

Worldwide Pollution Control Association

Gulf Power Coal to Gas Seminar
May 30-31, 2012

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WPCA Natural Gas Conversion

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May 30, 2012

ALSTOM

WPCA – Natural Gas Conversions of Coal Fired Boilers



Items to be covered

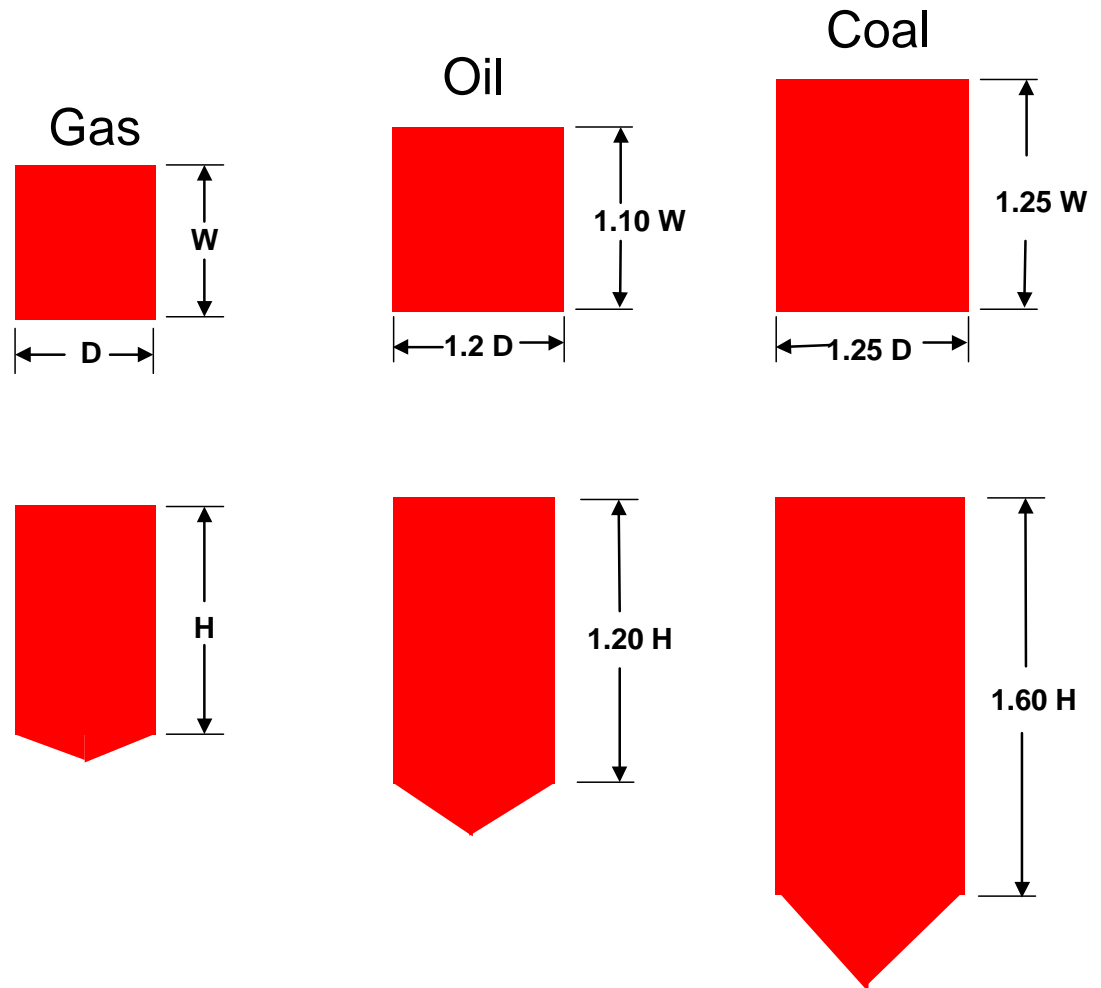
- **Boiler Sizing**
- **Gas Firing Components**
- **Gas Firing – Emissions**
- **Converting Bituminous Coal Fired Boiler to Gas Firing**
- **Converting PRB Coal Fired Boiler to Gas Firing**
- **Pulverizer and Fan Systems**
- **Summary**

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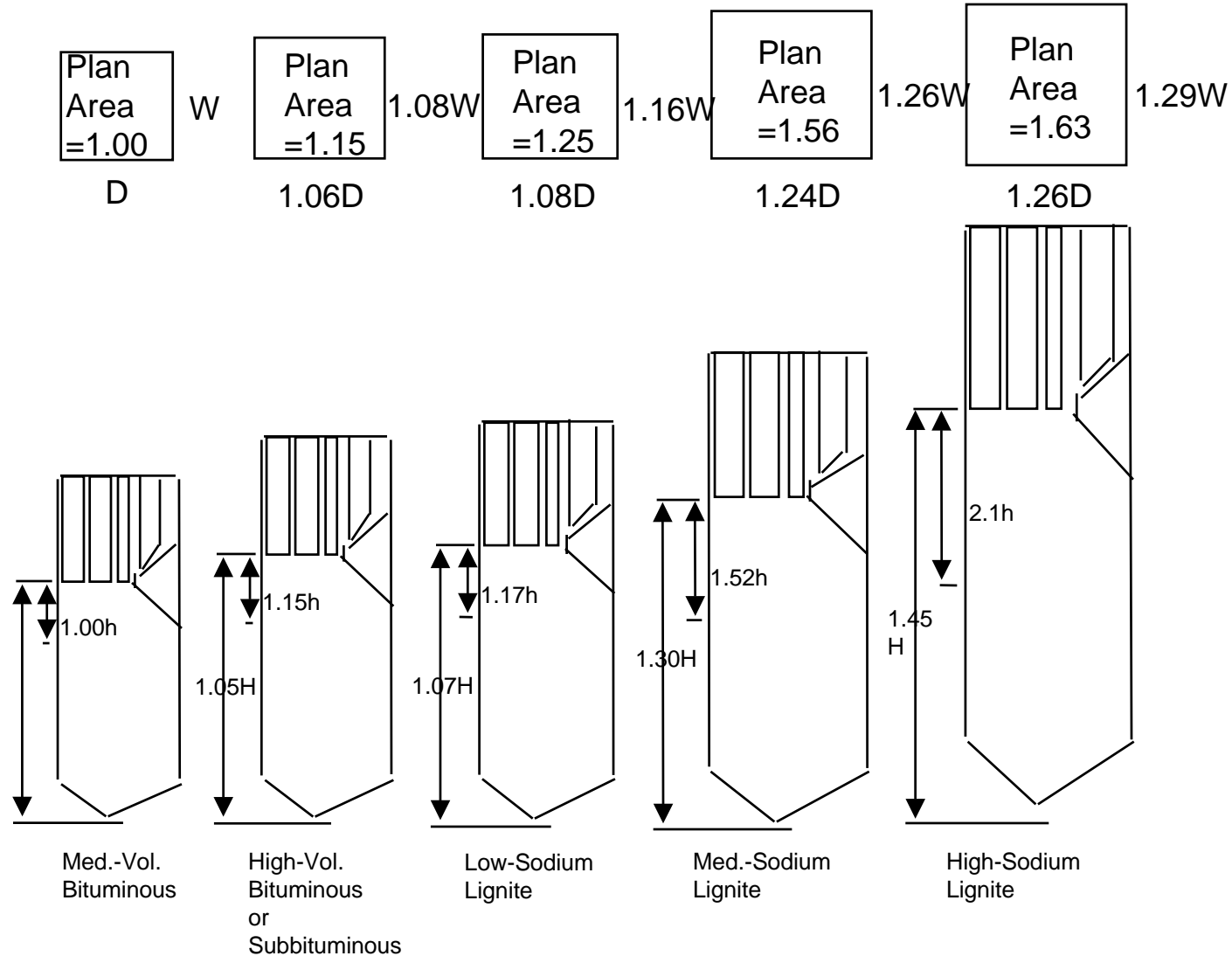
Normal Boiler Sizing



- Boilers are normally designed for a specific fuel.
- Anytime a boiler has a change in fuel, there will be performance compromises.



