Worldwide Pollution Control Association

Michigan Coal to Gas Seminar

June 5-6, 2012

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WPCA Natural Gas Conversion

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May 30, 2012

ALSTOM

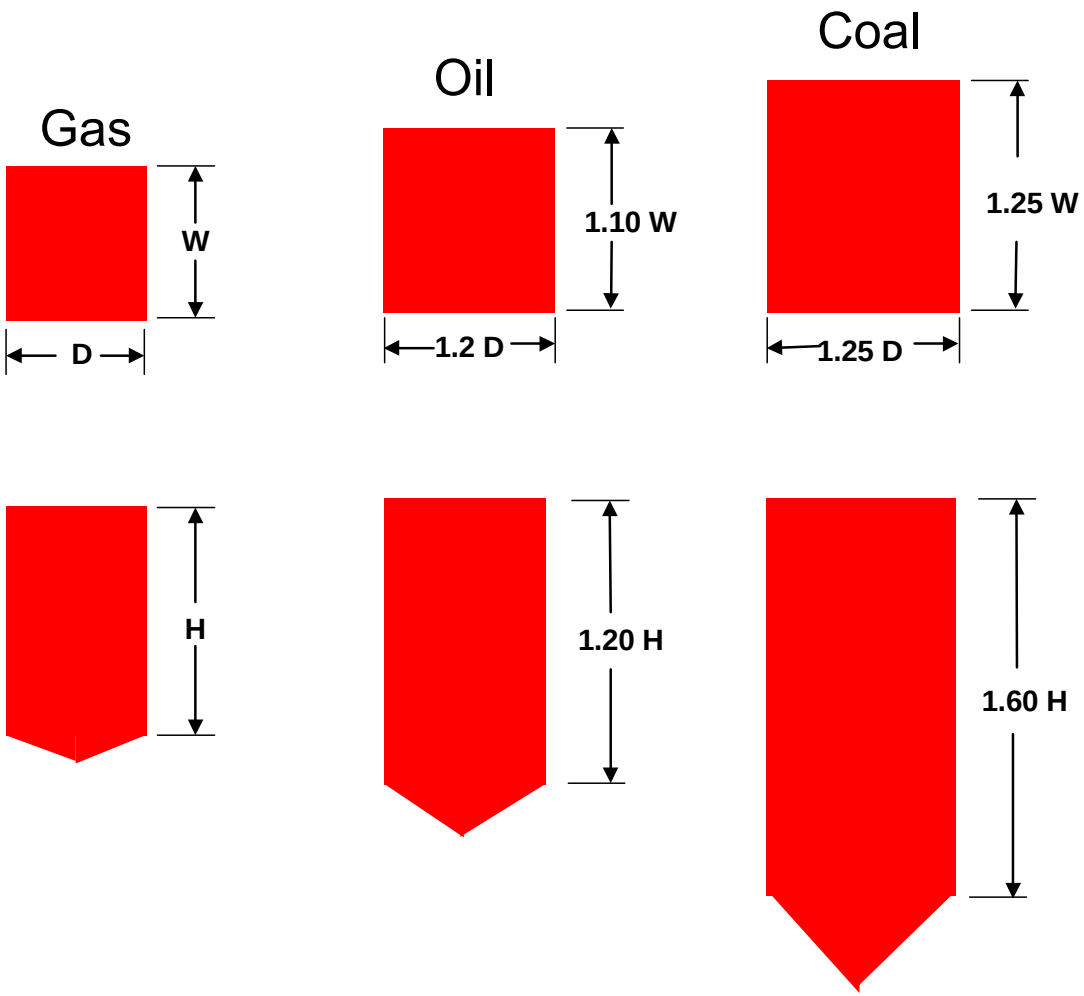
WPCA – Natural Gas Conversions of Coal Fired Boilers

Items to be covered

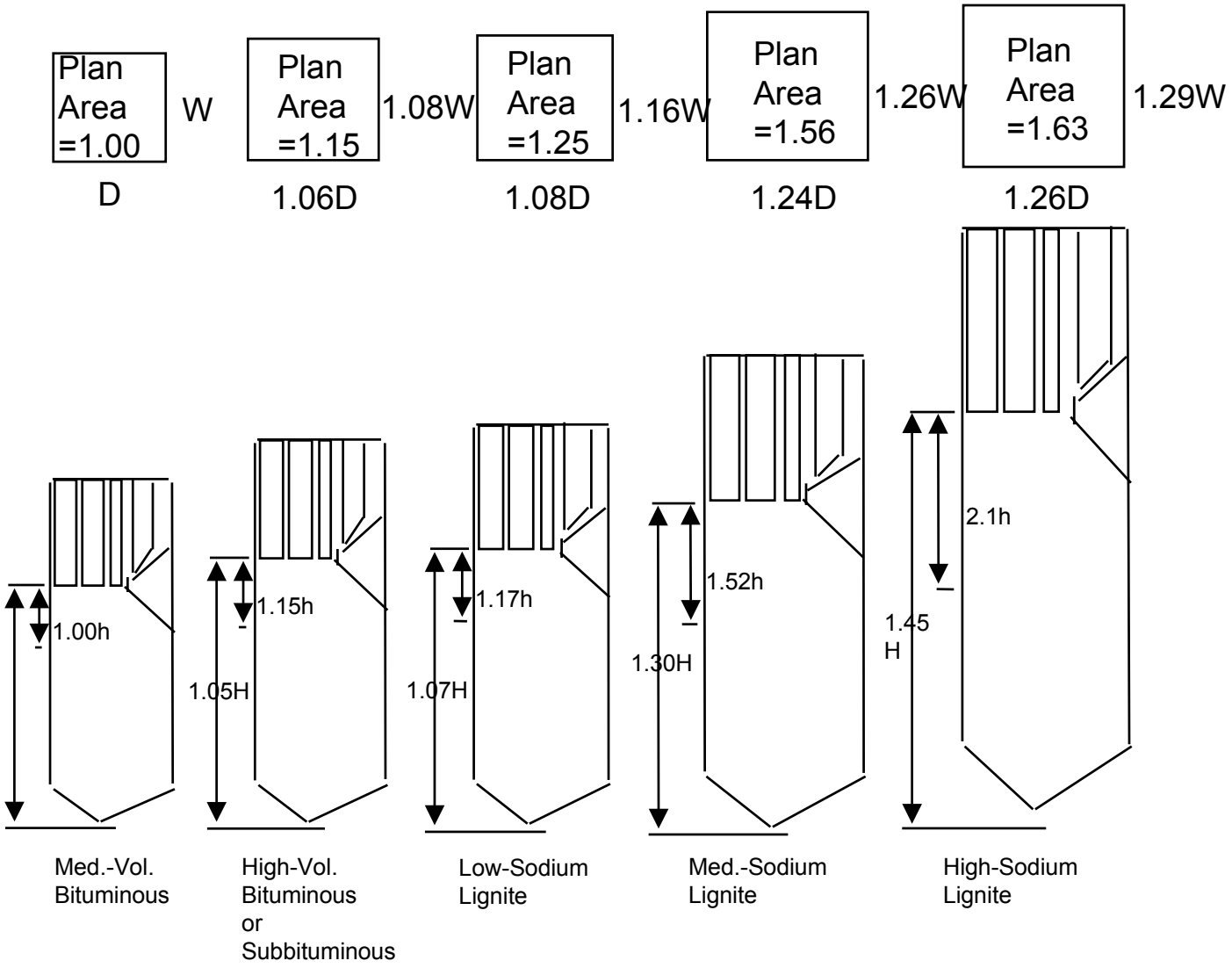
- Boiler Sizing
- Gas Firing Components
- Gas Firing – Emissions
- Converting Bituminous Coal Fired Boiler to Gas Firing
- Converting PRB Coal Fired Boiler to Gas Firing
- Pulverizer and Fan Systems
- Summary

