NOx REDUCTION OF A 165 MW WALL FIRED BOILER UTILIZING AIR AND FUEL FLOW MEASUREMENT AND CONTROL

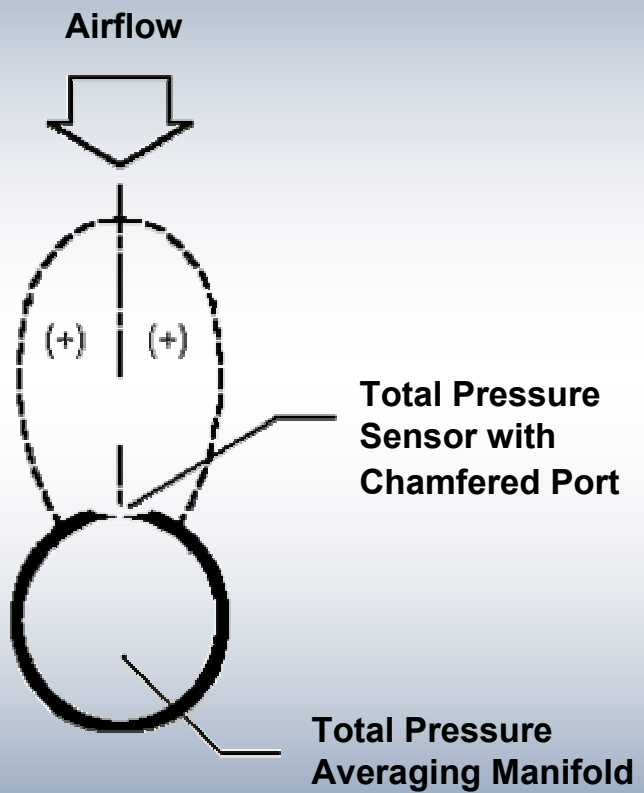
Author: Marion Cherry – Santee Cooper

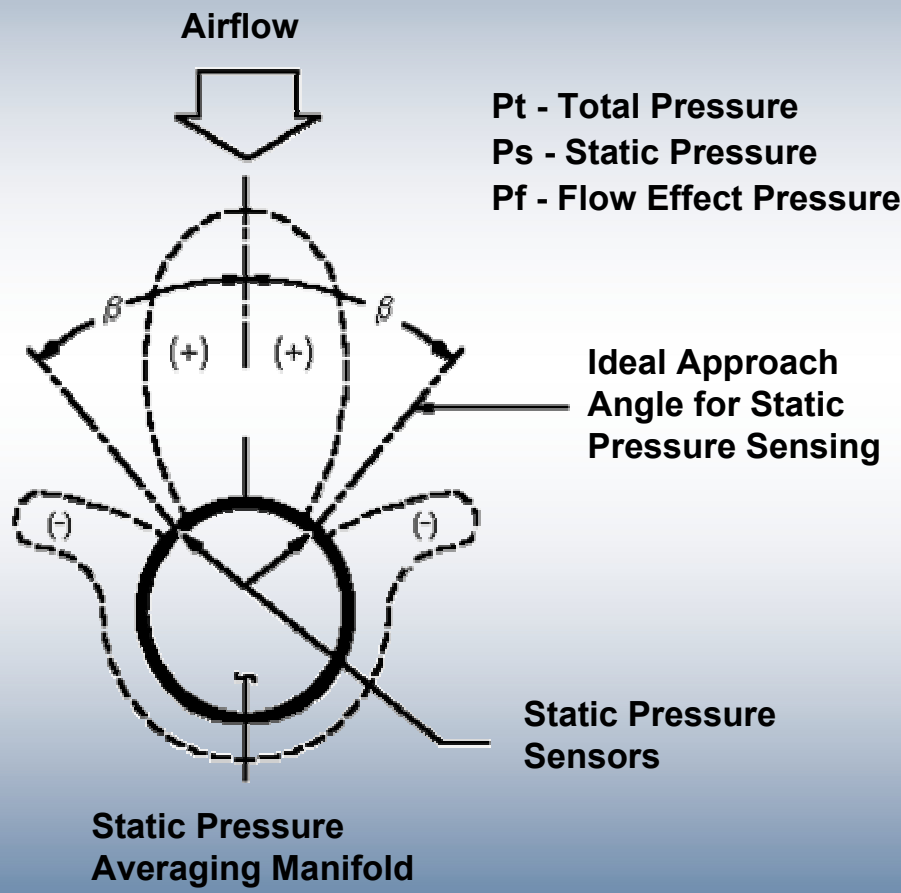
Co-Authors: Dave Earley – Air Monitor Corporation

David Silzle – Air Monitor Corporation

AIR MONITOR CORPORATION

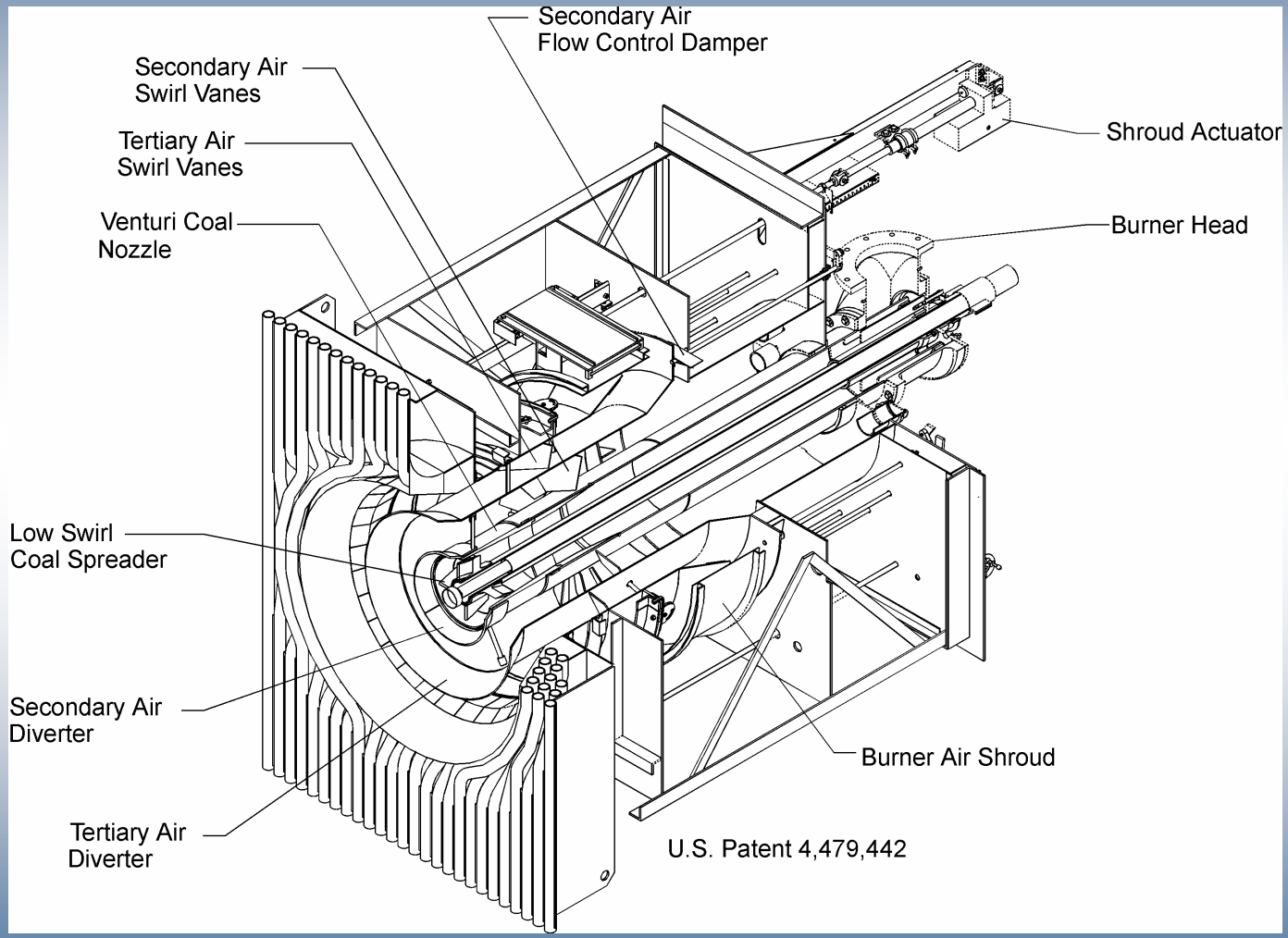
Airflow Measurement: Pitot-Fechheimer Probe