Coal Fired Boilers

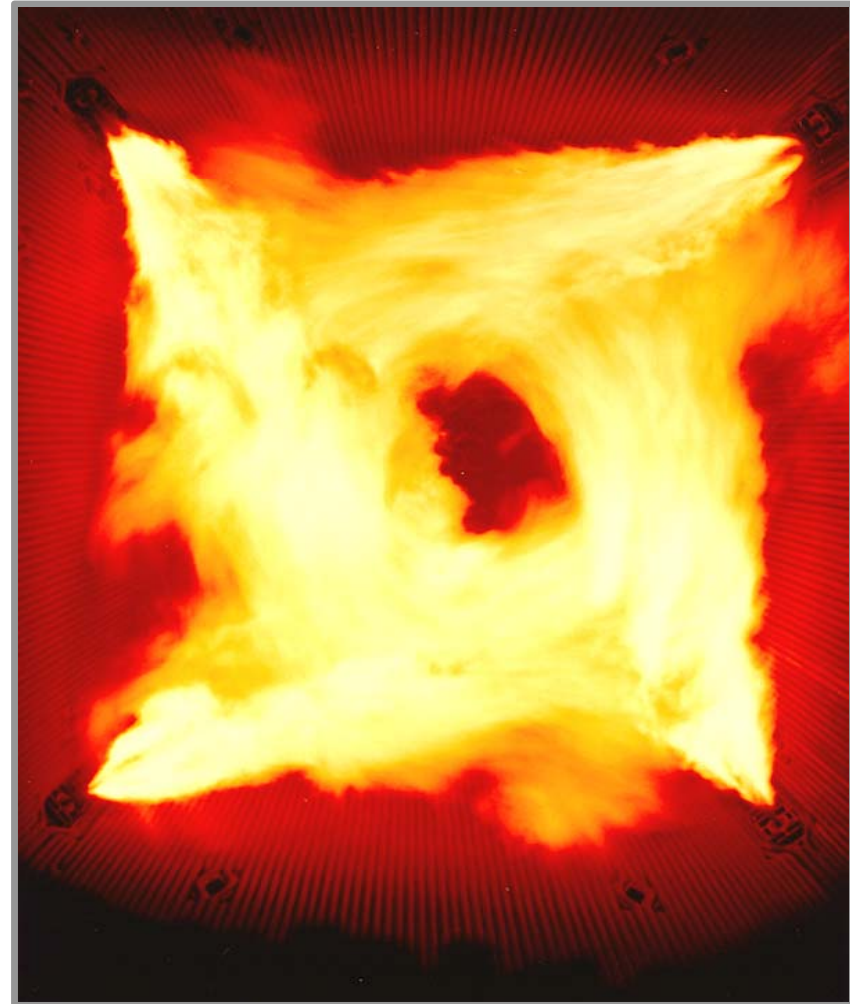


Gas Firing Components

Tangential Firing System



- Flame Pattern of Tangential Firing System

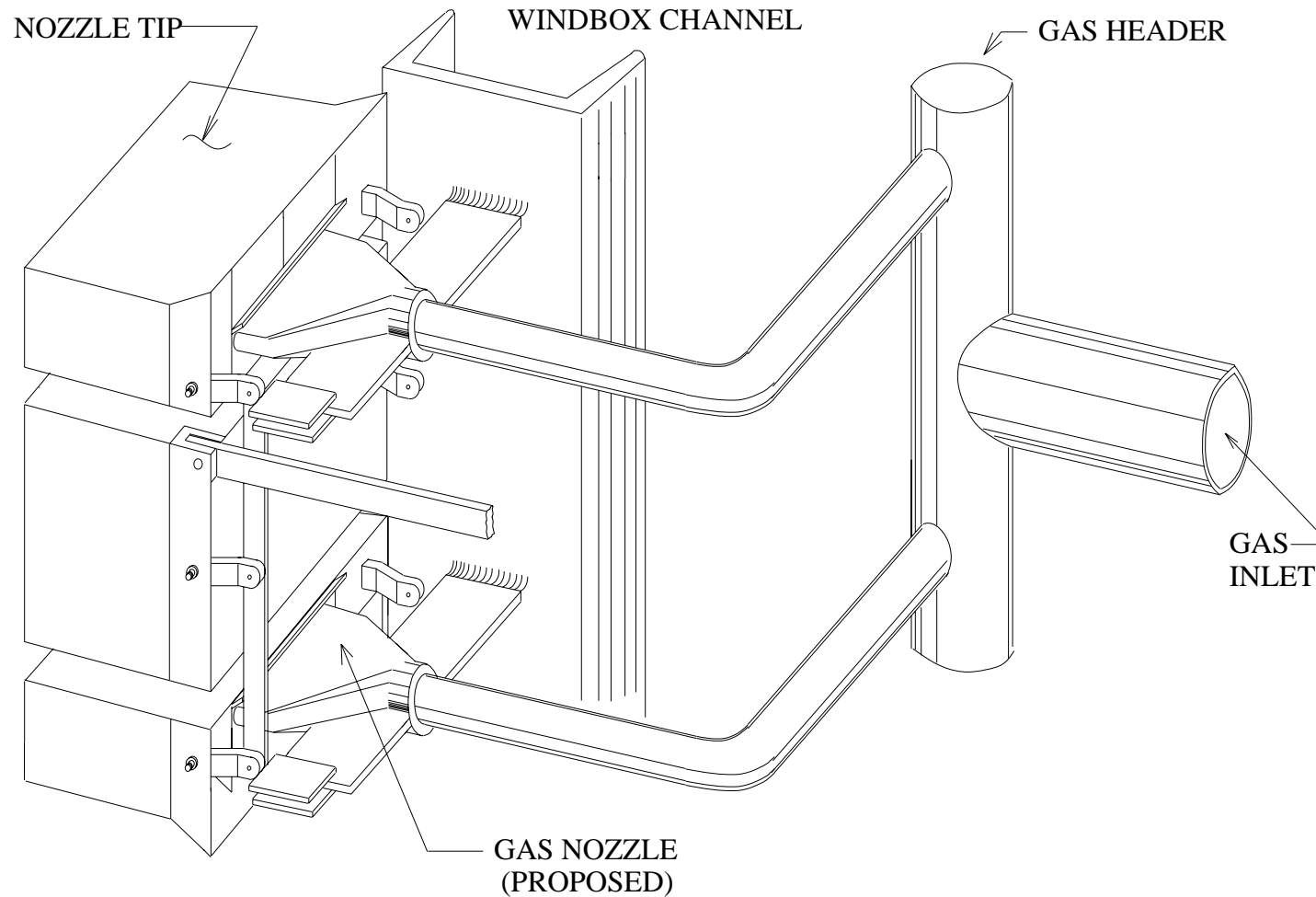


Key Gas Design Criteria

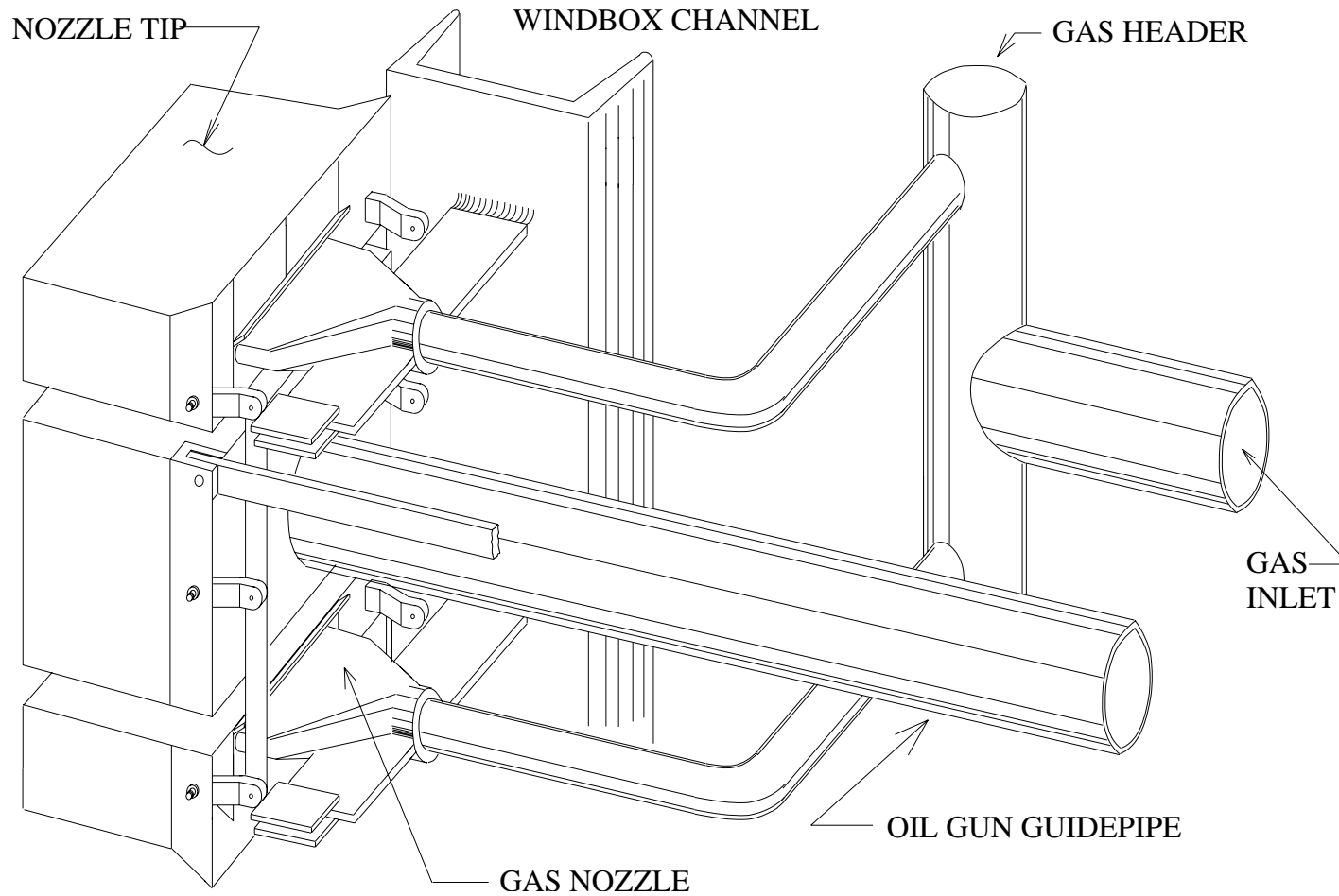


- Gas Composition
 - Flame Propagation Velocity
 - Heating Value
 - Specific Gravity
- Adiabatic Flame Temperature
- Air Flow Requirements
- Nozzle Design

Typical Gas Compartment



Gas With Oil Gun



Option for Skid-Mounted Gas & Ignitor Pipe Trains



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Option for Skid-Mounted Gas & Ignitor Pipe Trains



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Gas Firing - Emissions

NOx is formed by two primary mechanisms:

- Thermal fixation of atmospheric nitrogen--
“thermal NOx”
- Fixation of nitrogen contained in the fuel--
“fuel NOx” (no fuel NOx in gas)

- Boiler Operation
 - Unit Load
 - Tilt Position
 - Excess Air
 - WB Air Distribution
 - Fuel/Air Staging

Parameters Influencing NOx Formation



- Boiler Design
 - Heat Release Rates
 - Air Inleakage
 - Firing Systems Design

- Fuel Properties
 - Fuel Nitrogen - Not applicable

- Current NOx Emissions Levels
- Required (or desired) NOx Emissions Levels
- Available Options
- Current Performance
- Performance Requirements

- **Reduce Burner Zone Stoichiometry**
 - Low NOx Burners
 - Lower Excess Air
 - Overfire Air (OFA)
 - Flue Gas Recirculation
- **Lower Flame Temperature**
 - Reduce Secondary Air Temperature
 - Reduce Load
 - Steam/H₂O Injection
 - Flue Gas Recirculation
 - Spread Out the Heat Release
- **Flue Gas Recirculation**
 - Forced
 - Induced
 - Premixed
- **Reburn**
- **SNCR**

Low NOx Gas Fired Experience List



Plant	Nominal MW's	FHI / PA	Pre NOx, lb/Mbtu	Post NOx, lb/Mbtu	Low NOx System
Plant A	160	1.58	0.22	0.08	SOFA & Hopper FGR
Plant B	400	2.74	0.33	0.18	CCOFA
Plant C	400	2.74	0.33	0.18	CCOFA
Plant D	225	1.57	0.23	N/A	CCOFA
Plant E	235	1.69	0.42	N/A	CCOFA
Plant F	375	2.66	0.59	N/A	CCOFA
Plant G	365	1.97	N/A	0.14	CCOFA
Plant H	370	2.20		0.15	CCOFA & Hopper FGR
Plant I	370	2.20		0.15	CCOFA & Hopper FGR
Plant J	370	2.20		0.11	CCOFA & Hopper FGR
Plant K	363	2.95		0.11	CCOFA
Plant L	363	2.95		0.10	CCOFA
Plant M	500	2.05	0.14	N/A	SOFA
Plant N	550	3.03	0.21	N/A	VCCOFA

N/A = Not Available

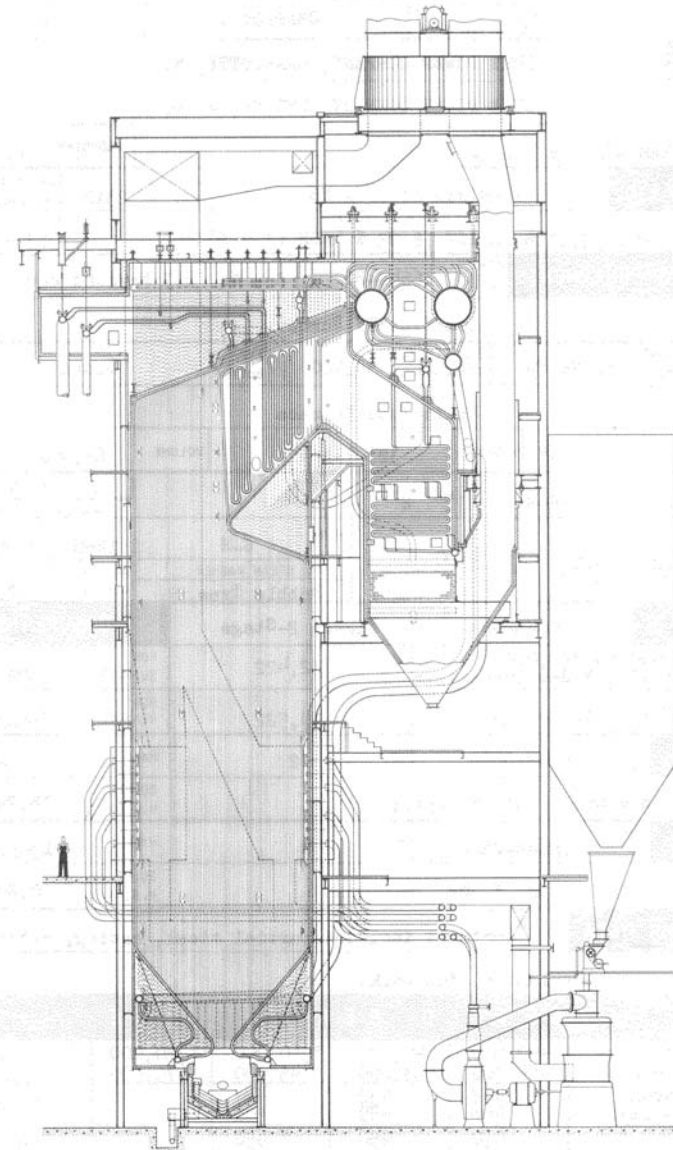
- CO
 - Incomplete Combustion
 - Time, Temperature, Turbulence