Normal Boiler Sizing

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



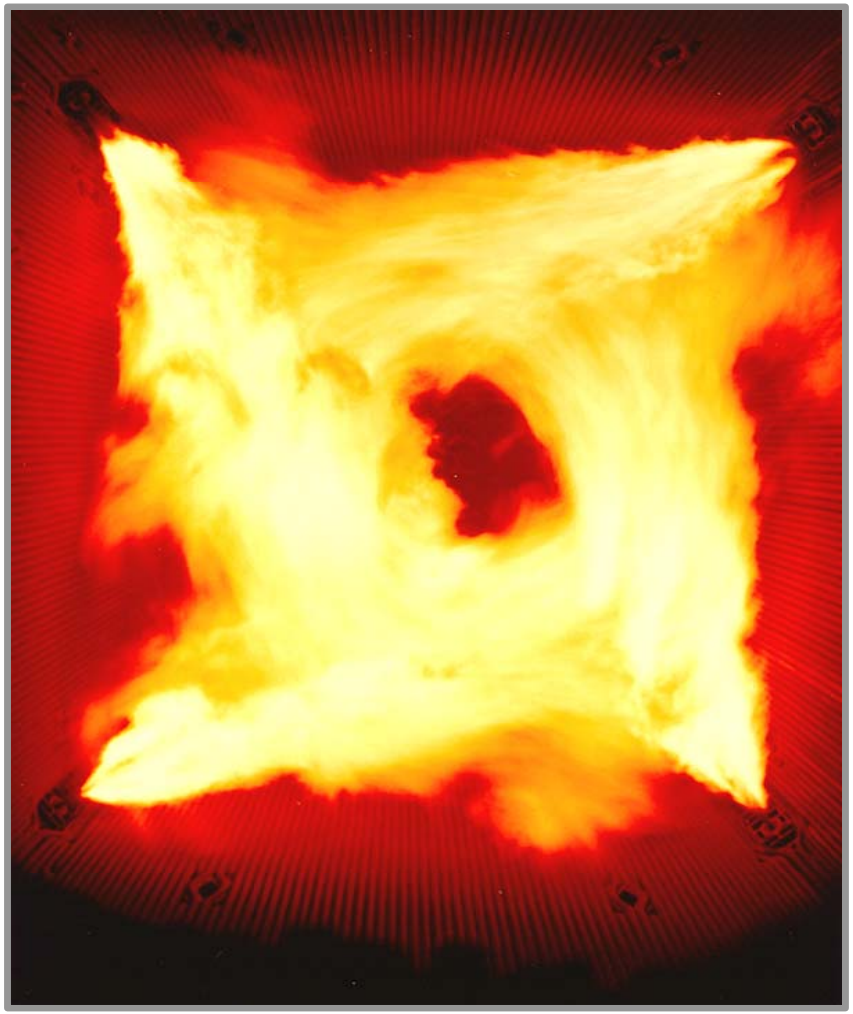
Coal Fired Boilers



Gas Firing Components

Tangential Firing System

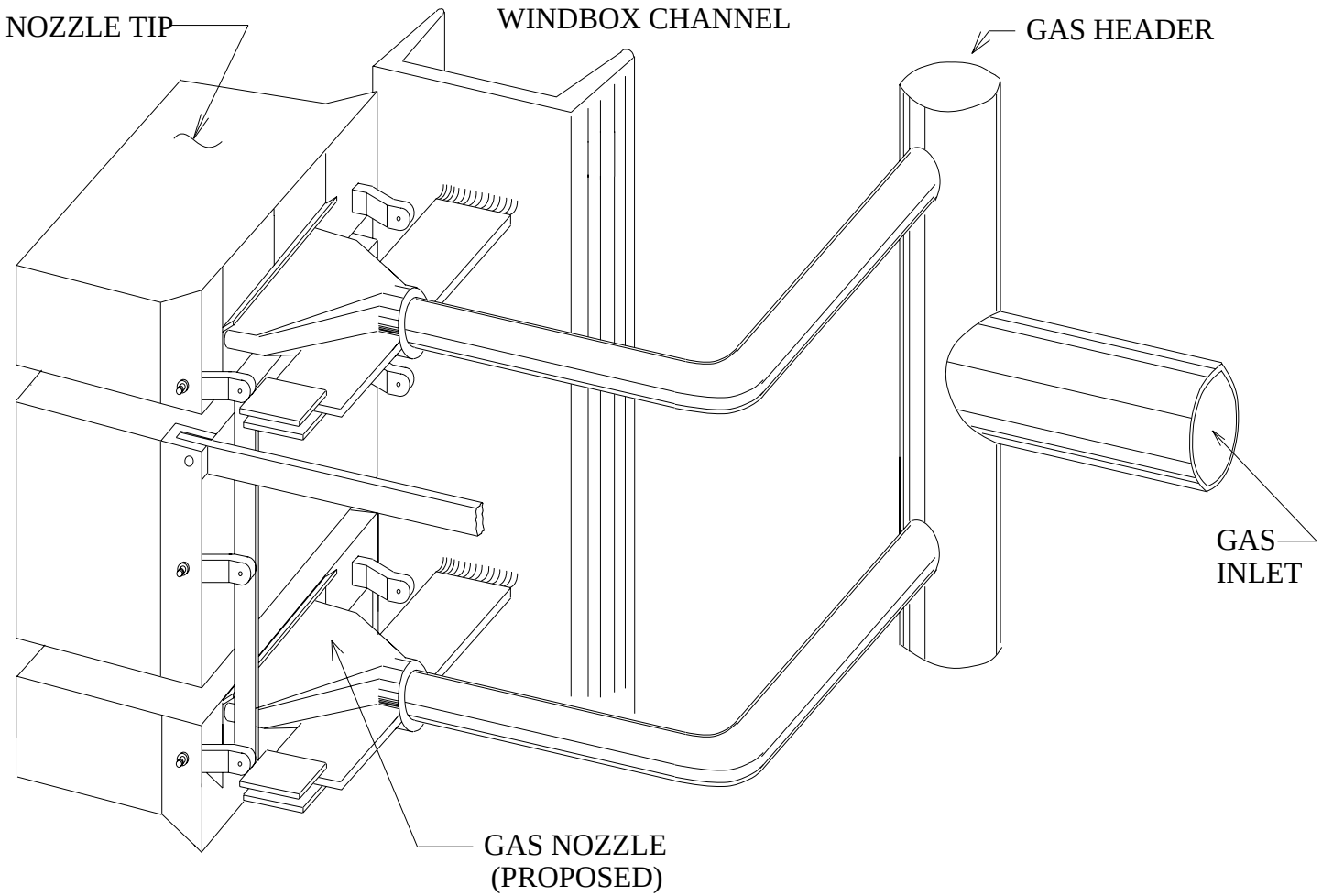
- Flame Pattern of Tangential Firing System



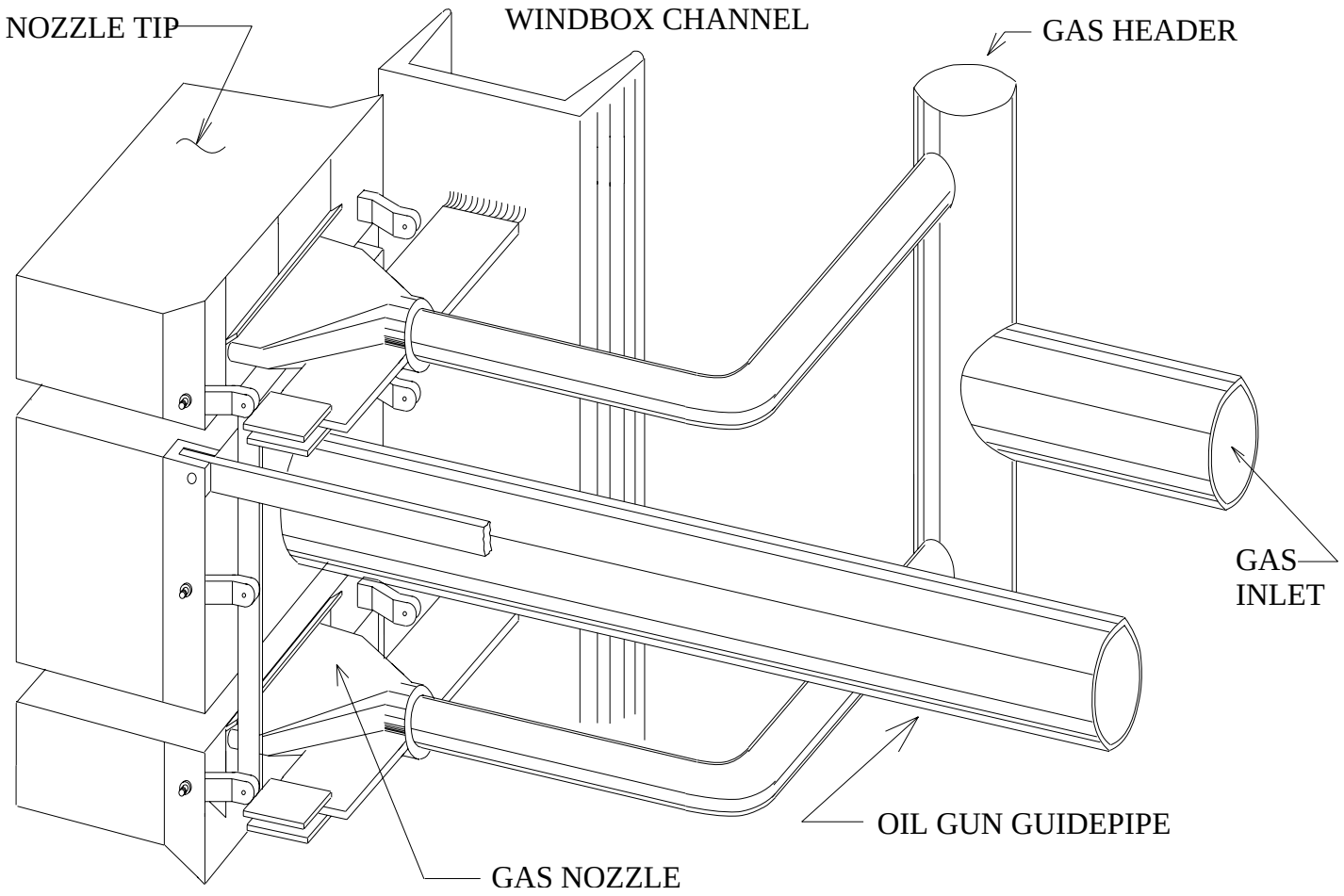
Key Gas Design Criteria

- 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

Option for Skid-Mounted Gas & Ignitor Pipe Trains

Gas Firing - Emissions

NOx Formation

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)