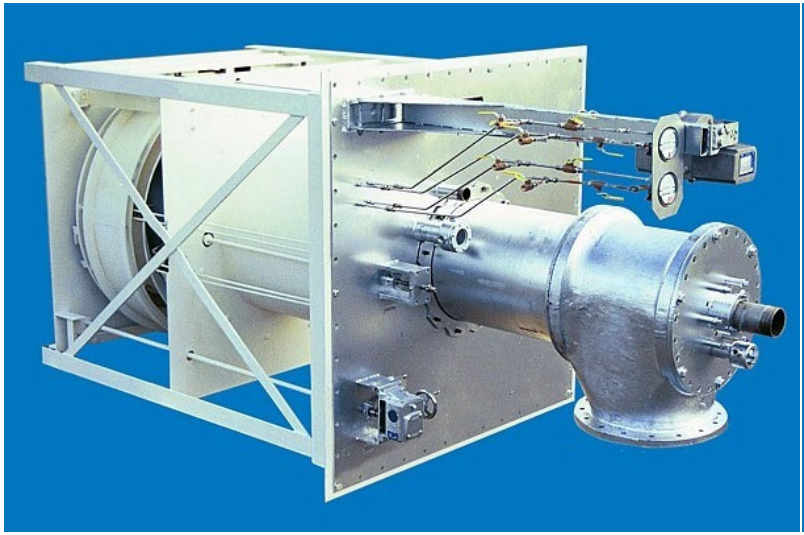
AIR MONITOR CORPORATION

CCV DAZ Low NO_x Burner

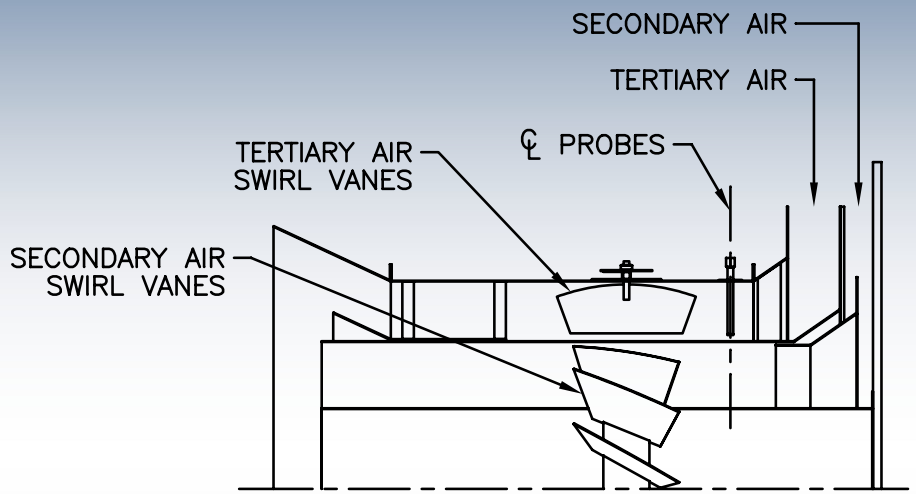


AIR MONITOR CORPORATION

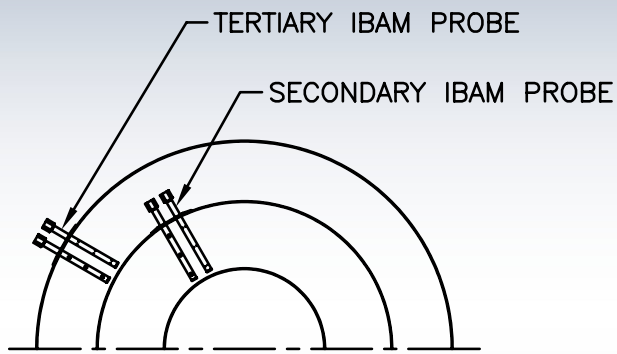
CCV® Dual Air Zone Burner



Sectional View of Burner

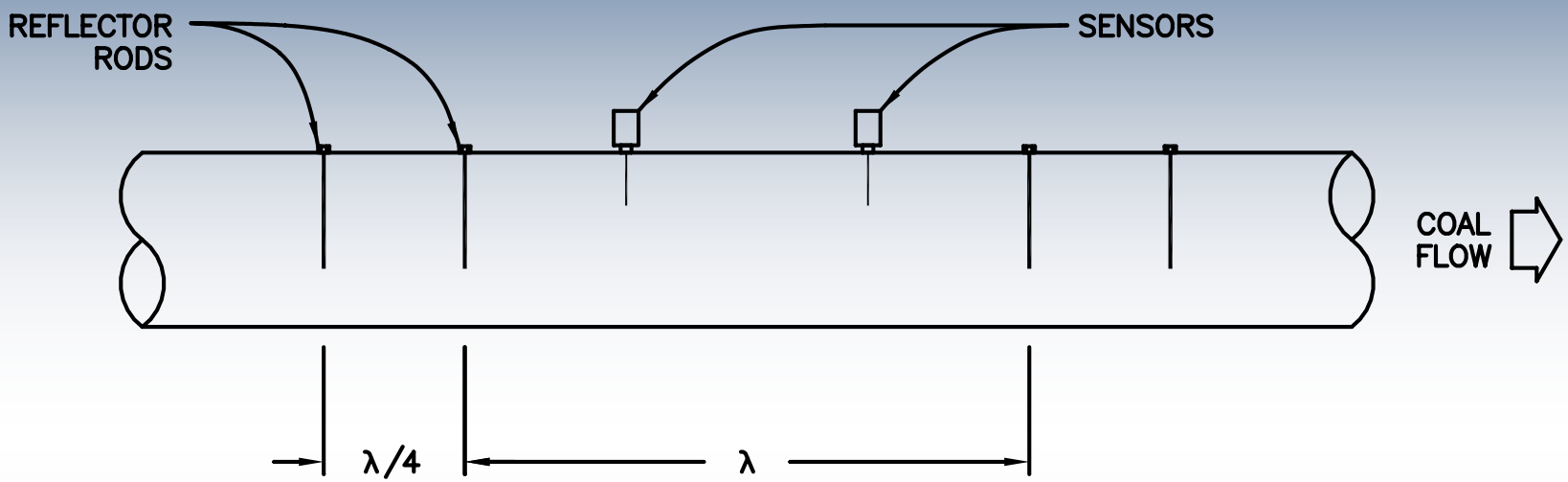


SECTIONAL SIDE VIEW

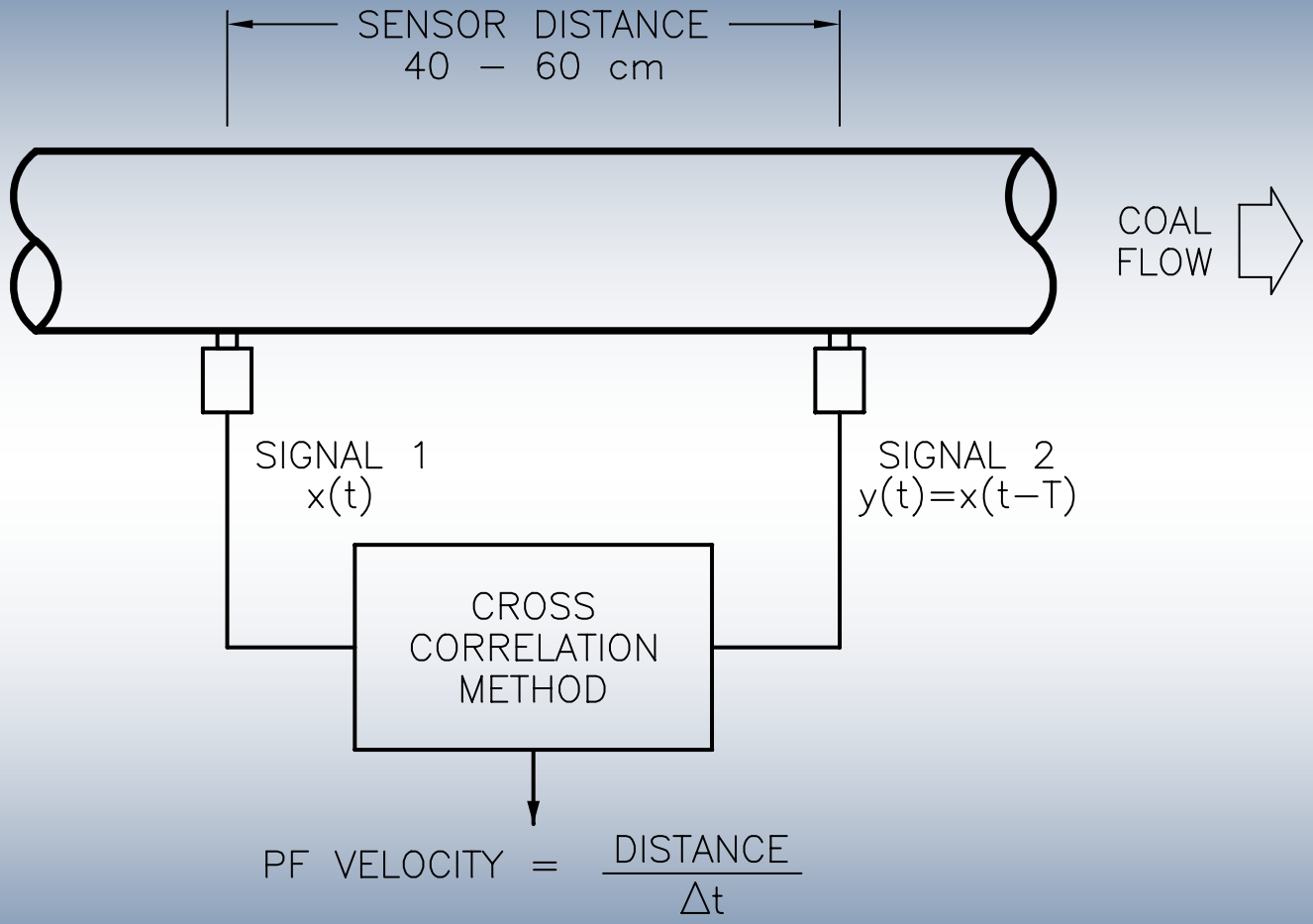


SECTIONAL END VIEW

Coal Density Measurement



Coal Velocity Measurement



AIR MONITOR CORPORATION

Absolute Measurement

- Independent
- Repeatable
- Individual
- Accurate

