

Reinhold Environmental Ltd.



2009 NO_x-Combustion Round
Table & Expo Presentation

February 9 & 10, 2009, Cleveland, OH

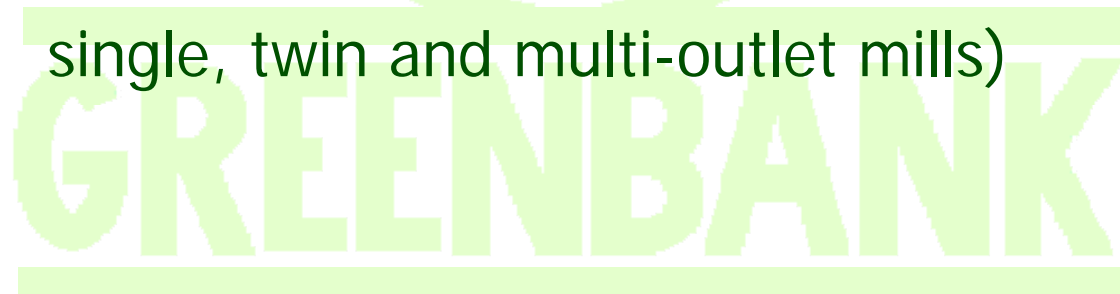
NOx-Combustion Round Table

Workshop III



Combustion benefits from Controlling PF distribution on coal-fired boilers

(front wall, opposed wall, W-fired, T-fired,
single, twin and multi-outlet mills)



Coal balance targets



- Maintain Coal flow balanced to $\pm 10\%$ between burners.
- Clean Air in the Coal conduits balanced to $\pm 2\%$ between burners
- Maintain dirty air balanced to $\pm 5\%$ between burners
- Fuel fineness should be 75% or more passing a 200 mesh screen. 99.9%. or more passing a 50 mesh screen
- Maintain a safe fuel line velocities of $\sim 3,500$ fpm.

What effects coal flow balance



- Coal Particle size and coal type
- Coal velocity and volume
- Coal moisture
- Air to fuel ratio
- Piping and or Mill geometry

Improved Fuel Distribution



- **Correction of PF Flows on Multi-Outlet Mills**

- **Correction of PF flows at Flow Dividing Splitters**
 - Bifurcator's (2-way)
 - Trifurcator's (3-way)
 - Quadrificator's (4-way)

The Benefits of Good PF Distribution and Control

Improved Coal Distribution Can Help Create:



- **Higher Combustion Efficiency.**
 - Stable Combustion
 - Reduced pipe erosion.

- **Reduced Carbon-in-Ash.**
 - Reduction of un-burnt carbon
 - Saleable ash
 - Reduction of disposal and land fill taxes

- **Reduction of NOx**
 - A function made possible by lowering air levels under stable operating conditions.

The Benefits of Good PF Distribution and Control

Good Control of PF Velocity Can Help Create:



- **Minimum (but safe ~3500 ft/min) Transport Velocity**
 - Reduction in volume and velocity of Primary air required
 - Reduction of pressure of air required

- **Improved Fineness of PF particles**
 - > 70% passing 200 mesh and < 0.1 retained on a 50 mesh.
 - Further reduction in erosion in PF pipes

- **Improved Burn**
 - Reduction in flame length
 - Elimination of flame detachment occurrences.
 - Reduced Carbon-in-Ash

How to Optimize PF Distribution and Velocity



- **Install Accurate, Repeatable and On-Line Flow Monitoring Equipment PfMaster**
 - Instantaneously measures PF distribution
 - Instantaneously measures PF velocity

- **Reduce PF Transport Velocity to Burner Design Velocity**
 - Increases residence time of coal in mill – improves fineness
 - Reduce volume and pressure of Primary Air.
 - Optimizes flame / eliminates flame detachment
 - Improves combustion efficiency.
 - Reduces NOx.

How we Optimize PF Distribution and Velocity



- **Install Flow Balancing Dampers in Classifier / Outlet Pipes**
 - Optimizes PF Distribution from Mill to burners
 - Accurately measure & balances coal/air flow to burners

- **Install PF VARB Diffusers / Rope Breakers/ Flow Dividers**
 - Destroys PF Ropes
 - Improves distribution at splitters
 - Reduces pipe erosion / maintenance
 - Reduces Carbon-in-Ash

- **Install PF Control Gates**
 - Optimizes PF Distribution at splitters
 - Accurately balances coal/air flow to burners



Greenbank's Patented Product:

High Performance Splitter

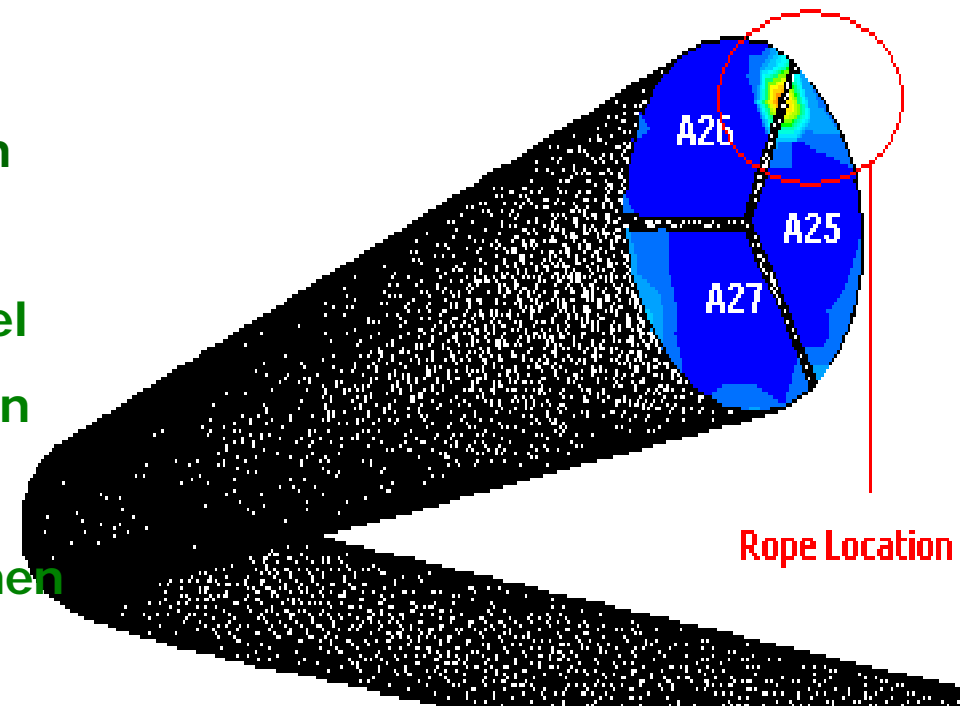
The VARB (Variable Area Rope Breaker)
breaks the rope,
homogenizes the PF flow
and equalizes the split.

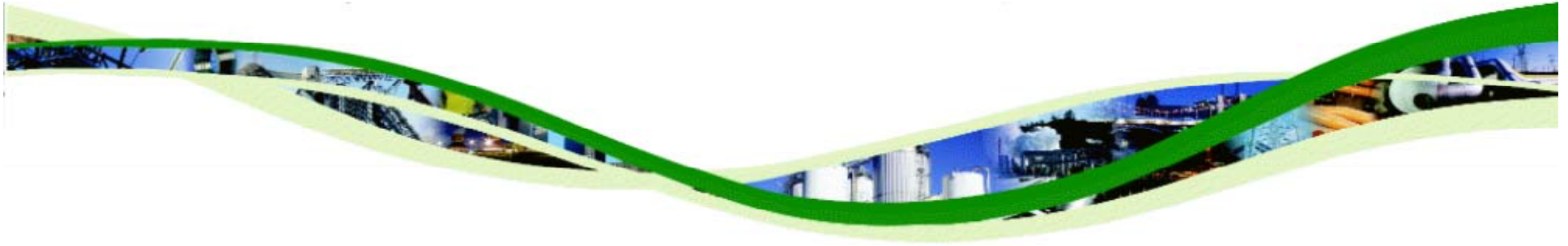
The VARB can be used prior to all types splitters:
Bifurcator (two way split).
Trifurcator (three way split).
Quadrafurcator (four way split).
In front of or in place of a standard riffle box



VARB Design, Testing and Installation Technique

- Obtain Customer's PF Distribution Data
- Create CFD Model
- Simulate Existing Fuel Distribution
- Predict Position of PF 'Rope'
- Insert VARB Design into CFD Model
- Optimize VARB Design and Position
- Verify Position of Rope by Survey
- Install VARB, Control Gates and then Optimize