Parameters Influencing NOx Formation

- 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

NOx Technology Questions

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

NOx Reduction Methods

- **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/H_20 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

Other Emissions

- CO
  - Incomplete Combustion
  - Time, Temperature, Turbulence

Converting Bituminous Coal Fired Boiler to Gas Firing

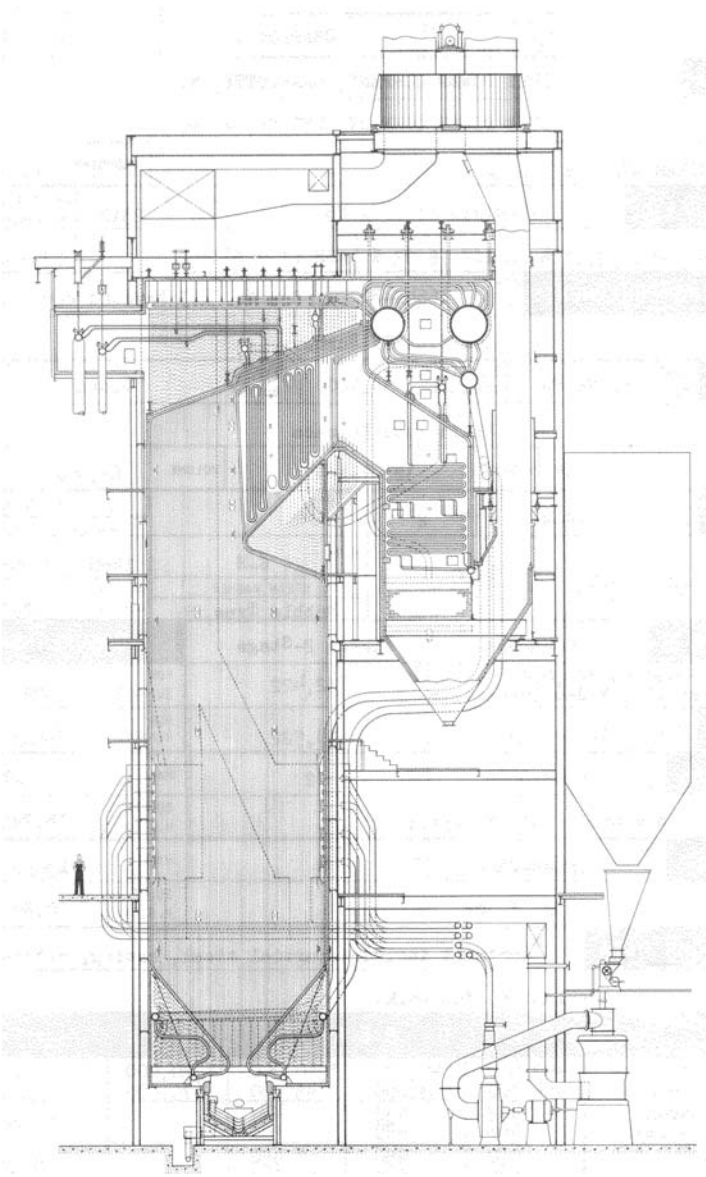
Bituminous Coal Fired Boiler #1

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	55
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 Coutant			
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 1450	PRESSURE OPERATING 1295 at S.O.	
DESIGNATION 32'-7-1/4" / 24'-11-3/4" 123-3 / 94-3 R 54-60 / 30			MFR. C-E			
			STEAM WASHER Bubble Type	BOILER NUMBER 1 and 2		
SUPERHEATER	CONT. NO. 16648-SH	TYPE Elesco 2-Stage		DESUPERHEATER		
CONTROL RANGE 490,000 to 780,000 by burner tilt & desuperheaters		SQ.FT. H.S. 32,422		FOR SUPHT'R. Spray Type		
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	490,000	640,000	*750,000	**780,000	*Guaranteed (Max.Cont.)
	Reheat	424,000	553,000	645,000	670,000	**12 Hr. Peak
FEEDWATER TEMP. TO	Econ.	408	432	447		
	Boiler	466	489	500		
STEAM TEMP. Fat S.O.& R.O		950	950	* 950		REHEATER DATA
HEAT RELEASE BTU/CU.FT./HR.		10,600	13,600	15,600		645,000 lb steam/hr.
TEMP. GAS FROM AIR HEATER		259	285	291		Enter Temp. 690 F
TEMP. AIR FROM AIR HEATER		578	610	619		" Press. 431 PSI
OVERALL EFFICIENCY %		89.35	88.78	*88.66		Leav. " 405 PSI

Form 1-2-50



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 Tiilt	degrees	Horiz	-8	-12	-12
Fuel Elevations in Service	number	4	4	3	3

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 Tiilt	degrees	+30	Horiz	Horiz
Fuel Elevations in Service	Number	2	1	1

Bituminous Coal Fired Boiler #1

		Original	Coal Data	Natural Gas
		Design	2/16/2011	
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	Coal Data	Natural Gas
		Design	2/16/2011	
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		

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

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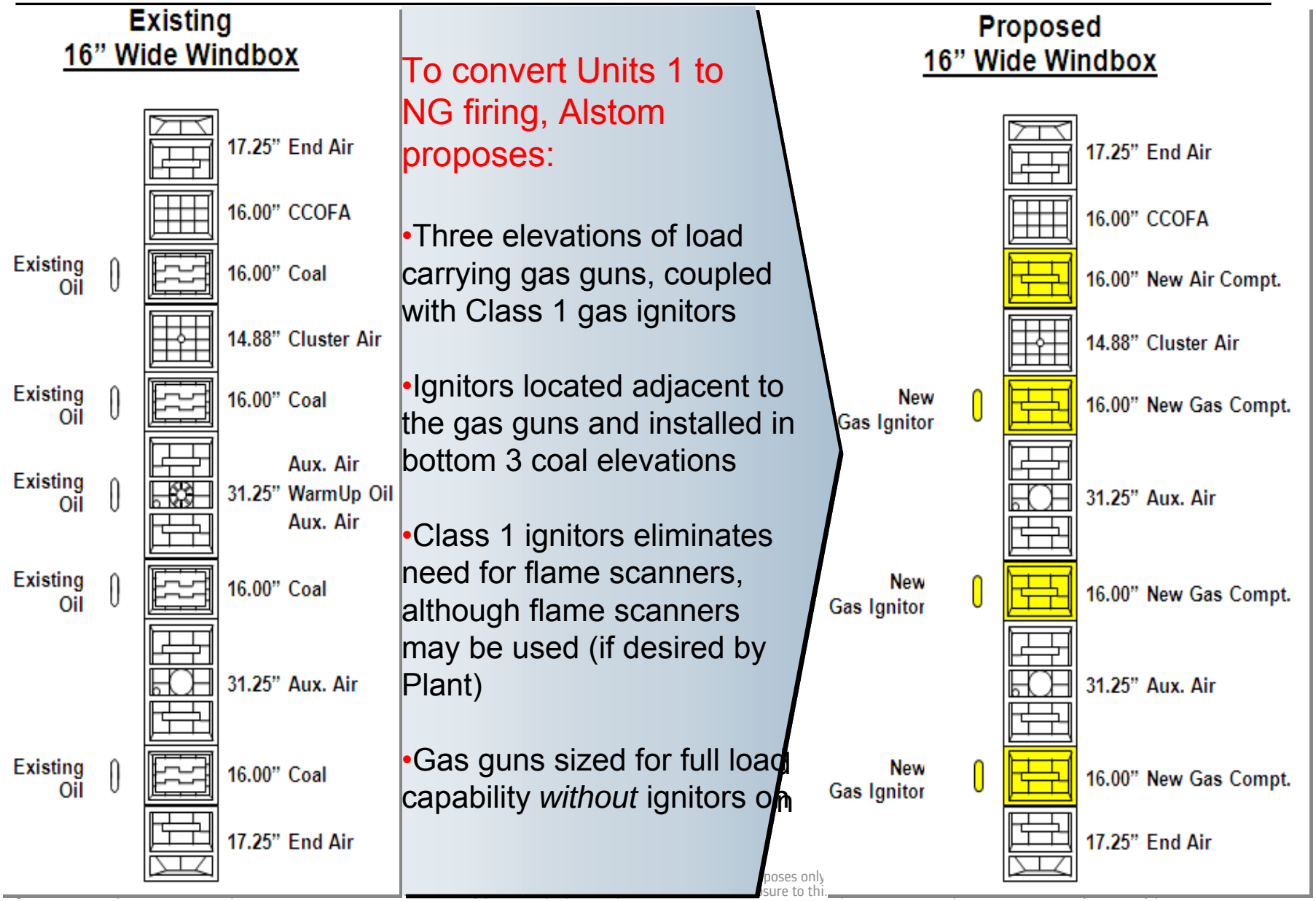
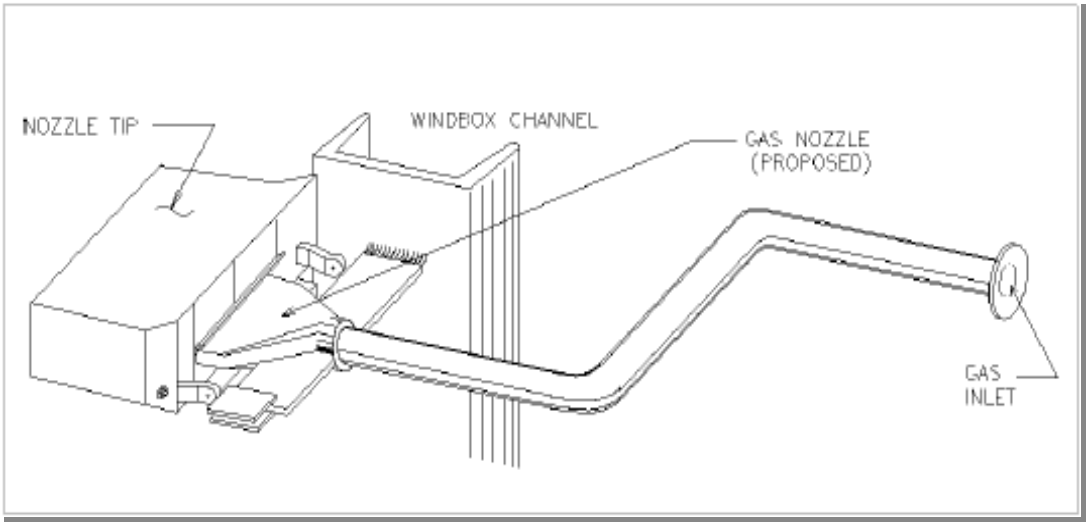