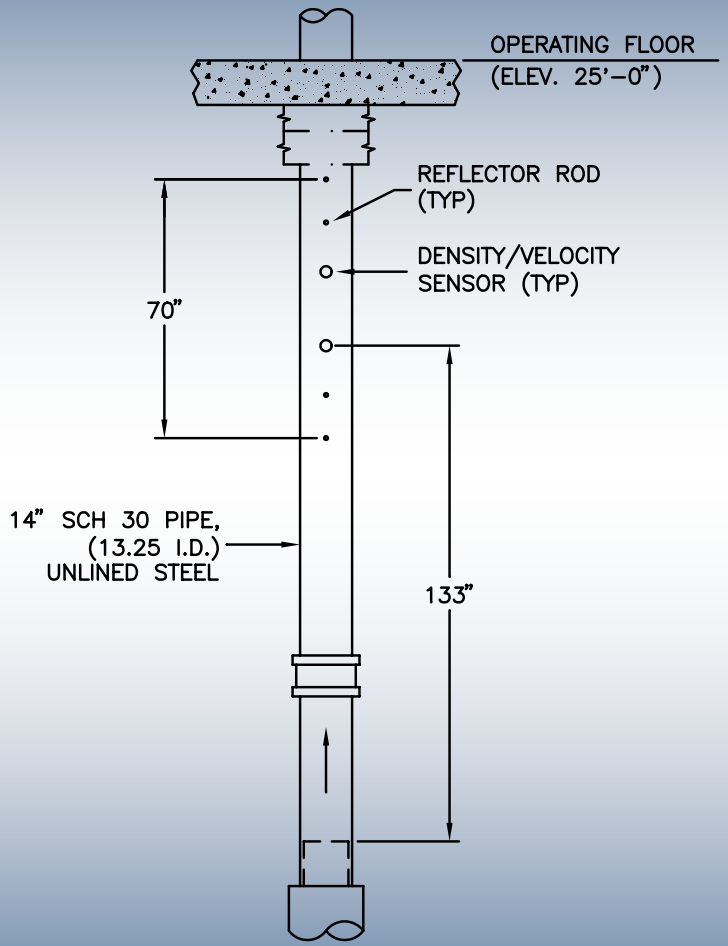
Absolute Coal Flow Measurement

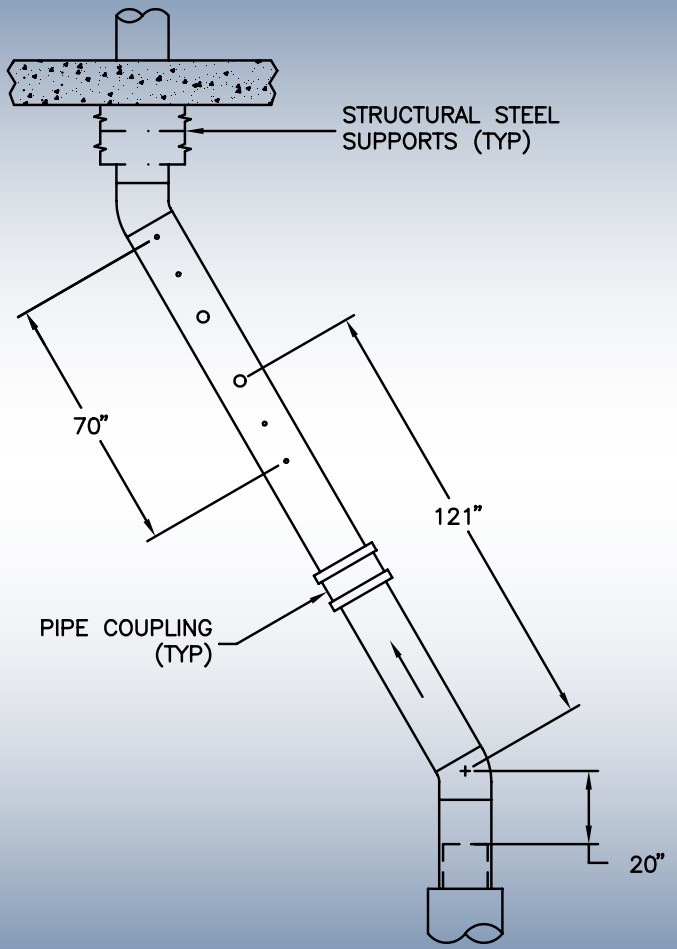
- Output from each pipe not dependent on other pipes, primary air, or other variables.
- Output not dependent on coal feeder information.
- No coal sampling required to yield relative flow distribution.
- Output is directly proportionate to coal flow in each pipe.

Scaled Mass Flow

- Only need to apply a scaling factor to absolute output.
- Scaling factor may be obtained from gravimetric feed rate input, or manual sampling of a single coal pipe.