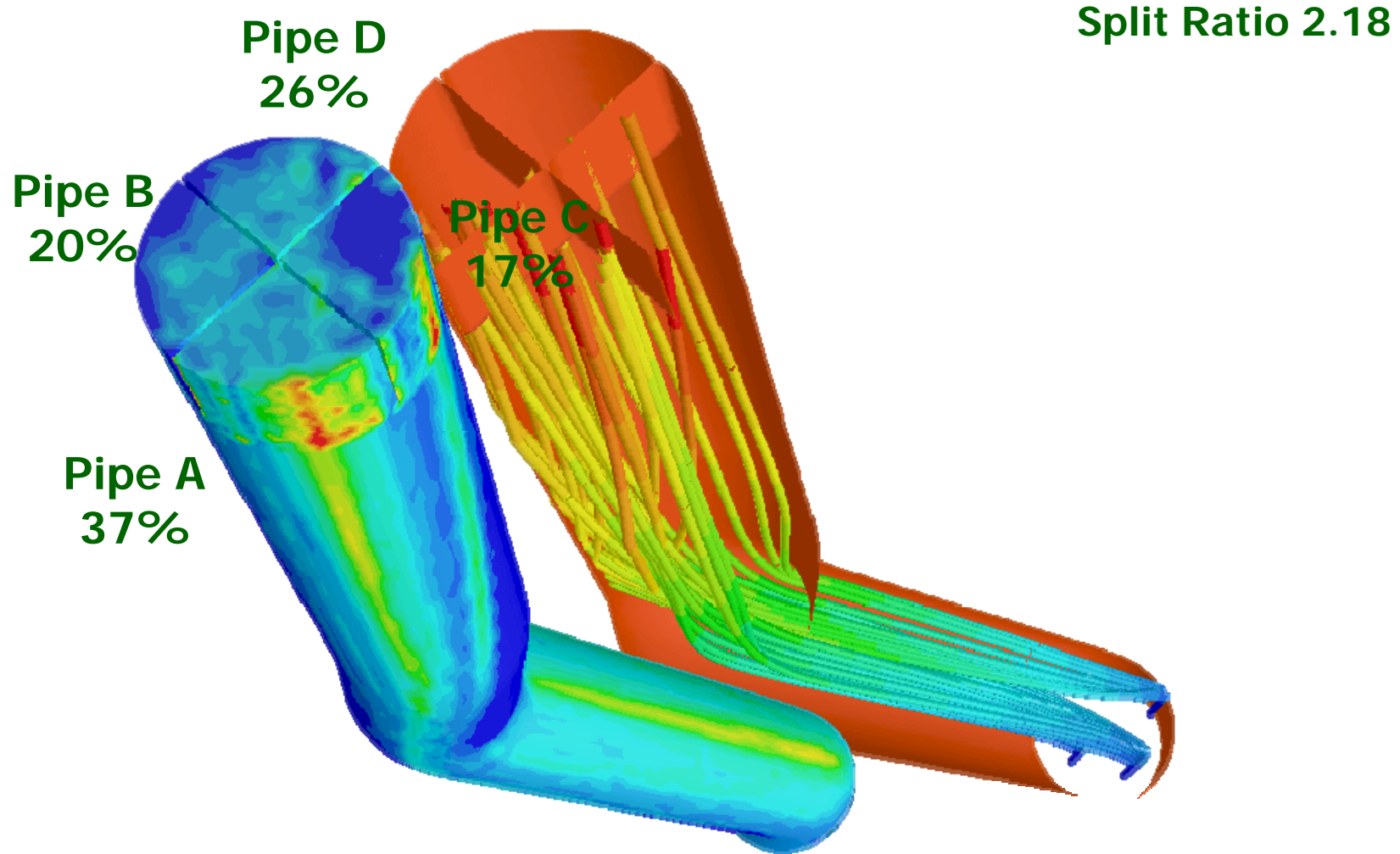


Site Data is Collected from
a 4-way splitter

Splits A: 37%, B: 20% C: 26% D: 17%

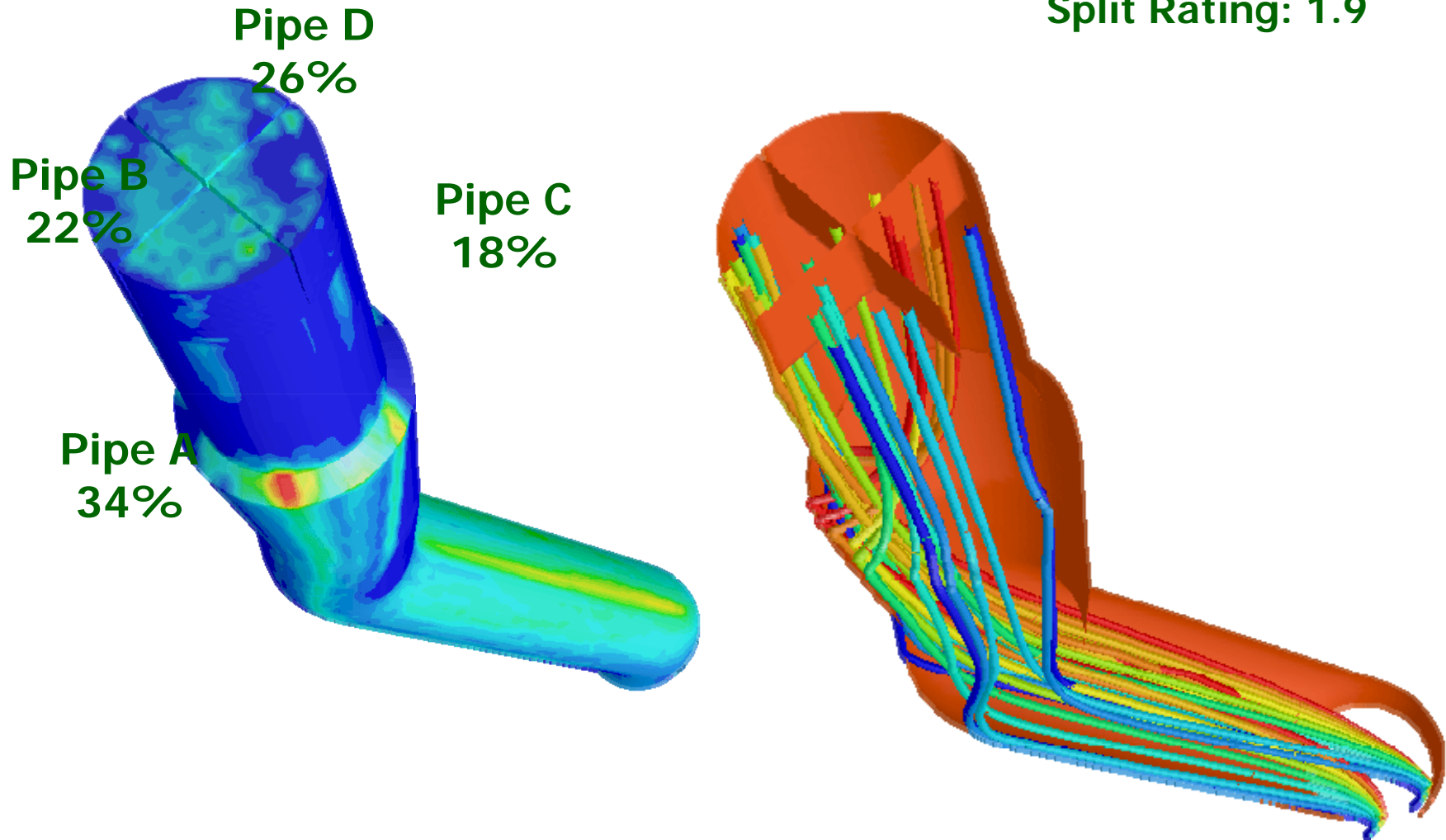
Max / min Split Ratio of 2.18

CFD Model Replicates site data



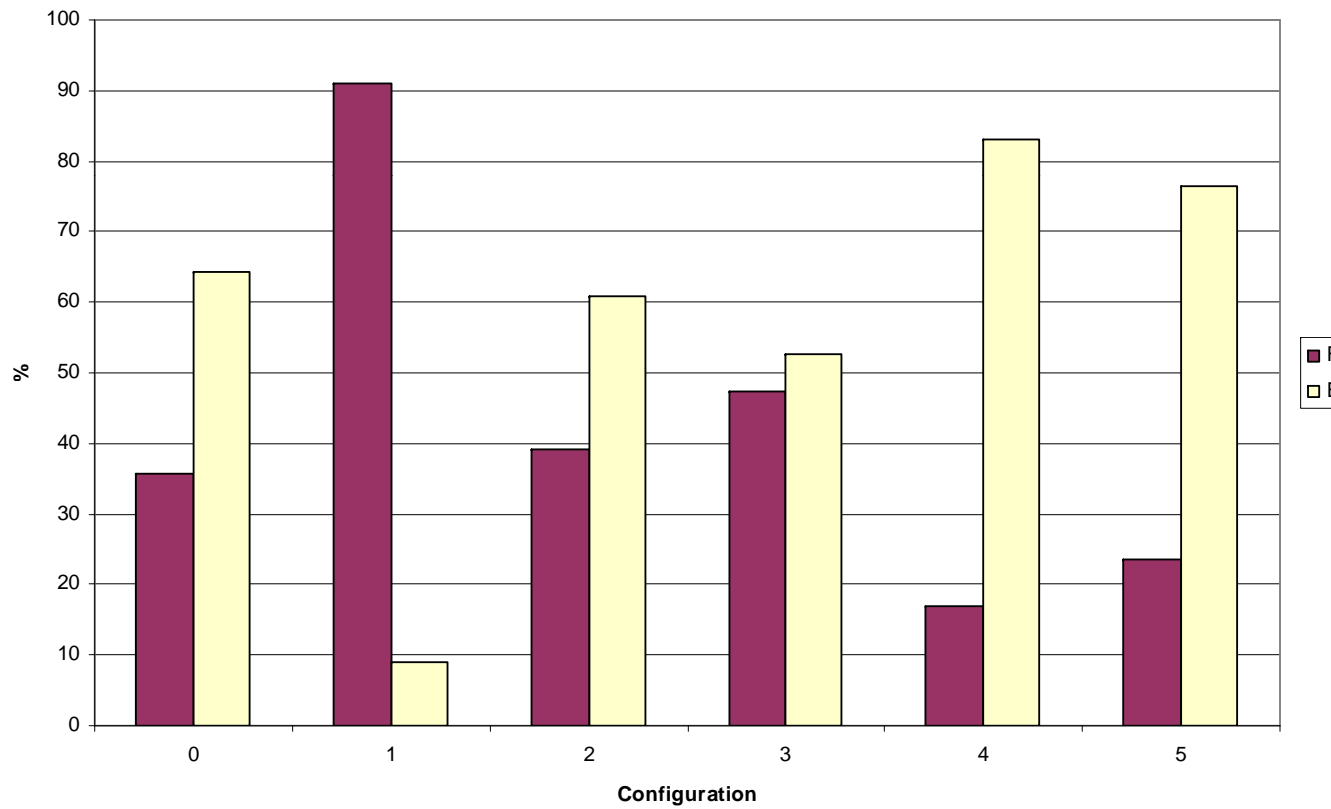
Standard 45° VARB 1.5-D prior to split

Split Rating: 1.9



Percentages

West Burton Splits

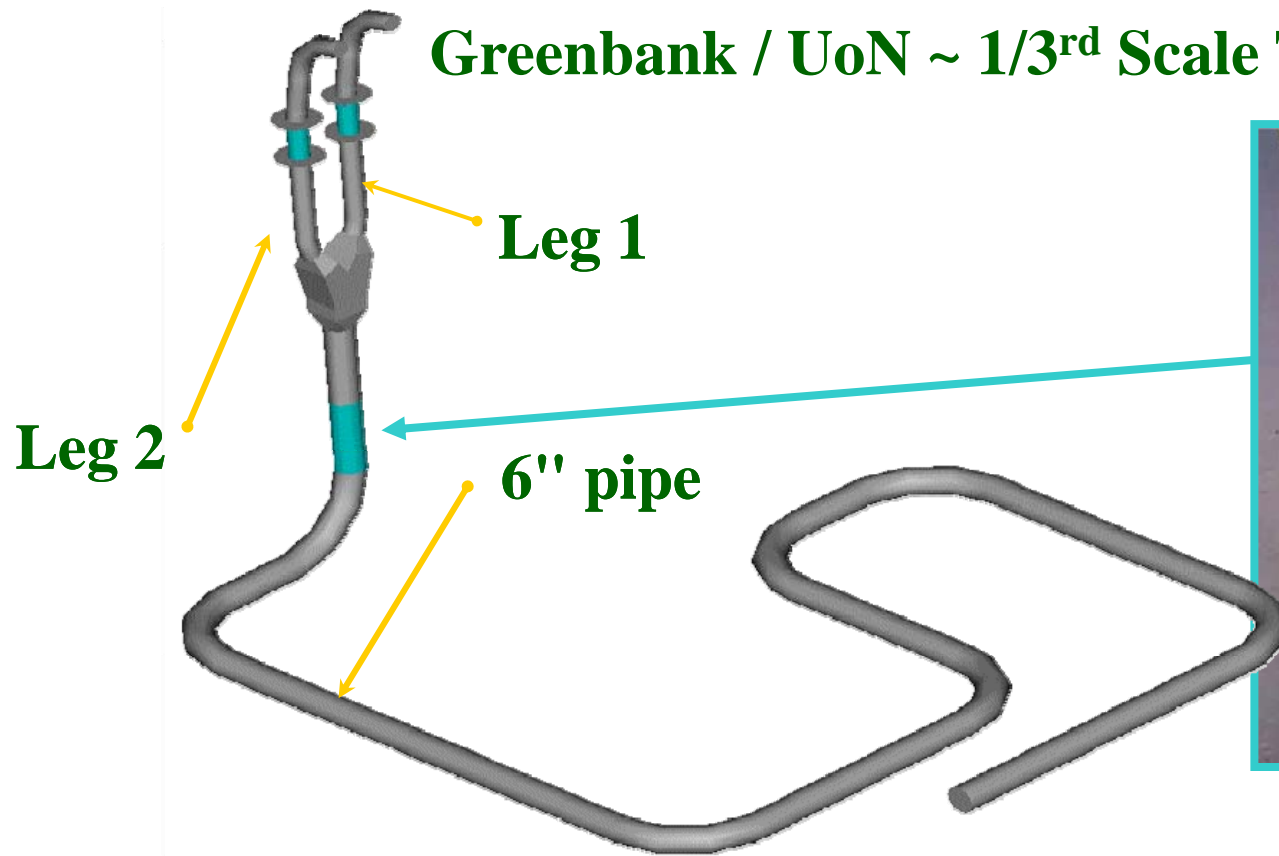






Development:

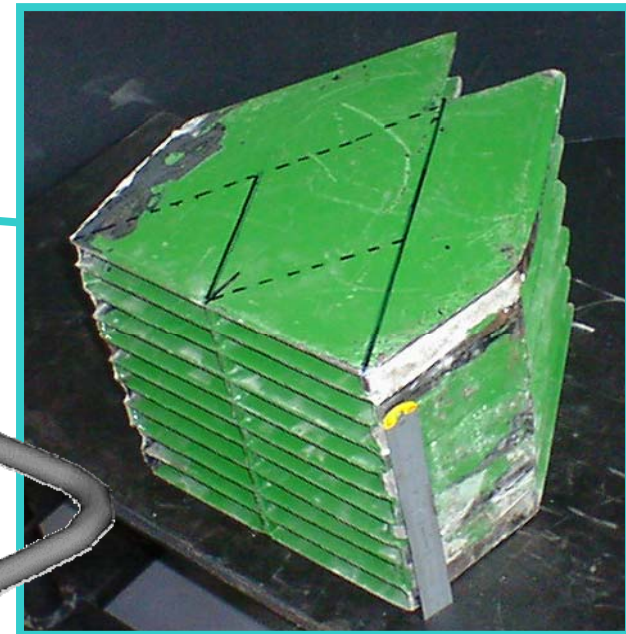
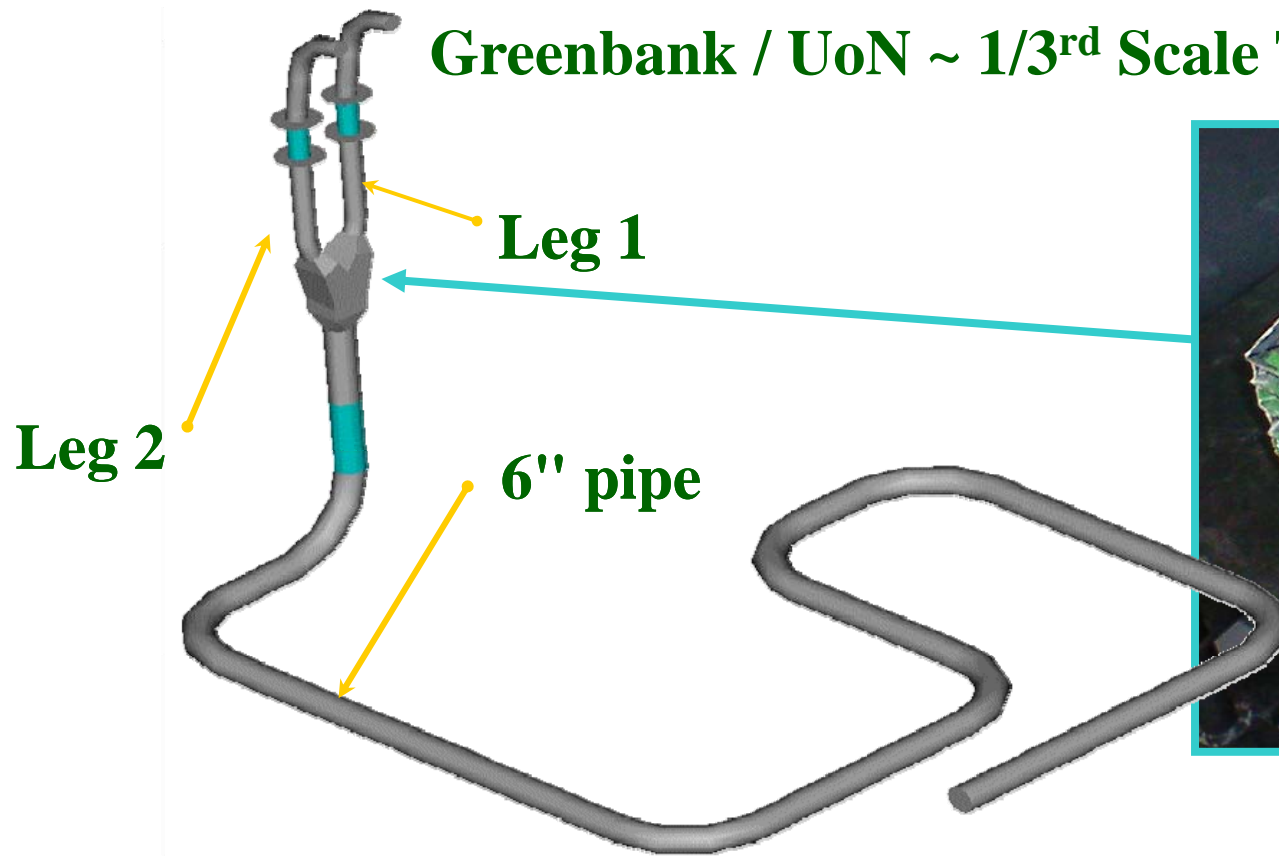
Greenbank / UoN ~ 1/3rd Scale Test Rig





Development:

Greenbank / UoN ~ 1/3rd Scale Test Rig



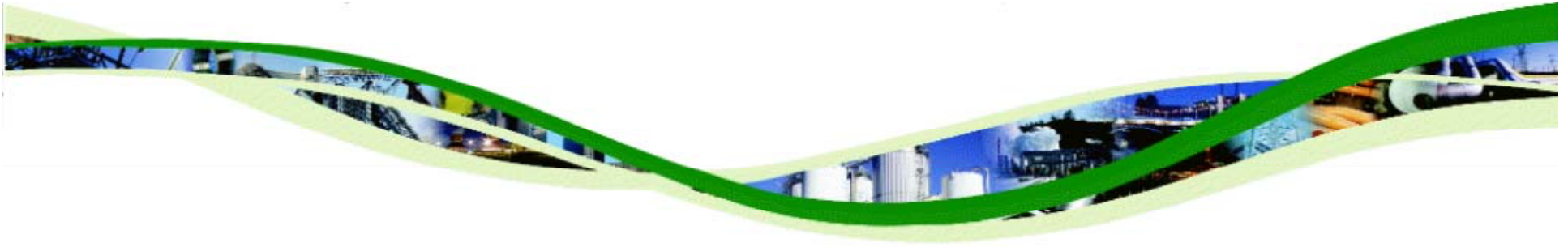


Nanticoke GS (splitting application)

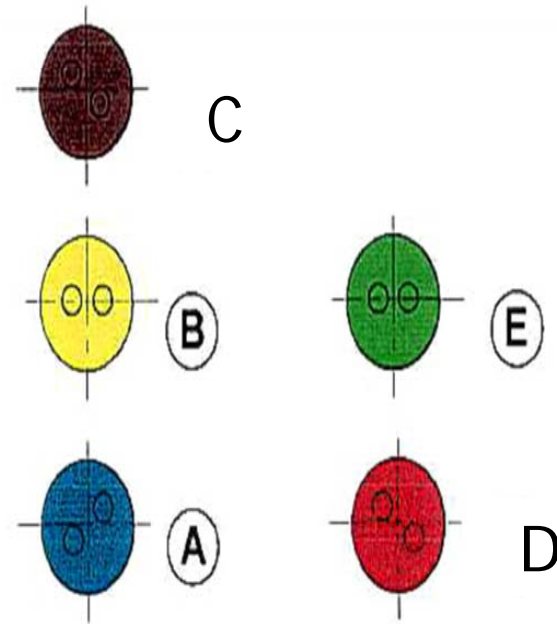
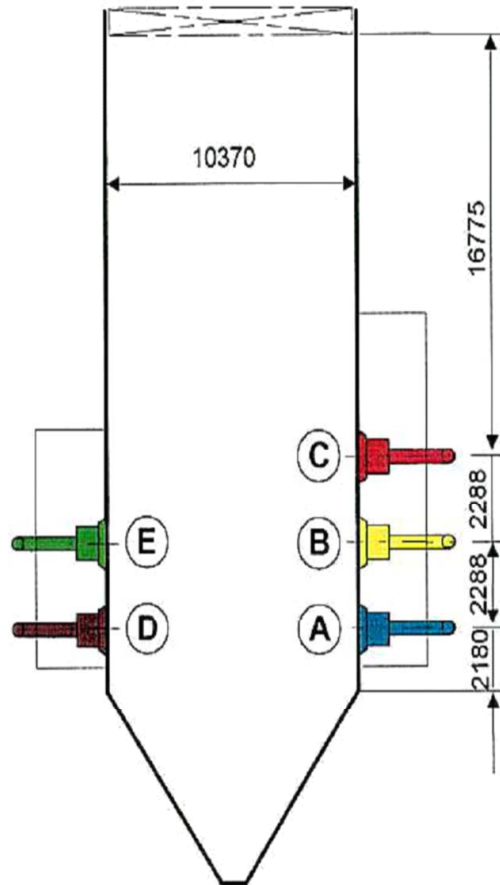
ONTARIO **POWER** GENERATION

- 8 x 500 MW
- 5 mills, 40 burners per unit
- Furnace coal blend
 - 80% PRB
 - 20% Central Appalachian



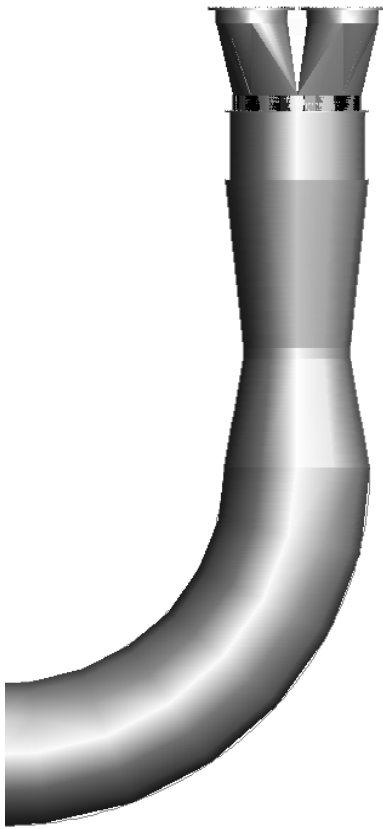


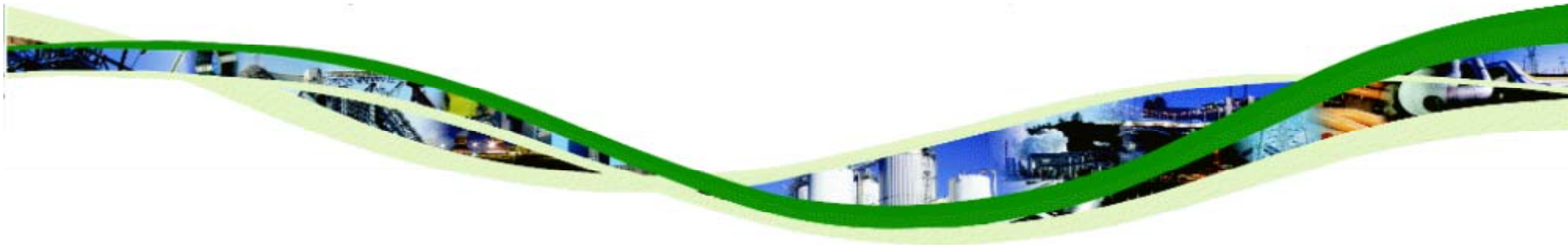
Burner / Pulverizer Layout





Original Coal Pipe Configuration



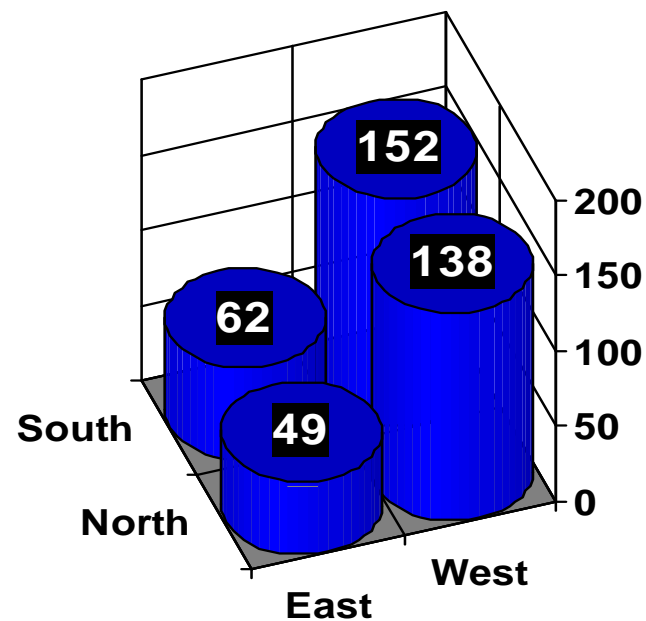


Baseline Fuel Balance

- **45% RMS**
- **Max/Min 3.1 to 1**

ONTARIO **POWER**
GENERATION

Mill A, Group 1
Normalised Distribution





Nanticoke Requirements

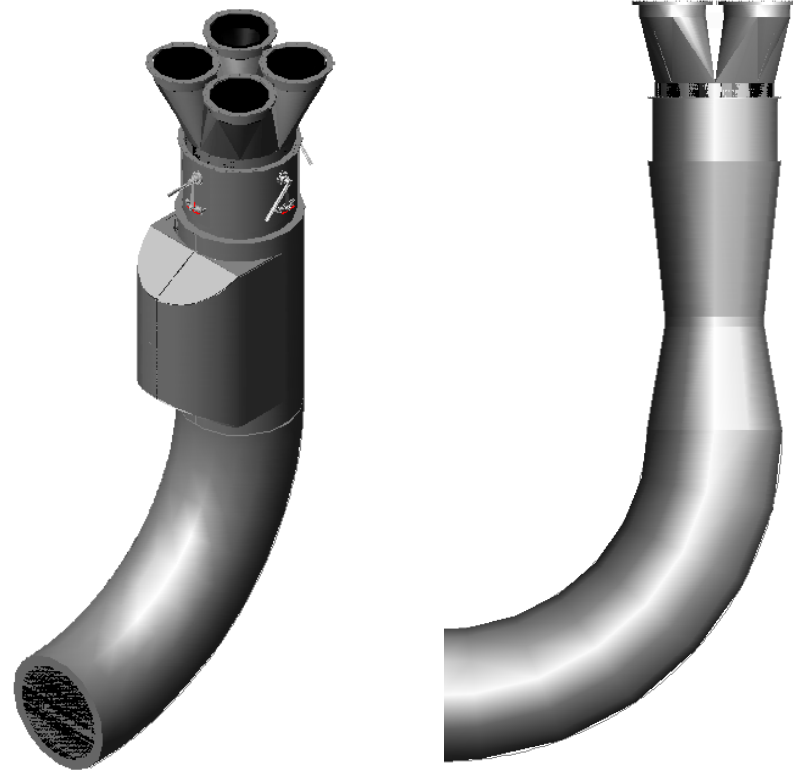
- Flange-to-flange installation
- No increase in system pressure drop
- Target PF distribution of 10% RMS
- Trial installation on mill 2A in fall 2006 & a full boiler in 2007
- Prove VARB design on NELs test rig





