

Reinhold Environmental Ltd.



2008 NO_x-Combustion Round
Table & Expo Presentation

February 4-5, 2008 in Richmond, VA

CoalCONTROL™ – EMISSIONS REDUCTION THROUGH BURNER BALANCING



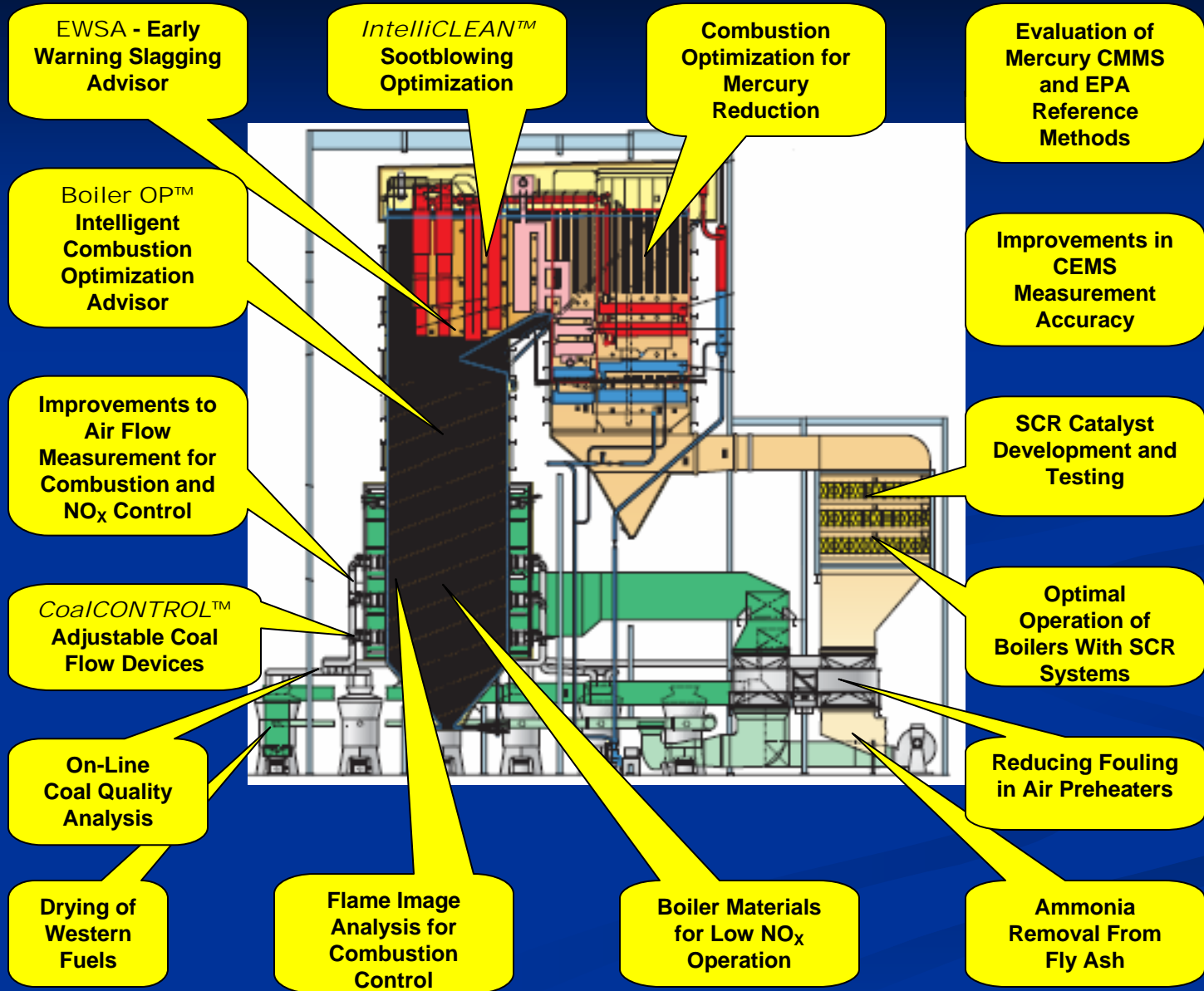
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WHO ARE WE?

- The ERC was established in 1973 to provide solutions to the Nation's energy problems. The Center has over 20 faculty, professional staff, graduate and undergraduate students affiliated with our programs.
- The ERC staff collaborates with faculty and professional staff from the colleges of:
 - Engineering and Applied Sciences
 - Arts and Sciences
 - Business and Economics
- ERC research programs are oriented toward energy efficiency, unit availability, and emissions reduction. The programs include both fundamental and applied research.

FOSSIL FUEL-FIRED BOILER PROJECTS AREAS



REASONS FOR COAL-FLOW BALANCING

❑ Improved Performance and Reduced Emissions

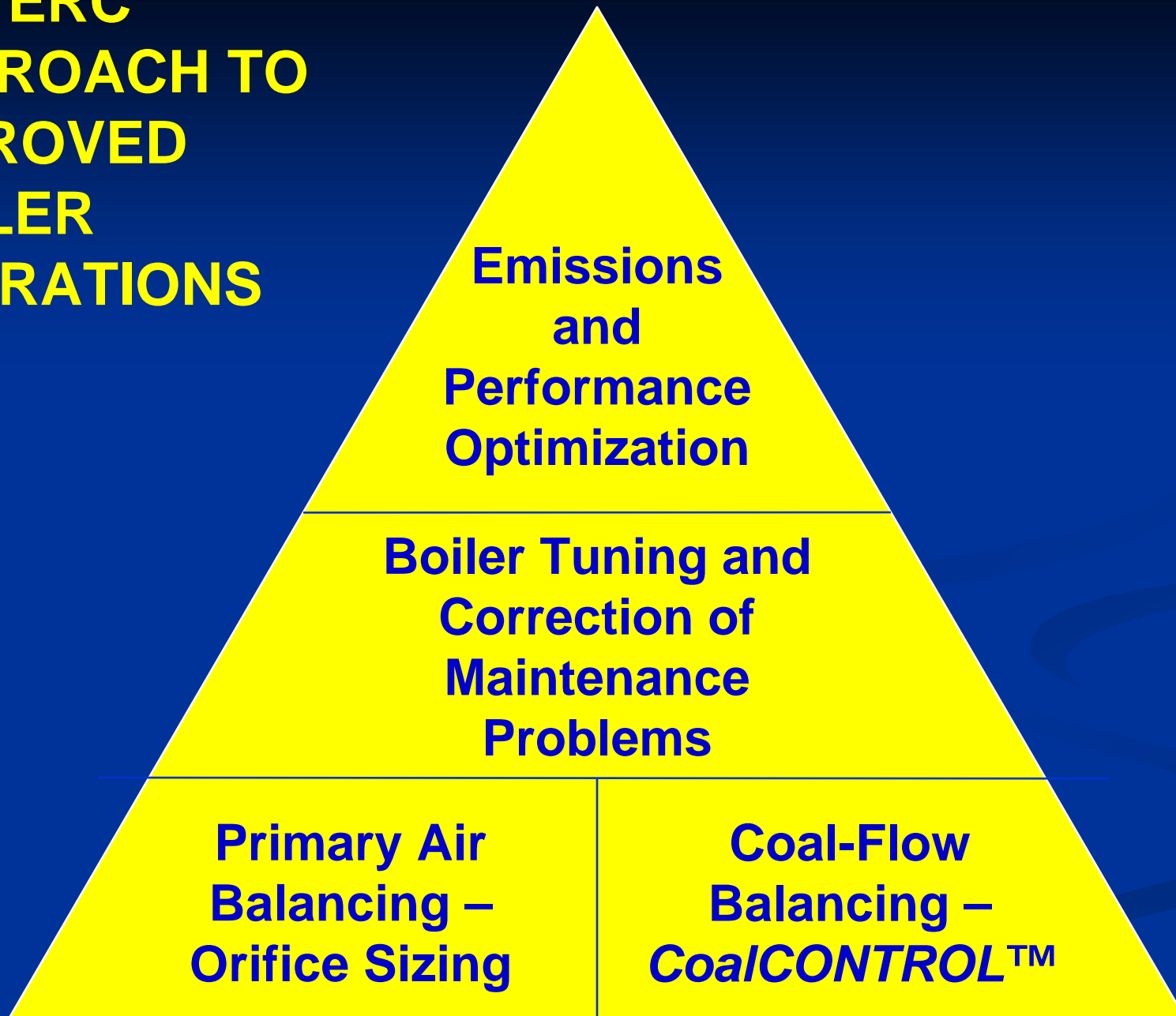
- Reduced Unburned Carbon
- Lower CO
- Improved Steam Temperature Control
- Lower NO_x
- Improved ESP Performance

❑ Reduced Maintenance Costs

- Lower Coal Pipe Erosion
- Less Coal Pipe Plugging - Windbox Fires
- Reduced Slag Buildup and Damage to Burner Tips
- Reduced Localized Slagging and Waterwall Wastage



**THE ERC
APPROACH TO
IMPROVED
BOILER
OPERATIONS**



TYPICAL CoalCONTROL™

PROJECT STEPS

- ❑ Evaluate rifflers and burner lines.
- ❑ Perform unit performance and emissions baselining.
Measure coal and PA flow imbalances.
 - Check measurement or collection location.
 - Review sample collection method.
 - Interpret data.
- ❑ Balance PA flow as needed.
- ❑ Design and fabricate *CoalCONTROL™* devices.
- ❑ Install and test *CoalCONTROL™*.
- ❑ Provide combustion tuning after installation.

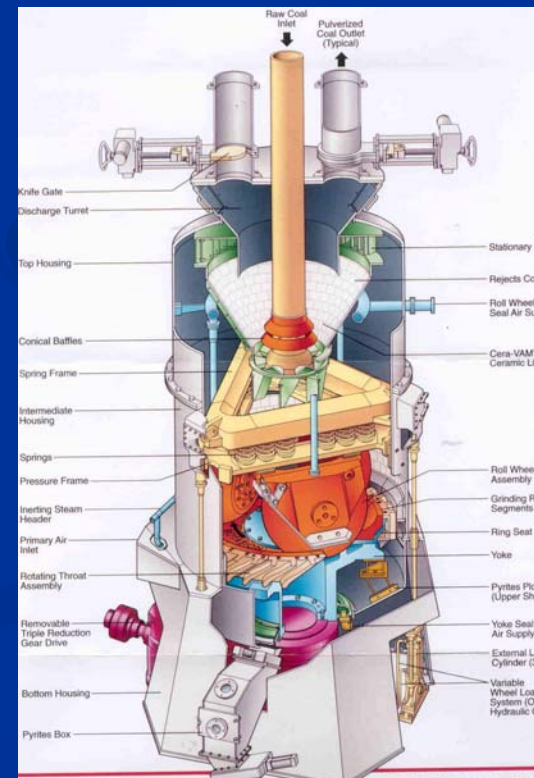
COAL-FLOW BALANCING

USES OF *CoalCONTROL*[™] FOR COMBUSTION IMPROVEMENTS

- ❑ Balanced coal flow may not be best for optimum combustion. Optimal burner stoichiometry should be the objective.
- ❑ Adjust combustion stoichiometry at the burner tip according to:
 - Coal flow measurements.
 - Flame characteristics.
- ❑ Eliminate problems with individual burner air/fuel control:
 - Fuel Rich – High CO, LOI, and Longer Flames
 - Fuel Lean – High Flame Temperature at Burner Tip
 - High Thermal NO_x