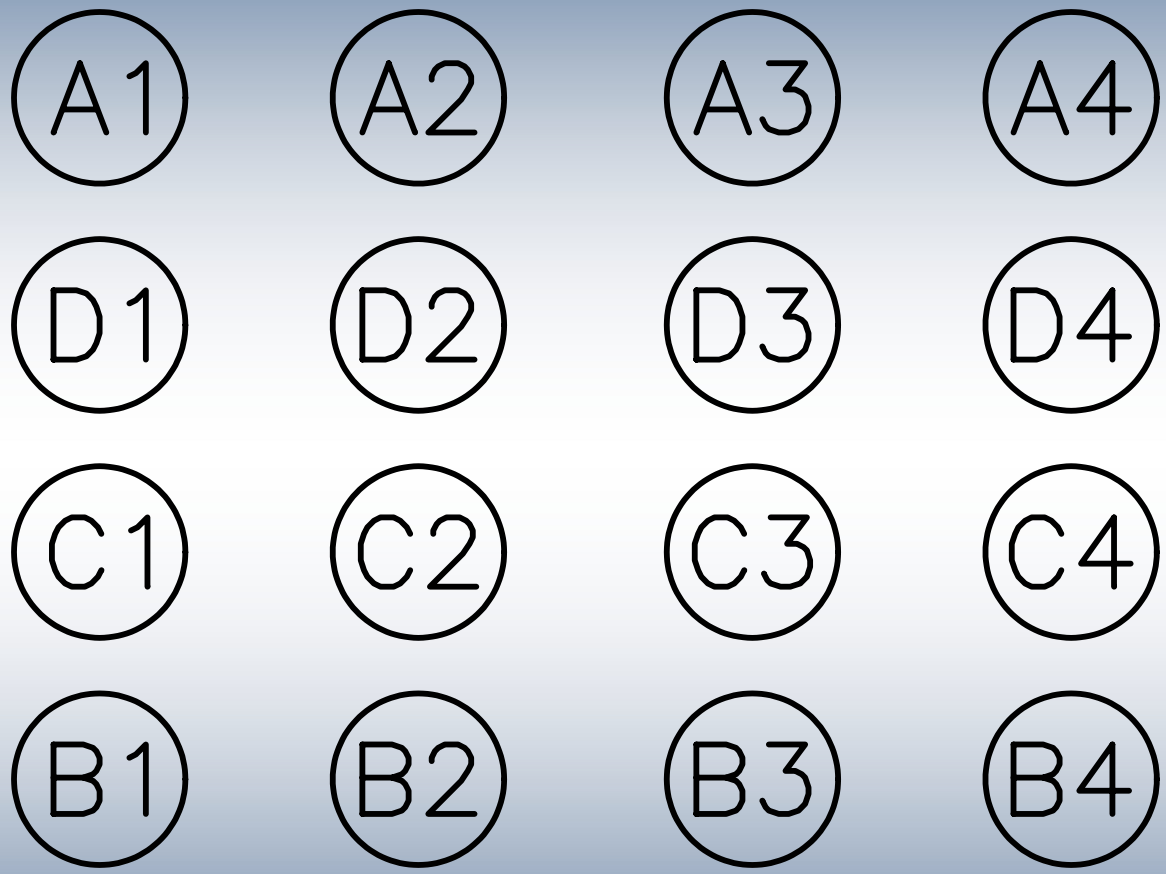
Pf-FLO Sensor Installation





AIR MONITOR CORPORATION

Burner Arrangement



AIR MONITOR CORPORATION

Baseline Air and Coal Data

Date: 7/24/01
Time: 10:30 PM
Load: 165 MW

O_2 Grid:	2.40	%	3.65	%	4.66	%	`4.59	%
	A1		A2		A3		A4	
Air Flow:	84078	lb/hr	89280	lb/hr	83115	lb/hr	80965	lb/hr
Fuel Flow:	6690	a.u.	5170	a.u.	6560	a.u.	7015	a.u.
Air / Fuel	12.57		17.27		12.67		11.54	
	D1		D2		D3		D4	
Air Flow:	83719	lb/hr	78715	lb/hr	73614	lb/hr	90834	lb/hr
Fuel Flow:	5005	a.u.	4550	a.u.	4800	a.u.	4625	a.u.
Air / Fuel	16.73		17.30		15.34		19.64	
	C1		C2		C3		C4	
Air Flow:	94041	lb/hr	103786	lb/hr	94041	lb/hr	91023	lb/hr
Fuel Flow:	5585	a.u.	5445	a.u.	5705	a.u.	4265	a.u.
Air / Fuel	16.84		19.06		16.48		21.34	
	B1		B2		B3		B4	
Air Flow:	66650	lb/hr	75626	lb/hr	66729	lb/hr	73563	lb/hr
Fuel Flow:	5715	a.u.	7020	a.u.	8260	a.u.	5790	a.u.
Air / Fuel	11.66		10.77		8.08		12.71	

AIR MONITOR CORPORATION

Data After Balancing Fuel/Air

Date: 7/25/01
Time: 1:30 AM
Load: 165 MW

O_2 Grid:	3.92	%	4.15	%	4.26	%	4.05	%
	A1		A2		A3		A4	
Air Flow:	95836	lb/hr	87396	lb/hr	87162	lb/hr	89076	lb/hr
Fuel Flow:	6300	a.u.	5000	a.u.	6030	a.u.	6750	a.u.
Air / Fuel	15.21		17.48		14.45		13.20	
	D1		D2		D3		D4	
Air Flow:	87485	lb/hr	77522	lb/hr	77827	lb/hr	89280	lb/hr
Fuel Flow:	6070	a.u.	4980	a.u.	5390	a.u.	5310	a.u.
Air / Fuel	14.41		15.57		14.44		16.81	
	C1		C2		C3		C4	
Air Flow:	97578	lb/hr	106969	lb/hr	97294	lb/hr	72906	lb/hr
Fuel Flow:	5600	a.u.	6510	a.u.	7260	a.u.	5040	a.u.
Air / Fuel	17.42		16.43		13.40		14.47	
	B1		B2		B3		B4	
Air Flow:	73388	lb/hr	75175	lb/hr	61599	lb/hr	77610	lb/hr
Fuel Flow:	5680	a.u.	6750	a.u.	7720	a.u.	7070	a.u.
Air / Fuel	12.92		11.14		7.98		10.98	

AIR MONITOR CORPORATION

NO_x Reduction BaselineData

Date: 9/12/01
Time: 10:00 AM
Load 162 MW

O_2 Grid:		3.80	%	4.52	%	5.20	%	4.42	%	4.48	%
		A1		A2		A3		A4		A – TOTAL	
Air Flow:		105643	lb/hr	94368	lb/hr	93648	lb/hr	90460	lb/hr	384119	lb/hr
Fuel Flow:		8290	a.u.	6080	a.u.	8050	a.u.	5660	a.u.	28080	a.u.
Air / Fuel		12.74		15.52		11.63		15.98		13.67	
PA Signal	4060										
Feeder Signal	46960										
		D1		D2		D3		D4		D – TOTAL	
Air Flow:		87485	lb/hr	76349	lb/hr	85601	lb/hr	89139	lb/hr	338574	lb/hr
Fuel Flow:		6080	a.u.	4500	a.u.	5540	a.u.	5070	a.u.	21190	a.u.
Air / Fuel		14.39		16.97		15.45		17.58		15.97	
PA Signal	4209										
Feeder Signal	45740										
		C1		C2		C3		C4		C – TOTAL	
Air Flow:		89076	lb/hr	104106	lb/hr	84707	lb/hr	92792	lb/hr	370681	lb/hr
Fuel Flow:		5750	a.u.	5320	a.u.	5280	a.u.	2580	a.u.	18930	a.u.
Air / Fuel		15.49		19.57		16.04		35.97		19.58	
PA Signal	4811										
Feeder Signal	45820										
		B1		B2		B3		B4		B – TOTAL	
Air Flow:		64880	lb/hr	73191	lb/hr	66797	lb/hr	77788	lb/hr	282656	lb/hr
Fuel Flow:		5830	a.u.	6190	a.u.	6580	a.u.	5060	a.u.	23660	a.u.
Air / Fuel		11.13		11.82		10.15		15.37		11.94	
PA Signal	5038										
Feeder Signal	43470										
Column Average	Air Flow	347085	lb/hr	348015	lb/hr	330753	lb/hr	350179	lb/hr	1376032	lb/hr
Column Average	Fuel Flow	25950	a.u.	22090	a.u.	25450	a.u.	18370	a.u.	91860	a.u.
Column Average	Air / Fuel	13.38		15.75		13.00		19.06		14.97	