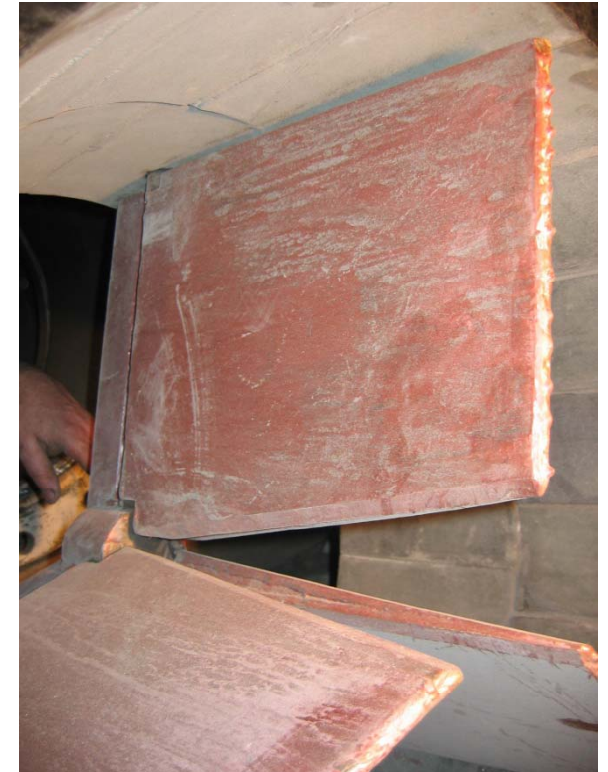
H-VARB High performance splitter Installation

- New inlet elbow
- H-VARB
- Control Gates
- New Quadrafurcator
- PF Master relocated

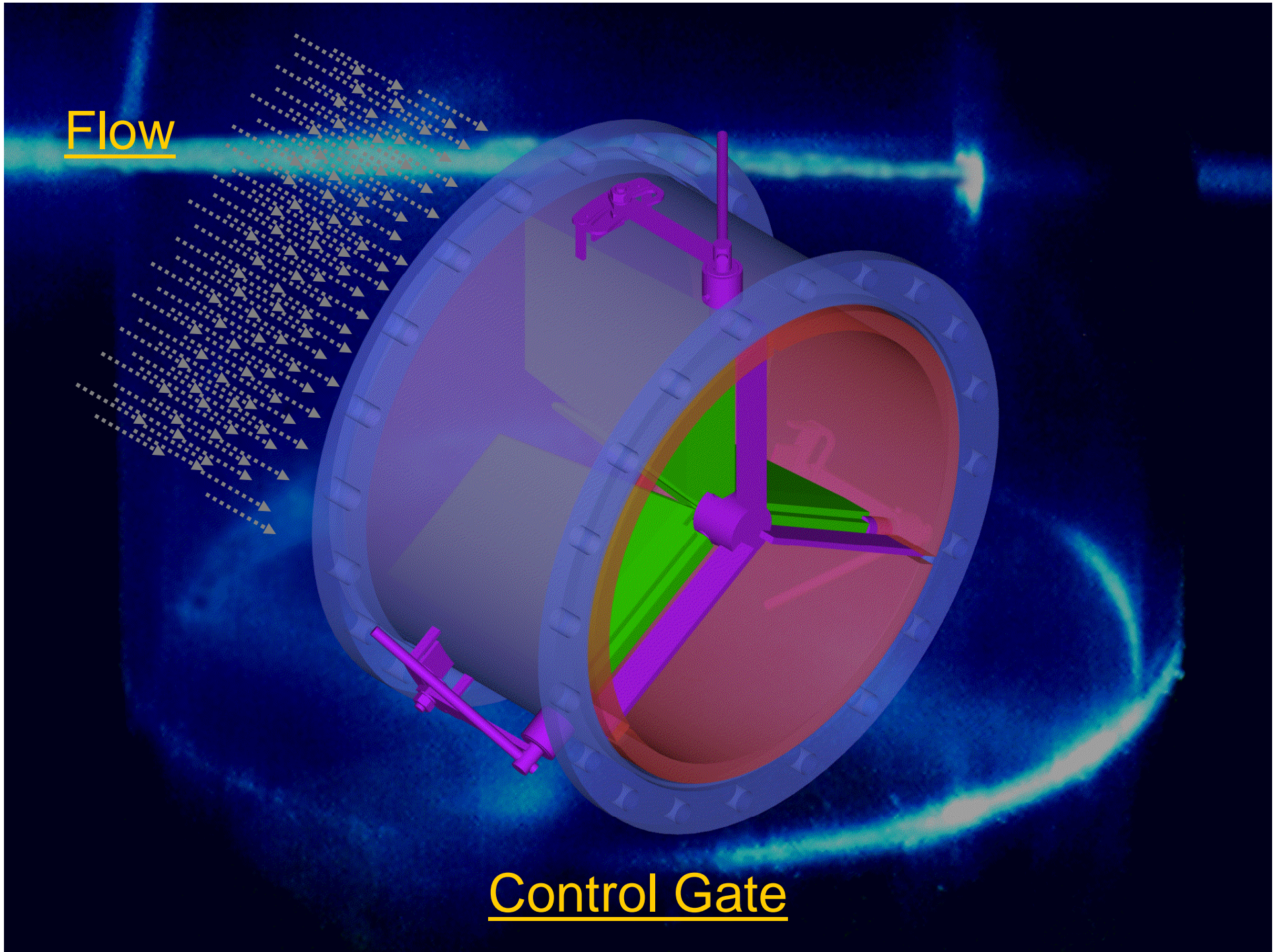


Close look at Control Gates

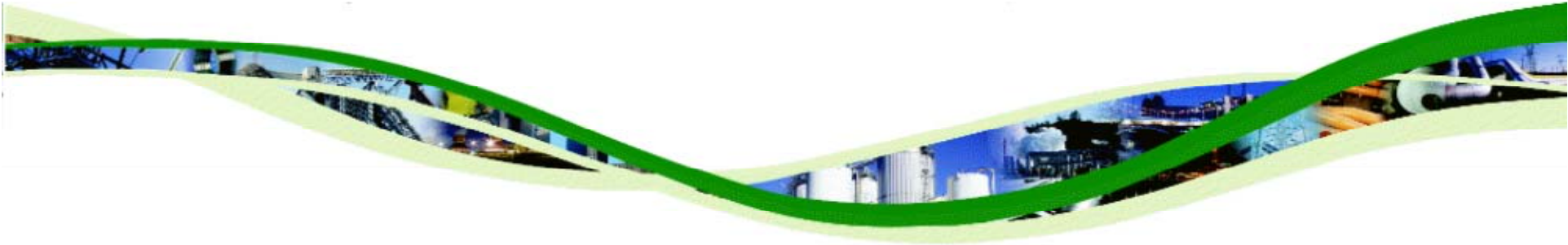
- Example 3-way Control Gate as in Ratcliffe GS
- Bias the coal phase without effecting the air phase



Flow

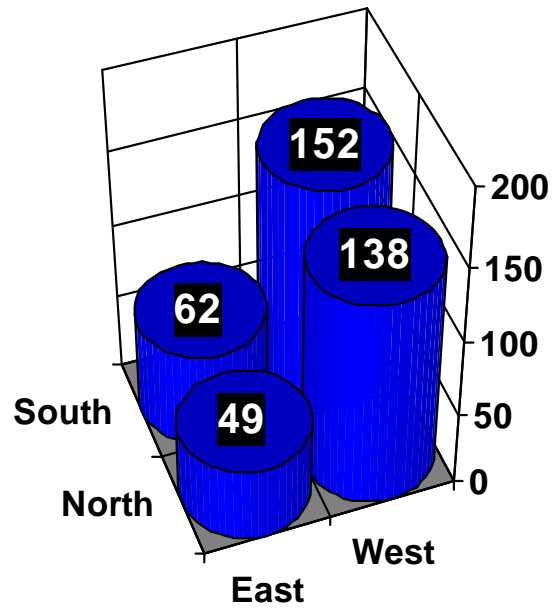


Control Gate

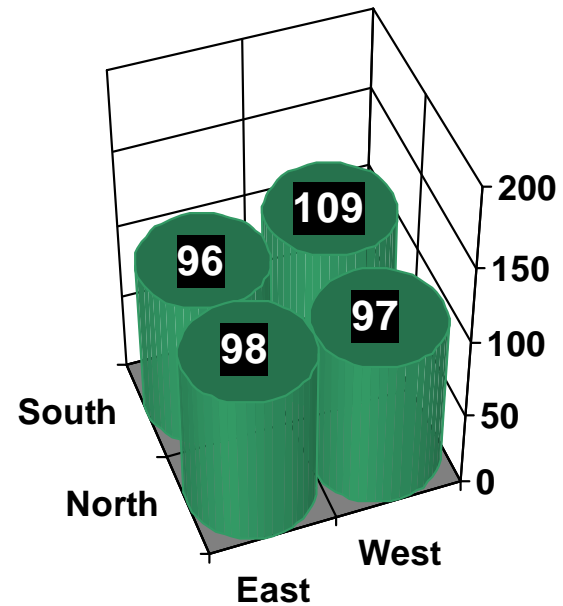


Group 1 Comparison

**Mill A, Group 1
Pre-VARB**



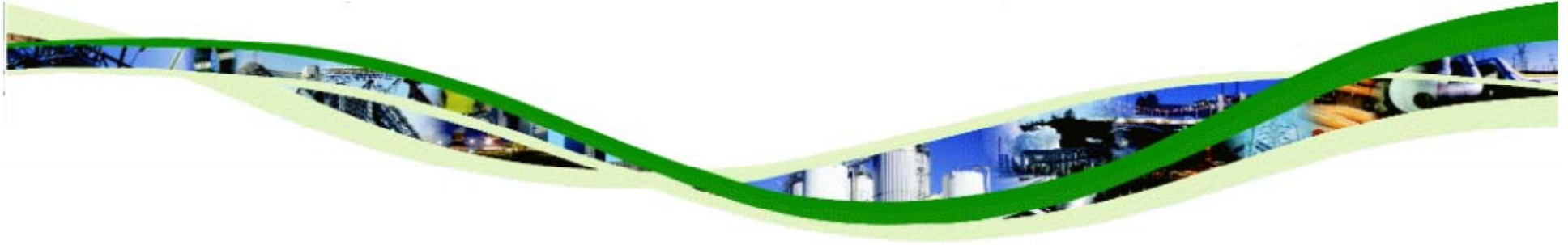
**Mill A, Group 1
Post-VARB**





Qualitative Observations Full Boiler set of VARBs on Unit #4

- Nanticoke installed a full boiler set of VARB / H-VARB devices in Fall 2007 (commissioned July 08)
- No coal flow measurement system installed on this full boiler set of VARBS, and as a result fine tuning was not done.
- Combustion results – 10% reduction in NO_x (20ppm) @ CO 50ppm.
- Low load flame stability without gas flame support.