CoalCONTROL™ DESIGNS

- ❑ Current design is for mills with 2, 3, and 4-way pipe splits.
 - Coal distribution is heavily affected by inlet maldistribution.
 - Riffles are used to improve coal flow distribution.
- ❑ Design in progress for pressurized vertical spindle mills
 - CFD modeling completed
 - Laboratory testing completed
 - Prototype field test in 2008



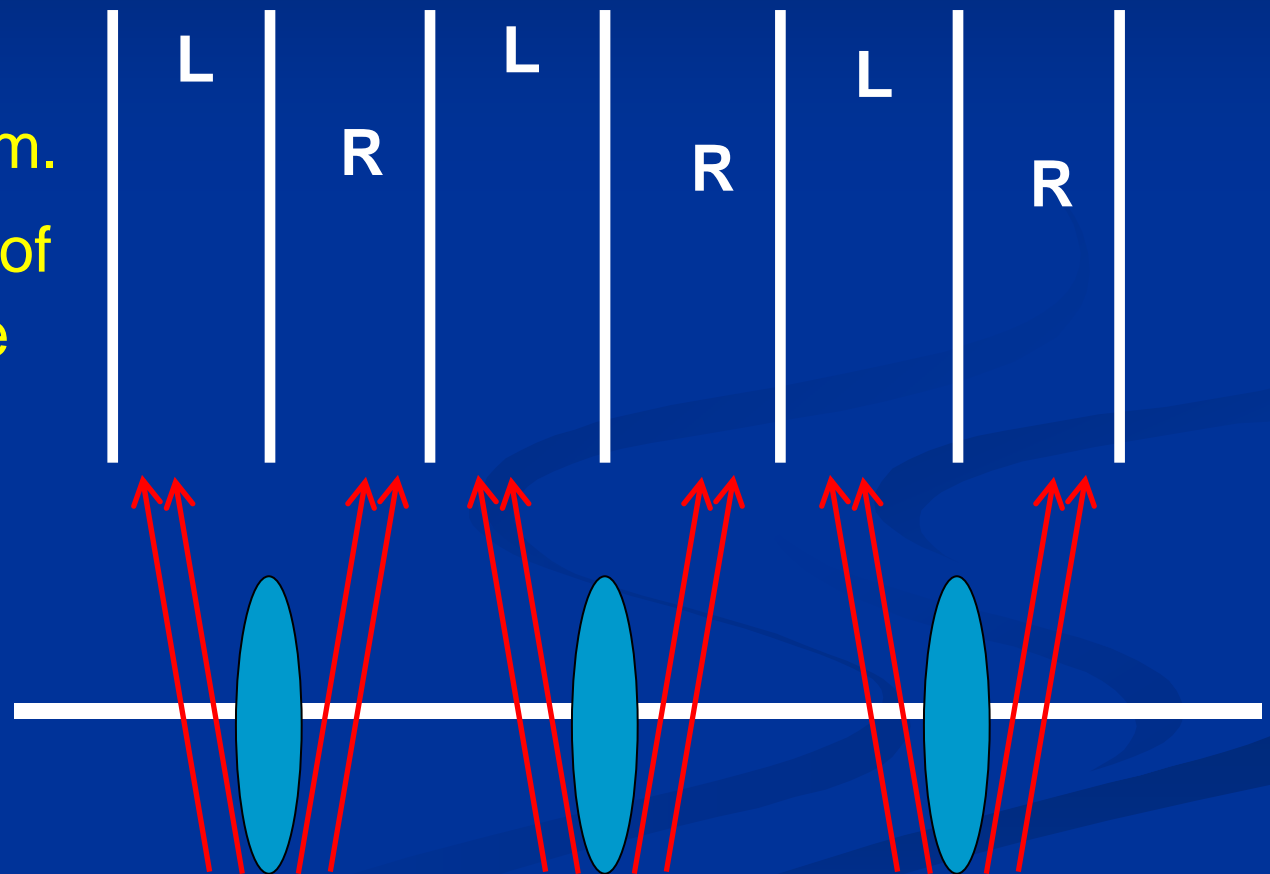
CoalCONTROL™ TECHNOLOGY FOR PIPES WITH SPLITS

- Dynamic coal flow control for two , three , and four-way splitters
- Negligible effect on Primary Air (PA) flow distribution
- Negligible additional pressure drop to existing systems
- Resistance to solid particle erosion
- Easy retrofit and cost effective
- U.S. patent Numbers: 6,789,488 and 6,966,508

CoalCONTROL™
HOW DOES IT WORK ?

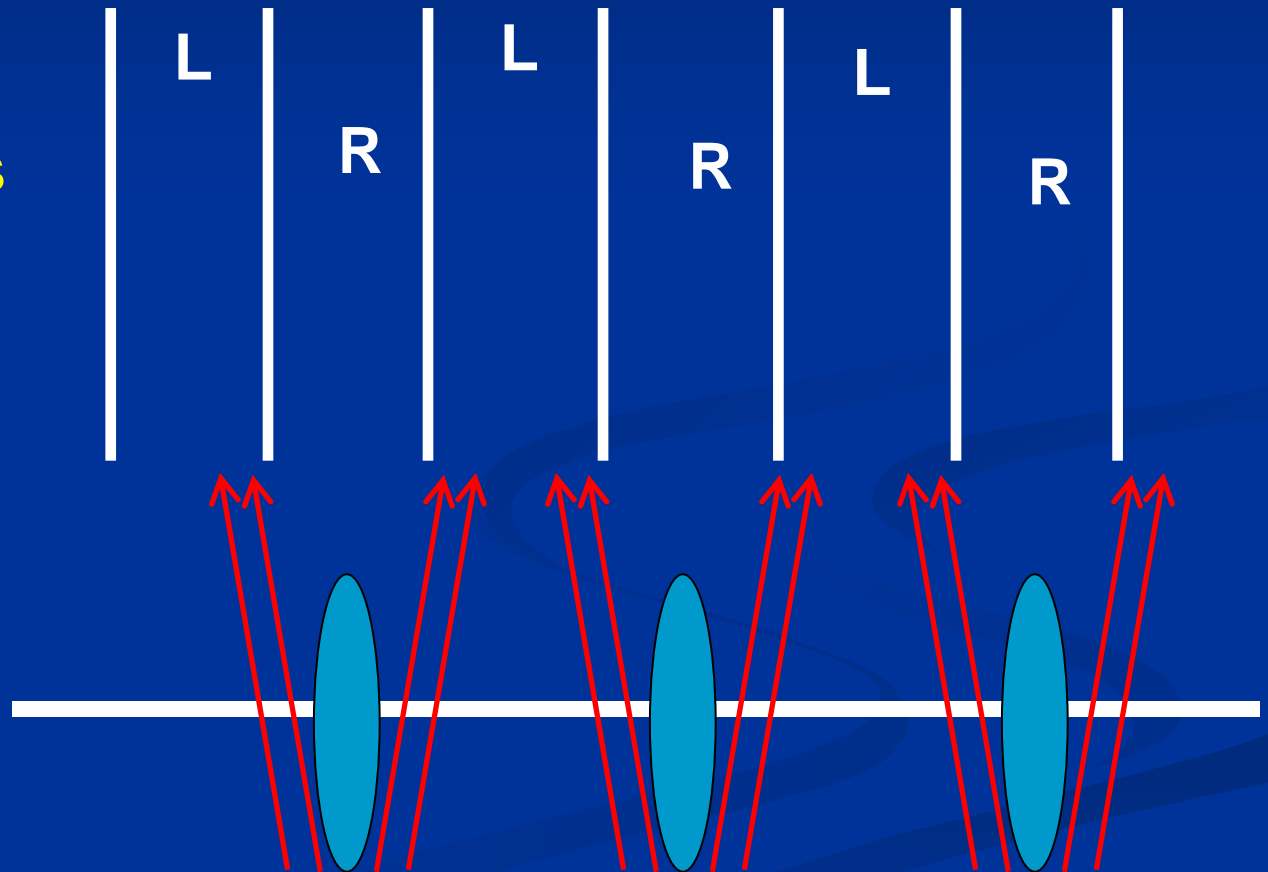
COAL FLOW BALANCING RESULTS WITH *CoalCONTROL*TM – Neutral Position

- ❑ Adds a streamline body into the coal/air flow stream.
- ❑ Takes advantage of two-phase particle flow.
 - Air phase will flow along the body without separation.
 - Coal phase will separate from the body.



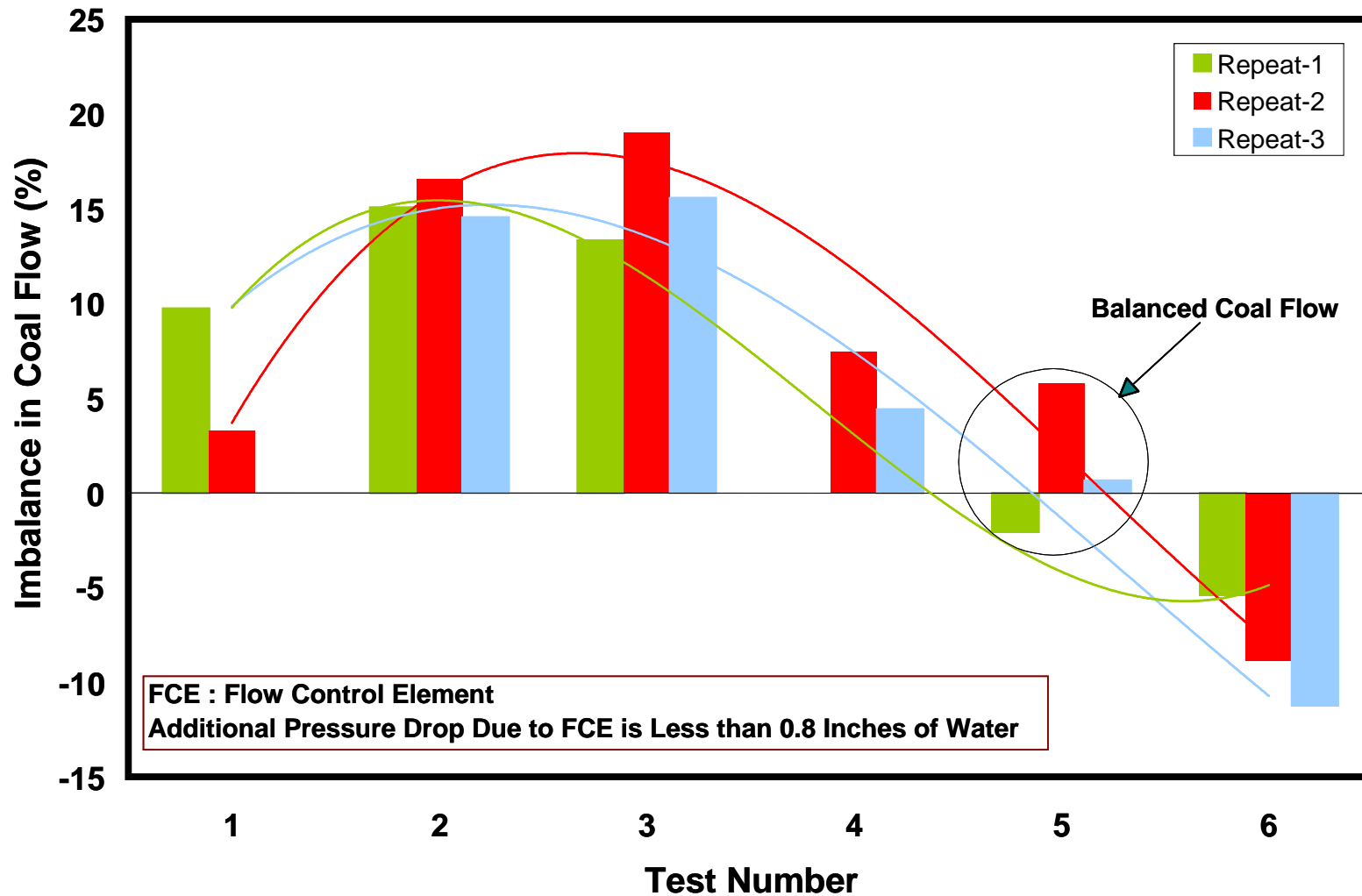
COAL FLOW BALANCING RESULTS WITH *CoalCONTROL*TM – Left Position

- ❑ Moving the streamline bodies changes the coal flow distribution.
- ❑ Changes in position doesn't affect the primary air distribution.