AIR MONITOR CORPORATION

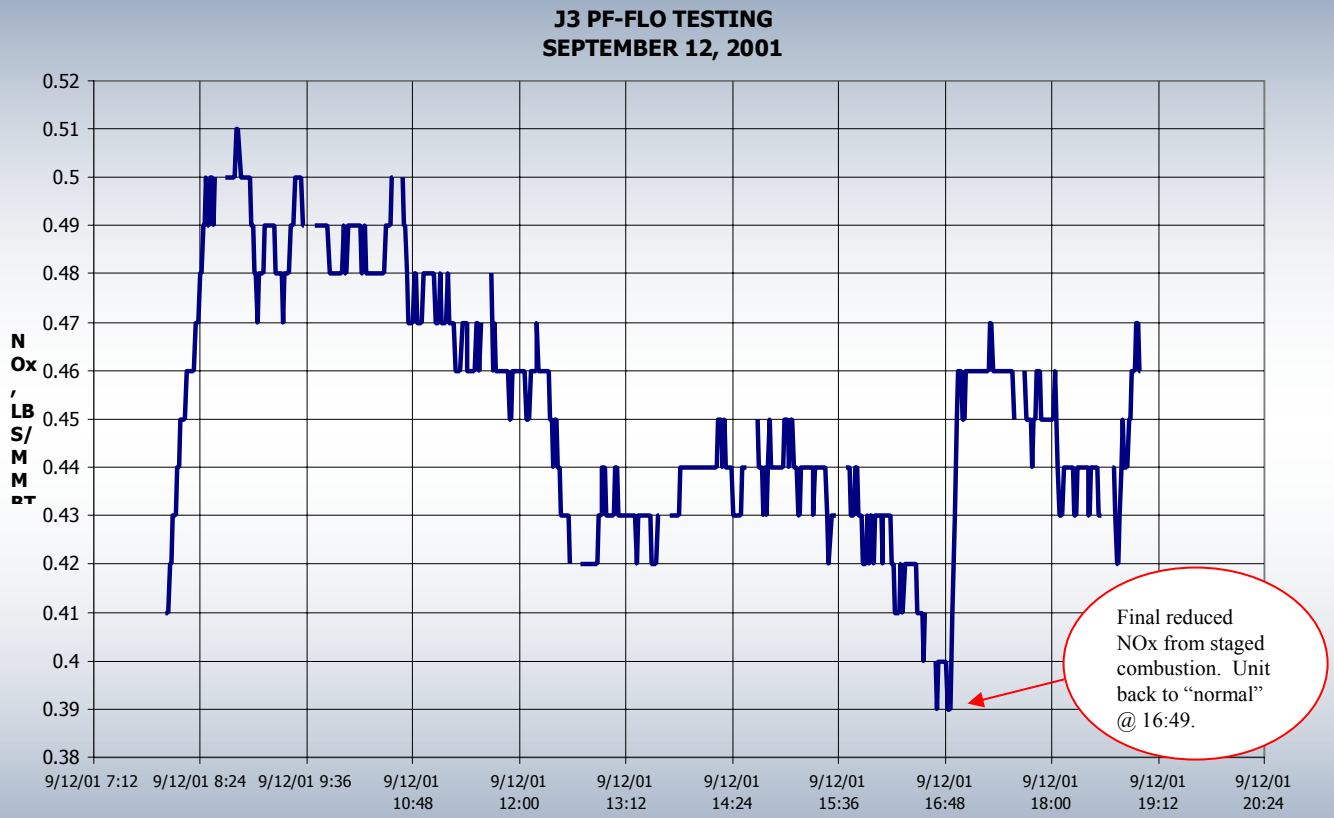
After Staging - Reduced NOx Data

Date: 9/12/01
Time: 10:00 AM
Load 160 MW

O_2 Grid:		4.06	%	4.79	%	4.52	%	3.04	%	4.10	%
		A1		A2		A3		A4		A – TOTAL	
Air Flow:		102534	lb/hr	75764	lb/hr	91733	lb/hr	94466	lb/hr	364497	lb/hr
Fuel Flow:		7850	a.u.	4800	a.u.	6380	a.u.	4840	a.u.	23870	a.u.
Air / Fuel		13.06		15.78		14.38		19.52		15.27	
PA Signal	4182										
Feeder Signal	3723										
		D1		D2		D3		D4		D – TOTAL	
Air Flow:		87485	lb/hr	71185	lb/hr	83749	lb/hr	69511	lb/hr	311930	lb/hr
Fuel Flow:		5780	a.u.	4530	a.u.	5530	a.u.	5470	a.u.	21310	a.u.
Air / Fuel		15.14		15.71		15.14		12.71		14.63	
PA Signal	4190										
Feeder Signal	4676										
		C1		C2		C3		C4		C – TOTAL	
Air Flow:		83115	lb/hr	71187	lb/hr	87162	lb/hr	58327	lb/hr	299791	lb/hr
Fuel Flow:		6350	a.u.	6070	a.u.	6280	a.u.	3320	a.u.	22020	a.u.
Air / Fuel		13.09		11.73		13.88		17.57		13.61	
PA Signal	4932										
Feeder Signal	5576										
		B1		B2		B3		B4		B – TOTAL	
Air Flow:		81442	lb/hr	68979	lb/hr	59098	lb/hr	65858	lb/hr	275376	lb/hr
Fuel Flow:		5930	a.u.	6730	a.u.	7240	a.u.	5430	a.u.	25330	a.u.
Air / Fuel		13.73		10.25		8.16		12.13		10.87	
PA Signal	5007										
Feeder Signal	4637										
Column Average	Air Flow	354576	lb/hr	287115	lb/hr	321742	lb/hr	288162	lb/hr	1251595	lb/hr
Column Average	Fuel Flow	25910	a.u.	22130	a.u.	25430	a.u.	19060	a.u.	92530	a.u.
Column Average	Air / Fuel	13.68		12.97		12.65		15.12		13.52	

AIR MONITOR CORPORATION

Recorded NOx During Testing



Air Monitor Corporation

LOI as Sampled During Test Period

	Loss on Ignition, % Hopper Designation / Sample					
	1	2	3	4	5	AVG
Full Load As-Found	8.5	8.7	9.2	11.0	9.3	9.3
Full Load After	8.1	8.0	10.4	9.4	6.7	8.5
LOI Change	– 0.4	– 0.7	+1.2	– 1.6	– 2.6	– 0.8

AIR MONITOR CORPORATION

Conclusions

- The use of individual burner air and fuel flow measurement can be used to:
  - Reduce overall NO_x levels: 18.7% decrease (from .48 to .39 lb/MMBtu).
  - Improve/flatten NO_x and O_2 profiles.
  - Reduce overall O_2 levels.
  - Improve heat rate.
  - Reduce LOI: .8% reduction while simultaneously reducing NOx by 18.7%.
  - Adjust feeder rate curves for better mill balance.

AIR MONITOR CORPORATION

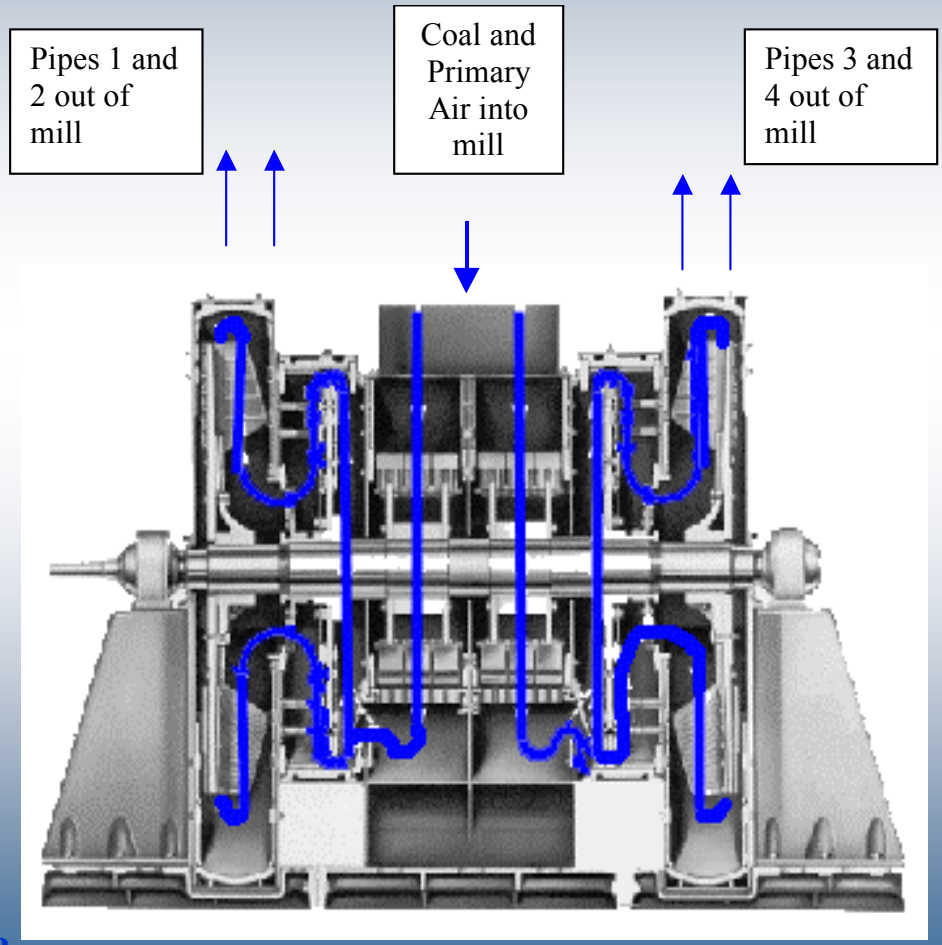
Effects of Pipe Balance on LOI

While the above NOx reduction program was performed on JSG Unit 3, this unit did not have adjustable coal valves.