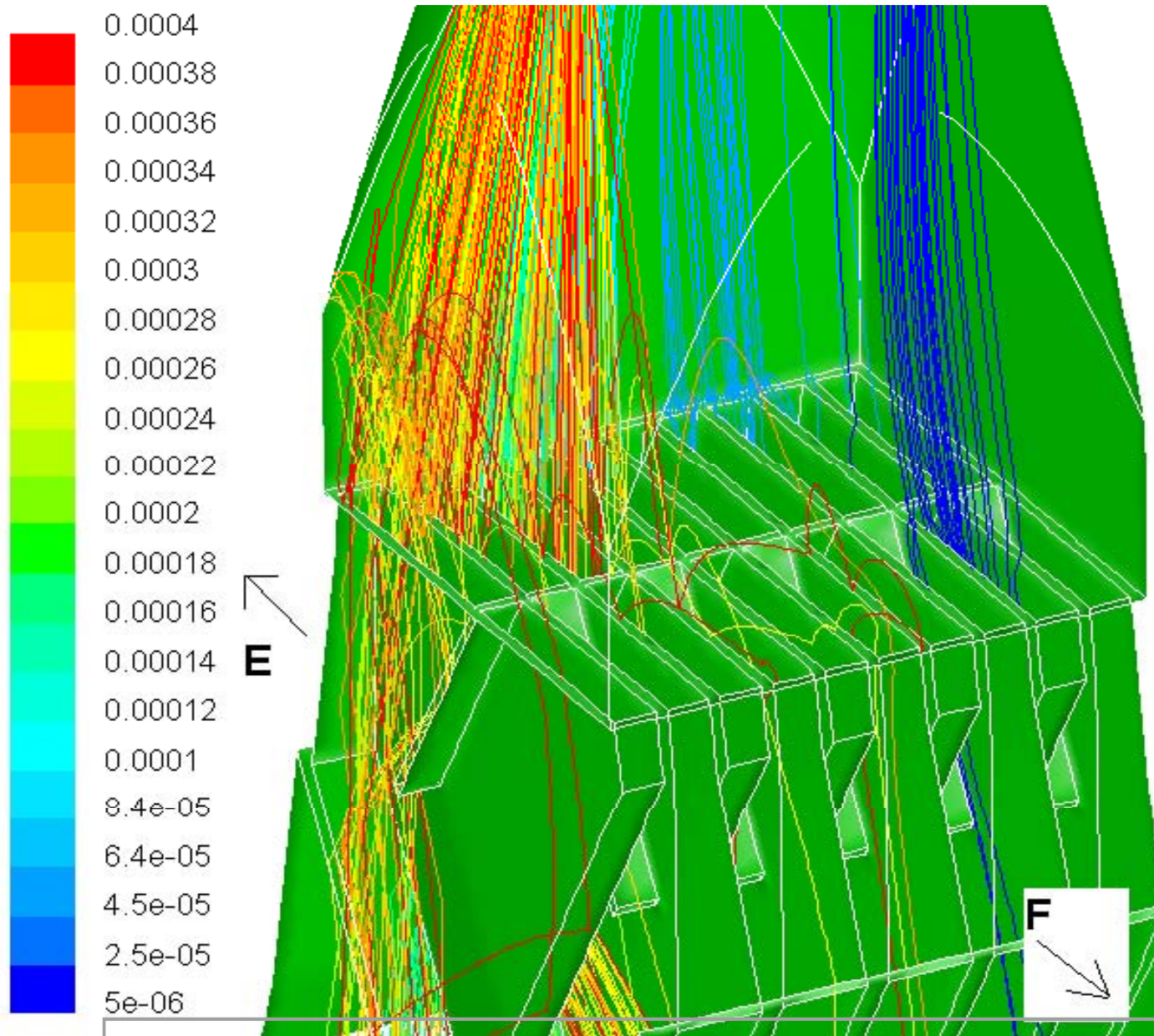
Exhauster application

**High Performance splitting
Technology**

together with coal flow measuring

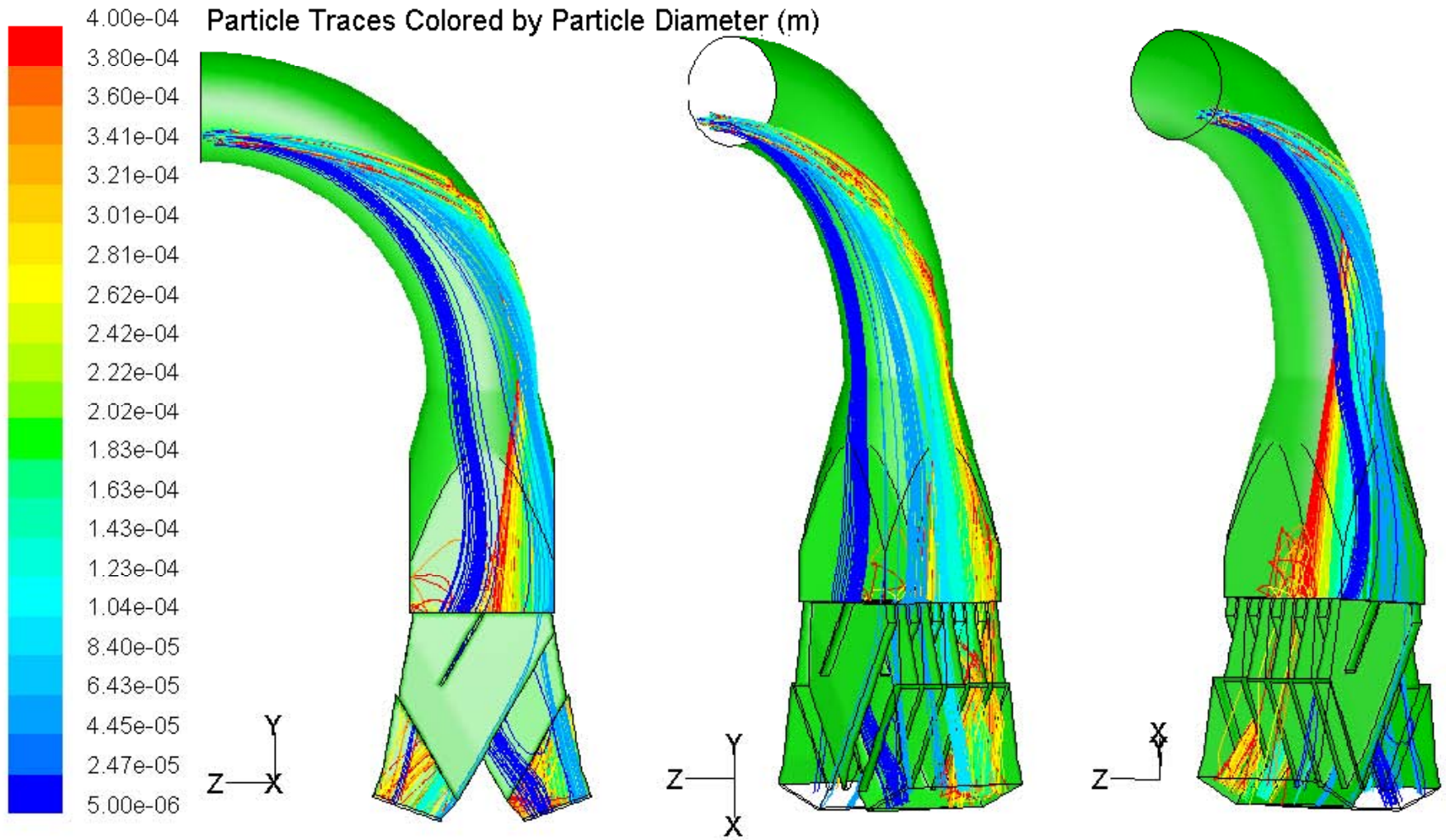


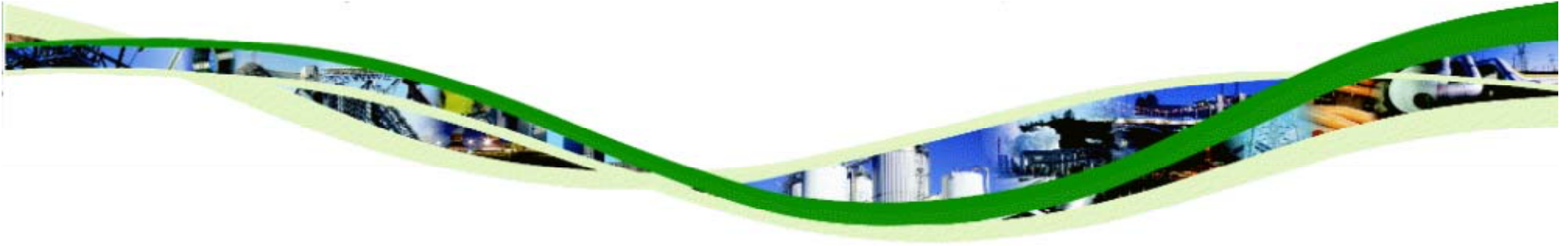
2-13
WEST



Interior of the riffle box

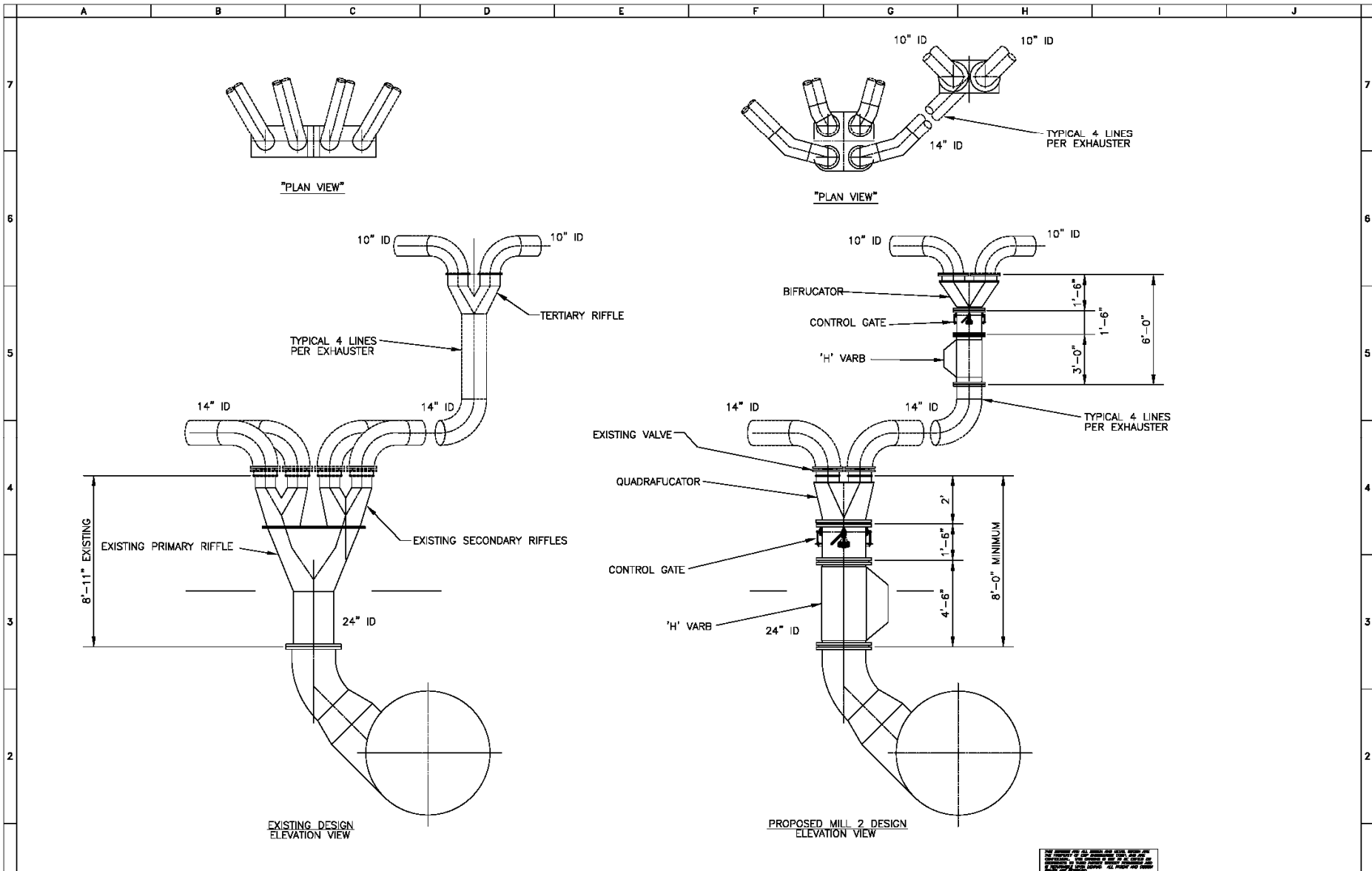
Existing geometry





Riffle replacement Biomass application

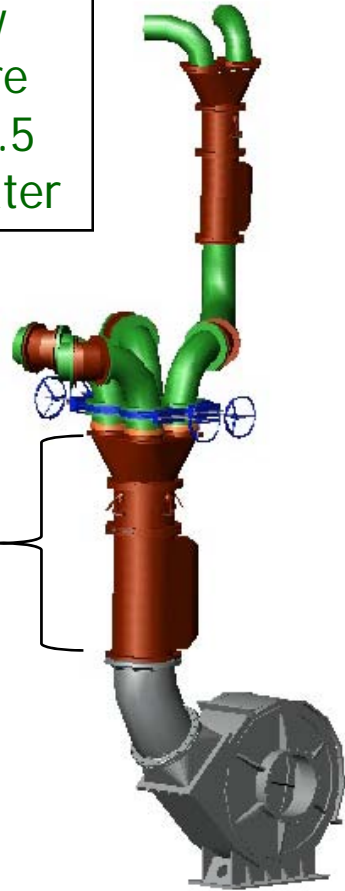
1. First time that a VARB has been installed to directly replace a Rifflebox for the purposes of pressure drop reduction to increase throughput.
2. Goal was to reduce the total pressure drop of the system by 20% while maintaining a 10% distribution split delivered theoretically by the Rifflebox.
3. The Riffle was a coarse model CERL riffle without eggbox. The split consisted of 16 separator plates. Three riffles were removed, 2 secondary and 1 primary.
4. The split also contained a shallow venturi (about ½" D in length, 15% blockage) in addition to the riffleboxes.
5. By reducing the pressure drop by at least 20% the station were able to increase their loading by 40%
6. The VARB was shown to maintain the split at several different conditions.
7. The installation included a VARB and control gate.
8. The split was controlled and maintained by the stations flow measurement system.
9. The plant plans to automate the system with Greenbank in future.



												185 Plumpton Ave. Washington, WA 98301 800-468-1180 www.cbpenengineering.com		DRAWING DESCRIPTION 24" TO 10" PROPOSED VARB REPLACEMENT ARRANGEMENT		APPROVED BY: _____ DATE: _____ CHECKED BY: _____ DATE: _____ DRAWN BY: _____ DATE: _____			