CONTROLLABILITY OF *CoalCONTROL*TM

COAL FLOW IMBALANCES AS A FUNCTION OF FCE POSITION TWO-WAY SPLITTER



FIELD TEST RESULTS

CoalCONTROL™ - 51 INSTALLATIONS

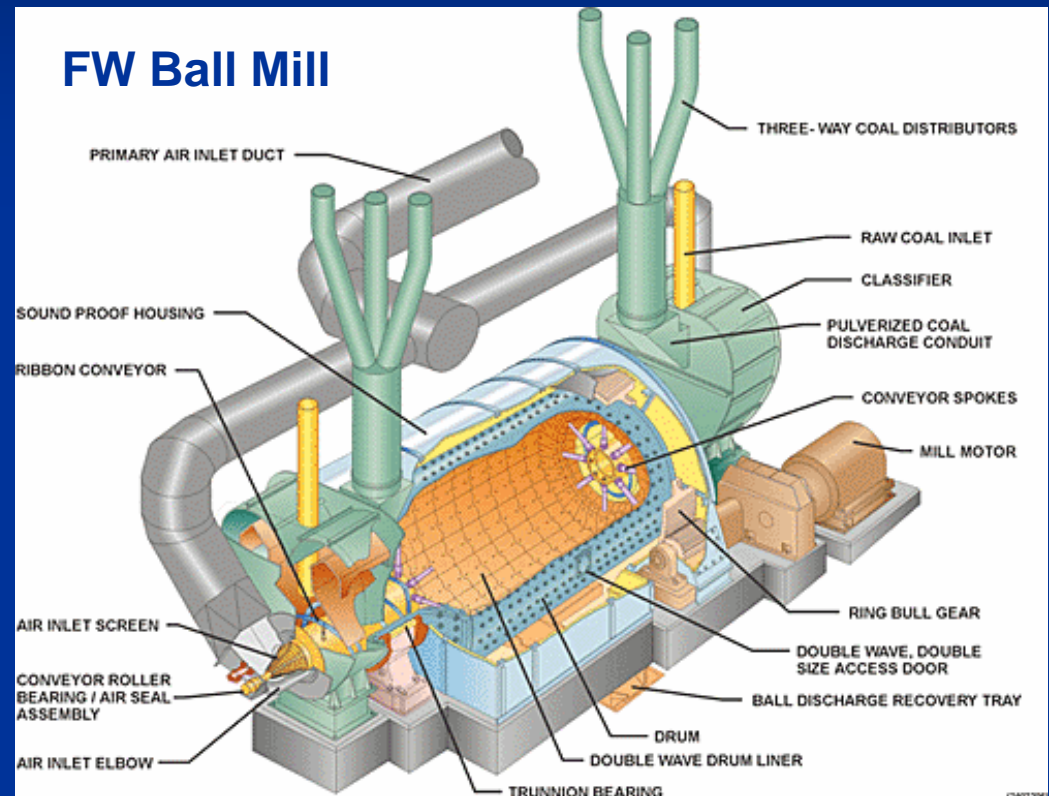
STATION	CoalCONTROL™ CONFIGURATION	COAL IMBALANCE, %		OBJECTIVES (SITE SPECIFIC)
		Before	After	
FirstEnergy Sammis Plant Unit 3	One 3-Way Controller	+14% to +17%	±4%	First Full-Scale Demonstration
Cogentrix Logan Station Unit 1	Four 3-Way Controllers and Riffles	+50% to -30%	±5%	CO, NO_x and LOI
WE Energy Presque Isle Units 5&6 (Babcock Power)	Eight 2-Way Controllers	No Data	No Data	Reduction in LOI
New Energy Corporation (Babcock Power)	Two 2-Way Controllers	No Data	No Data	No Data
Smurfit Stone Container (Babcock Power)	One 2-Way Controllers	No Data	No Data	No Data
PPG Industries (Babcock Power)	Three 2-Way Controllers	No Data	No Data	No Data
New Installation – Shipping in April 2008 (Babcock Power)	Sixteen 2-Way Controllers	No Data	No Data	No Data
PSEG Mercer Station Unit 2	Two 4-Way Controllers and Riffles	25/25/25/25	Target: 20/30/30/20 Actual: 22/27/28/23	Heat Input Distribution
AES Beaver Valley Unit 4	Two 3-Way Controllers and Riffles	+22% to -29%	±8%	Reduction in LOI
Conectiv Edge Moor Station Unit 3	Twelve 2-Way Controllers	+33% to -26%	±8%	Low NO_x Burner Retrofit

LOGAN GENERATING STATION



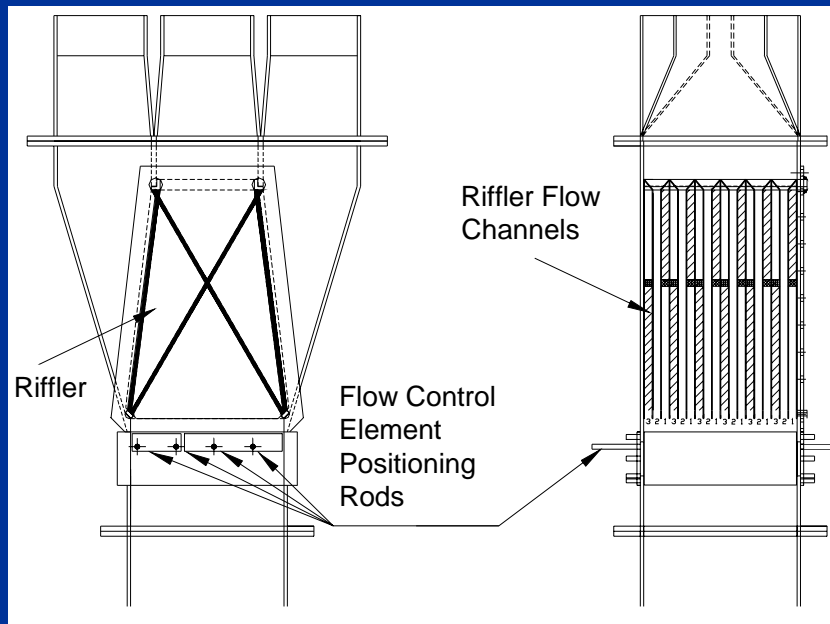
PROJECT SCOPE

- ❑ **Four 3-Way CoalCONTROL™** systems were designed, fabricated and installed on the Logan Generating Station's 245 MW front wall-fired unit.
- ❑ The **CoalCONTROL™** systems replaced the existing 3-way coal distribution splits on the Foster Wheeler (FW) horizontal ball mills.



CoalCONTROL™ DESIGN AND FABRICATION

- ❑ The ERC designed a combined coal-flow controller and riffler assembly.
- ❑ Resistance to solid particle erosion was provided using Tungsten Carbide (WC) material.



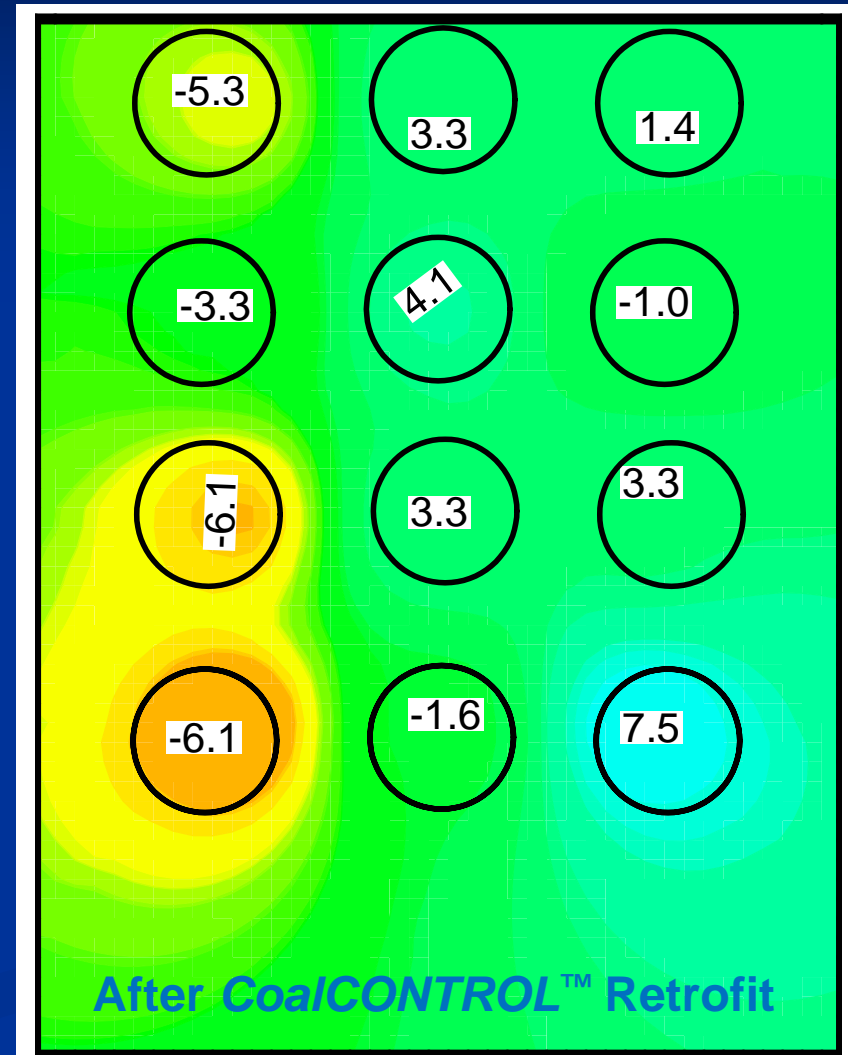
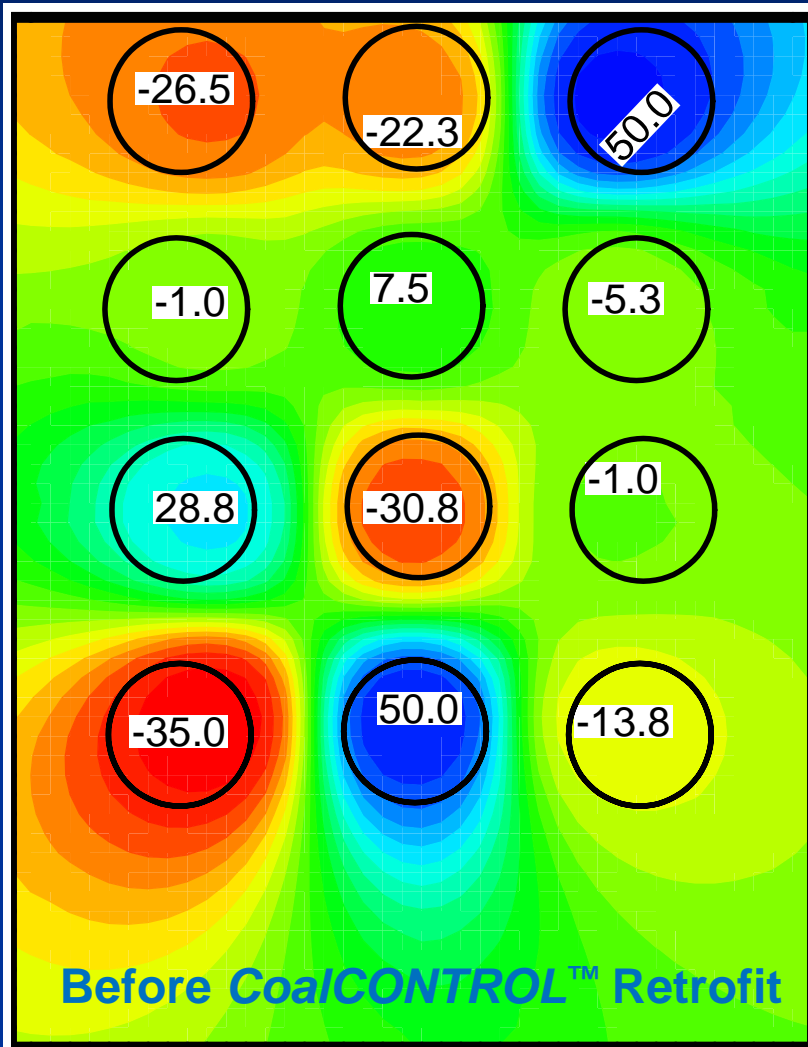
FIELD RESULTS