Santee Cooper wanted to try to reduce its LOI on both units at JSG.

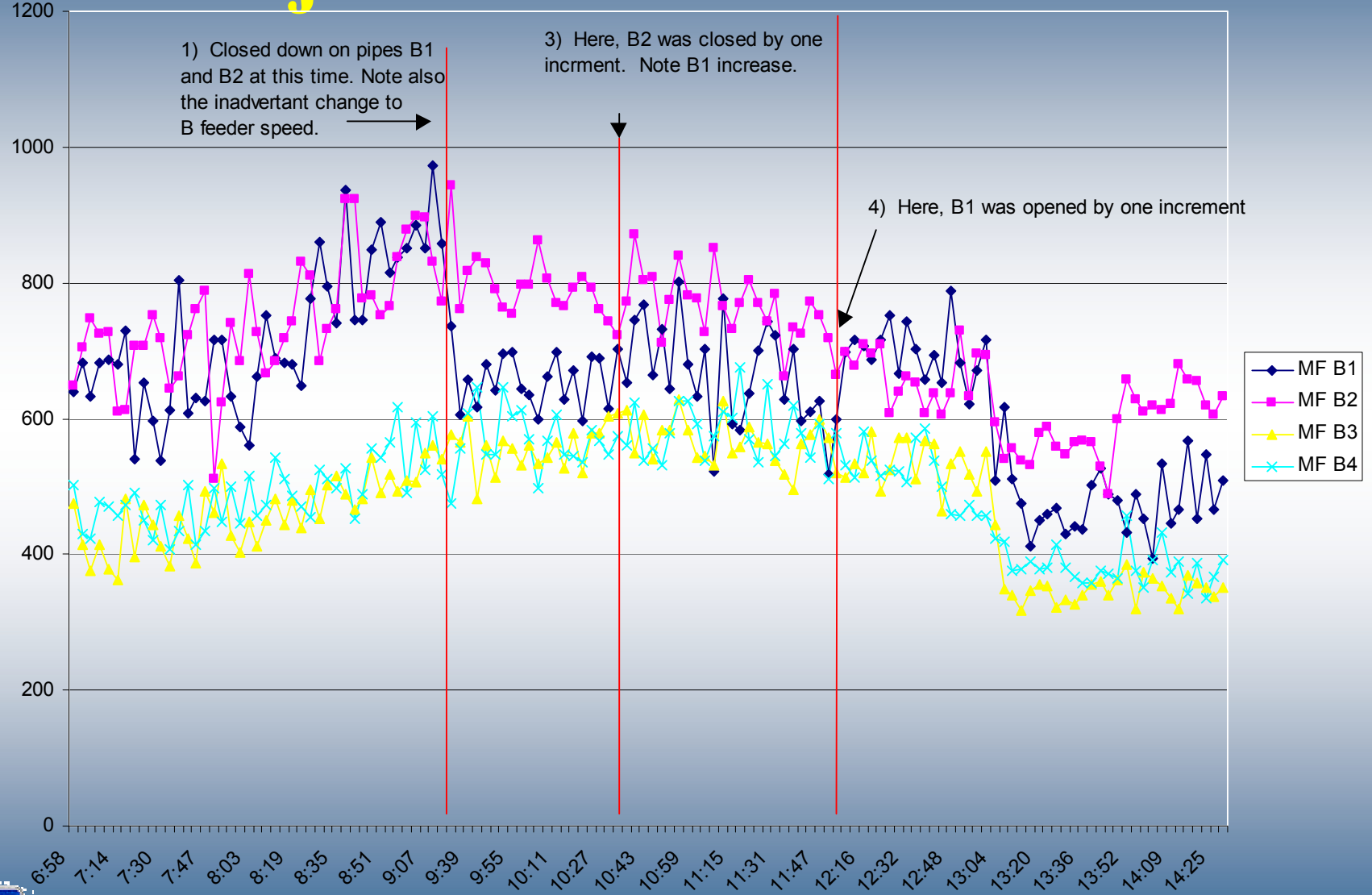
JSG Unit 4 is “identical” to unit 3 but it has adjustable coal valves on all 16 pipes.