A Subsidiary of The Greenbank Group Inc.										PURCHASE ORDER: _____ NOTES: not to scale		THEORY NUMBER: _____ CONTRACT NUMBER: _____		RD 8/7/08 DRAWING NUMBER: J020-1 REV. 0					
NUMBER	DESCRIPTION	NO.	DETAIL	REVISIONS	DATE	BY	CHK'D	NO.	DETAIL	REVISIONS	DATE	BY	CHK'D						
REFERENCE DRAWINGS		B		C		D		E		F		G		H		I		J	

Primary and Secondary Riffle Replacement

VARB w/Low
total pressure
drop ~2.5-3.5
inches of water



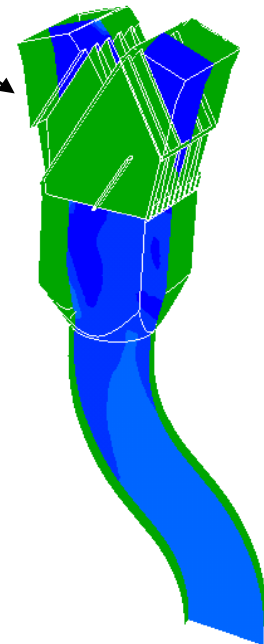
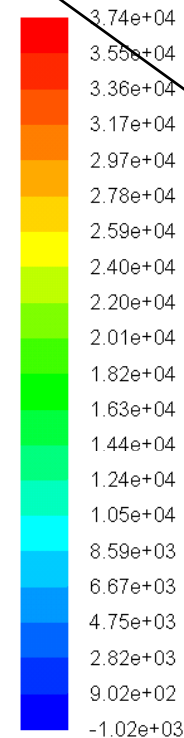
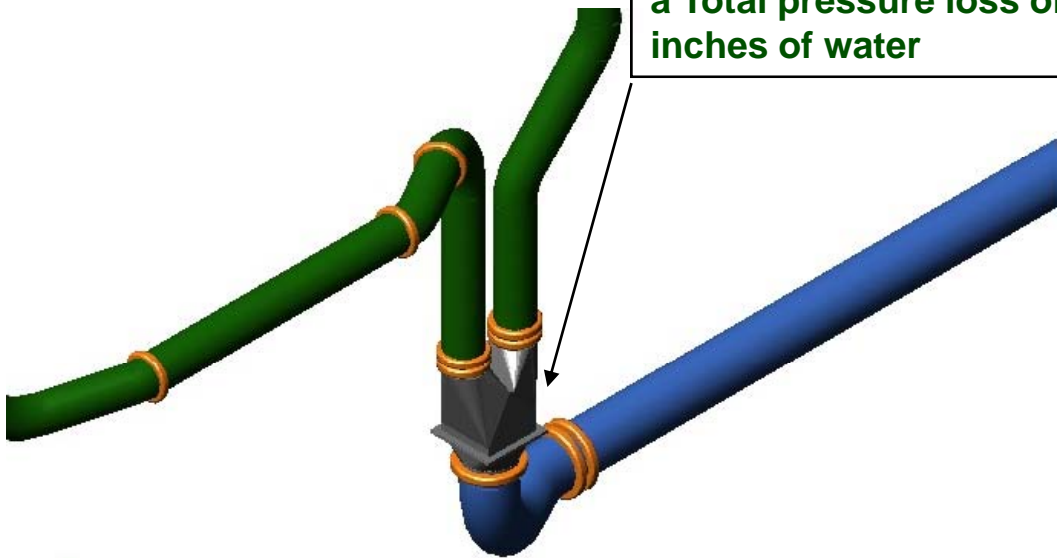
Primary Riffle ~4-6
inches of water
Secondary Riffle
~4-6 inches of
water **Total
pressure drop ~
8-12 inches of
water**

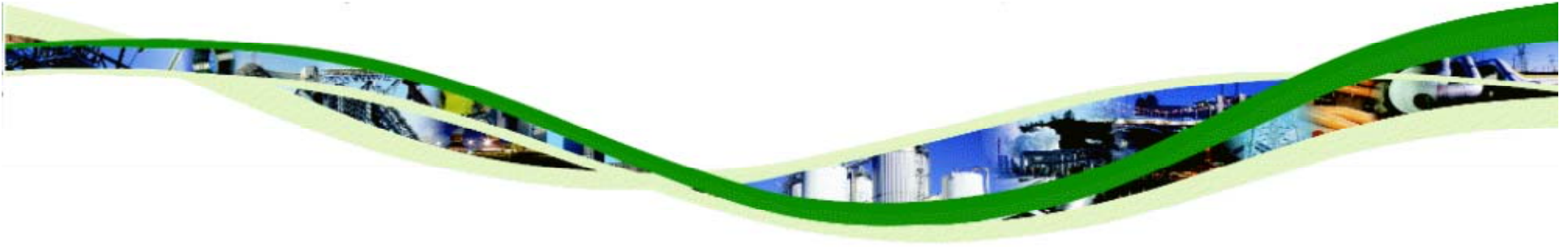




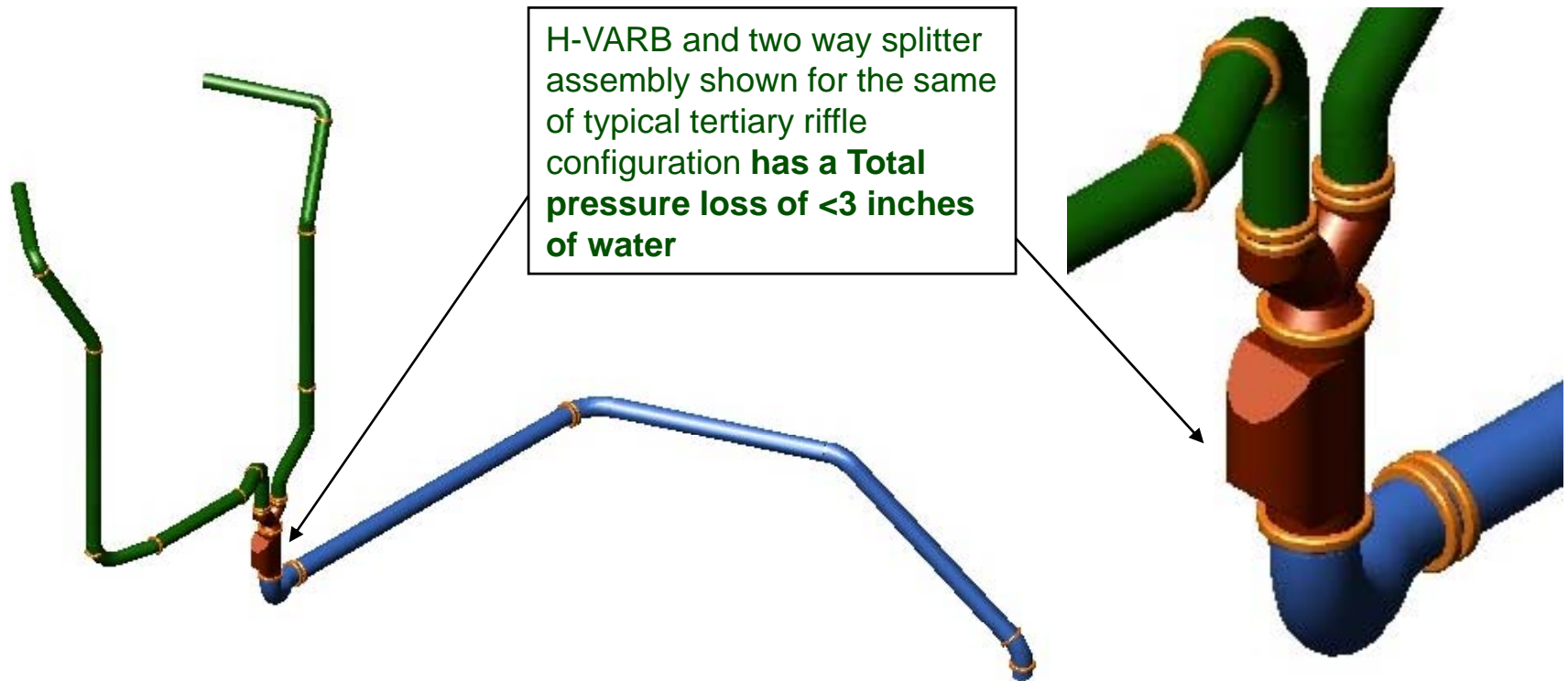
Tertiary Riffle replacement

Rifle elements and housing assembly shown of typical tertiary riffle configuration **has a Total pressure loss of ~ 4-6 inches of water**





Tertiary Riffle replacement



H-VARB and two way splitter assembly shown for the same of typical tertiary riffle configuration has a Total pressure loss of <3 inches of water

Consumers Energy JH Campbell Plant (multi-outlet mill application)



Consumers Energy JH Campbell Plant Unit 3

- PfMaster installed on Mill D after its been in service for approx 3000 hours
- 800MW Foster Wheeler boiler
- Unit 3 is fed front and back, 24 Mitsui Low NOx burners to the back and 24 to the front.
- 8 Alstom Mills, each feed the boiler by 6 outlet pipes.