The following were observed and measured improvements:

- ❑ Reduction in Fly ash LOI
- ❑ Reduction in CO emissions
- ❑ Reduction in SCR Ammonia injection rate
- ❑ More stable unit operations

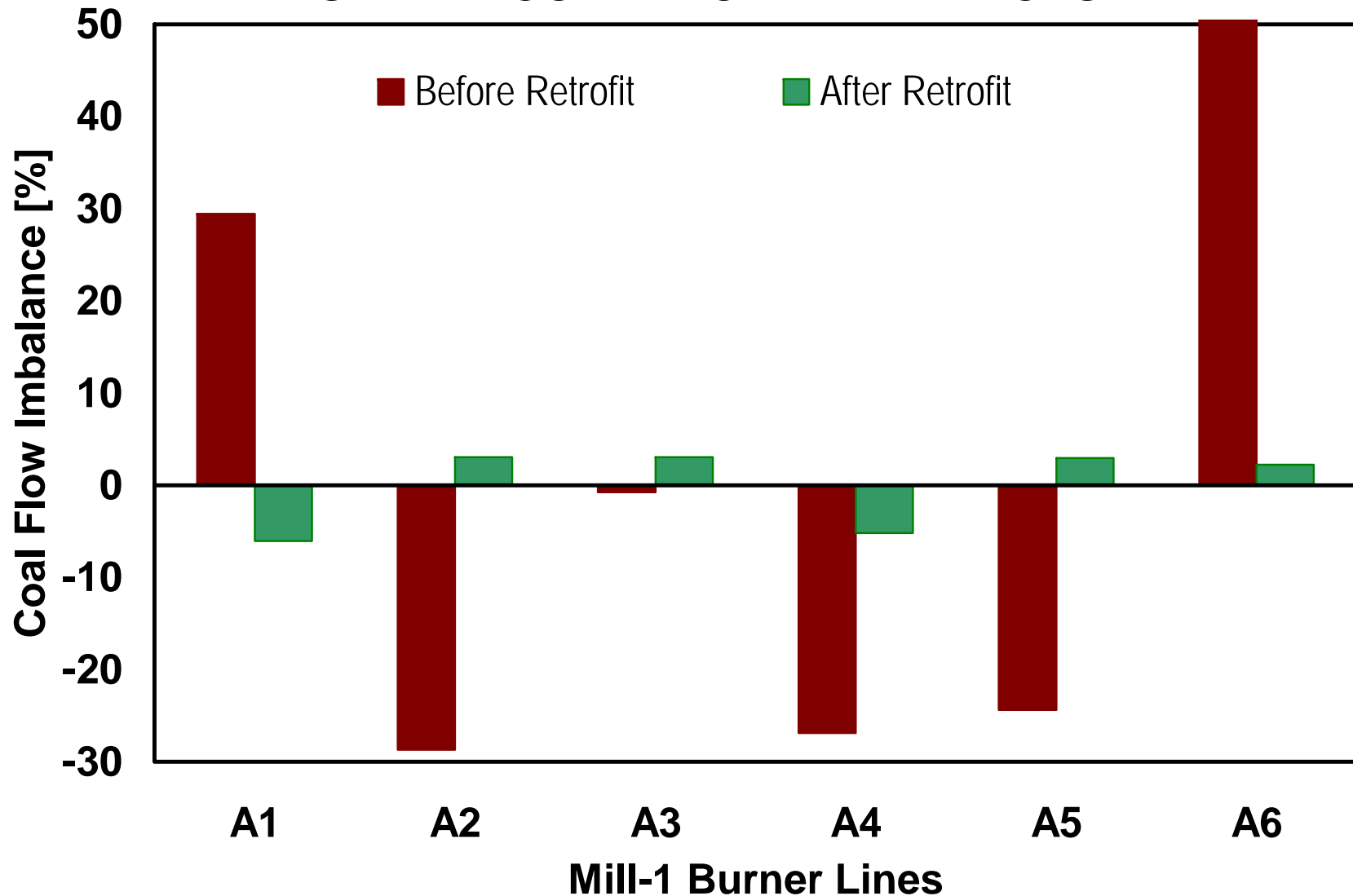


IMPROVED COAL FLOW DISTRIBUTION WITH *CoalCONTROL*[™]



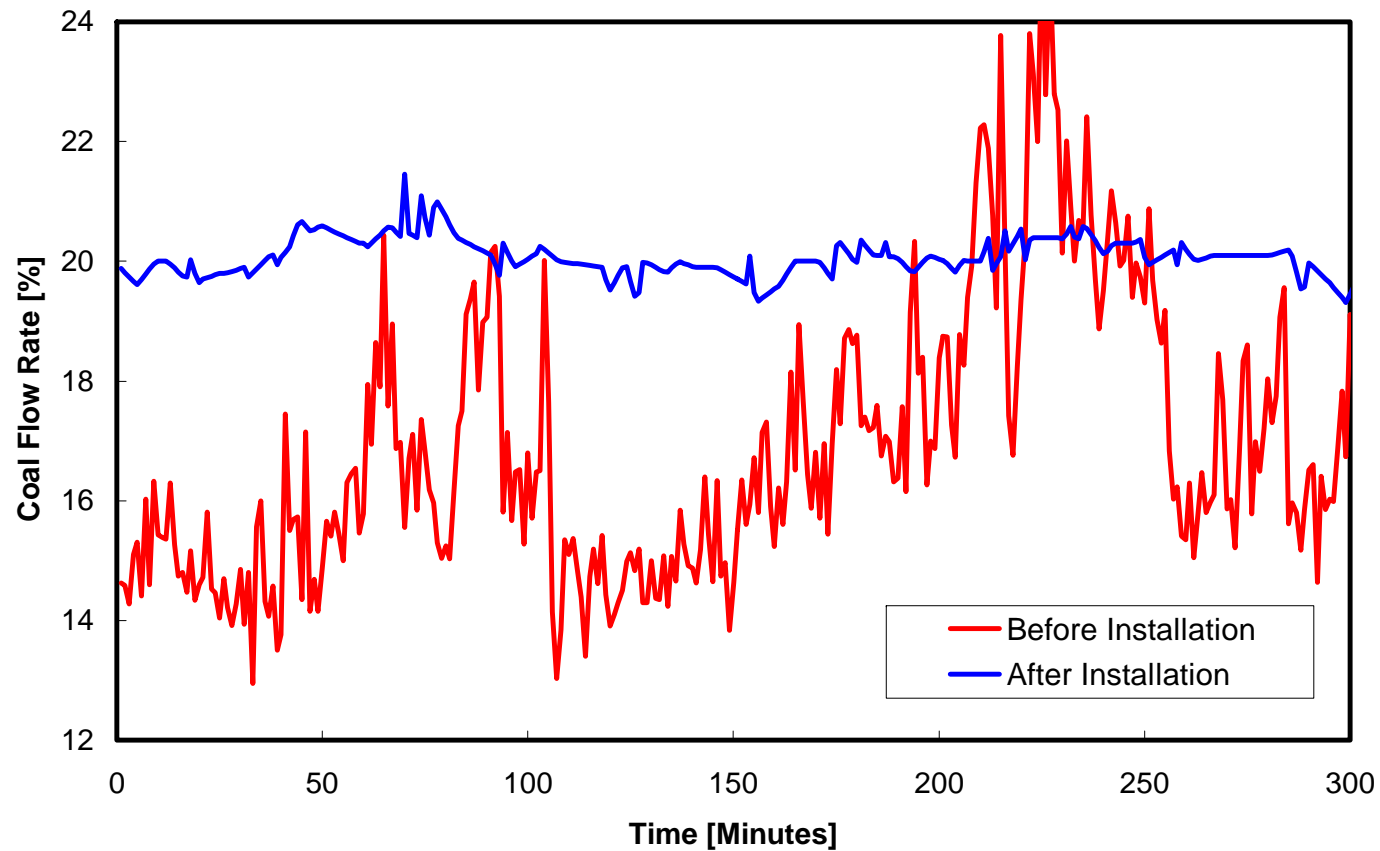
COAL BALANCE IMPROVEMENT USING *CoalCONTROL*TM – MILL 1

UNIT A - COAL FLOW IMBALANCES



STABLE COAL FLOW CONTROL WITH *CoalCONTROL*TM

Coal Flow Variations in Burner B2
Before and After Lehigh Coal Flow Mechanism
Installation