Double ended Atrita Mills



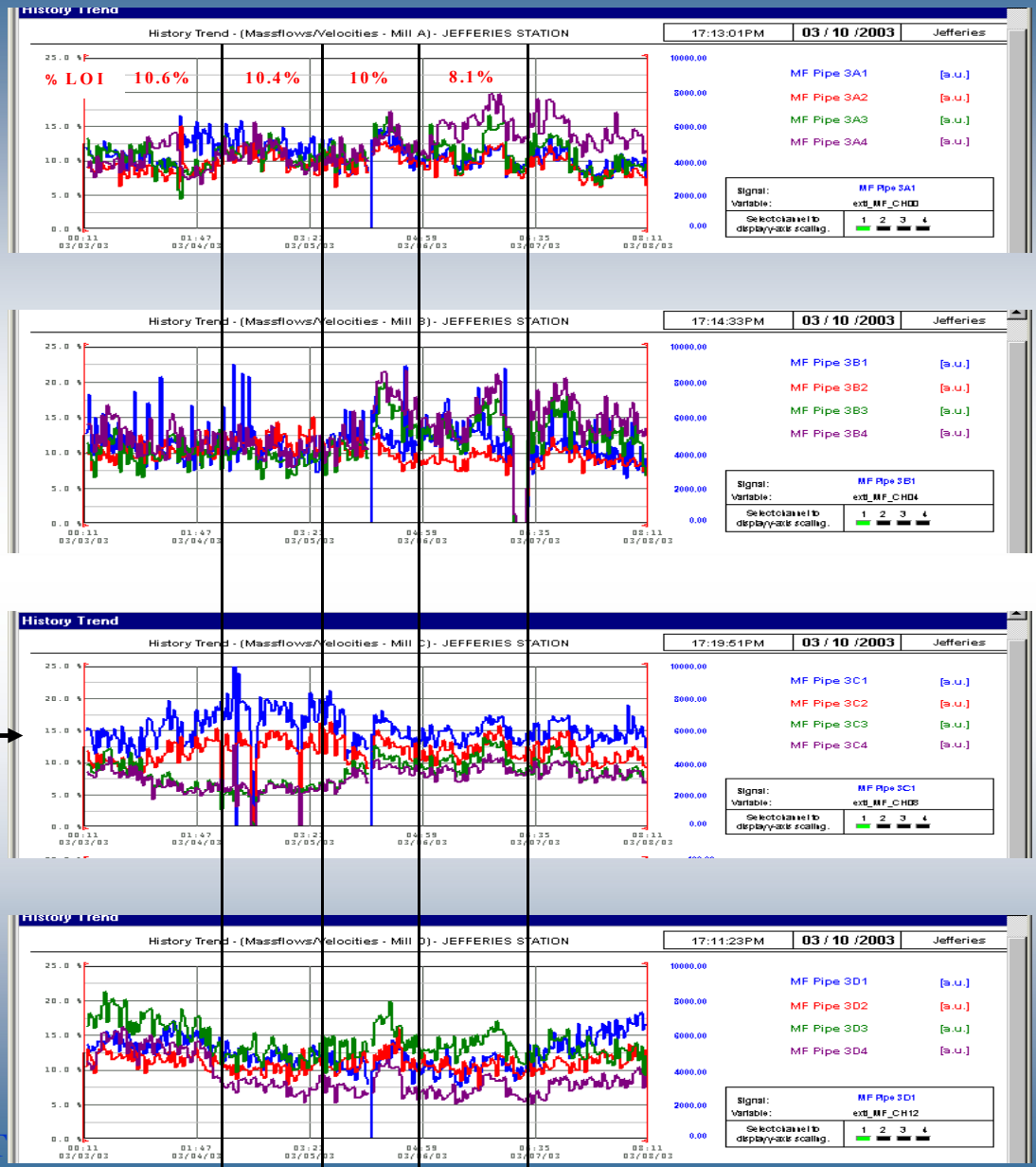
Air Monitor Corporation

Adjustable Coal Valves

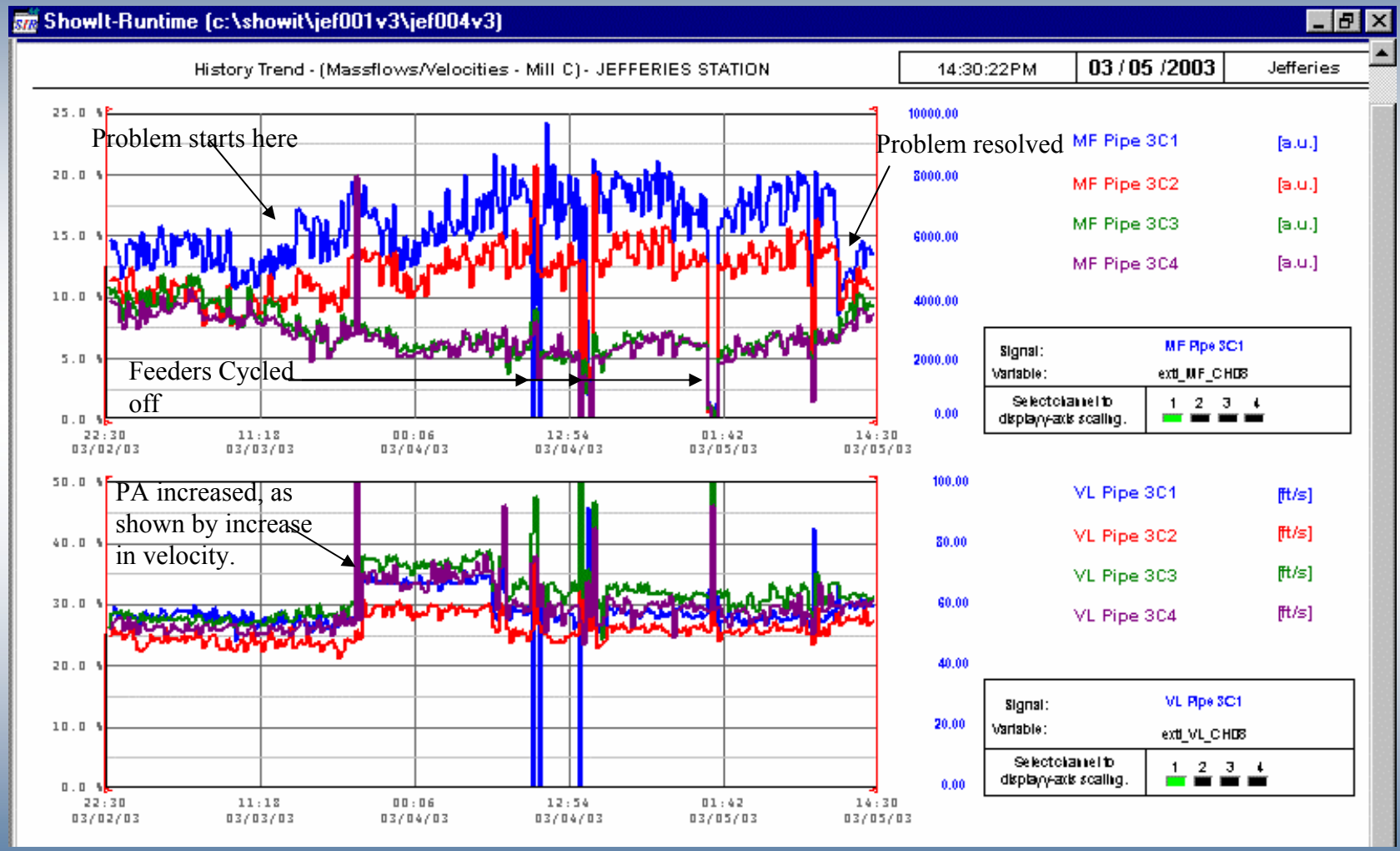


AIR MONITOR CORPORATION

Problem with C Mill. →



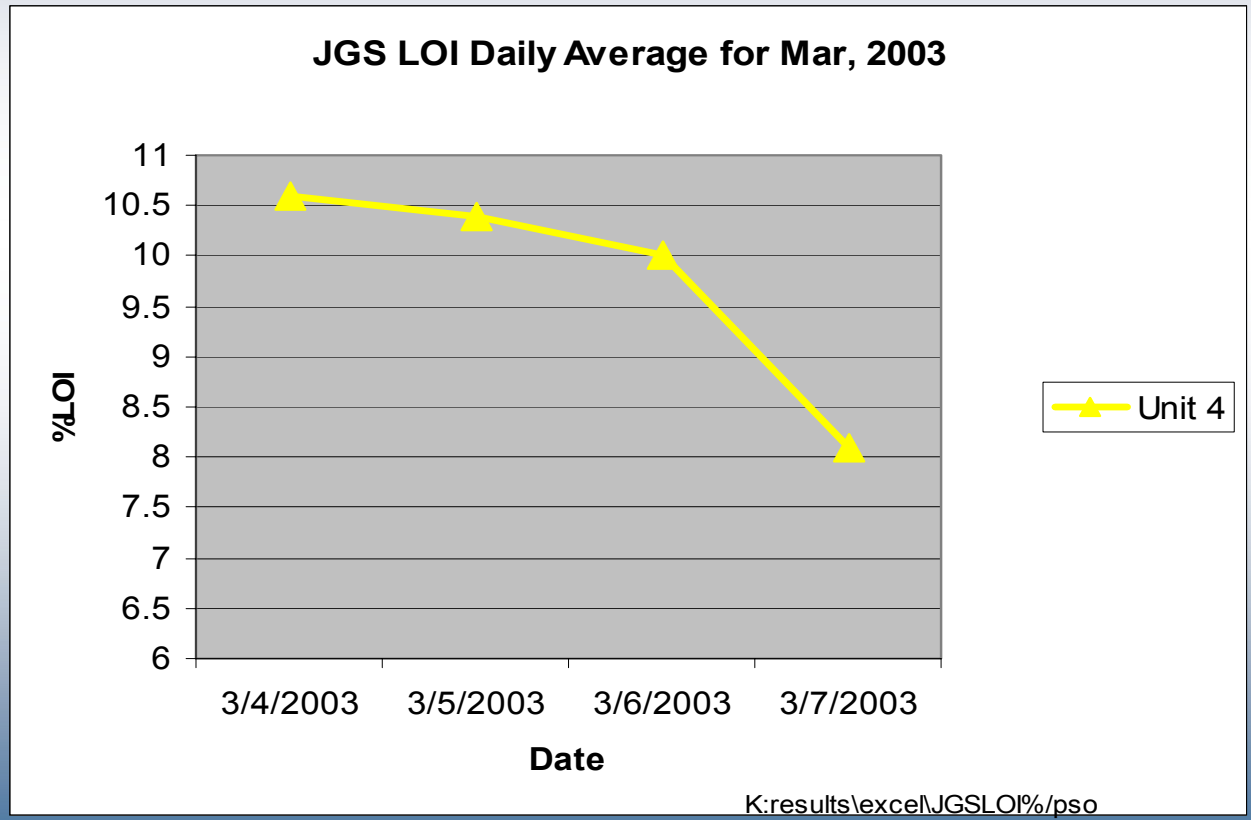
Diagnosing a Mill Problem



Air Monitor Corporation

Effects of Pipe Balance on LOI

When the mill problem was corrected, the LOI in the flyash was reduced by 24% (from 10.6% to 8.1%).