Bituminous Coal Fired Boiler #1 – Gas Gun Assembly



- 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 x 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

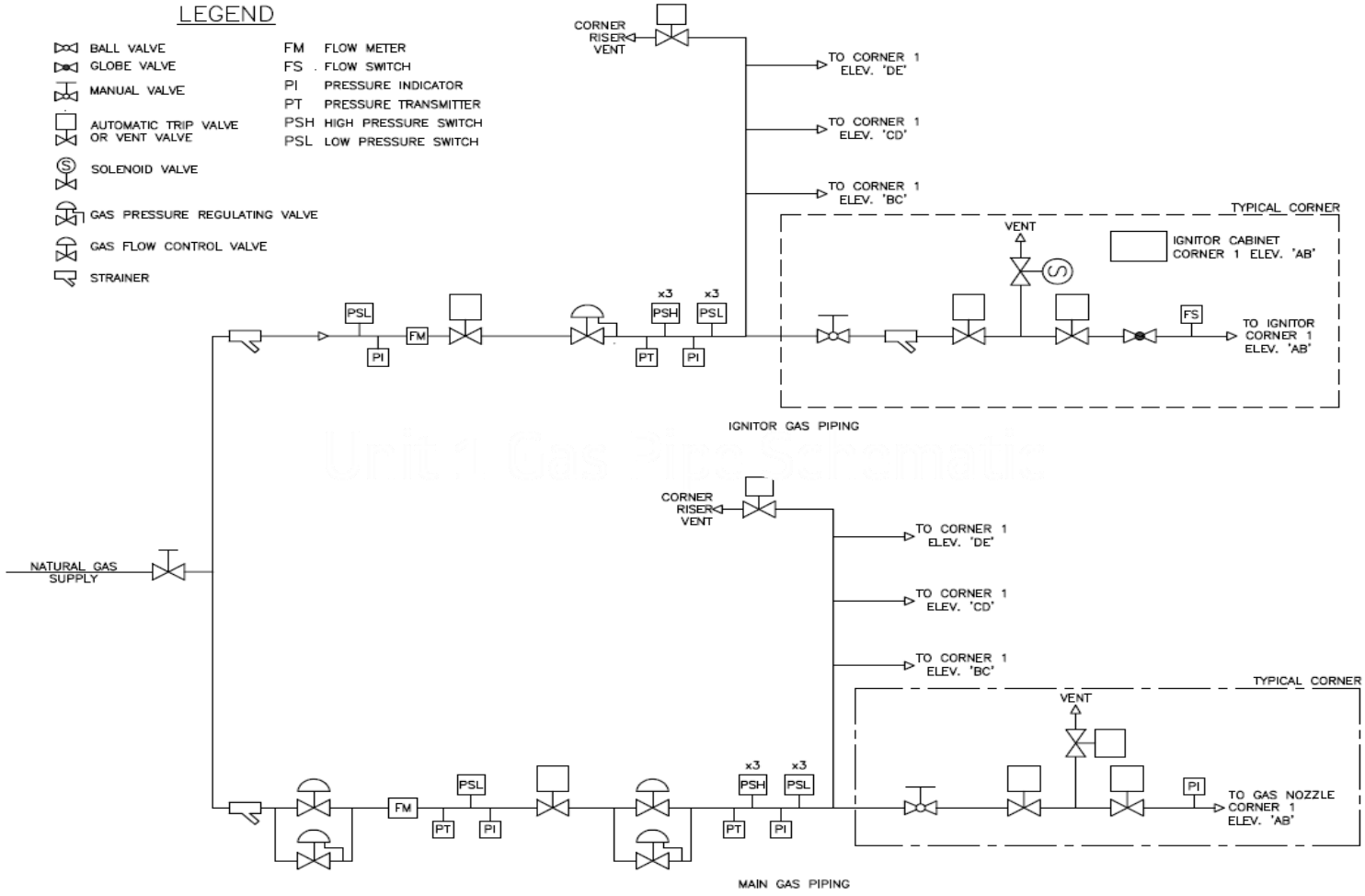
Ignitor Air System

- 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.

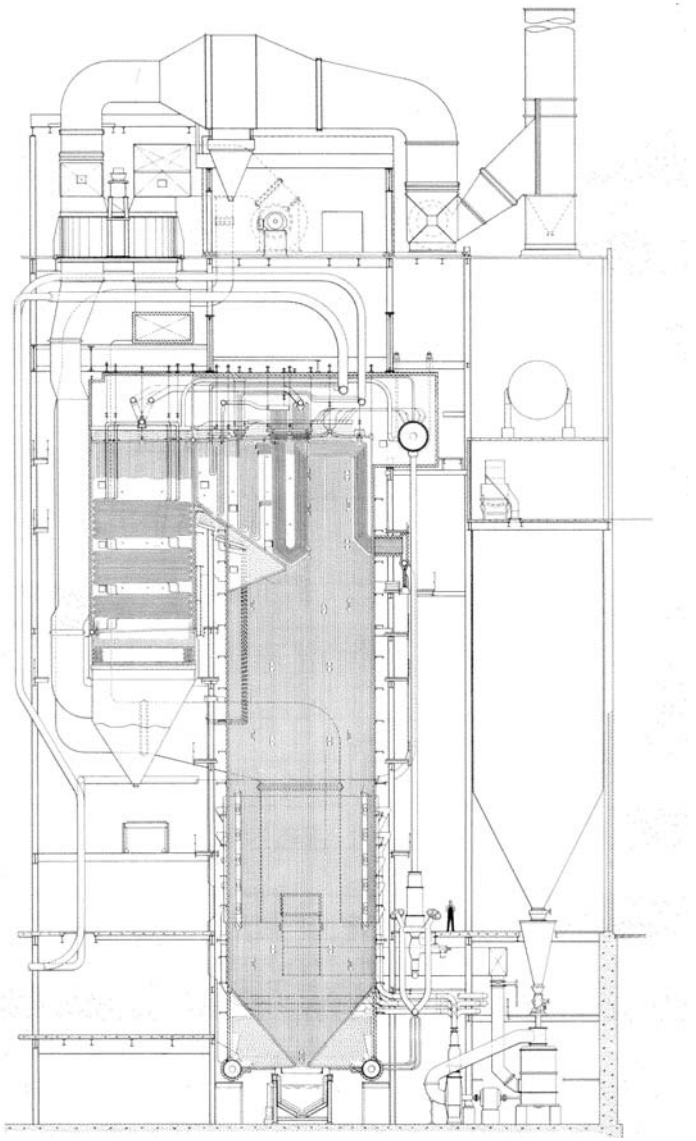
Bituminous Coal Fired Boiler #1 - Gas Pipe Schematic