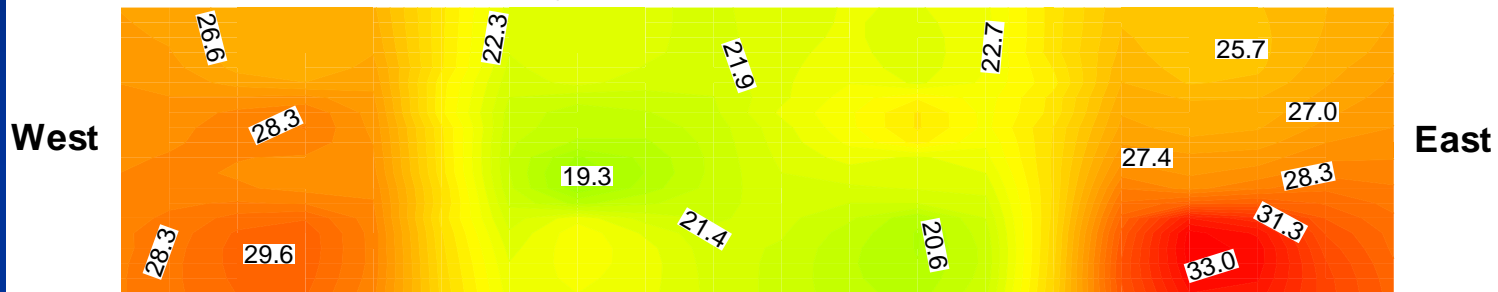
REDUCTION IN LOI LEVEL IN FLY ASH WITH *CoalCONTROL*TM

Fly Ash LOI Distribution - Before May 2004 Outage
(Before Riffler Retrofit)

Average O2 = 5.3 Percent

Average LOI = 25 percent

Ammonia Injection Rate = 104 Gph

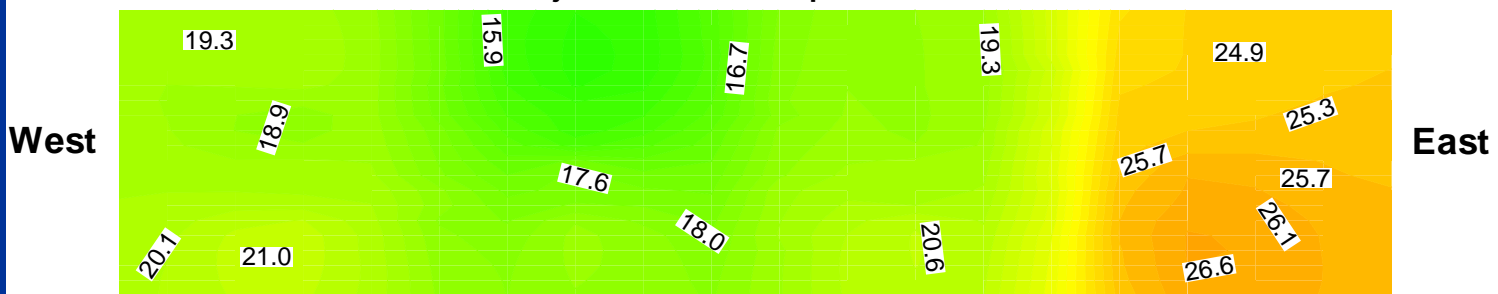


Fly Ash LOI Distribution - After May 2004 Outage
(After Riffler Retrofit)

Average O2 = 4.6 Percent

Average LOI = 20 percent

Ammonia Injection Rate = 80 Gph



CoalCONTROL™ BENEFITS SUMMARY

Description	Units	Before Retrofit	After Retrofit	Difference (%)
Net Electrical Generation	MW	240.5	243.6	1.27
Average Flue Gas O ₂ (Grid)	%	3.68	3.09	-0.59
Ammonia Inlet Flow	gph	106.84	88.04	-21.36
Stack NO _x	ppm	83.26	78.86	-5.58
CEMS CO Monitor	ppm	86.21	76.68	-12.43
Heat Rate	Btu/kWh	10,187	10,098	-0.88
Average LOI in Fly Ash	%	24.9	20.3	-4.56

- ❑ Savings based on lower heat rate and reduced fly ash handling cost – \$ 400,000 per year
- ❑ Payback in 5 months for **CoalCONTROL™**

MERCER GENERATING STATION



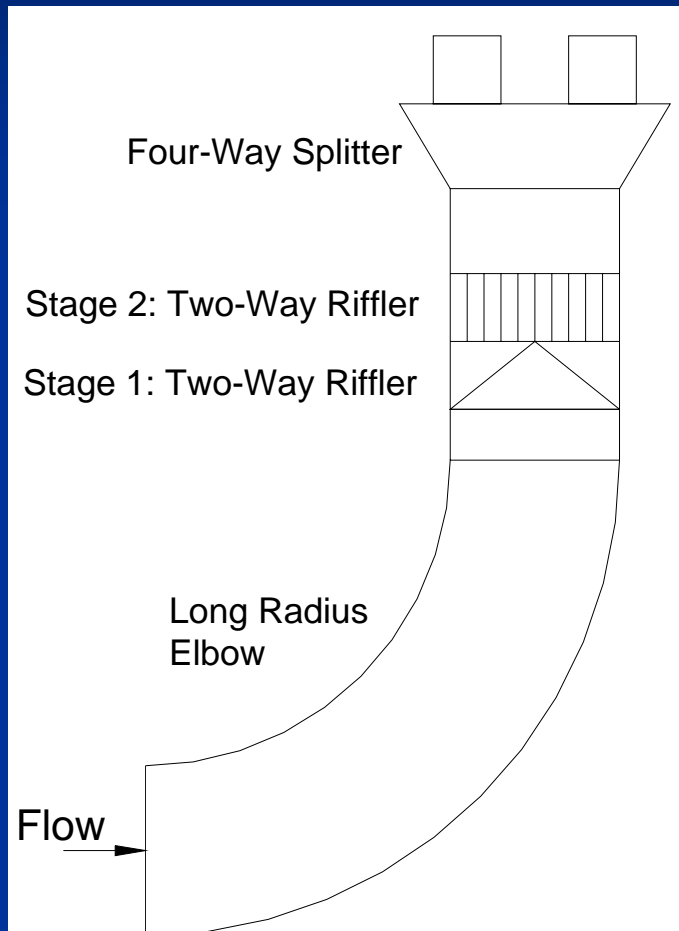
PROJECT SCOPE

- ❑ Designed and fabricated two *CoalCONTROL*[™] 4-Way rifflers and flow controllers for one mill.
- ❑ Installation and coal flow adjustments – Adjusted *CoalCONTROL*[™] to achieve the specified coal distribution profile of 20/30/30/20 percent of coal flow through each burner at each elevation

PROJECT APPROACH

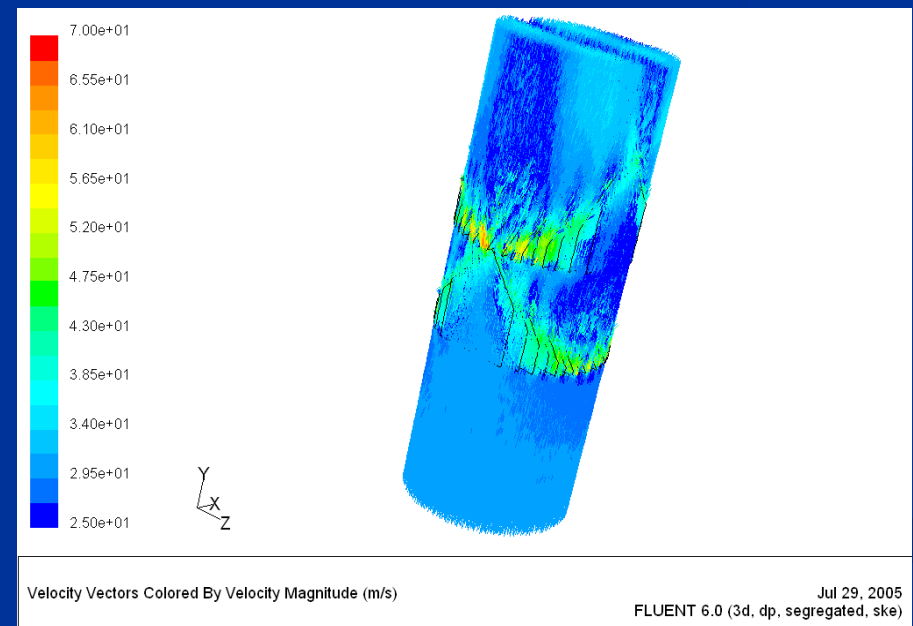
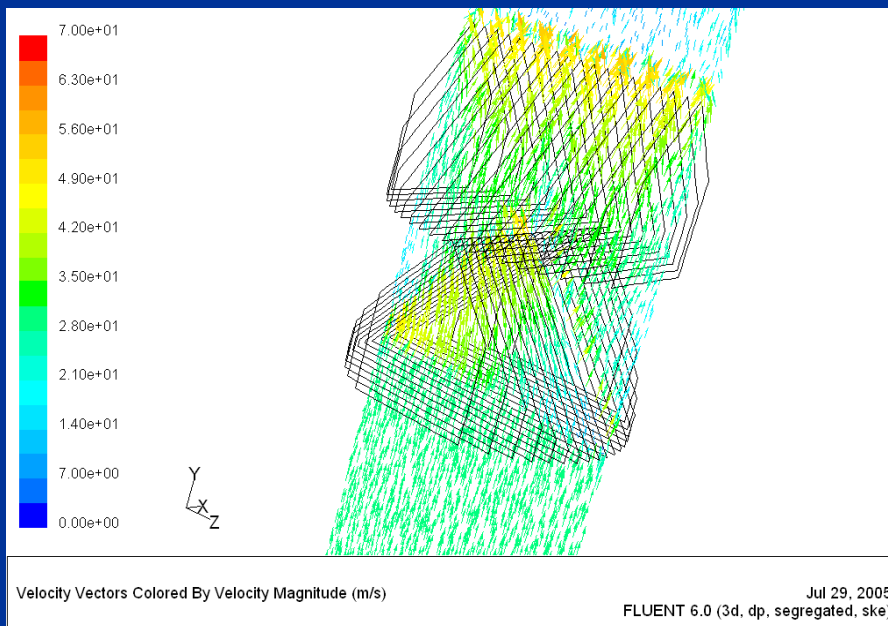
- ❑ Preliminary study was performed using the PSEG Energy Liaison Program (ELP) account.
 - CFD modeling – Pressure drop calculations and design improvement were done.
 - Contacted fabricators for cost estimates.
- ❑ Fabricated, installed and tested the **CoalCONTROL™** technology.
- ❑ Future work – Installation of **CoalCONTROL™** on the remaining mills.