Converting Bituminous Coal Fired Boiler to Gas Firing

Bituminous Coal Fired Boiler #1



PROPOSED FUEL		VIRGINIA BITUMINOUS		ASH FUS. TEMP. F	2310	BTU PER LB AS FIRED	HARDGROVE GRIND	
F.C.	47.84 %	VOL.	33.13 %	MOIST.	6.03 %	ASH	13.0 %	
				SUL.			12,450	
FUEL BURNING EQUIPMENT		CONT. NO.	16648-RB	8 - No. 613 Raymond Bowl Mills				
and Type TV Burners								
FURNACE	CONT. NO.	16648-PS	SQ. FT. H.S. PER FURN.	38,480	TYPE OF BOTTOM			Contant
Plain Tube Furnace								
FRONT TO REAR	24'-11-3/4"	WIDTH	32'-7-1/4"	VOLUME	63,000	CU. FT. GROSS		
BOILER	CONT. NO.	16648-BR	NO.	2	SQ. FT. H.S.EA.	-		
				PRESSURE				
				DESIGN		OPERATING		
DESIGNATION				MFR.	C-E	1450	1295 at S.O.	
32'-7-1/4" 123-3 R 54-60								
24'-11-3/4" 94-3								
				STEAM WASHER		BOILER NUMBER		
				Bubble Type		1 and 2		
SUPERHEATER	CONT. NO.	16648-SH	TYPE	Elesco 2-Stage		DESUPERHEATER		
CONTROL RANGE	490,000 to 780,000		SQ. FT. H.S.	32,422		FOR SUPHT'R. Spray Type		
by burner tilt & desuperheaters								
REHEATER	TYPE	Interstage		SQ. FT. H.S.	10,522			
				FOR REHEATER Spray Type				
ECONOMIZER	CONT. NO.	16648-CONS	NO.	2		MAKE C-E		
TYPE	CF-S 10H x 45W x 33'-6" Split			SQ. FT. H.S.EA. 15,795				
AIR HEATER	CONT. NO.	16648-CAHL	NO.	4		MAKE Ljungstrom		
TYPE	32 V 62			SQ. FT. H.S.EA. 90,800				
MISCELLANEOUS DATA		Contract included partial steel, casing, setting, insulation, ductwork.						
EXPECTED PERFORMANCE								
LB STEAM PER HR-ACTUAL	Primary Reheat	490,000	640,000	*750,000	**780,000	*Guaranteed (Max.Cont.) **12 Hr. Peak		
	Econ. Boiler	424,000	553,000	645,000	670,000			
FEEDWATER TEMP. TO		408	432	447		REHEATER DATA 645,000 lb steam/hr. Enter Temp. 690 F * Press. 431 PSI Leav. * 405 PSI		
		466	489	500				
STEAM TEMP. Fat S.O. & R.O		950	950	* 950				
HEAT RELEASE BTU/CU.FT./HR.		10,600	13,600	15,600				
TEMP. GAS FROM AIR HEATER		259	285	291				
TEMP. AIR FROM AIR HEATER		578	610	619				
OVERALL EFFICIENCY %		89.35	88.78	*88.66				



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Bituminous Coal Fired Boiler #1



		Original Design	Test Data Coal	Natural Gas	Natural Gas
Date			2/16/2011		
Gross Load	MW		110		
Load	%	104% MCR	106% MCR	106% MCR	106% MCR
Main Steam Flow	lb/hr	780,000	795,110	795,110	795,110
Reheater Steam Flow	lb/hr	670,000	689,093	697,292	702,476
SH Spray Flow	lb/hr	0	11,574	18,350	18,077
RH Spray Flow	lb/hr	0	0	8,199	13,383
SH Outlet Steam Temperature	°F	950	944	950	950
RH Outlet Steam Temperature	°F	950	961	962	950
CRH Steam Temperature	°F	697	692	697	697
Economizer Water Inlet Temperature	°F	450	442	442	442
Economizer Water Outlet Temperature	°F	502	478	477	477
Drum Pressure	psig	1,356	1,243	1,243	1,243
SHO Pressure	psig	1,295	1,200	1,200	1,200
CRH Pressure	psig	447	400	400	400
Economizer Outlet Gas Temperature	°F	720	687	691	691
Air Heater Inlet Gas Temperature	°F	720	628	691	691
Air Heater Outlet Gas Temperature uncorr.	°F	309	345	345	345
Air Heater Outlet Gas Temperature corr.	°F	290	325	324	324
Air Heater Outlet Air Temperature	°F	616	552	593	592
Air Heater Inlet Air Temperature	°F	80	108	108	108
Boiler Efficiency	%	88.59	88.60	84.08	84.08
Heat Input	Mbtu/hr	1,020	1,051	1,120	1,121
Excess Air	%	15	18	8	8
Fuel Nozzle Tilt	degrees	Horiz	-8	-12	-12
Fuel Elevations in Service	number	4	4	3	3

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Bituminous Coal Fired Boiler #1



		Original Design	Test Data Coal	Natural Gas
Date			2/16/2011	
Gross Load	MW		20 MW	
Load	%	65%.MCR	23% MCR	23% MCR
Main Steam Flow	lb/hr	490,000	169,490	169,490
Reheater Steam Flow	lb/hr	424,000	154,514	154,514
SH Spray Flow	lb/hr	0	1,560	0
RH Spray Flow	lb/hr	0	0	0
SH Outlet Steam Temperature	°F	950	808	808
RH Outlet Steam Temperature	°F	950	741	740
CRH Steam Temperature	°F	625	450	450
Economizer Water Inlet Temperature	°F	408	318	318
Economizer Water Outlet Temperature	°F	466	389	379
Drum Pressure	psig	1,320	1,017	1,017
SHO Pressure	psig	1,295	1,013	1,013
CRH Pressure	psig	281	70	70
Economizer Outlet Gas Temperature	°F	644	489	479
Air Heater Inlet Gas Temperature	°F	644	489	479
Air Heater Outlet Gas Temperature uncorr.	°F	274	314	299
Air Heater Outlet Gas Temperature corr.	°F	254	301	288
Air Heater Outlet Air Temperature	°F	572	475	462
Air Heater Inlet Air Temperature	°F	80	118	118
Boiler Efficiency	%	89.35	87.62	84.12
Heat Input	Mbtu/hr	674	239	249
Excess Air	%	15	73	47
Fuel Nozzle Tilt	degrees	+30	Horiz	Horiz
Fuel Elevations in Service	Number	2	1	1

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Bituminous Coal Fired Boiler #1



		Original Design	Coal Data 2/16/2011	Natural Gas
Air Weight to FD Fan	lb/hr	900,000	908,921	961,999
Excess Air	%	15	18	8
Air Temperature to FD Fan	°F	100	100	100
Air Volume	ACFM	211,500	219,989	232,163
Air Volume per Fan	ACFM	105,750	109,995	116,418
25% Tolerance @ 100°F	ACFM	132,200		
Delta P	"w.g.	9.30	9.03	9.60
25% Pressure Tolerance	"w.g.	11.60		

		Original Design	Coal Data 2/16/2011	Natural Gas
Gas Weight to ID Fan	lb/hr	1,111,000	1,135,113	1,055,110
Excess Air	%	15	18	8
Gas Temperature to ID Fan	°F	302	325	324
Gas Volume	ACFM	356,000	393,341	365,152
Gas Volume per Fan	ACFM	178,000	196,670	182,576
21% Tolerance	ACFM	215,000		
Delta P	"w.g.	7.80	11.34	9.47
37% Pressure Tolerance	"w.g.	10.70		

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Bituminous Coal Fired Boiler #1

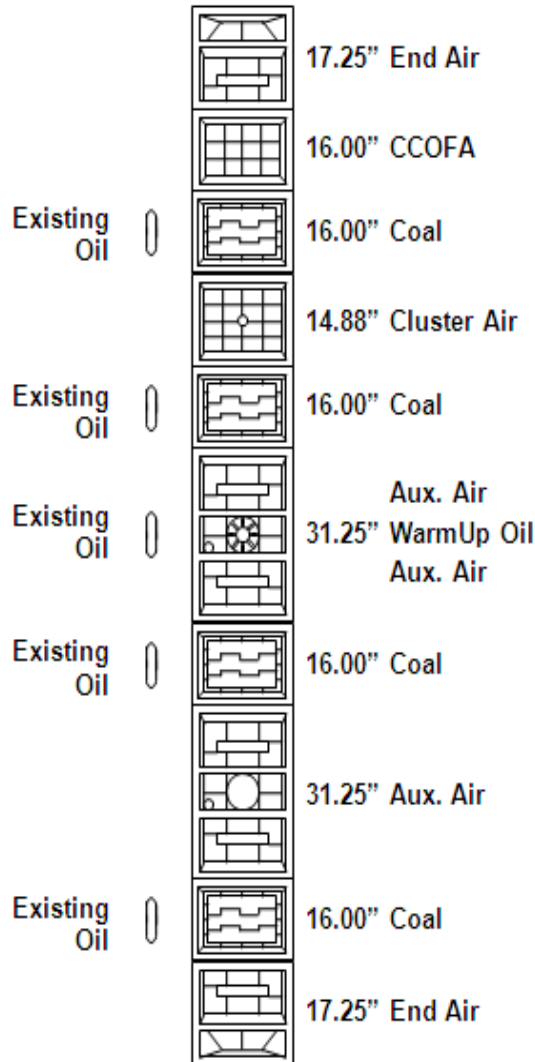


- Alstom performed a study to convert to 100% natural gas firing. For study purposes, the customer has defined normal full load (NFL) at 107 MW (approximately 795 MBtu/hr steam flow). Coal firing will be eliminated.
- To convert this unit to natural gas firing, the Company will provide three elevations of load carrying gas guns, coupled with Class 1 gas-fired ignitors. The ignitors will be located adjacent to the gas guns, which will be installed in the bottom three coal elevations. Using Class 1 ignitors eliminates the need for flame scanners; however, they can be used if desired by the plant. The gas guns will be sized for full load capability *without* ignitors on, in case the plant installs flame scanners, now or in the future.

Bituminous Coal Fired Boiler #1



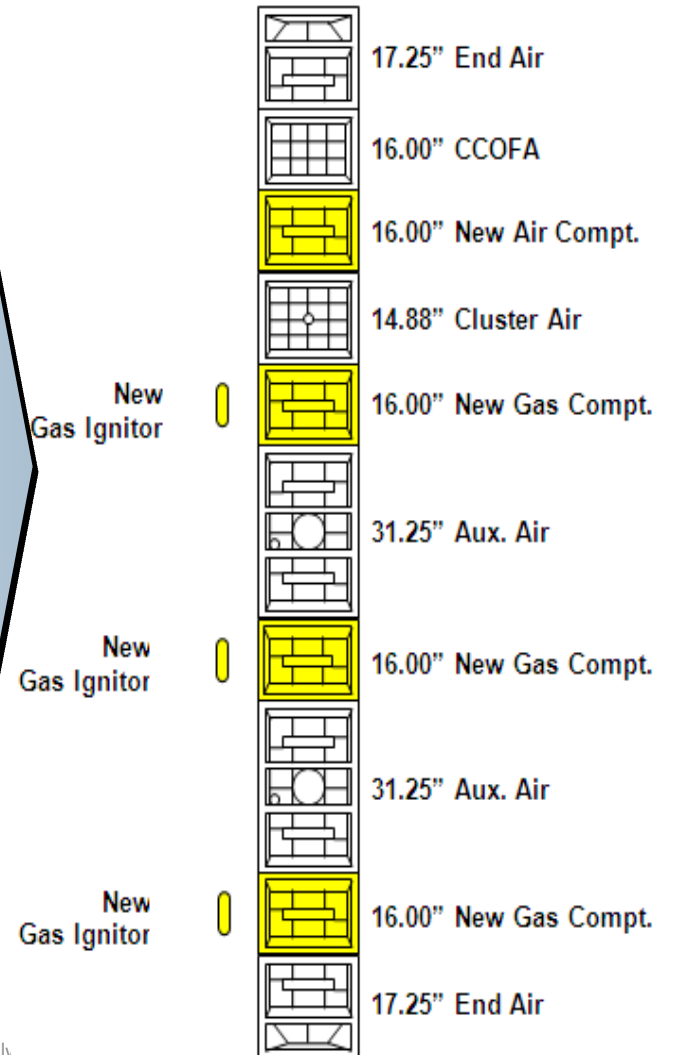
Existing 16" Wide Windbox



To convert Units 1 to NG firing, Alstom proposes:

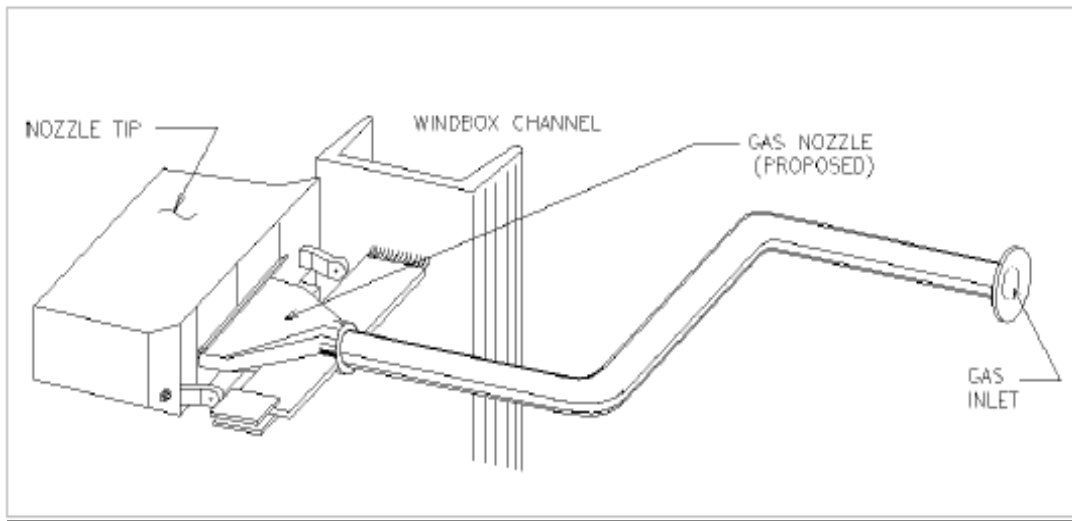
- Three elevations of load carrying gas guns, coupled with Class 1 gas ignitors
- Ignitors located adjacent to the gas guns and installed in bottom 3 coal elevations
- Class 1 ignitors eliminates need for flame scanners, although flame scanners may be used (if desired by Plant)
- Gas guns sized for full load capability *without* ignitors on

Proposed 16" Wide Windbox



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sure to thi.

Bituminous Coal Fired Boiler #1 – Gas Gun Assembly



- Gas gun assemblies based on Alstom's standard gas gun arrangement
- Composed of one spud located in bottom three coal elevations
- Each spud connected to a header at the back of the windbox.
- Flanged inlet pipe will protrude from the windbox to connect to the gas supply stainless steel flex hose.
- Gas gun assembly sized for approx. 94×10^6 Btu/hr per compartment.
- 7:1 turndown capability with gas supply pressure of 25 psig to gas gun and minimum operating pressure of 1/2 psig above furnace pressure at burner spud

Bituminous Coal Fired Boiler #1



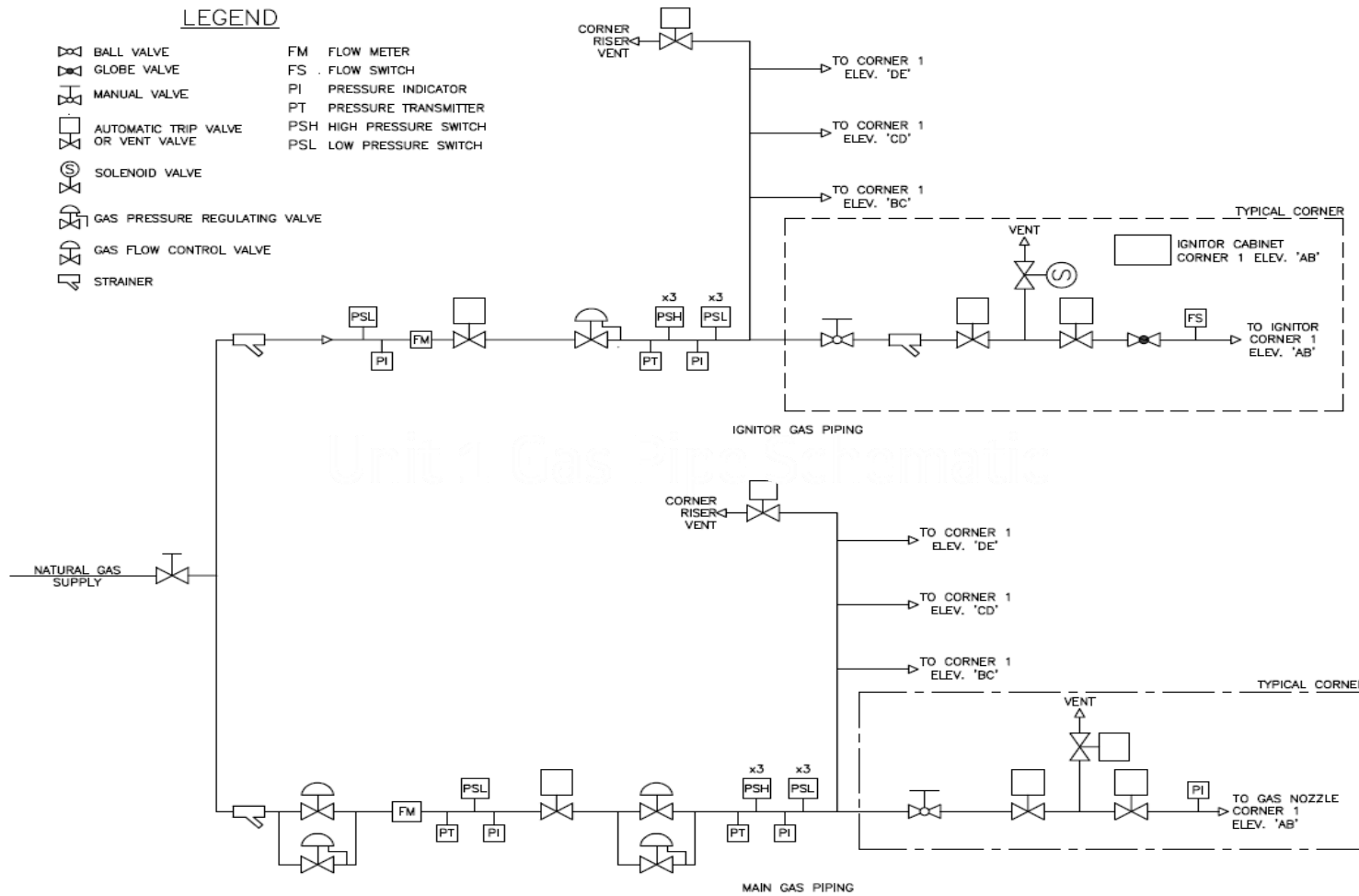
Ignitor Air System

- The existing 10,880 CFM ignitor air system is sufficient for the new ignitors (and any flame scanners, if the plant elects to install flame scanners).

SOFA Windbox

- No modifications are planned for the SOFA windbox. The Company expects the SOFA airflow required to meet NOx emission targets will be less than the current SOFA is designed for. The reduced airflow will require retuning the SOFA over the load range.

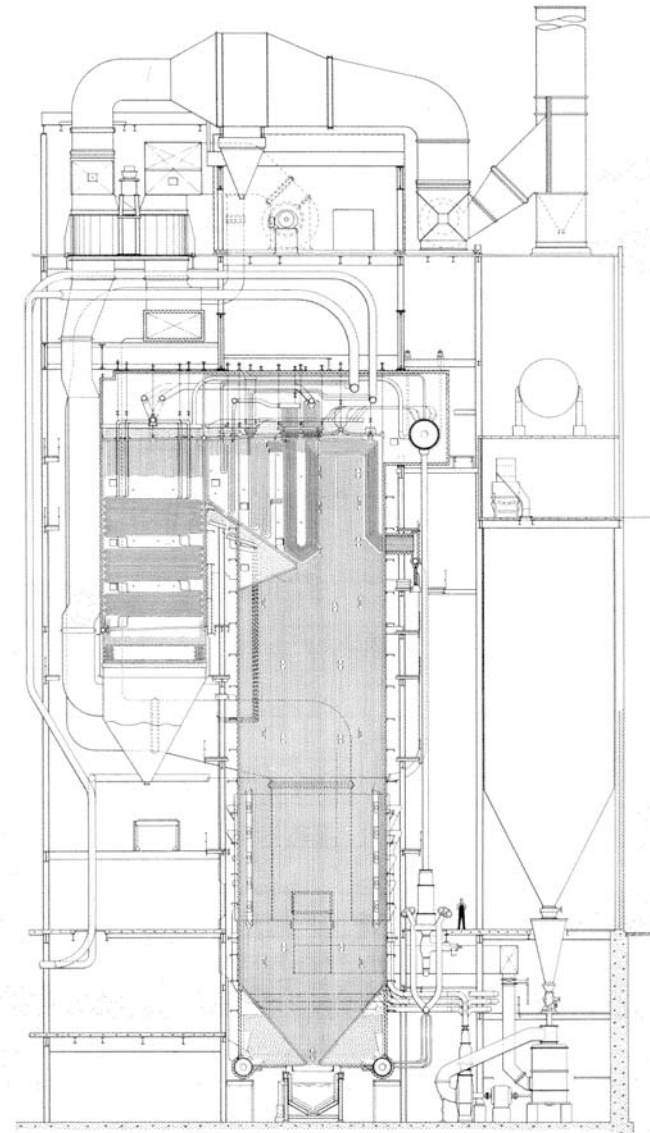
Bituminous Coal Fired Boiler #1 - Gas Pipe Schematic



Bituminous Coal Fired Boiler #2



PROPOSED FUEL		EASTERN BITUMINOUS COAL				ASH FUS. TEMP. F.	BTU PER LB AS FIRED	HARDGROVE GRIND
F.C. 55.8 %	VOL. 31.1 %	MOIST. 4.0 %	ASH 9.1 %	S. -	-	13,370	55	
FUEL BURNING EQUIPMENT		CONT. SECT. RB	5 - No. 633 Raymond Bowl Mills					
and Tilting Tangential Burners								
FURNACE	CONT. SECT. PFSS	SQ. FT. H.S. PER FURN. 54,000	TYPE OF BOTTOM Basket					
Plain Tube Furnace								
FRONT TO REAR	28'-2"	WIDTH	40'-6-1/2"	VOLUME	116,500	CU. FT. GROSS		
BOILER	CONT. SECT. BCC	NO. 1	SQ. FT. H.S.EA. -	PRESSURE				
DESIGNATION	40'-6 1/2" 28'-2"	320-1 1/2 160-1 1/2	CCRR 60 2-36	MFR. C-E	2700	2450 at S.O.		
				STEAM WASHER	BOILER NUMBER 3			
SUPERHEATER	CONT. SECT. SH	TYPE Multi-Stage with Channel		DESUPERHEATER				
CONTROL RANGE	660,000 to 1,200,000 with burner tilt & desuperheater		SQ. FT. H.S. 100,300	FOR SUPHT'R. Spray				
REHEATER	TYPE Interstage	SQ. FT. H.S. 15,200		FOR REHEATER Spray				
ECONOMIZER	CONT. SECT. CONS	NO. 1		MAKE C-E				
TYPE:	CF-S 8H x 76W x 40'-6" lg.			SQ. FT. H.S.EA. 26,575				
AIR HEATER	CONT. SECT. CAHL	NO. 2		MAKE Ljungstrom				
TYPE	24-1/2 H 54			SQ. FT. H.S.EA. 100,800				
MISCELLANEOUS DATA Contract included steel-encased settings, insulation, duct-work, circulation pumps & piping, steam temp. controls.								
EXPECTED PERFORMANCE						GENERATOR KW		
FUEL		C O A L				1 - 165,000		
LB STEAM PER HR-ACTUAL	PRIMARY REHEAT	660,000	1,100,000	*1,160,000	*1,200,000	- 6 Hr. Peak - 18 Hr. Interval.		
	ECON. BOILER	592,500	975,000	1,023,000				
FEEDWATER TEMP. TO		420	467	470		REHEAT DATA 1,023,000 LB STEAM/HR. Enter. Temp. 669 F " Press. 507 Psi Leav. Temp. 1000 F " Press. 474 Psi		
STEAM TEMP. at S.O. & R.O.		1050-1000	1050-1000	*1050-1000				
HEAT RELEASE BTU/CU. FT./HR.		8,150	12,850	13,450				
TEMP. GAS FROM AIR HEATER		245	280	282				
TEMP. AIR FROM AIR HEATER		525	562	567				
OVERALL EFFICIENCY %		89.71	88.99	*68.95				



