3 data)

Average values of Oxygen in flue gas obtained in the sampling grid at AH A and B Inlet in Test 3

	A	B	C	D	E	F
1	3.46	3.06	1.72	0.60	0.56	1.05
2	2.96	3.61	3.39	0.97	1.10	1.22
3	3.15	2.90	3.13	1.11	1.30	1.82

Air heater A - Zirconia average - 1.2 %

	A	B	C	D	E	F
1	1.98	2.10	2.87	2.52	3.12	XXX
2	3.18	2.38	2.66	3.25	3.00	XXX
3	2.66	2.55	2.67	3.02	3.08	XXX

Air heater B - Zirconia average - 2.7 %

Average values of CO in flue gas obtained in the sampling grid at AH A and B Inlet in Test 3

	A	B	C	D	E	F
1	2973	2563	2882	2495	2536	1734
2	2485	2104	2498	1990	1902	976
3	2361	2289	1976	2063	1982	1064

Air heater A - CO average - 2159 ppm

	A	B	C	D	E	F
1	220	187	119	75	142	XXX
2	124	105	53	62	181	XXX
3	101	98	111	194	60	XXX

Air heater B - CO average - 122 ppm

## OXYGEN SET POINT TO BE REPRESENTATIVE OF DUCT CONDITIONS & CONDITIONS IN THE FURNACE

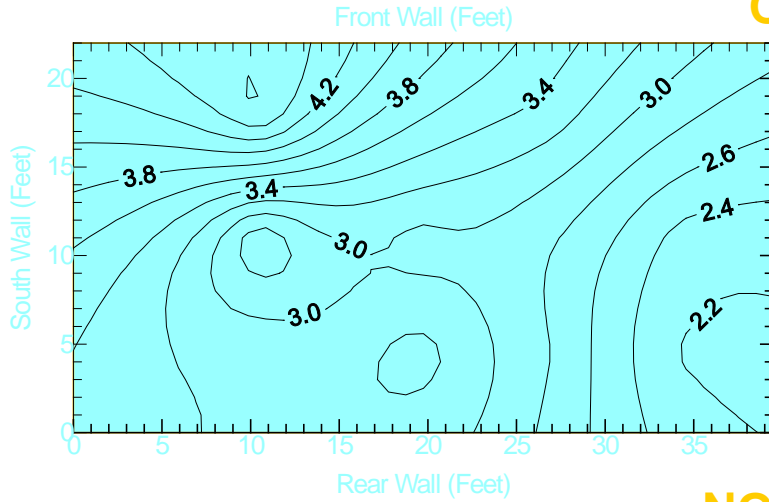
- Oxygen as measured On line using ‘Zirconia Probes” should represent the process.
- Left & right difference of Oxygen value could be a realistic statement and not instrument error.
- No of Zirconia probes to be increased to improve the reliability of feedback. Probes provided at AH outlet to work out on line leakage.