CURRENT RIFFLER DESIGN AT MERCER

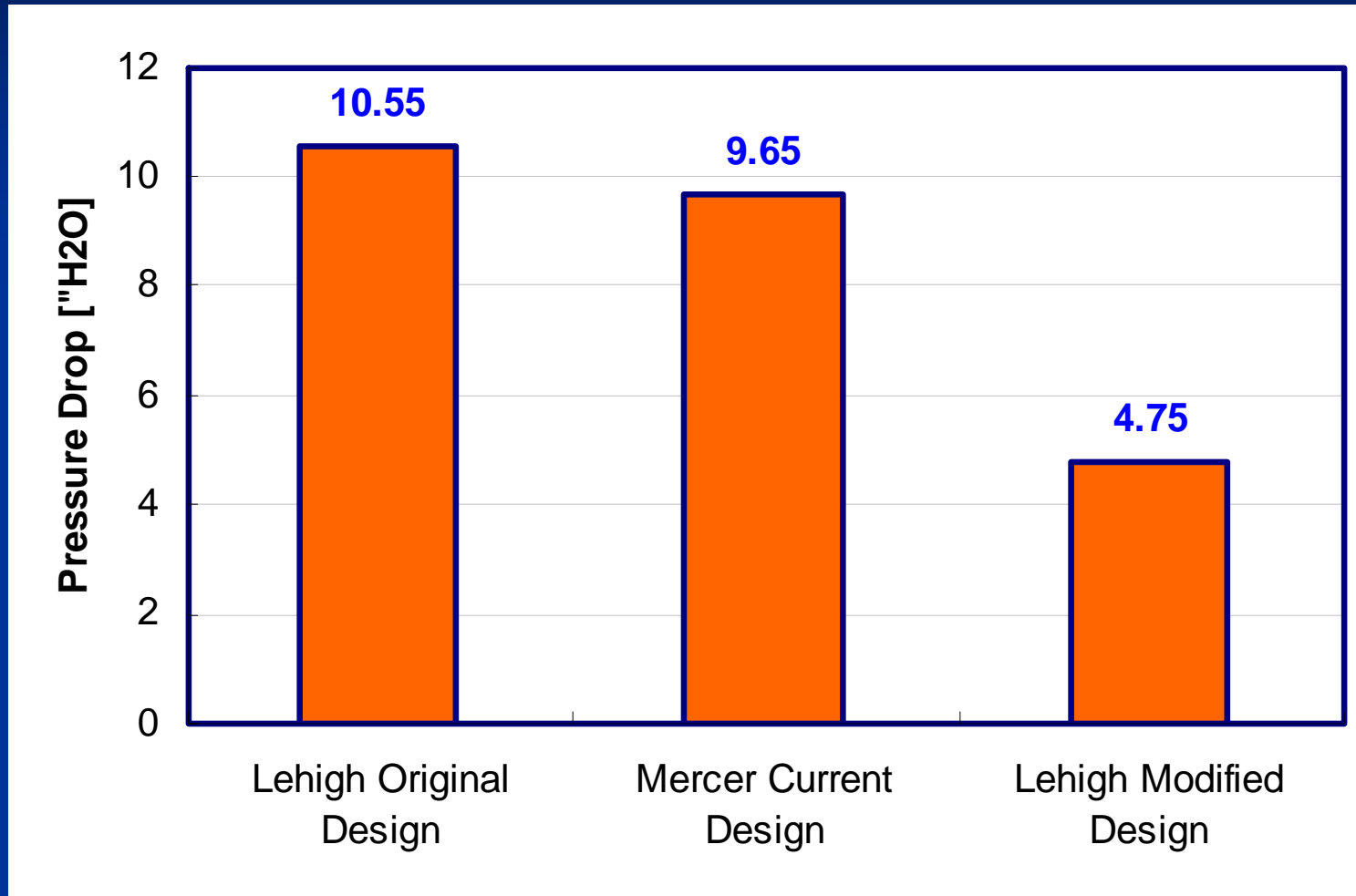


CFD MODELING OF THE EXISTING AND PROPOSED DESIGN

- ❑ Computed the pressure drop (dP) of the two designs
- ❑ Improve the proposed design to minimize dP

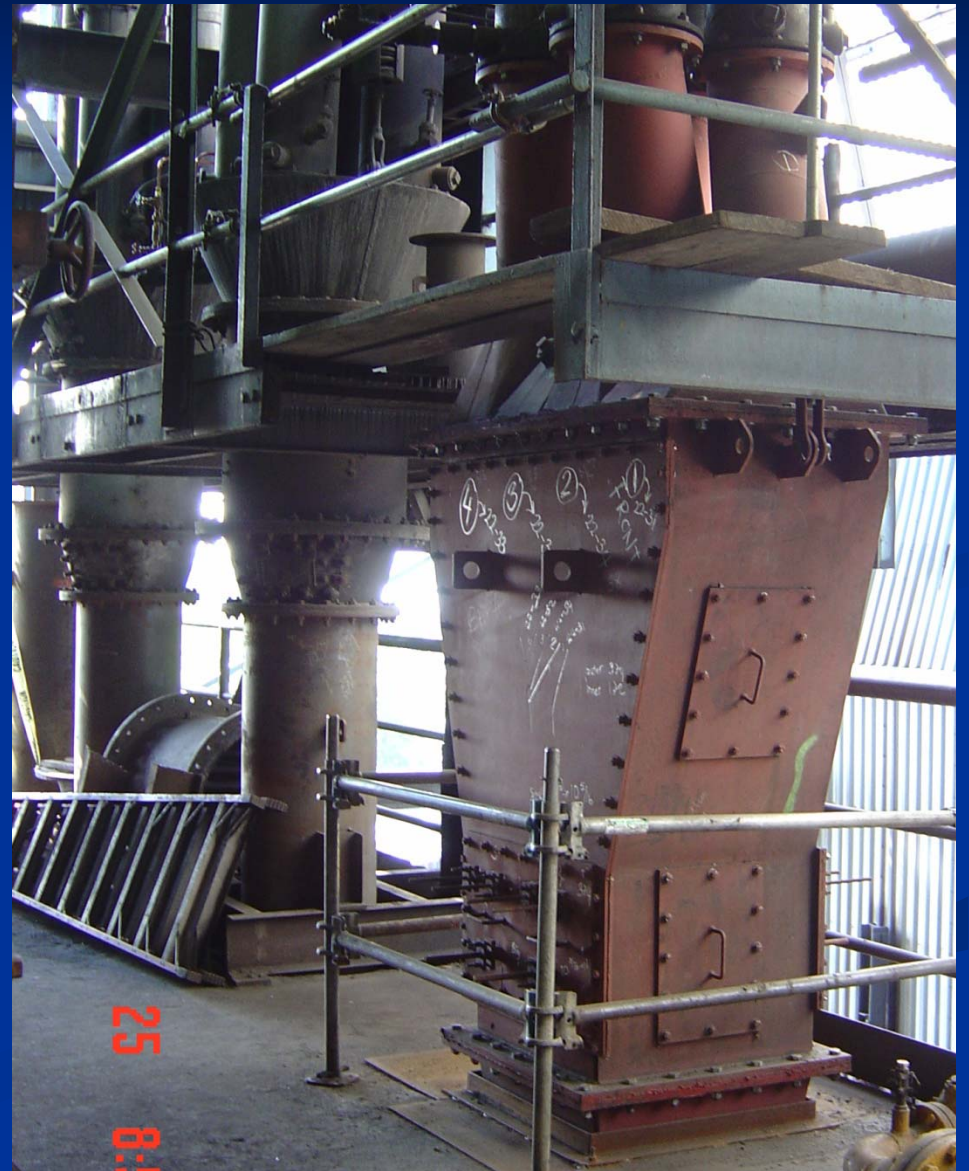


PRESSURE DROP (dP) COMPARISONS

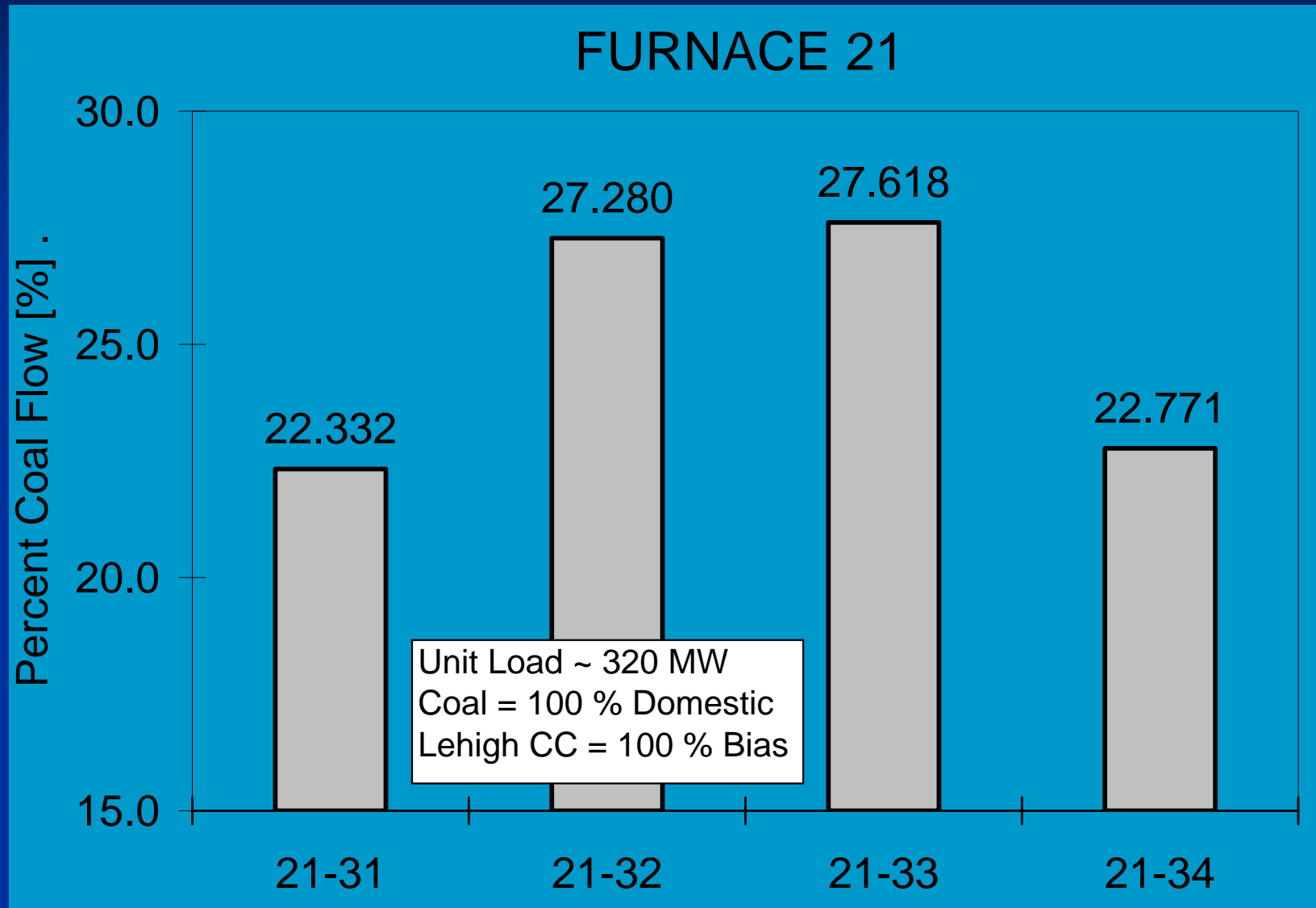


PSEG MERCER STATION – 4-WAY *CoalCONTROL*[™] ASSEMBLY

- ❑ Design and fabrication of two 4-Way *CoalCONTROL*[™] riffler and flow controller assemblies was done in the Winter 2006.
- ❑ Installation and adjustments of *CoalCONTROL*[™] to achieve the specified coal distribution profile was done in Spring 2007.