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 DESIGN 2700	PRESSURE OPERATING 2450 at S.O.		
DESIGNATION 40'-6½" / 28'-2" 320-1½ / 160-1½ CCRR 60 / 2-36	MFR. C-E	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	COAL				1 - 165,000
LB STEAM PER HR-ACTUAL PRIMARY	660,000	1,100,000	*1,160,000	*1,200,000	- 6 Hr. Peak - 18 Hr. Interval.
LB STEAM PER HR-ACTUAL REHEAT	592,500	975,000	1,023,000		
FEEDWATER TEMP. TO ECON.	420	467	470		REHEAT DATA
FEEDWATER TEMP. TO BOILER	465	505	507		1,023,000 LB STEAM/HR.
STEAM TEMP at S.O.& R.O.	1050-1000	1050-1000	*1050-1000		Enter. Temp. 669 F
HEAT RELEASE BTU/CU.FT./HR.	8,150	12,850	13,450		" Press. 507 Psi
TEMP. GAS FROM AIR HEATER	245	280	282		Leav. Temp. 1000 F
TEMP. AIR FROM AIR HEATER	525	562	567		" Press. 474 Psi
OVERALL EFFICIENCY %	89·71	88.99	*88.95		



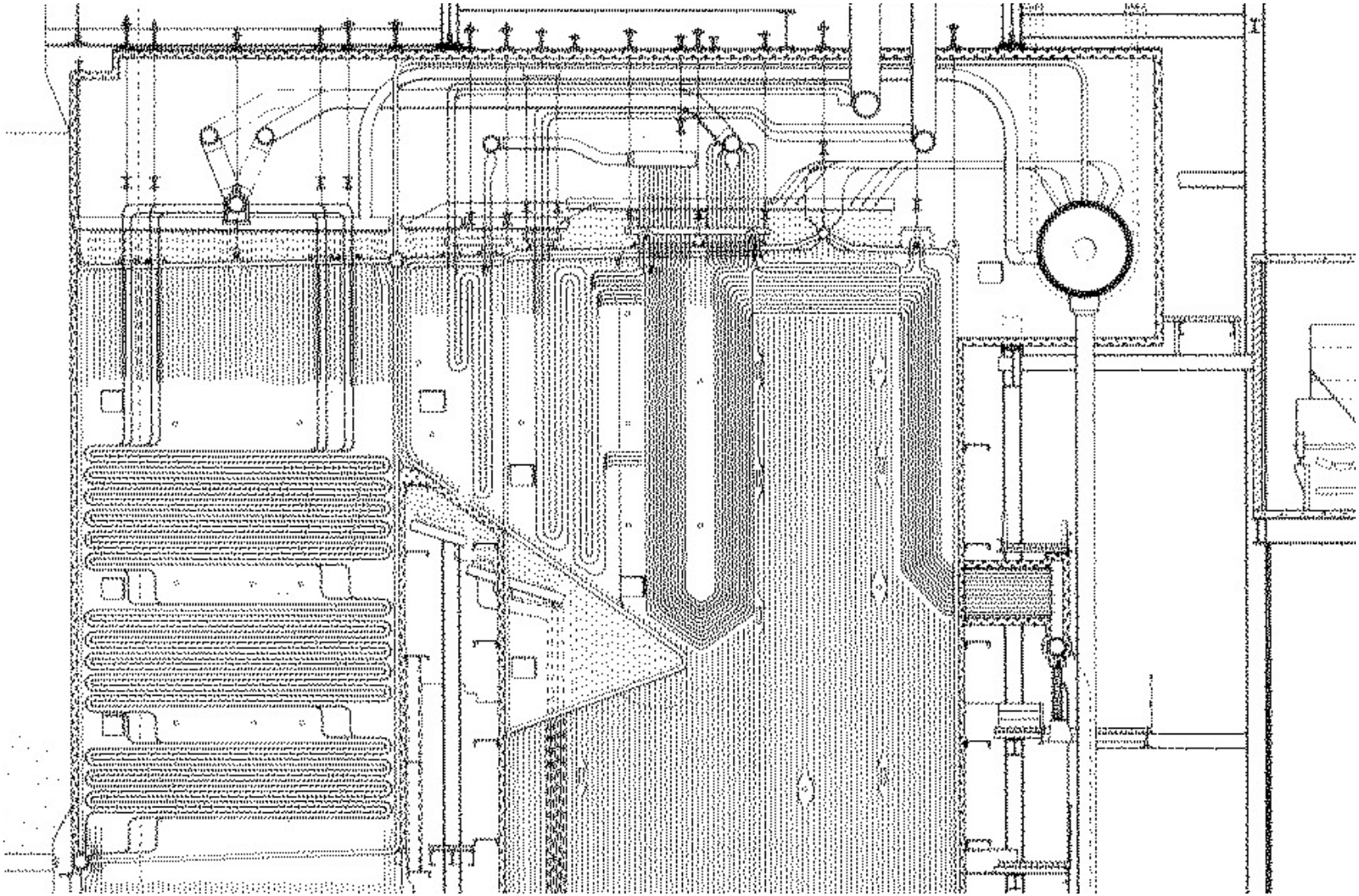
Bituminous Coal Fired Boiler #2

		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	104.8% MCR	104.8% MCR	104.8% MCR	104.8% MCR
		6Hr. Peak				
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 Tiilt	degrees	Horiz.	-7	+15	+15	+15
Gas Recirculation	%					20
Fuel Elevations in Service	Number	5	5	4	4	4

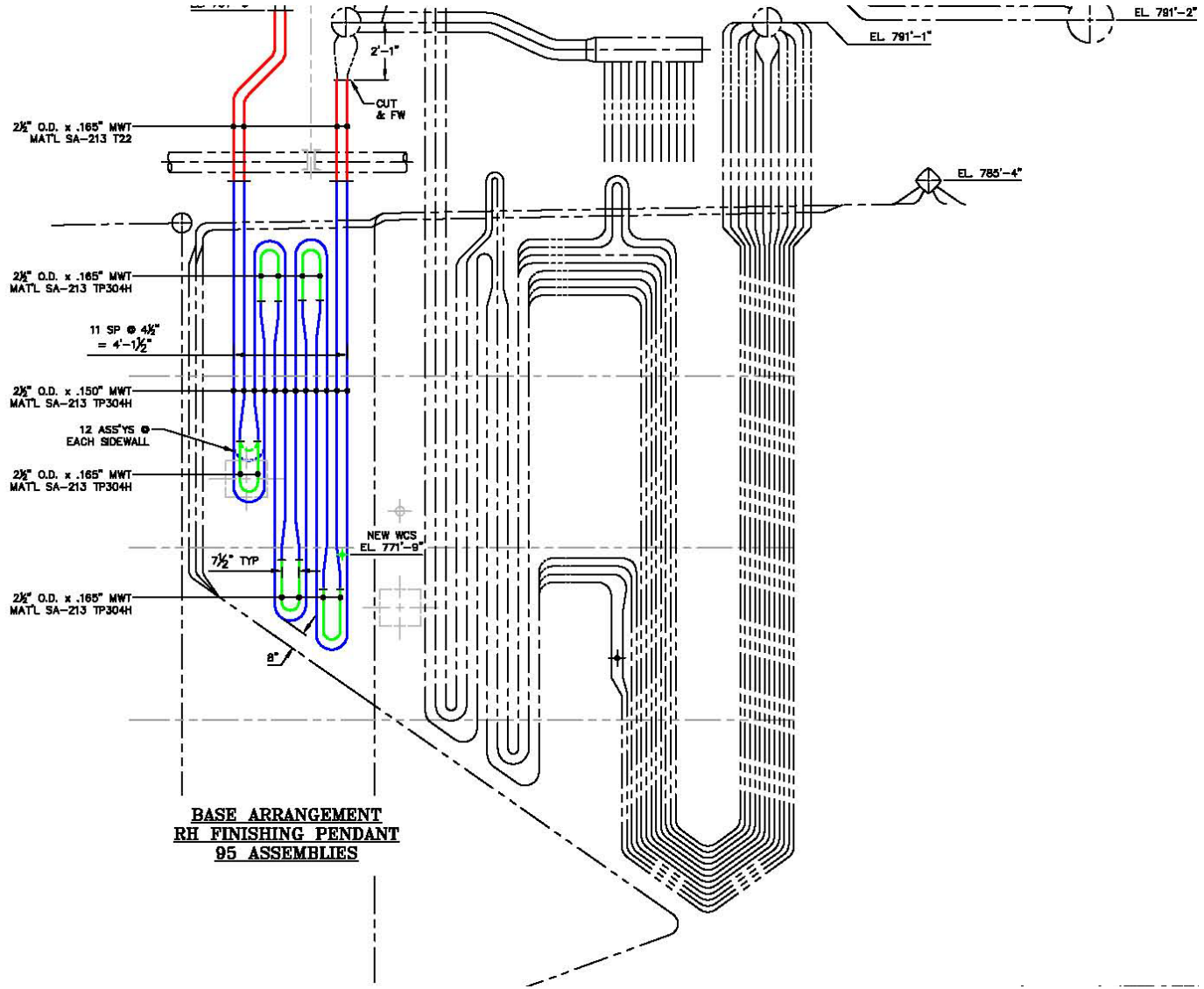
Bituminous Coal Fired Boiler #2

		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 Tiilt	degrees	+30	Horiz	Horiz	+2
Fuel Elevations in Service	Number	3	2	2	2