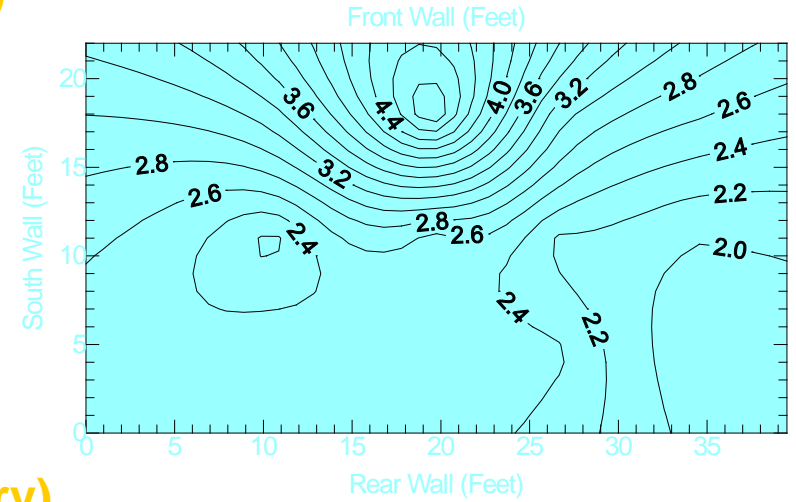
# IMPROVEMENT 375 MW UNIT

**Before**

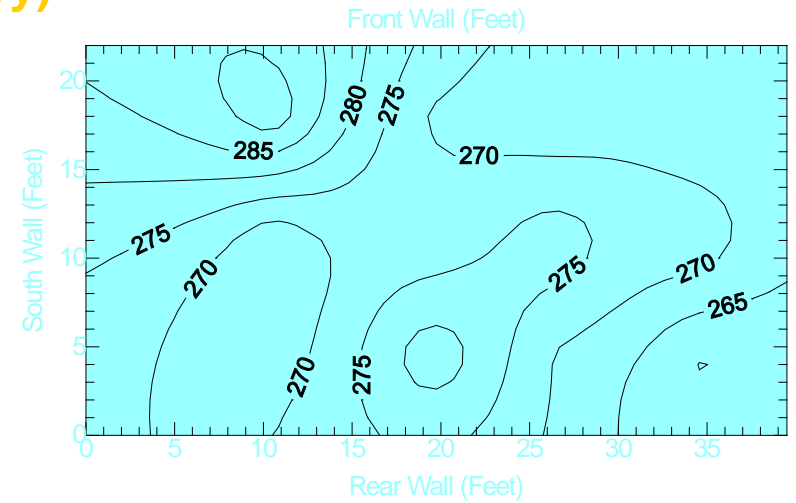
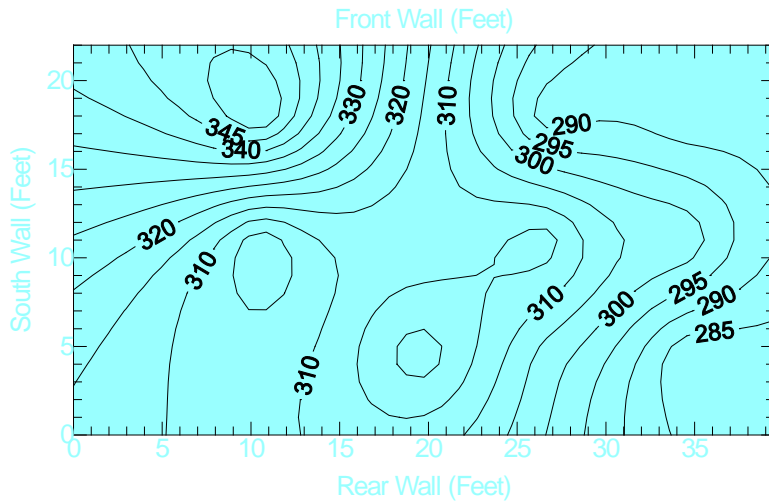
**O<sub>2</sub> (% , dry)**



**After**



**NO (ppm<sub>c</sub>, dry)**



# Boiler Performance Optimization

- To evolve an **optimum operating regime** for a boiler; a set of operating parameters and equipment settings for safe, reliable and efficient operation.
- To establish **interrelationships** between different operating parameters.
- 6 to 11 test runs are conducted using accurate Off-line instruments used as per ASME test code.
- To build a **database** by various parametric tests; a repeatable database for problem solving and diagnosis.

## Boiler Performance Optimization a must to reduce CO<sub>2</sub> emissions in coal fired plants

*Boiler performance optimization regime was worked out and its effectiveness demonstrated at various stations.*

Station	Nominal O <sub>2</sub> %	Optimum O <sub>2</sub> %	Eff.Imp %	HR Imp. kcal/kWh (approx.)
210 MW -WR	3.8	2.5	0.3	8
210 MW	3.8	3.8	0.3	8
67.5 MW	3.5	2.4	0.4	10
210 MW-SR	3.8	0.8	- 2.54	\$
210 MW -NR	3.8	2.25	0.65	17

\$ Loss in boiler efficiency on account of operation at lower level of oxygen as compared to a rated value.

## Typical Optimum Combustion Regime

Unit load	205 MW
Main steam flow	640-650 T/hr
Total air flow	880 to 890 T/hr
Control room O <sub>2</sub> %	5.5%
PA header Pressure	740 mmWC
W B Pressure	100 mmWC
Fuel air damper	closed
AA dampers	10 % open
Burner tilt	-20 degree.