PSEG MERCER STATION – 4-WAY *CoalCONTROL™* RESULTS



CONNECTIV EDGE MOOR STATION



PROJECT SCOPE

- ❑ Station retrofitted a low NO_x system. Vendor required balanced coal-flow distribution ($\pm 10\%$)
- ❑ Designed and fabricated twelve (four primary and eight secondary) *CoalCONTROL*TM 2-way coal-flow control elements for four mills.
- ❑ Installed and adjusted the *CoalCONTROL*TM elements to achieve the required coal-flow distribution.

PROJECT APPROACH

- ❑ Preliminary study used the Conectiv Energy Liaison Program (ELP) account.
 - Coal-flow element design.
 - Contacted fabricators for cost estimate
- ❑ Fabricated, installed and tested the **CoalCONTROL™** technology.

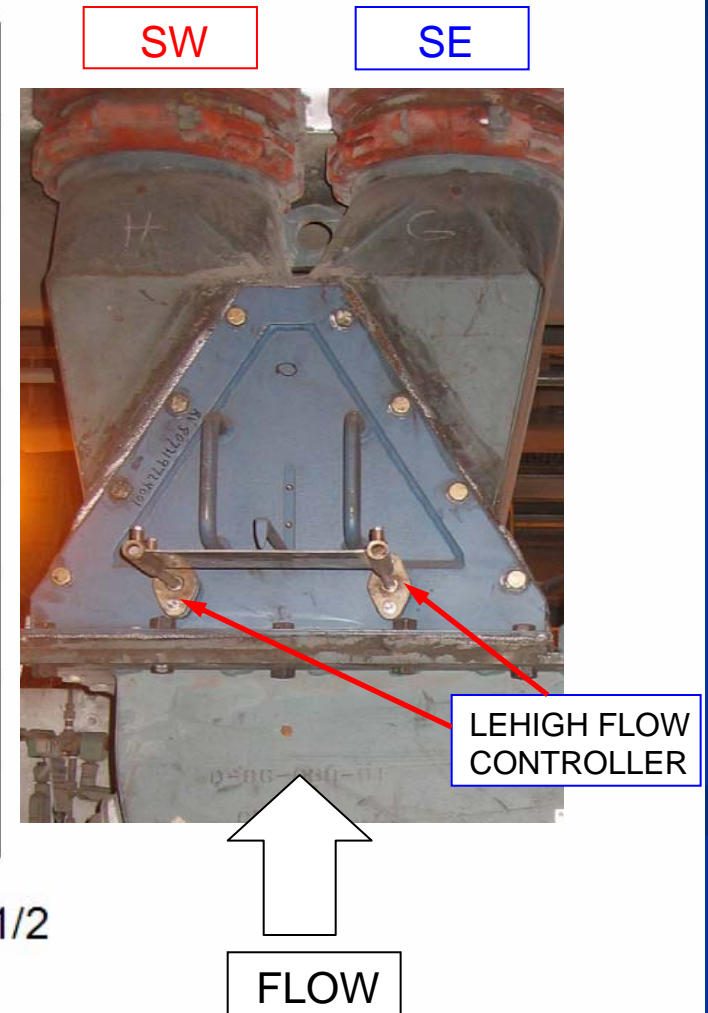
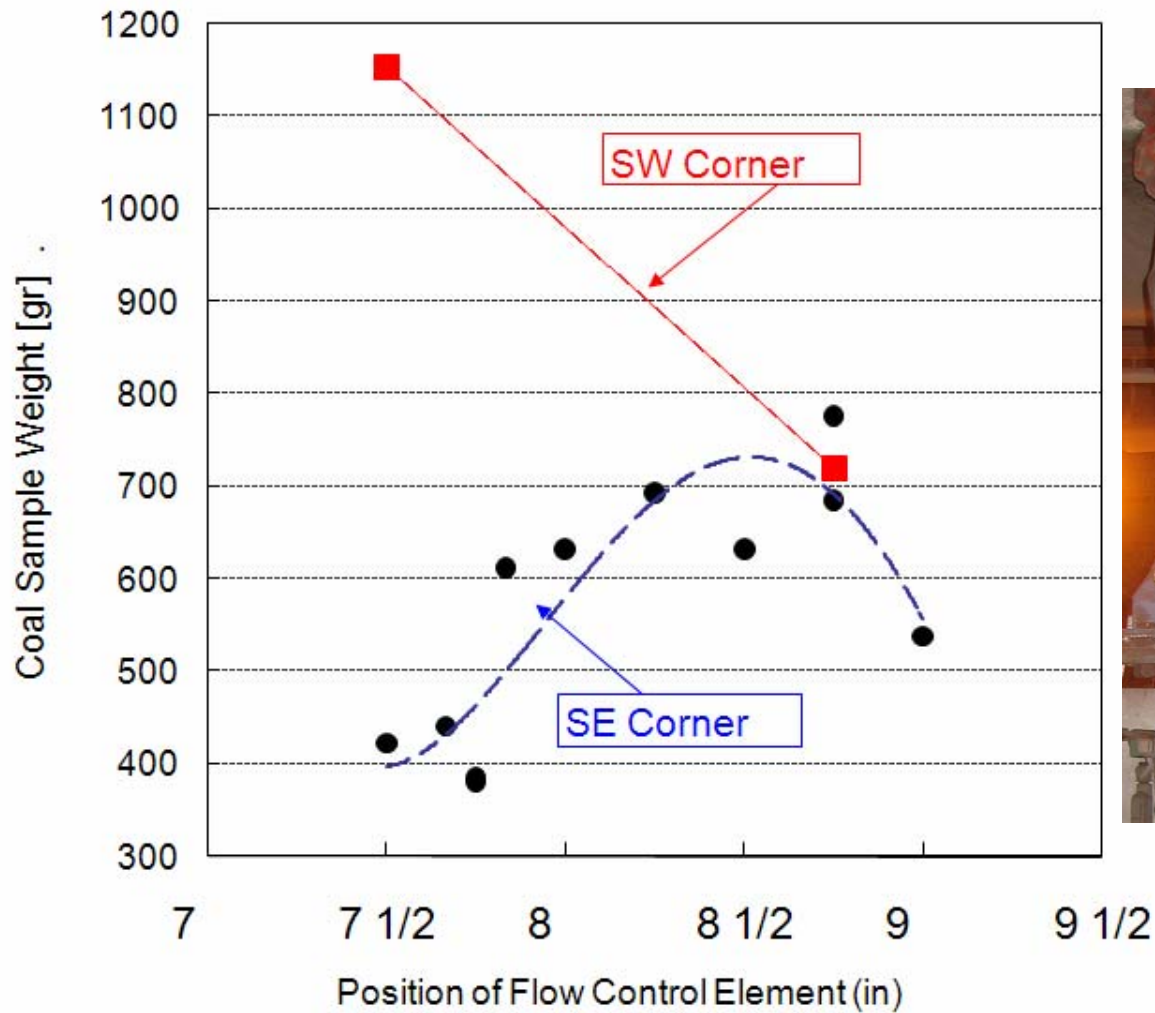
CONNECTIV EDGE MOOR EXISTING RIFFLER HOUSING



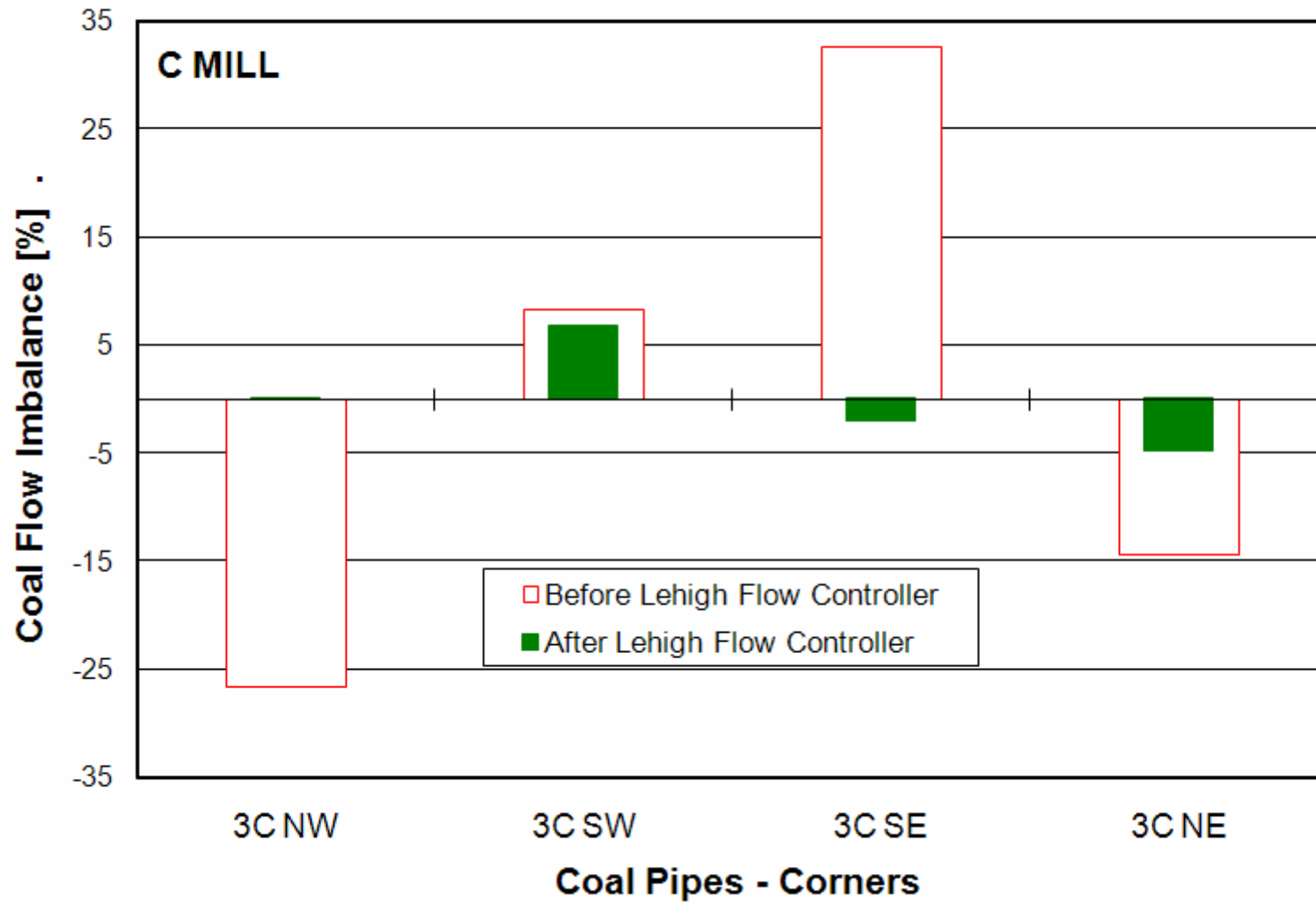
LEHIGH CoalCONTROL™ INSTALLATION



LEHIGH CoalCONTROL™ CONTROLIBILITY



C MILL – COAL FLOW



REAL TIME COAL-FLOW CONTROL

REAL TIME CONTROL OF COAL COMBUSTION

Specified coal flow bias between burners

- Windbox design
- Water wall tube temperature
- Slagging
- CO emission

REAL TIME CONTROL OF COAL COMBUSTION – Manual Adjustments

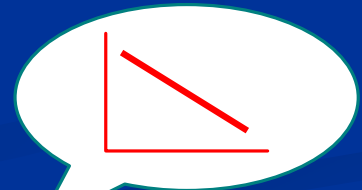
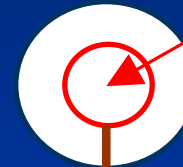
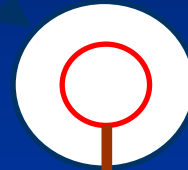
- ❑ Visual Flame Inspection
- ❑ Flue Gas Measurements and Streamlining