Bituminous Coal Fired Boiler #2



Bituminous Coal Fired Boiler #2



Bituminous Coal Fired Boiler #2

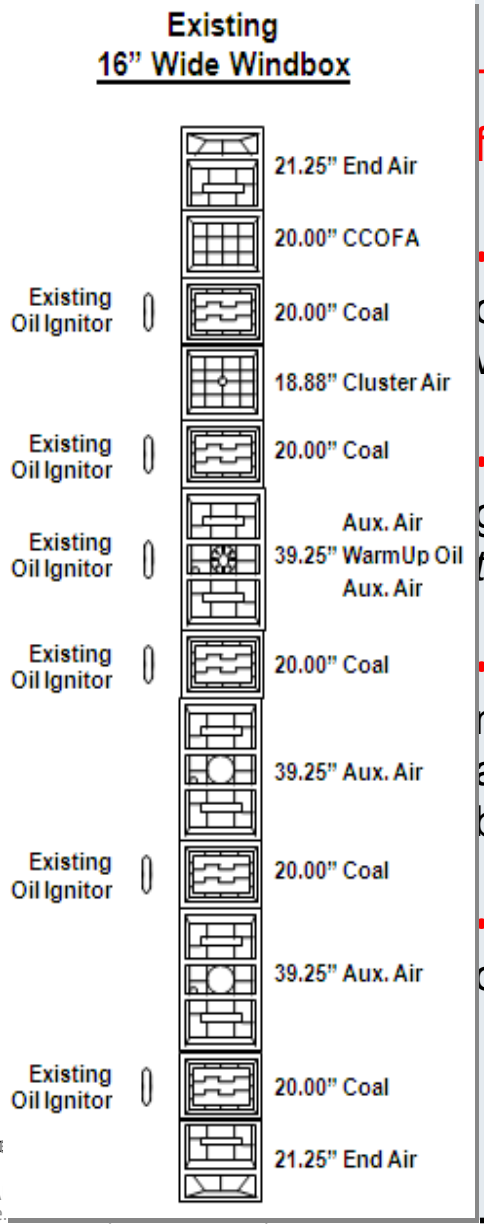
		Original Design	Coal Data	Natural Gas
			2/16/2011	With or Without Additional RH Surface
Air Weight to FD Fan	lb/hr	1,418,000	1,367,521	1,578,988
Excess Air	%	15	16	20
Air Temperature to FD Fan	°F	100	100	100
Air Volume	ACFM	333,600	330,986	382,169
Air Volume per Fan	ACFM	166,800	165,493	191,085
27% 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		

Bituminous Coal Fired Boiler #2

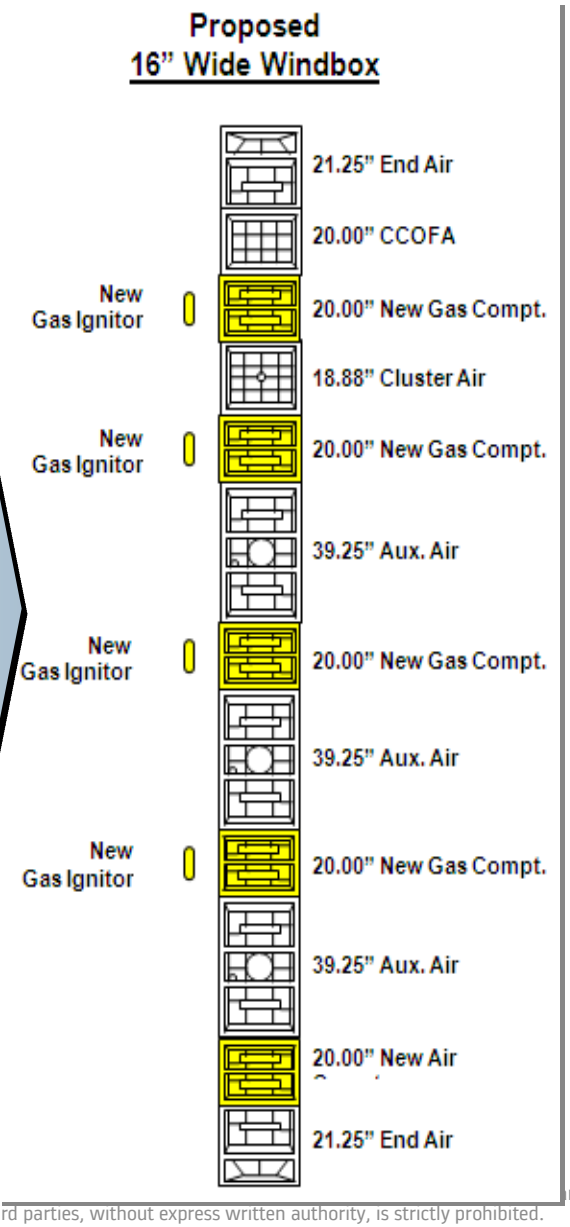
- Alstom performed a study to convert to 100% natural gas firing. For study purposes, customer has defined normal full load (NFL) at 185 MW. Coal firing will be eliminated.
- To convert the unit to natural gas firing, the Alstom will provide four elevations of load carrying gas guns, coupled with Class 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.

Bituminous Coal Fired Boiler #2

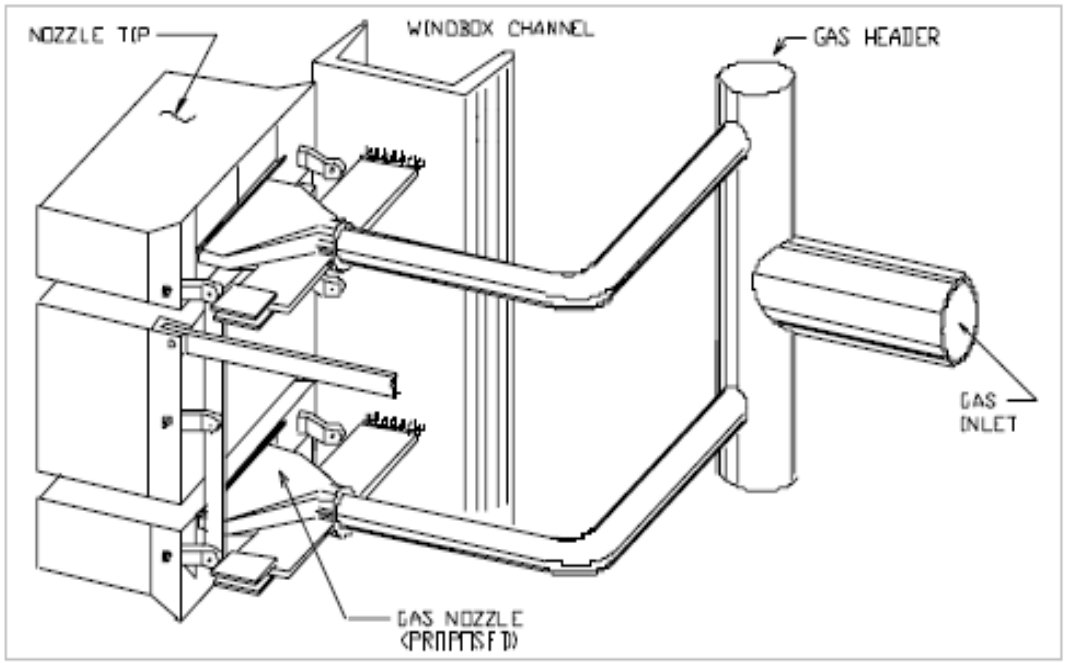


To convert Unit 2 to NG firing, Alstom proposes:

- 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



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 x 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 #2