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Bituminous Coal Fired Boiler #2



		Original Design	Test Data Coal	Natural Gas	Natural Gas	Natural Gas
Date			03/29/2' 011			
				No Mods.	Add 31% more RH Finishing Surface	Add Gas Recirculation
Gross Load	MW		184			
Load	%	103.5% MCR 6Hr. Peak	104.8% MCR	104.8% MCR	104.8% MCR	104.8% MCR
Main Steam Flow	lb/hr	1,200,000	1,216,118	1,216,118	1,216,118	1,216,118
Reheater Steam Flow	lb/hr	1,063,000	1,113,651	1,113,651	1,113,651	1,113,651
SH Spray Flow	lb/hr	0	51,558	11,804	7,062	85,317
RH Spray Flow	lb/hr	0	0	0	0	0
SH Outlet Steam Temperature	°F	1,050	1,050	1,050	1,050	1,050
RH Outlet Steam Temperature	°F	1,000	999	972	1,000	990
CRH Steam Temperature	°F	670	686	686	686	686
Economizer Water Inlet Temperature	°F	472	457	457	457	457
Economizer Water Outlet Temperature	°F	508	509	507	507	519
Drum Pressure	psig	2,568	2,386	2,386	2,386	2,386
SHO Pressure	psig	2,450	2,290	2,290	2,290	2,290
CRH Pressure	psig	524	494	494	494	494
Economizer Outlet Gas Temperature	°F	681	665	664	664	689
Air Heater Inlet Gas Temperature	°F	681	619	664	664	689
Air Heater Outlet Gas Temperature uncorr.	°F	290	310	314	314	323
Air Heater Outlet Gas Temperature corr.	°F	270	301	305	305	313
Air Heater Outlet Air Temperature	°F	570	512	532	531	556
Air Heater Inlet Air Temperature	°F	80	93	93	93	93
	%	88.94	88.76	83.98	83.98	84.08
Heat Input	Mbtu/hr	1,618	1,667	1,742	1,763	1752
Excess Air	%	15	16	20	20	12
Fuel Nozzle Tilt	degrees	Horiz.	-7	+15	+15	+15
Gas Recirculation	%					20
Fuel Elevations in Service	Number	5	5	4	4	4

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Bituminous Coal Fired Boiler #2

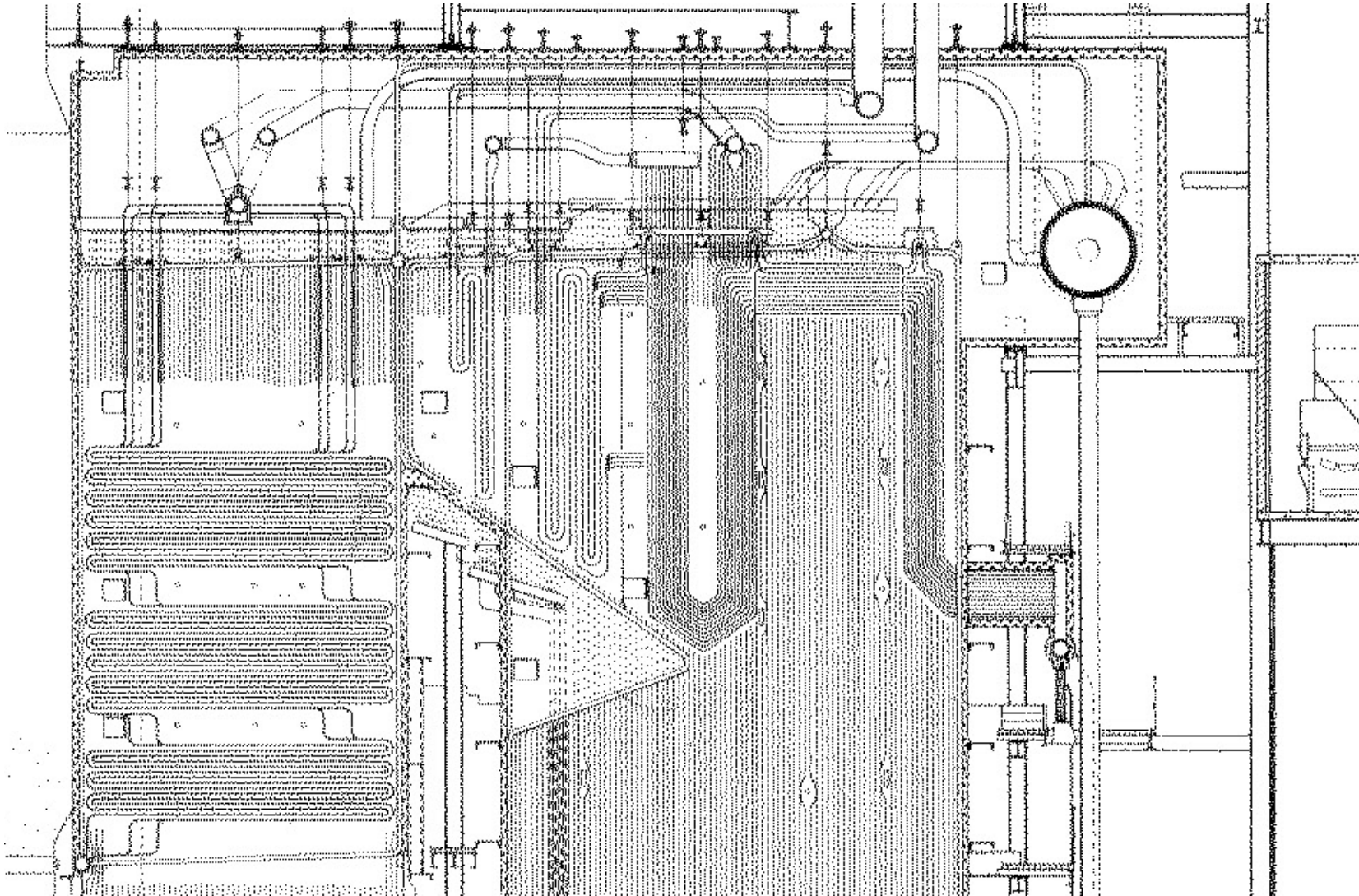


		Original CL Design	Test Data Coal	Natural Gas	Natural Gas
Date			03/29/2`011		
				No Mods.	Add 31% more RH Finishing Surface
Gross Load	MW		45		
Load	%	57% MCR	31% MCR	31% MCR	31% MCR
Main Steam Flow	lb/hr	660,000	356,085	356,085	356,085
Reheater Steam Flow	lb/hr	592,500	330,859	331,158	330,859
SH Spray Flow	lb/hr	0	0	1,047	1,343
RH Spray Flow	lb/hr	0	0	299	0
SH Outlet Steam Temperature	°F	1,050	916	916	916
RH Outlet Steam Temperature	°F	1,000	795	797	824
CRH Steam Temperature	°F	590	466	464	466
Economizer Water Inlet Temperature	°F	420	337	337	337
Economizer Water Outlet Temperature	°F	464	424	425	425
Drum Pressure	psig	2,490	1,820	1,820	1,820
SHO Pressure	psig	2,450	1,810	1,810	1,810
CRH Pressure	psig	288	124	124	124
Economizer Outlet Gas Temperature	°F	605	512	517	517
Air Heater Inlet Gas Temperature	°F		474	517	517
Air Heater Outlet Gas Temperature uncorr.	°F		283	282	283
Air Heater Outlet Gas Temperature corr.	°F	245	275	275	275
Air Heater Outlet Air Temperature	°F	525	440	462	462
Air Heater Inlet Air Temperature	°F		102	102	102
Boiler Efficiency	%	89.71	88.72	83.70	83.68
Heat Input	Mbtu/hr	940	511	541	546
Excess Air	%		54	54	54
Fuel Nozzle Tilt	degrees	+30	Horiz	Horiz	+2
Fuel Elevations in Service	Number	3	2	2	2

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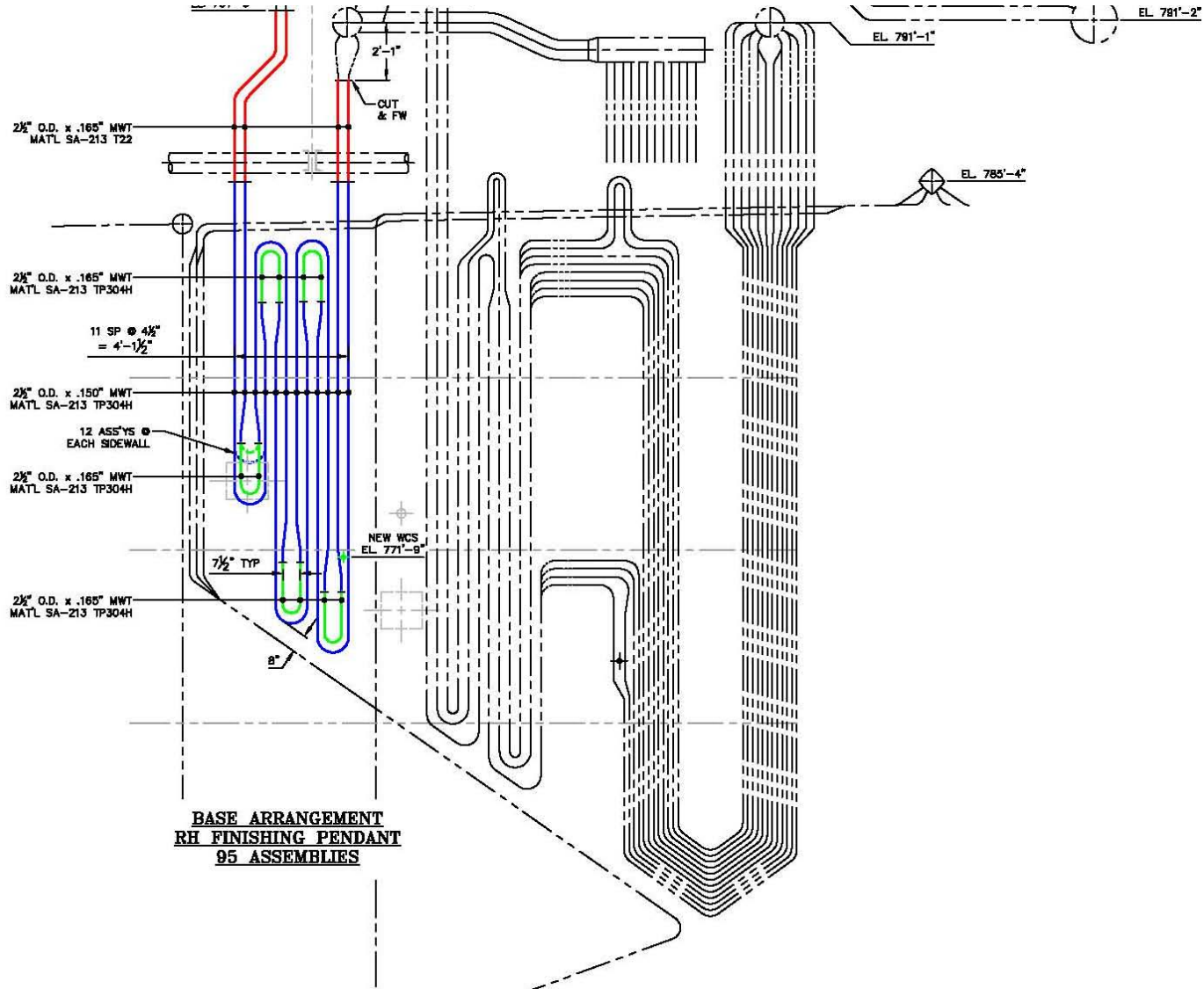
Bituminous Coal Fired Boiler #2