Secondary Air Flow

PA and Coal Flow

CoalCONTROL™

Manual Adjustments



REAL TIME CONTROL OF COAL COMBUSTION – On-Line Coal Flow Measurements

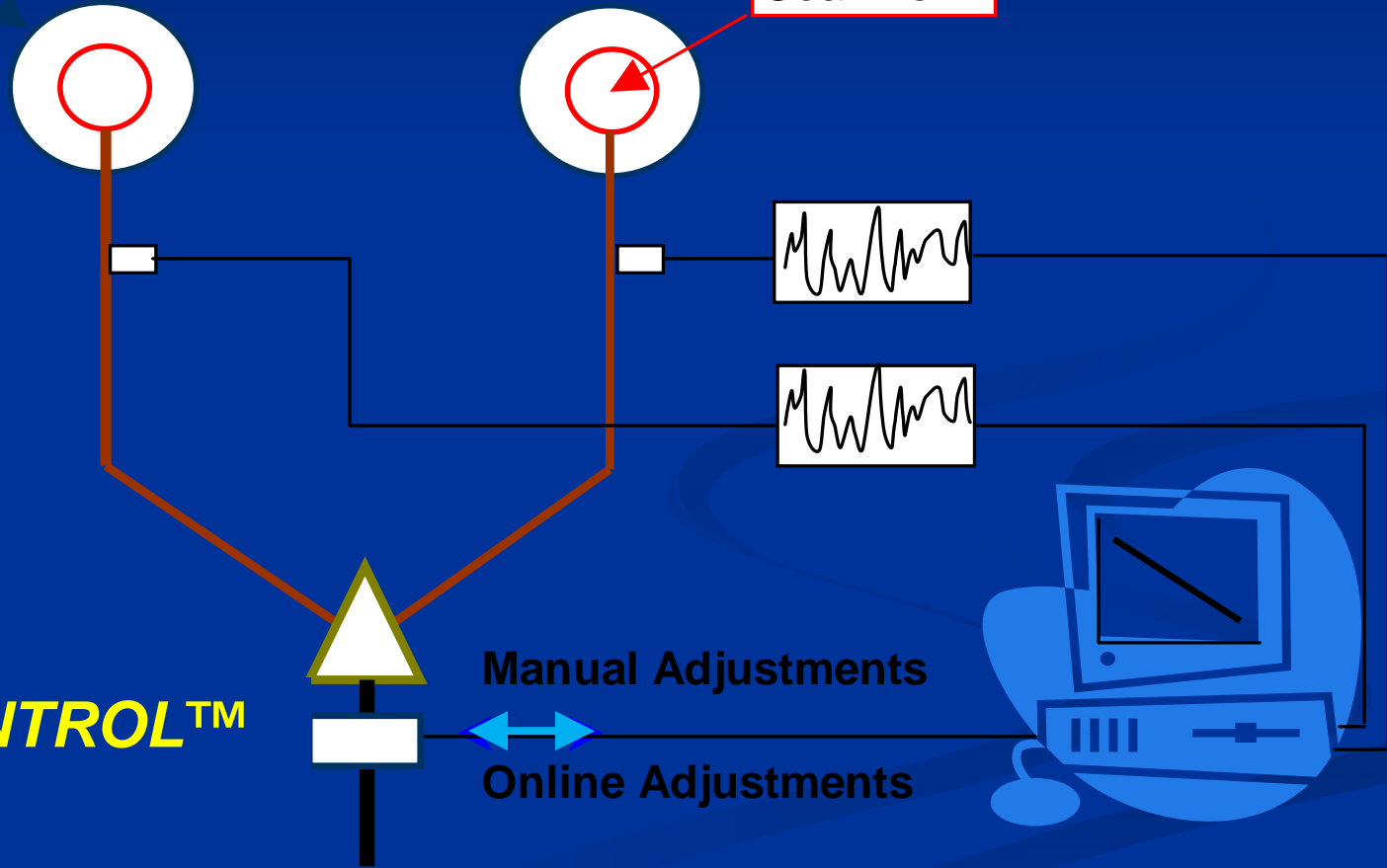
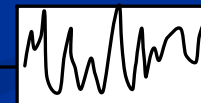
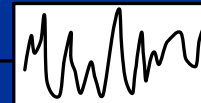
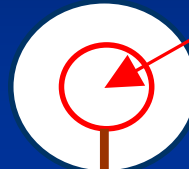
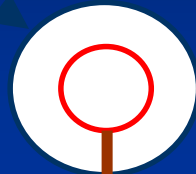
Secondary Air Flow

PA and Coal Flow

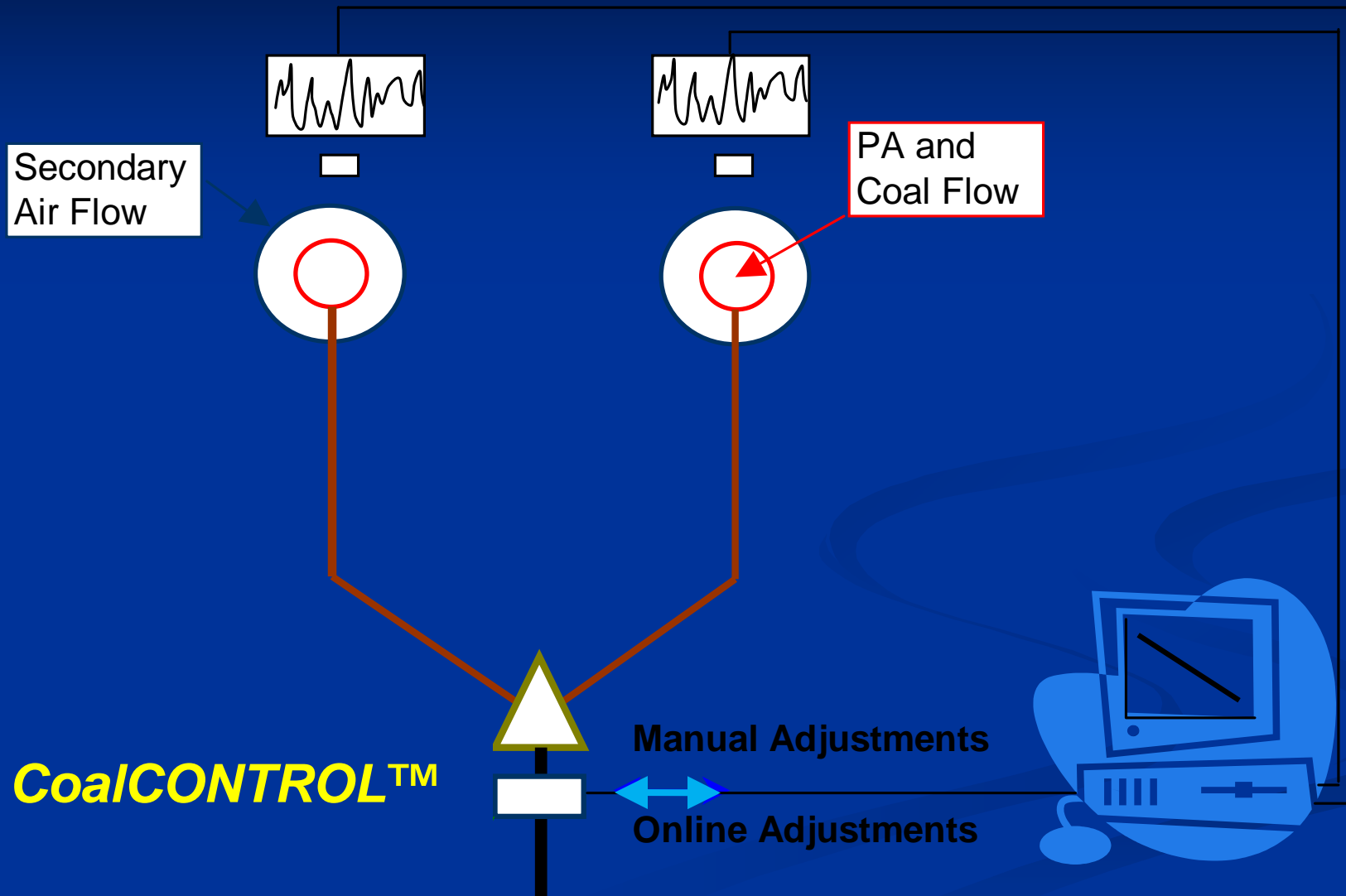
CoalCONTROL™

Manual Adjustments

Online Adjustments



REAL TIME CONTROL OF COAL COMBUSTION – On-Line Flame Monitors

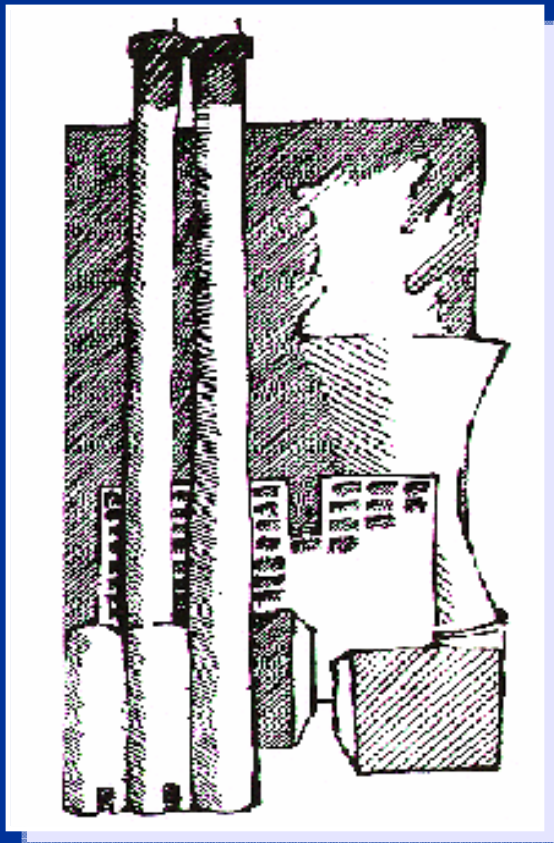


CONCLUSIONS

- ❑ *CoalCONTROL*[™] has been tested in the field and has shown excellent results
- ❑ Primary air flow distribution was not affected by coal flow changes
- ❑ Reduced coal flow imbalances to less than $\pm 10\%$
- ❑ Minimal impact on pressure drop
- ❑ Provides a useful tool for on-line combustion optimization

ENERGY RESEARCH CENTER

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