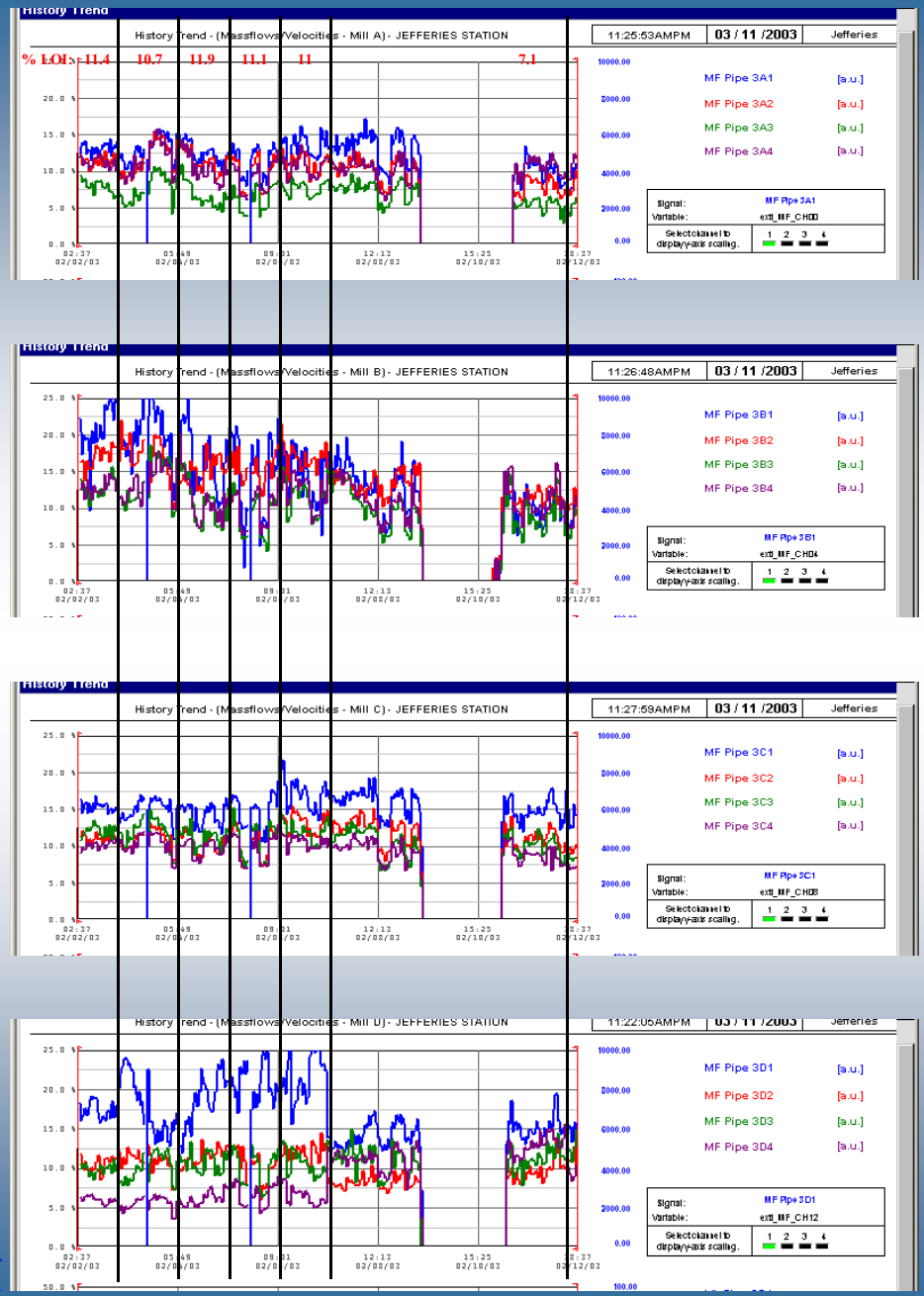
Air Monitor Corporation

Effects of Pipe Balance on LOI

Why the large change here?

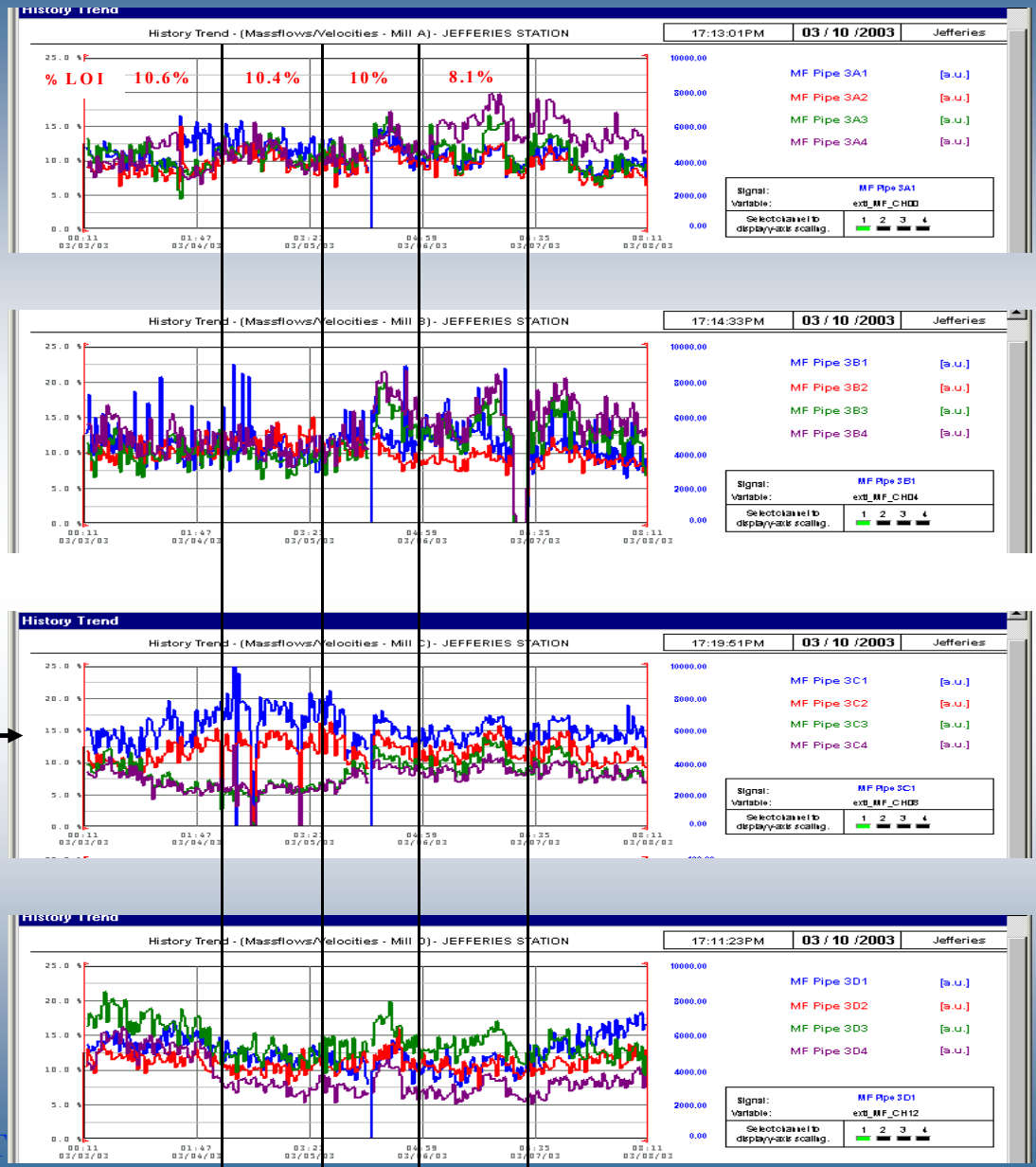
Jefferies Fly Ash – Unit Daily Average	
Date	Unit 4
2/3/2003	11.4
2/4/2003	10.7
2/5/2003	11.9
2/6/2003	11.1
2/6/2003	10.7
2/7/2003	11.0
2/10/2003	–
2/11/2003	–
2/12/2003	7.1
2/13/2003	7.4
2/14/2003	8.1
2/17/2003	7.4
2/18/2003	7.5
2/19/2003	7.3
2/20/2003	7.5
2/21/2003	7.6
2/24/2003	7.2
2/25/2003	7.2
2/26/2003	7.2
2/27/2003	7.4
2/28/2003	6.9

An imbalance in Mill D pipes was causing high LOI



AIR MONITOR CORPORATION

Problem with C Mill. →



Conclusions

- In addition to being able to reduce NOx, Pf-FLO can be used to help reduce overall LOI levels.
- Pf-FLO offers assistance with mill diagnostics.
- Coal pipe balancing can lead to LOI reductions of over 35%.
- Balancing coal pipes may require more than the use of adjustable coal valves.