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		Original Design	Coal Data	Natural Gas
			2/16/2011	With or Without Additional RH Surface
Air Weight to FD Fan	lb/hr	1,418,000	1,367,521	1,578,988
Excess Air	%	15	16	20
Air Temperature to FD Fan	°F	100	100	100
Air Volume	ACFM	333,600	330,986	382,169
Air Volume per Fan	ACFM	166,800	165,493	191,085
27% Tolerance @ 140°F	ACFM	212,000		
Delta P	"w.g.	11.00	10.59	11.10
41% Pressure Tolerance	"w.g.	15.50		

		Original Design	Coal Data	Natural Gas
			2/16/2011	With or Without Additional RH Surface
Gas Weight to ID Fan	lb/hr	1,684,000	1,685,711	1,733,470
Excess Air	%	15	16	20
Gas Temperature to ID Fan	°F	285	301	305
Gas Volume	ACFM	524,000	565,177	585,380
Gas Volume per Fan	ACFM	262,000	282,588	292,690
15% Tolerance	ACFM	301,000		
Delta P	"w.g.	16.00	11.41	10.92
26% Pressure Tolerance	"w.g.	20.20		

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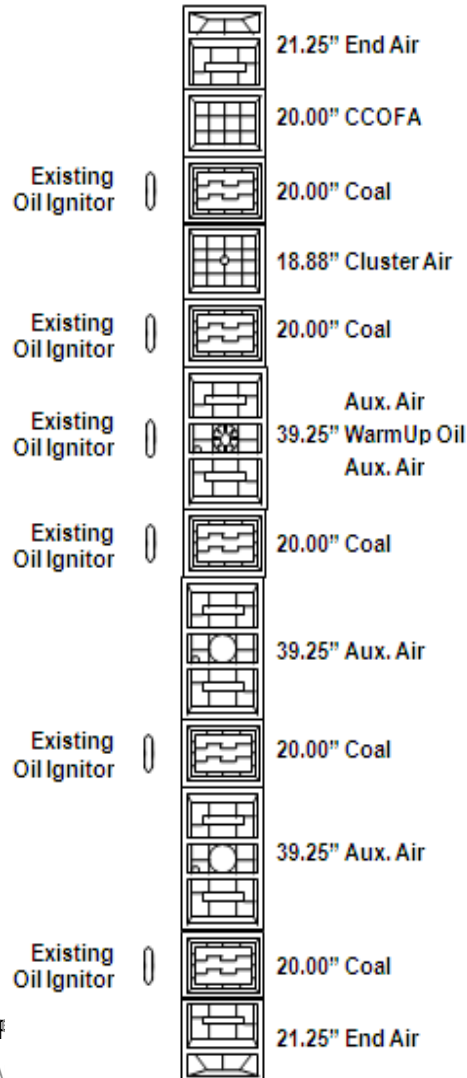


- Alstom performed a study to convert to 100% natural gas firing. For study purposes, customer has defined normal full load (NFL) at 185 MW. Coal firing will be eliminated.
- To convert the unit to natural gas firing, the Alstom will provide four elevations of load carrying gas guns, coupled with Class 1 gas-fired ignitors. The ignitors will be located adjacent to the gas guns, which will be installed in the top four coal compartments. Using Class 1 ignitors eliminates the need for flame scanners; however, they can be used if desired by the plant. The gas guns will be sized for full load capability *without* ignitors on, in case the plant installs flame scanners, now or in the future.

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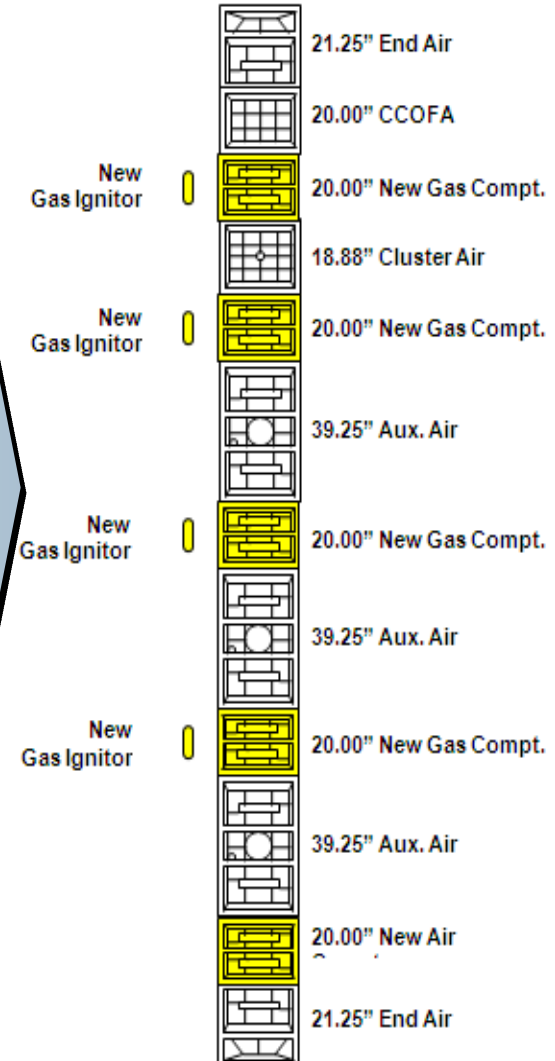
Existing 16" Wide Windbox



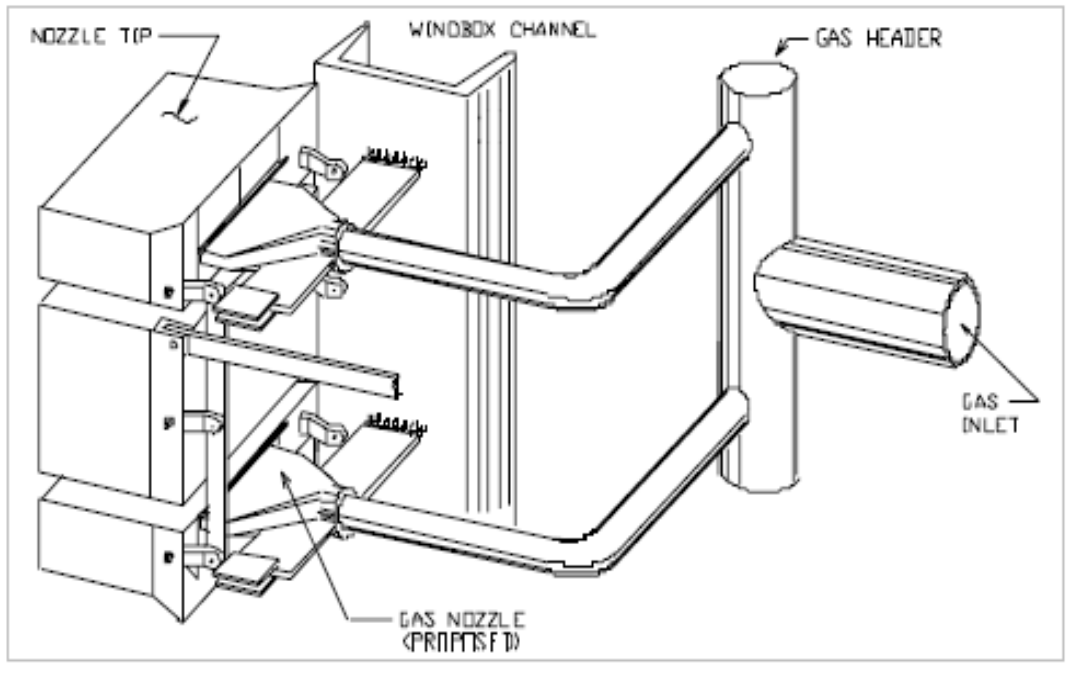
To convert Unit 2 to NG firing, Alstom proposes:

- Four elevations of load carrying gas guns, coupled with Class 1 gas ignitors.
- Ignitors located adjacent to gas guns and installed in the *top four* coal compartments.
- Class 1 ignitors eliminates need for flame scanners, although flame scanners may be used (if desired by Plant)
- Gas guns sized for full load capability *without* ignitors on

Proposed 16" Wide Windbox



Bituminous Coal Fired Boiler #2 – Gas Gun Assembly



- Gas gun assemblies based on Alstom's standard gas gun arrangement
- Composed of two spuds located in the top four coal compartment
- Each spud connected to a header at the back of the windbox.
- Flanged inlet pipe will protrude from the windbox to connect to the gas supply stainless steel flex hose.
- Gas gun assembly sized for approx. 111×10^6 Btu/hr per compartment.
- 7:1 turndown capability with gas supply pressure of 25 psig to gas gun and minimum operating pressure of 1/2 psig above furnace pressure at burner spud

Ignitor Air System

- The existing 12,880 CFM ignitor air system is sufficient for the new ignitors (and any flame scanners if the plant elects to install flame scanners).

SOFA Windbox

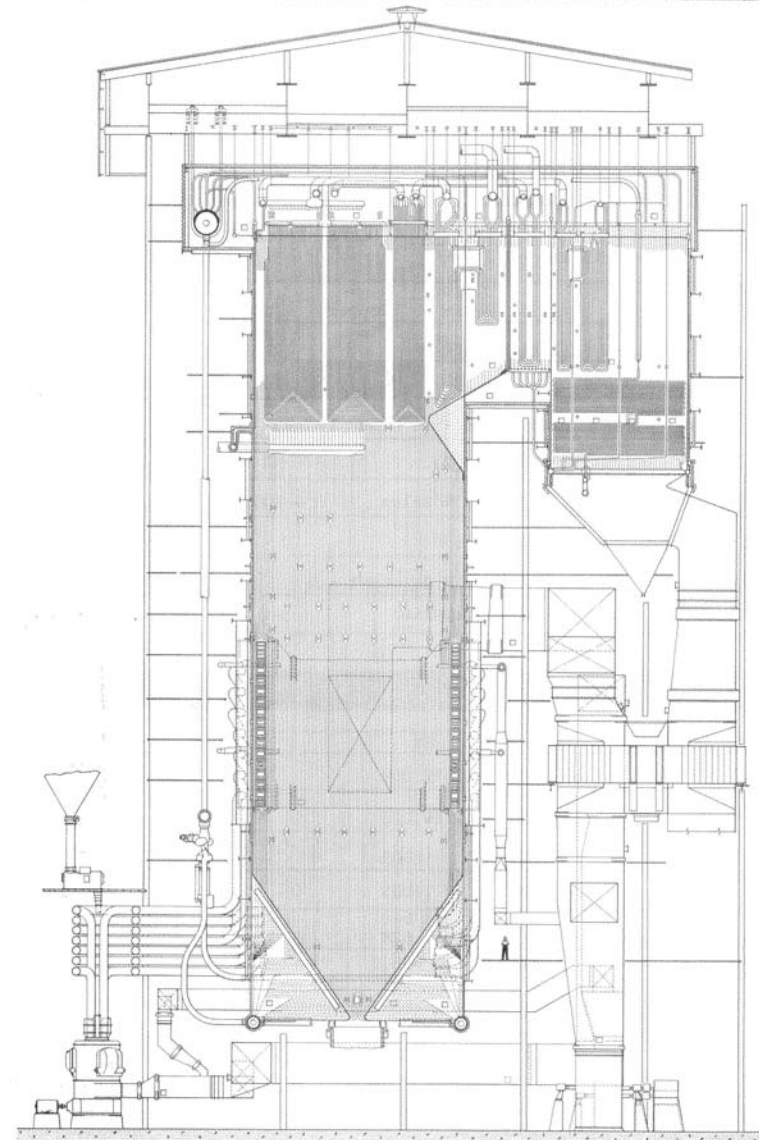
- No modifications are planned for the SOFA windbox. The Company expects the SOFA airflow required to meet NOx emission targets will be less than the current SOFA is designed for. The reduced airflow will require retuning the SOFA over the load range.