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	PRESS DESIGN	2990
DESIGNATION	65' - 0" / 52' - 7 15/16"	311 - 2" / 234 - 2"	CCRR	PRESS OPER. S.O.	2620
				PRESS 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	TYPE Multistage with Panels & Platens	REHEATER	TYPE Multistage with Radiant Wall - Front & Sides		
ECONOMIZER	NO. 1	TYPE Plain Tube - In Line 206 W x 48 H			
AIR HEATER	NO. 2	TYPE 31½ VI 84 (T)		MAKE Ljungstrom	
FUEL BURNING EQUIPMENT	TT Fuel Nozzles	6-1003 RP Mills*			

FUEL	ASH FUSION TEMP. F	GRINDABILITY	HHV
East Decker Sub-Bituminous - C			
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*		

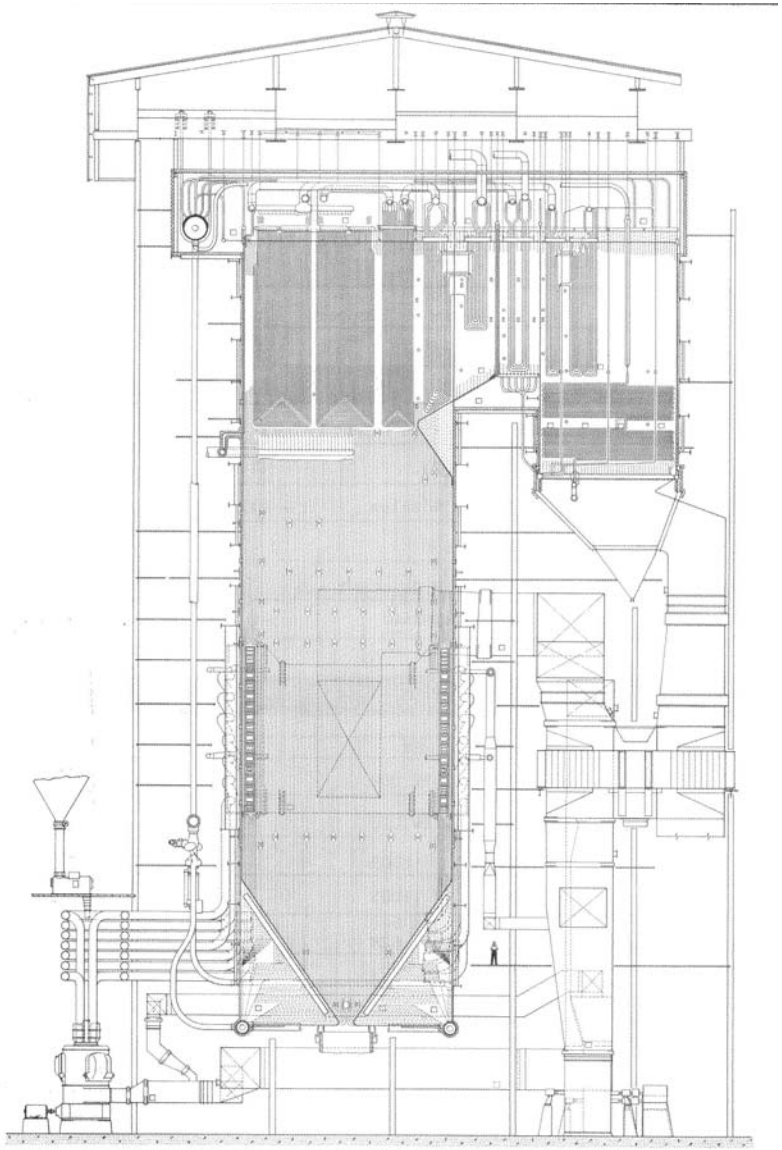
FORM NO 1-2-62

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.



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

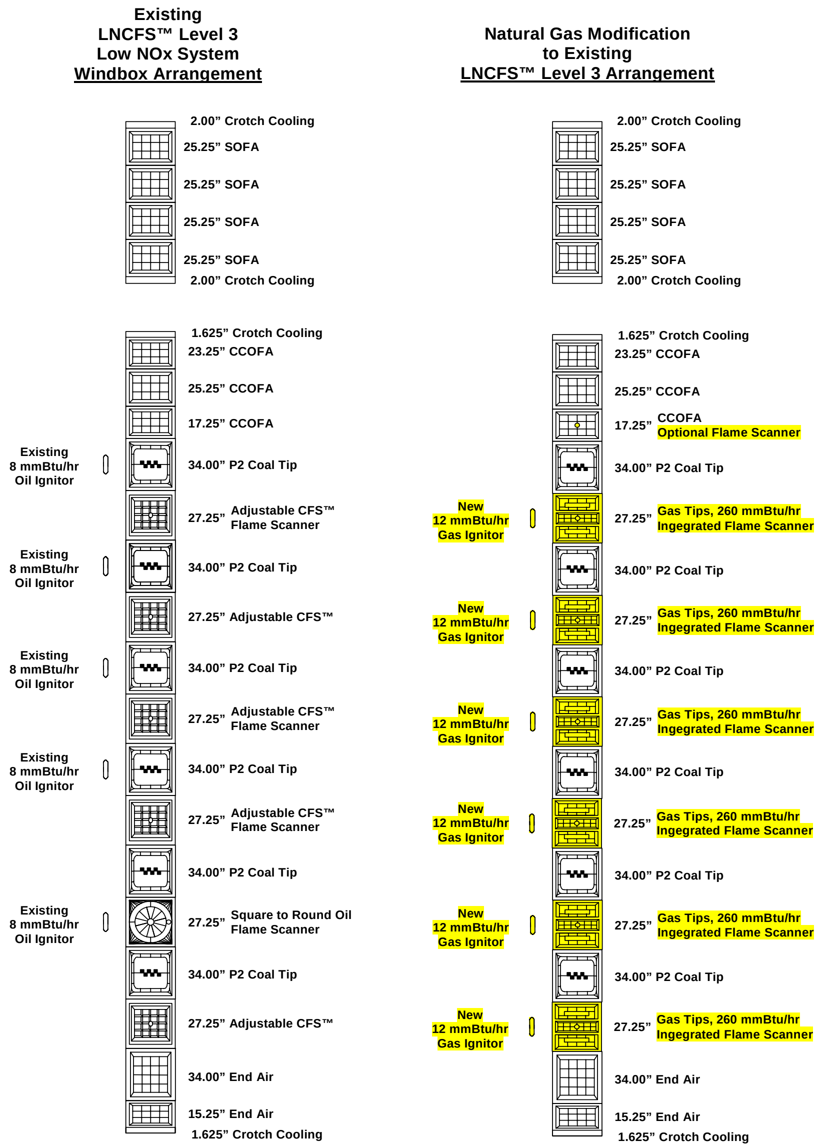
PRB Coal Fired Boiler– Low Load

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

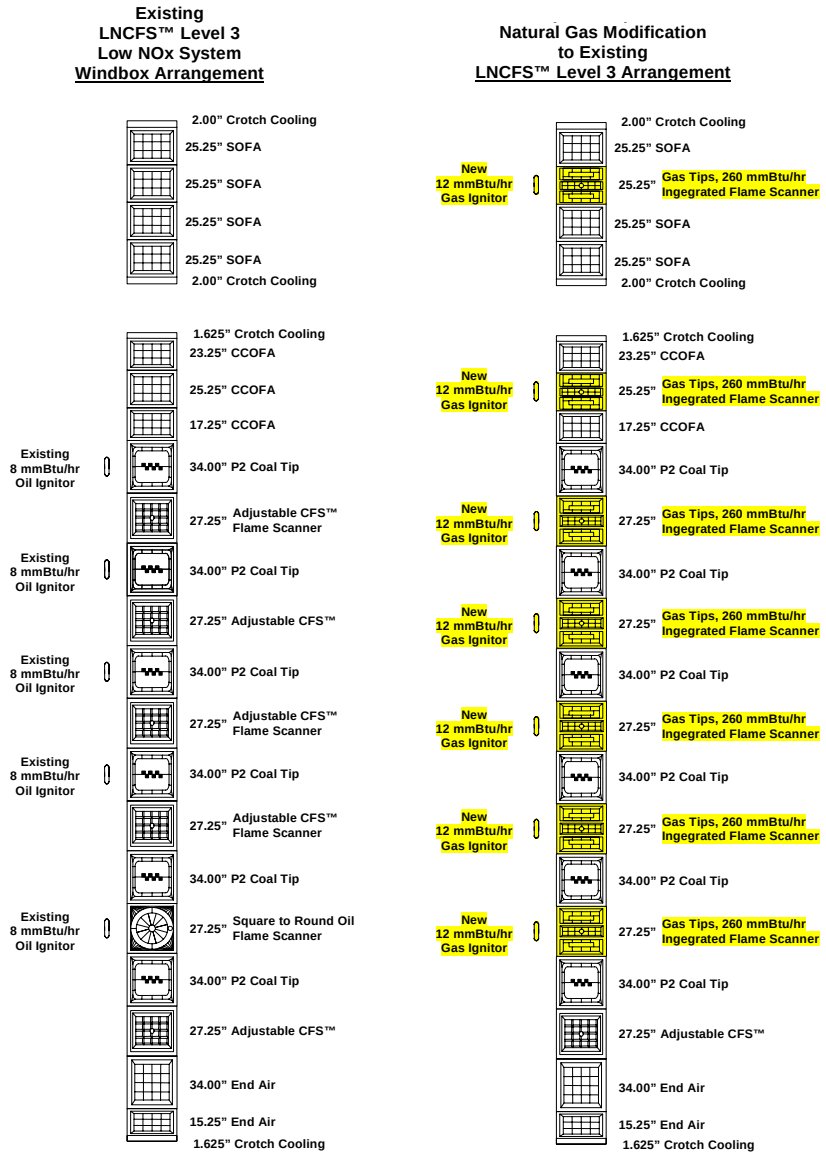
ALSTOM

- 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.