Coal flow balance was achieved by :

Making adjustments in the rotary classifier speed

Making adjustments to the mill outlet assembly

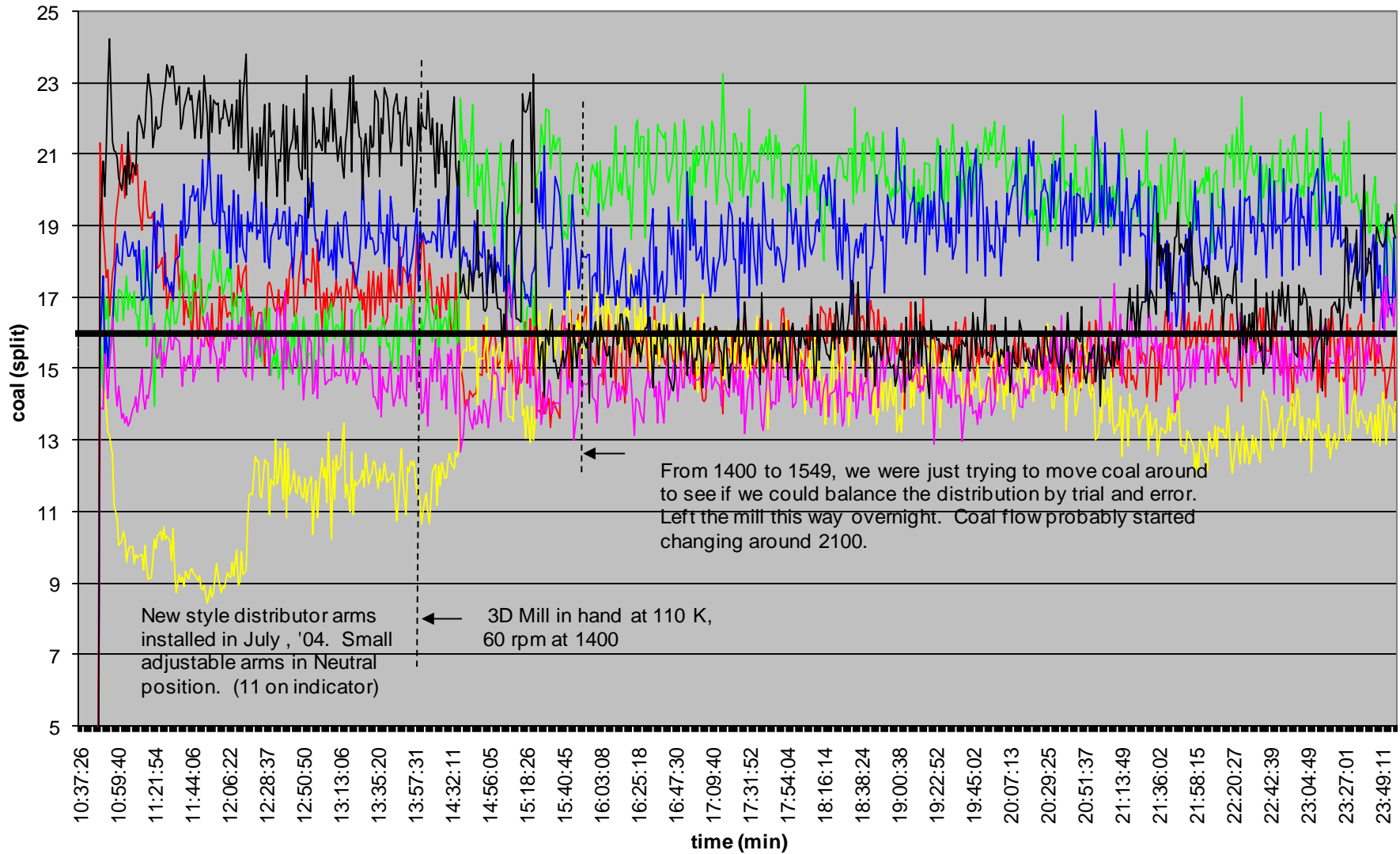
Balance splits would be 16.67% in each of the six outlet pipes



11. 5. 2004

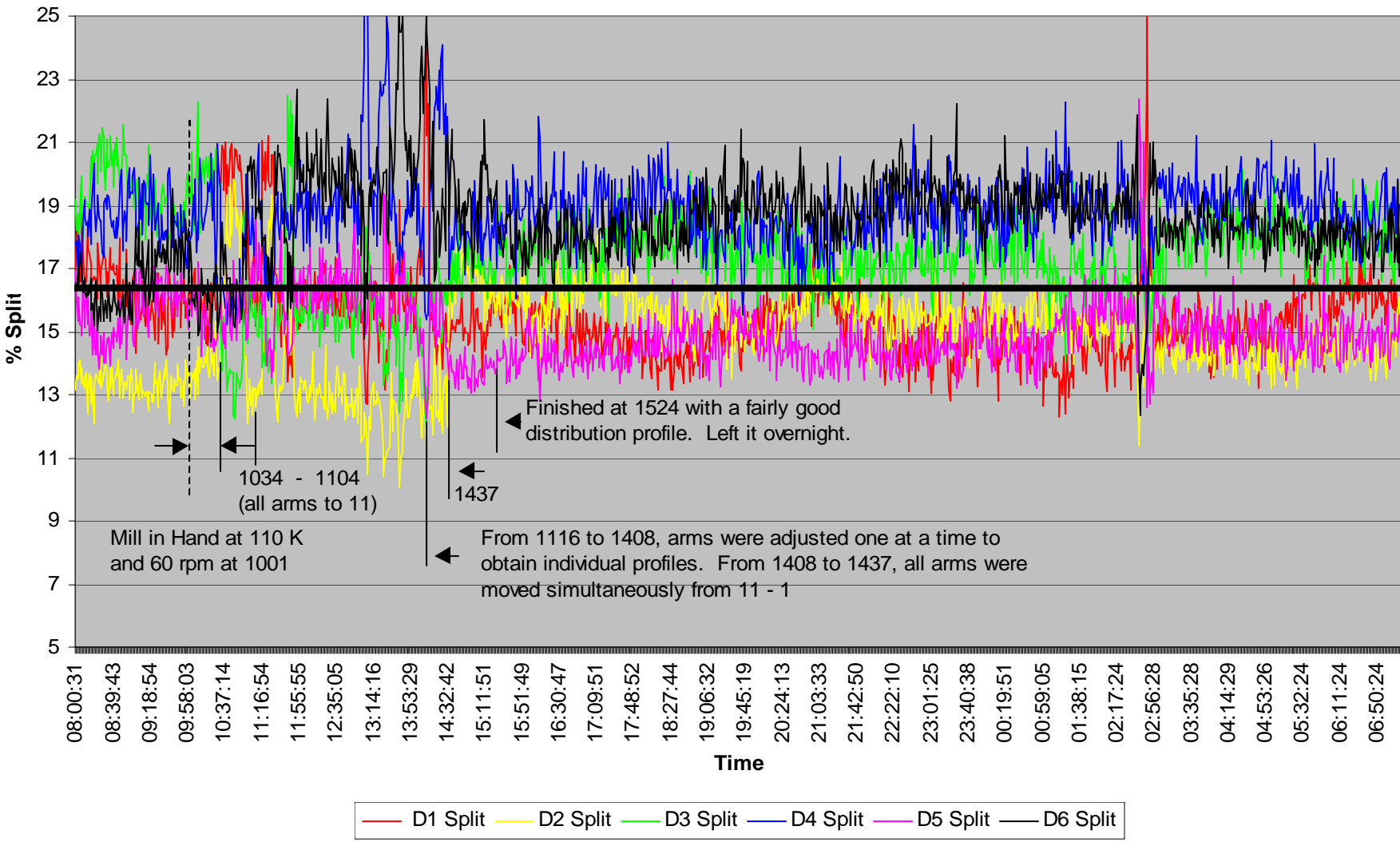


JHC3 - "D" Mill 31 Aug 2004



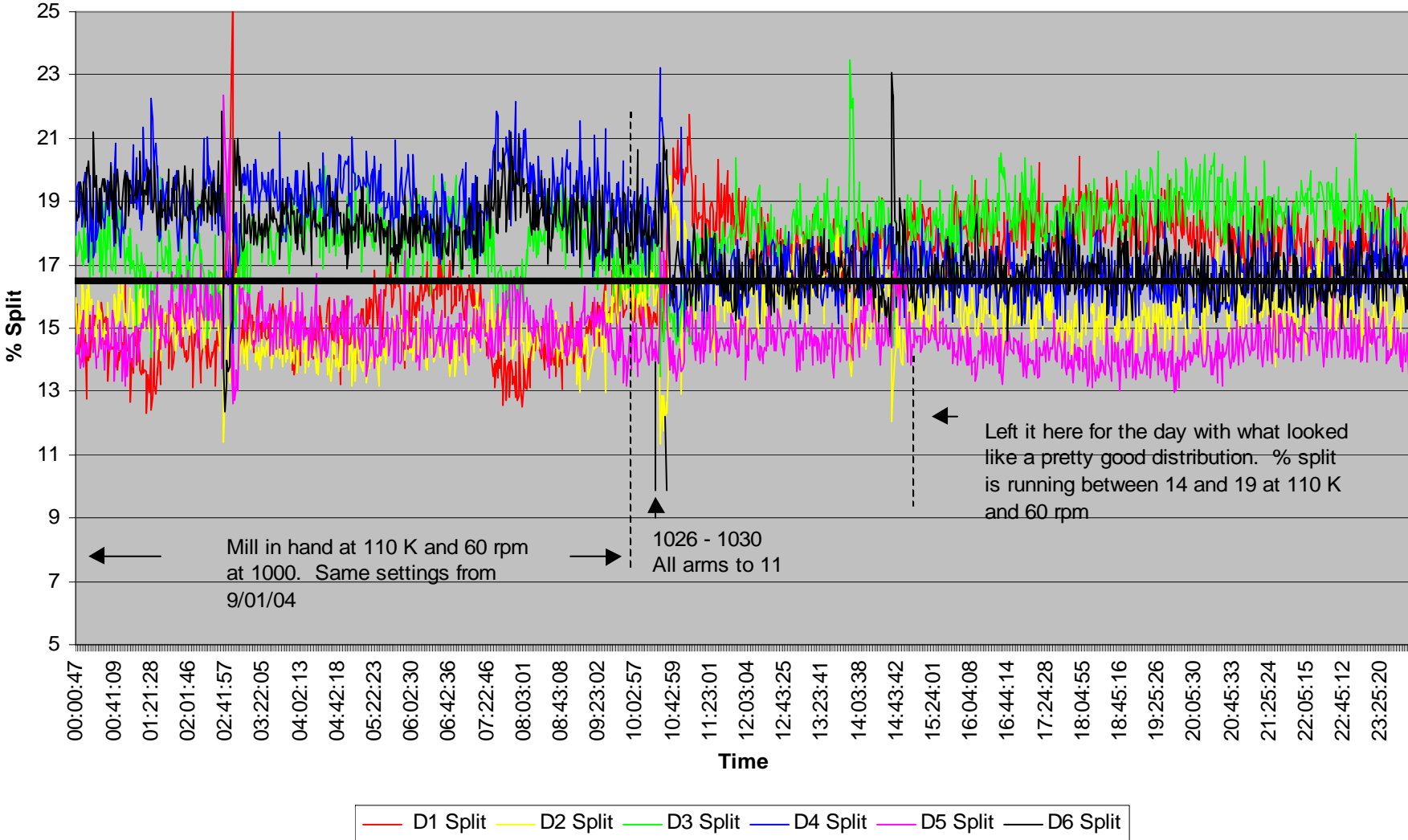
On-line Monitoring and Control - Campbell Plant, USA