Converting PRB Coal Fired Boiler to Gas Firing

PRB Coal Fired Boiler



BOILER		Units #1 & #2	SQ. FT. H.S. PER UNIT	107,647	DESIGN	2990		
DESIGNATION		65' - 0"	311 - 2"	CCRR	OPER.	2620		
		52' - 7 15/16"	234 - 2"		S.O.	TURBINE		
					THROTTLE	2520		
FURNACE		VOLUME CU. FT. TOTAL	597,625	TYPE OF BOTTOM	Hopper	WIDTH 65' - 0"		
		Fusion Welded Walls - Balanced Draft				FRONT TO REAR	52' - 7 15/16"	
SUPERHEATER		Multistage with Panels & Platens		REHEATER	Multistage with Radiant Wall - Front & Sides			
ECONOMIZER		NO. 1	TYPE Plain Tube - In Line 206 W x 48 H					
AIR HEATER		NO. 2	TYPE 3 1/2 VI 84 (T)		MAKE Ljungstrom			
FUEL BURNING EQUIPMENT		TT Fuel Nozzles 6-1003 RP Mills*						
FUEL		East Decker Sub-Bituminous - C			ASH FUSION TEMP. F	GRIND-ABILITY	WHV	
		24.71% Moist.	31.76% Vol	39.23% F.C.	43% Ash	2190	50	9238
		(Future - Texas Lignite)						
		FOSSIL SERVICES						
OPERATING CONDITIONS								
		CONTROL POINT		MCR				
LB STEAM PER HOUR ACTUAL	PRIMARY	2,100,000	4,199,000					
	REHEAT	1,899,000	3,724,000					
STEAM TEMP. F LEAVING	SUPERHEATER	1005	1005					
	REHEATER	1005	1005					
REHEAT DATA	ENTERING TEMP.	572	648					
	ENTERING PRESS.	319	628					
FEEDWATER TEMP. F		426	495.2					
TEMP. AIR TO AIR HEATER		125	90					
TEMP. GAS FROM AIR HEATER		256	290 (UNCORR.)					
OVERALL EFFICIENCY % *Guaranteed		87.49	86.56*					
SUPPLEMENTARY DATA		*Provision made for 7th Mill for Lignite O.F.A.; Refractory: Insulation & Lagging; F.D. & P.A. Fans; Soot Blowing System; Steam Coil; Circ. System; Cold Precipitator by Customer.				GENERATOR KW MFR. RATING		
						600,000		
						PLANT ELEV. 376 FT.		



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PRB Coal Fired Boiler– Full Load



SH Steam Flow	lb/hr	4208428	4208428	4208428	4208428	4208428	4208428	4208428
RH Steam Flow	lb/hr	3926131	3848276	3899221	3814276	3814276	3839524	3814276
SHO Temp	degF	1004	990	1004	863	986	1004	978
SH Desup Spray	%	1.3	0.1	0.6	0	0	0	0
RH Desup Spray	%	2.9	0.9	2.2	0	0	0.7	0
SHDesuperheater Spray	lb/hr	56190	0	26563	0	0	625	0
RHDesuperheater Spray	lb/hr	111855	0	84945	0	0	25248	0
RHO Temp	degF	1005	1004	1005	789	988	1006	974
RHDESUP OUT TMP	degF	589	606	599	506	617	622	609
Feedwater Temp	degF	470	470	470	470	470	470	470
Econ Exit Gas Temp	degF	778	763	769	695	765	760	783
AH TGO Uncorr	degF	308	304	306	306	317	320	336
Tilt	degree	-5	-5	5	5	25	15	5
Excess Air	%	20	20	20	10	30	20	10
Boiler Efficiency	%	85.58	85.32	85.27	84.21	83.11	83.47	83.58
Gas Recirculation	%	0	0	0	0	0	0	35
NHI/PA	Btu/hr-ft ²	1.85	1.81	1.83	1.54	1.79	1.79	1.84
Q FIRED	Btu/hr	6052.8	5952	6037.9	5347.5	6017.8	6084.5	5940.5
Gas Leaving AH	degF	6524397	6317903	6400794	4889759	6347443	5967469	5403267
Gas In Temp	degF	2699	2642	2684	2454	2555	2687	2353
Percent Coal		100	80	80	0	0	0	0
Percent Gas		0	20	20	100	100	100	100
Existing Windbox Configuration		Yes	Yes	Yes	Yes	Yes	No	Yes

PRB Coal Fired Boiler– Low Load



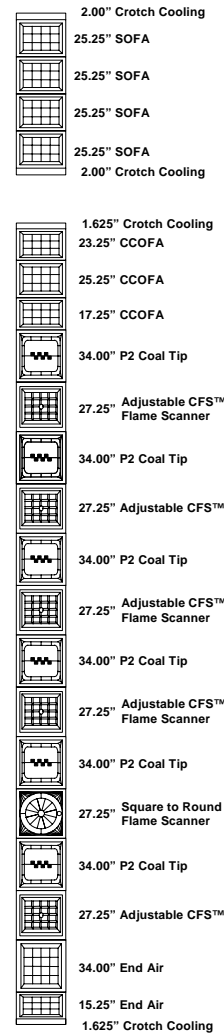
SH Steam Flow	lb/hr	1501008	1501008	1387762	1387762	1387762
RH Steam Flow	lb/hr	1461186	1461186	1329376	1329376	1329376
SHO Temp	degF	999	962	933	1005	1005
SH Desup Spray	%	0.6	0	0.4	4.4	5.2
RH Desup Spray	%	0	0	0	0	0
SHDesuperheater Spray	lb/hr	9448	0	5218	60655	71677
RHDesuperheater Spray	lb/hr	0	0	0	0	0
RHO Temp	degF	924	867	832	946	952
RHDESUP OUT TMP	degF	601	568	540	605	605
Feedwater Temp	degF	383	383	376	376	376
Econ Exit Gas Temp	degF	539	528	510	529	572
AH TGO Uncorr	degF	249	250	280	284	301
Tilt	degree	-2	-2	25	25	25
Excess Air	%	31.6	31.6	33.3	33.3	33.3
Boiler Efficiency	%	87	86.59	84.12	84.03	83.58
Gas Recirculation	%	0	0	0	0	35
NHI/PA	Btu/hr-ft ²	0.66	0.64	0.58	0.62	0.66
Q FIRED	Btu/hr	2241.7	2191.9	2055.1	2173	2190.1
Gas Leaving AH	degF	2756536	2656381	2364819	2486853	2508275
Gas In Temp	degF	2025	1943	1900	2156	1882
Percent Coal		100	80	0	0	0
Percent Gas	Percent Gas	0	20	100	100	100
Existing Windbox Configuration		Yes	Yes	Yes	No	Yes

PRB Coal Fired Boiler

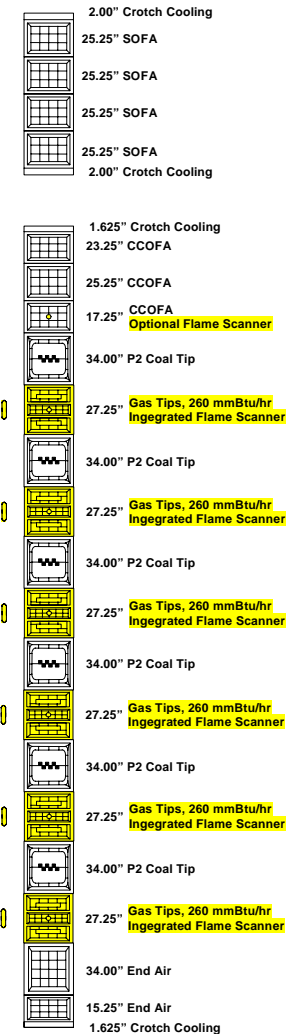


- Retaining coal firing capability
- Existing oil fired ignitors were eliminated that are adjacent to the coal compartments.
- New gas fired ignitors adjacent to the new gas compartments and coal will be ignited by the gas elevations.

Existing LNCFS™ Level 3 Low NOx System Windbox Arrangement



Natural Gas Modification to Existing LNCFS™ Level 3 Arrangement



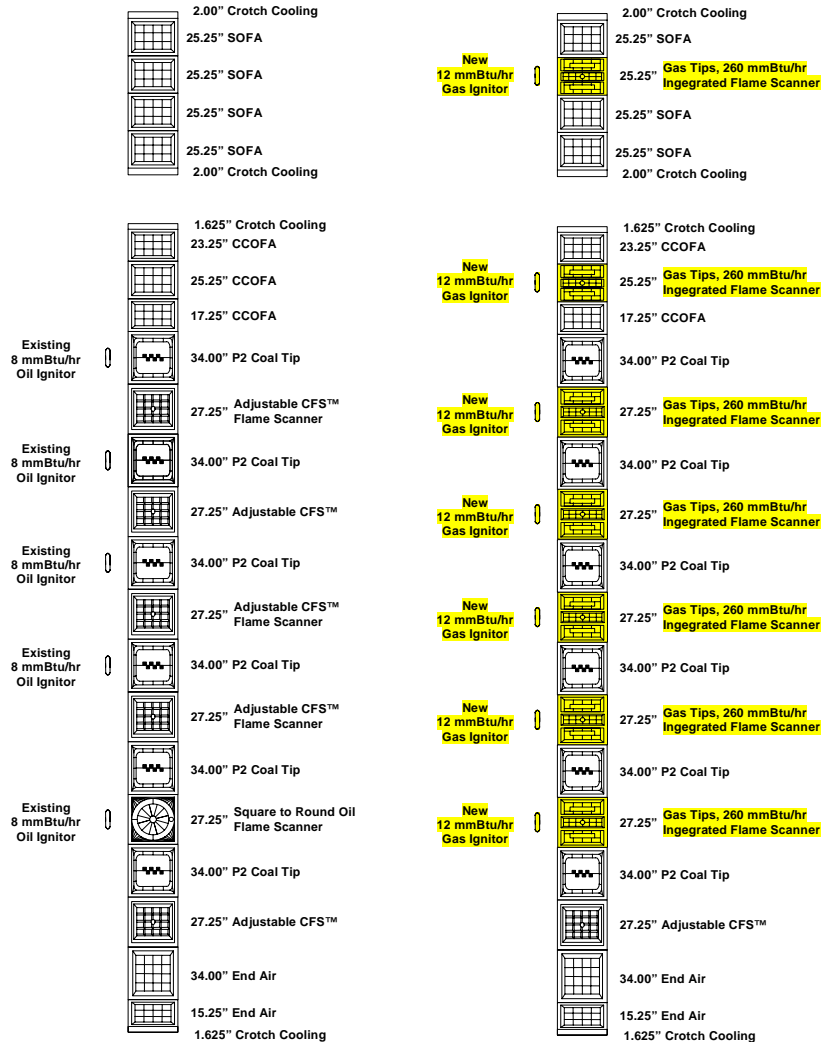
PRB Coal Fired Boiler



- Optional gas firing arrangement
- Install one elevation located in the SOFA to raise furnace outlet gas temperature so steam temperature can be achieved.