JHC3 Distributor Blade Adjustment 1 Sept 04



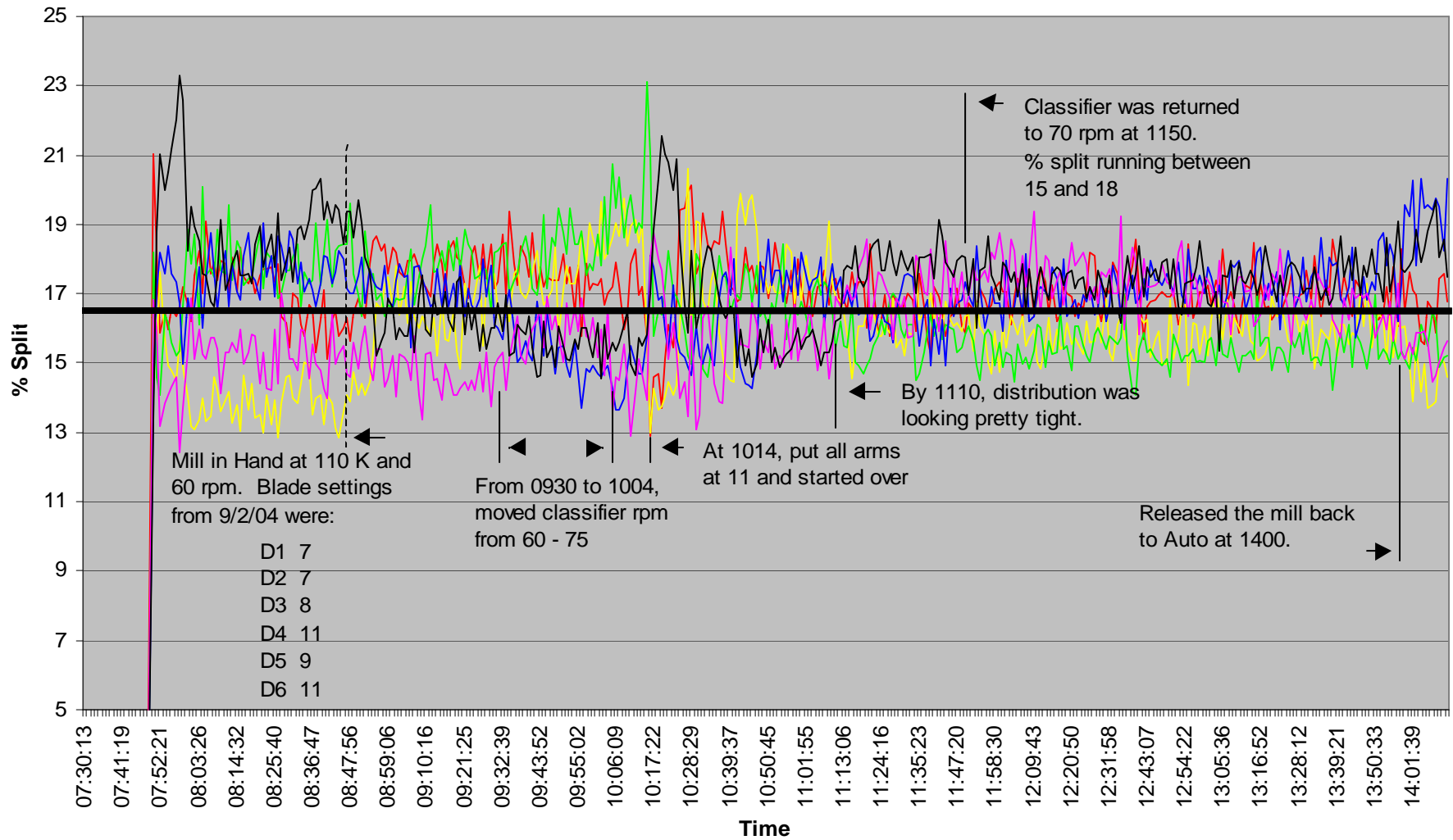
On-line Monitoring and Control - Campbell Plant, USA

JHC3 Distributor Blade Adjustment 2 Sept 04

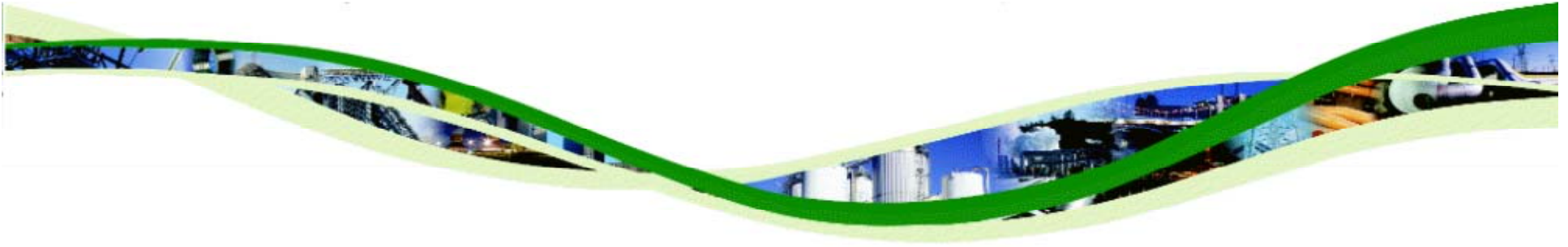


On-line Monitoring and Control - Campbell Plant, USA

JHC3 'D'Mill Distribution 3 Sept 04



On-line Monitoring and Control - Campbell Plant, USA

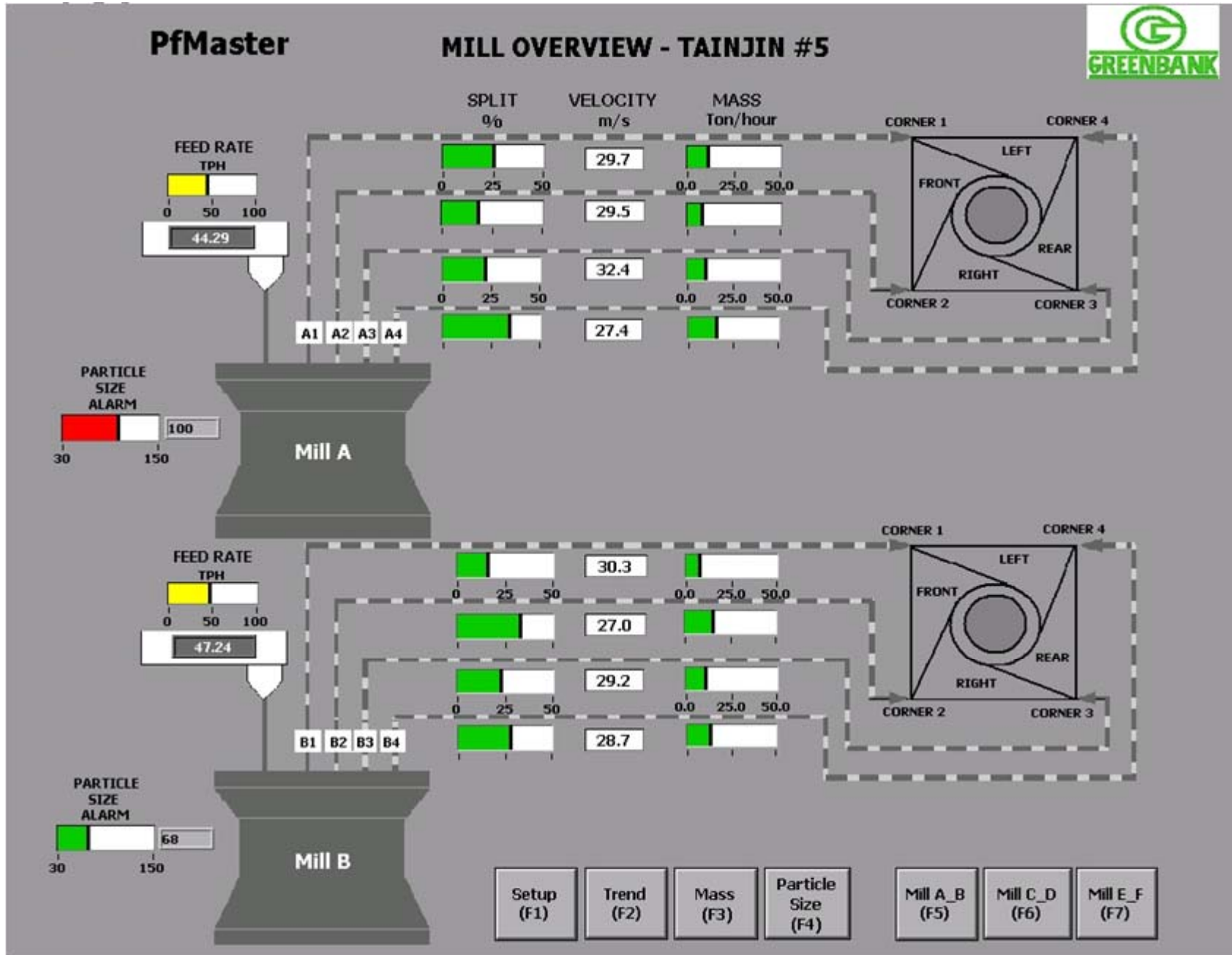


**Accurate PF Coal Flow Monitoring
and Velocity Measurement**

Interface

**PfMaster - Coal Flow Monitoring System
(CFMS)**

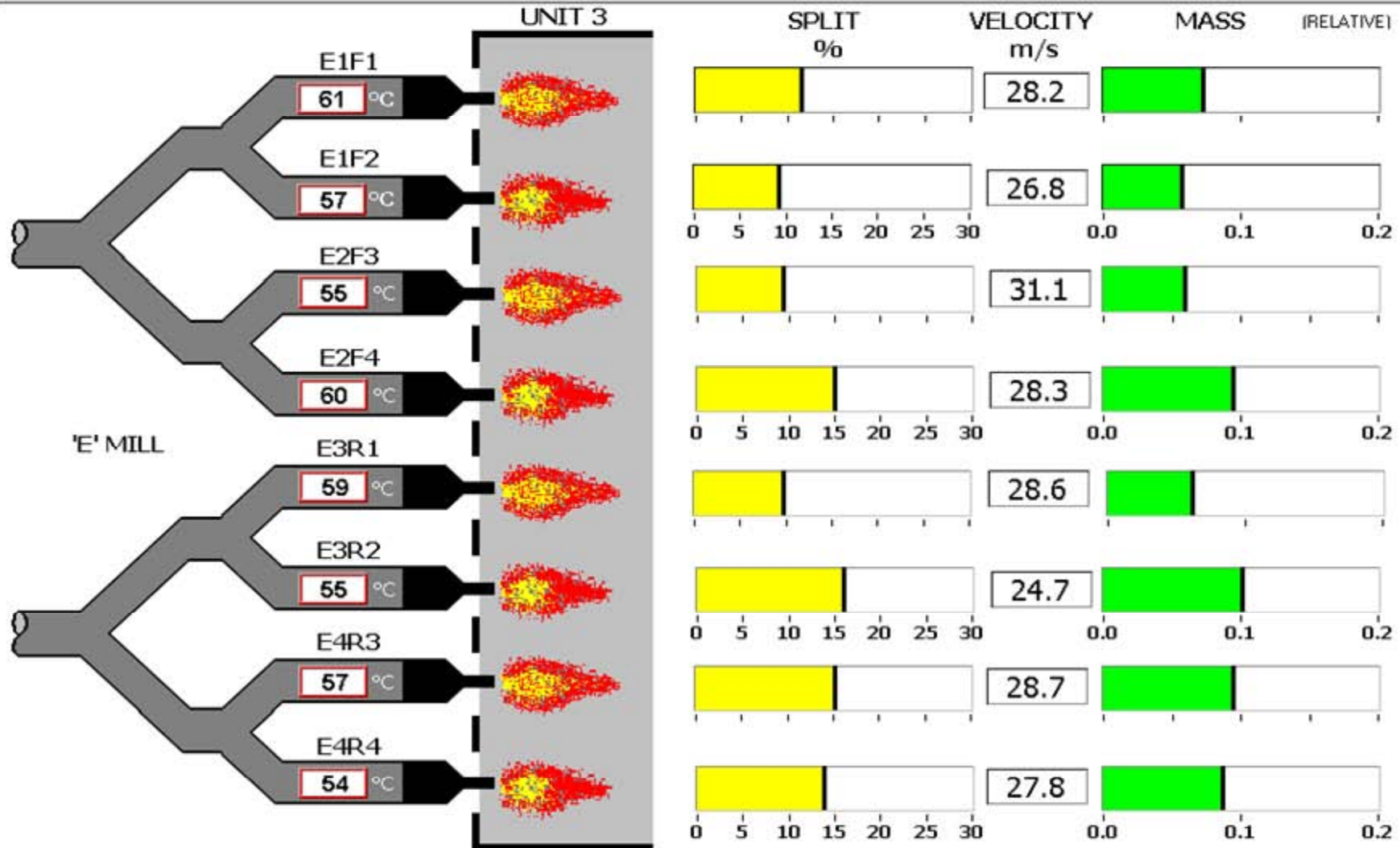
Screen Shots – PF Distribution and Velocity



Screen Shots – PF Distribution and Velocity

UNIT 3 - PF DISTRIBUTION

PfMaster



Setup (F1)

Trend (F2)

Log (F3)



GREENBANK



Thank you for your kind attention.

Questions?