Existing LNCFS™ Level 3 Low NOx System Windbox Arrangement

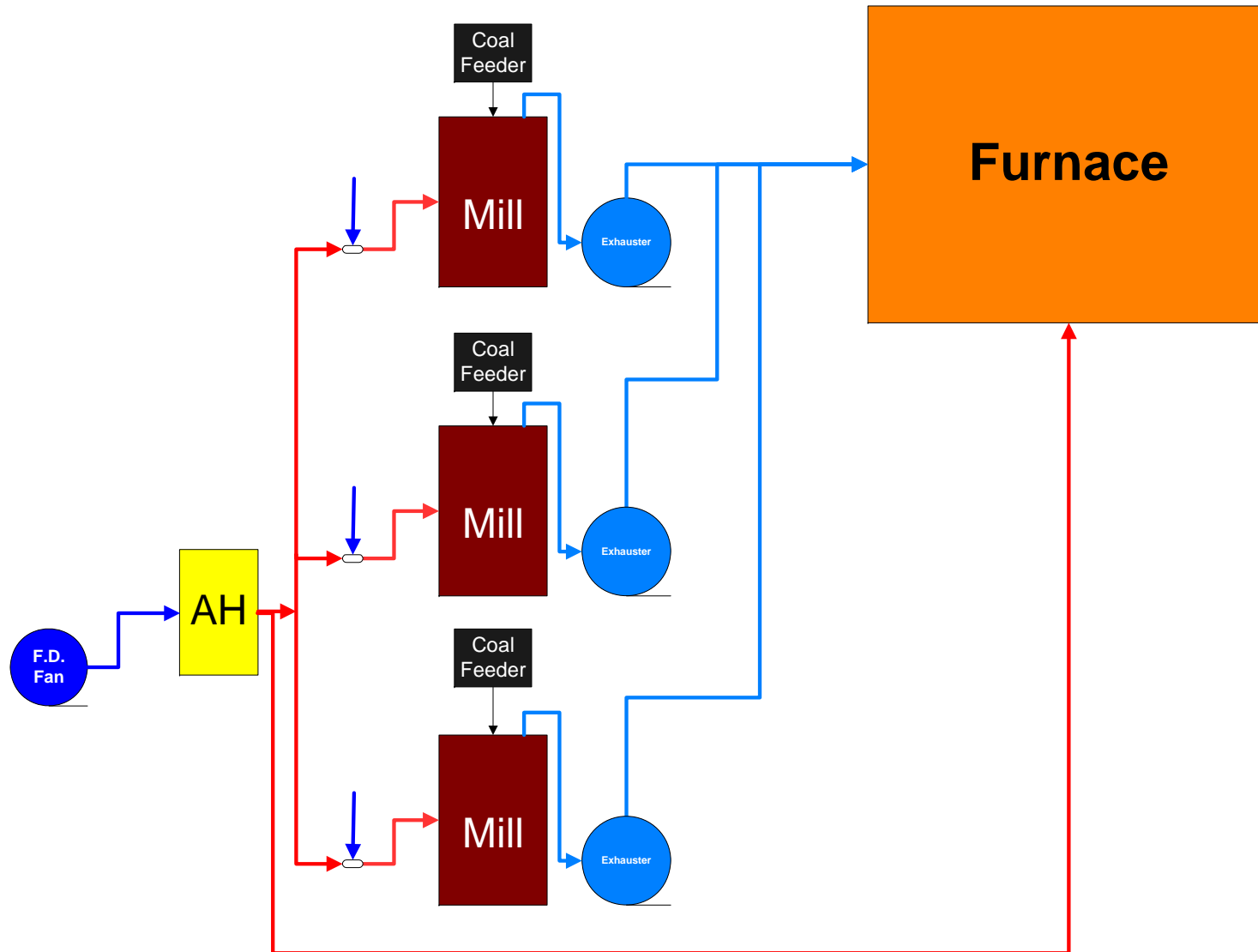
Natural Gas Modification to Existing LNCFS™ Level 3 Arrangement



Pulverizer and Fan Systems

-
- How do we get the required combustion air flow to the windbox and furnace?
 - What operating or equipment modifications will be required?

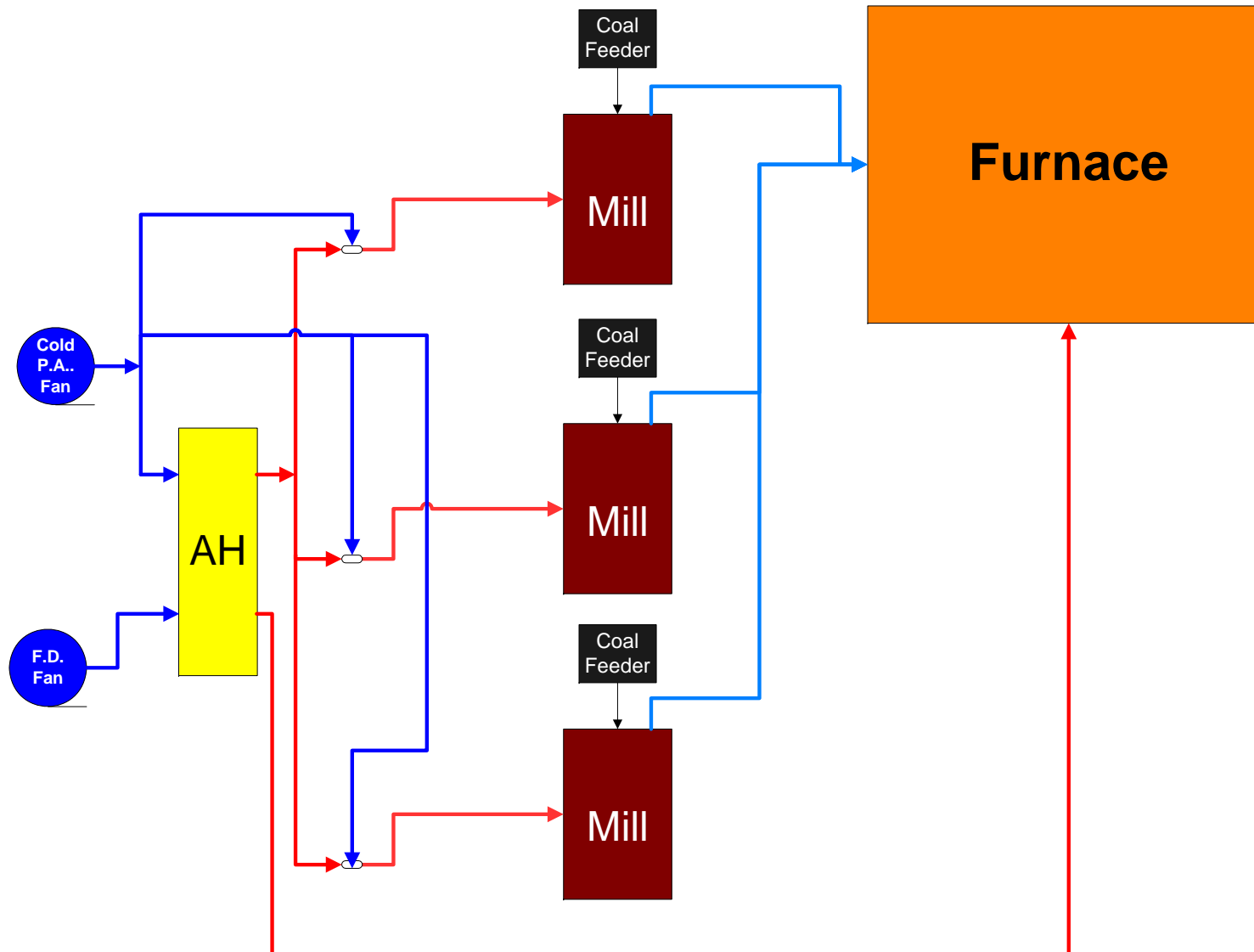
Pulverizer System with Exhausters



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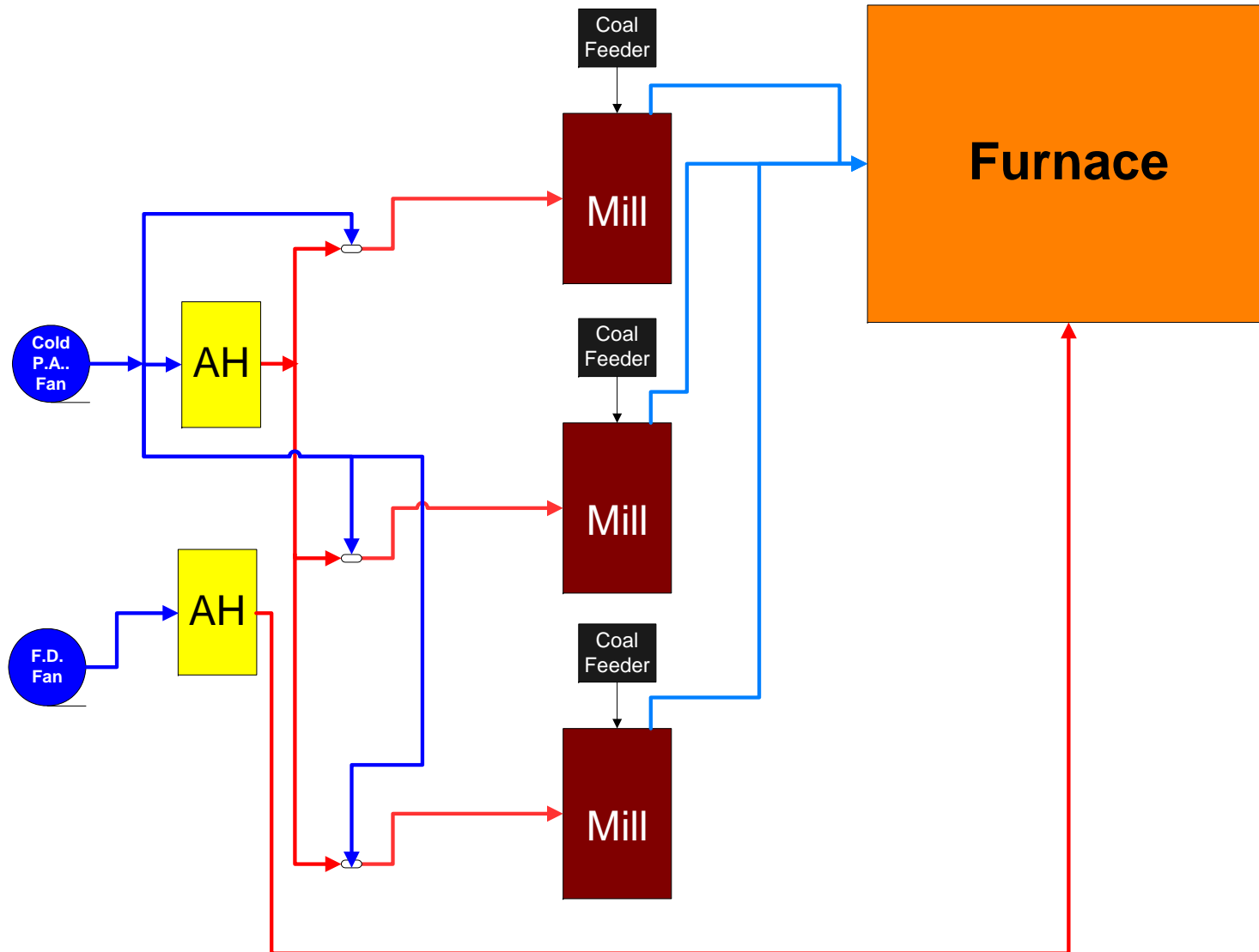
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Cold Primary Air System



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Cold Primary Air System with Bisector AH



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Converting Coal Fired Boilers to Gas Firing Summary

Possible Issues Include:

- An increase in SH desuperheater spray water flow
- An increase in RH desuperheater spray water flow
- An increase in forced draft fan volumetric flow
- SHO & RHO steam temperatures may not be achieved in some cases

These issues may or may not require capacity increases in their respective equipment

Bituminous Coal to Natural Gas Conversion

Solution:

- Increase the SH desuperheater spray water capacity
- “Tip” the forced draft fans to increase their volumetric flow capacity
- May require re-surfacing for steam temperature

Possible Issues Include:

- Inability to attain design SH steam outlet temperature
- Inability to attain design RH steam outlet temperature
- Insufficient forced draft fan volumetric capacity
- Insufficient forced draft fan motor size
- Primary air system not useful
- Exceeding steam turbine steam inlet temperature lower limits
- Exceeding steam turbine SH/RH steam inlet differential temperature limits

Solution:

Raise the gas firing elevation in the furnace to increase furnace outlet temperature when firing natural gas

- Increases SH steam outlet temperature to design level
- Eliminates steam turbine steam temperature issues
- Customer may choose to let forced draft fan capacity determine MCR
- FD fan volumetric capacity may be increased by “tipping” the fan (may require motor HP increase)
- FD fan volumetric capacity may be augmented with the primary air fans
- Primary air system may need to be redesigned

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