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.

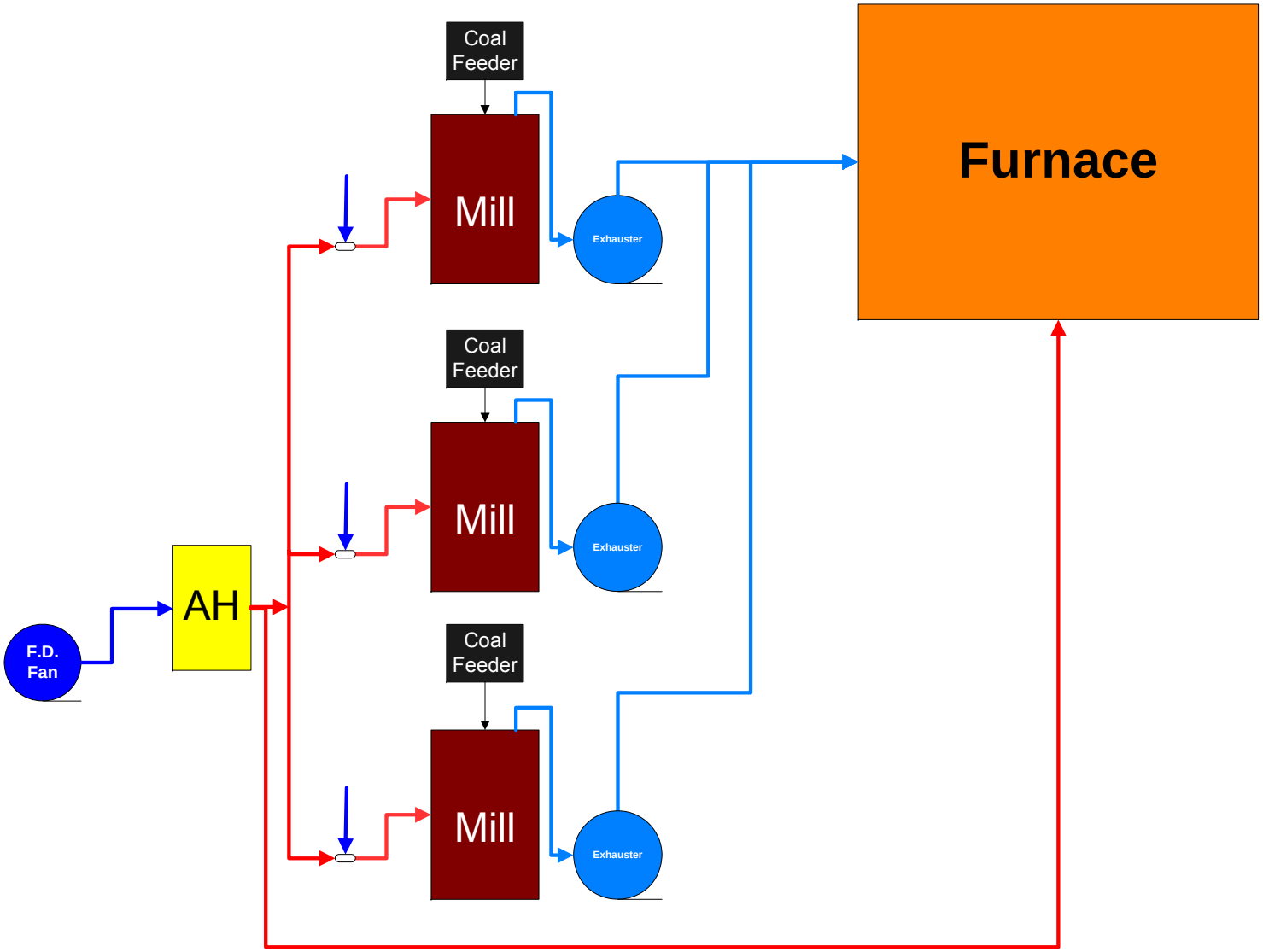


Pulverizer and Fan Systems

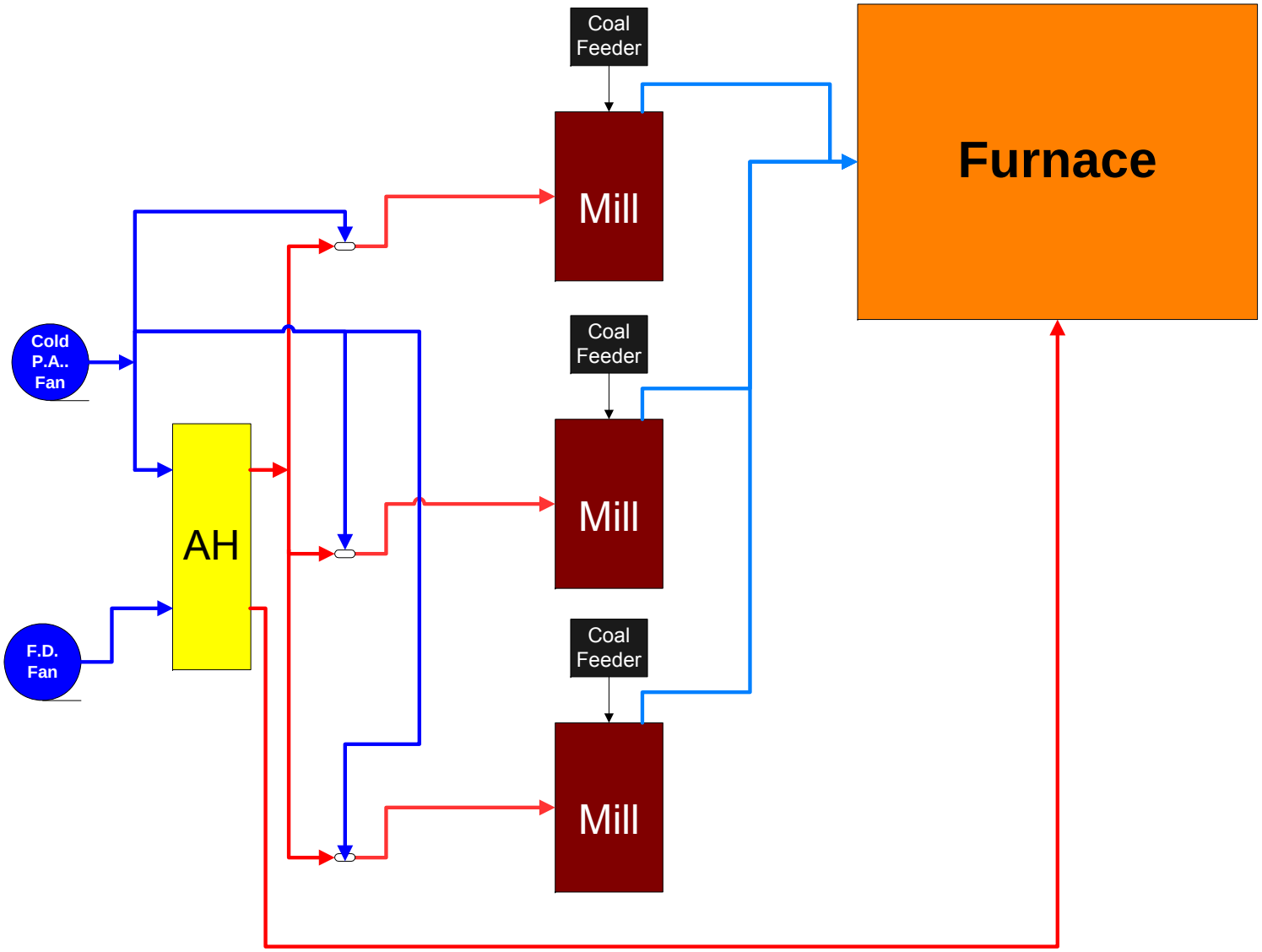
Pulverizer and Fans

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

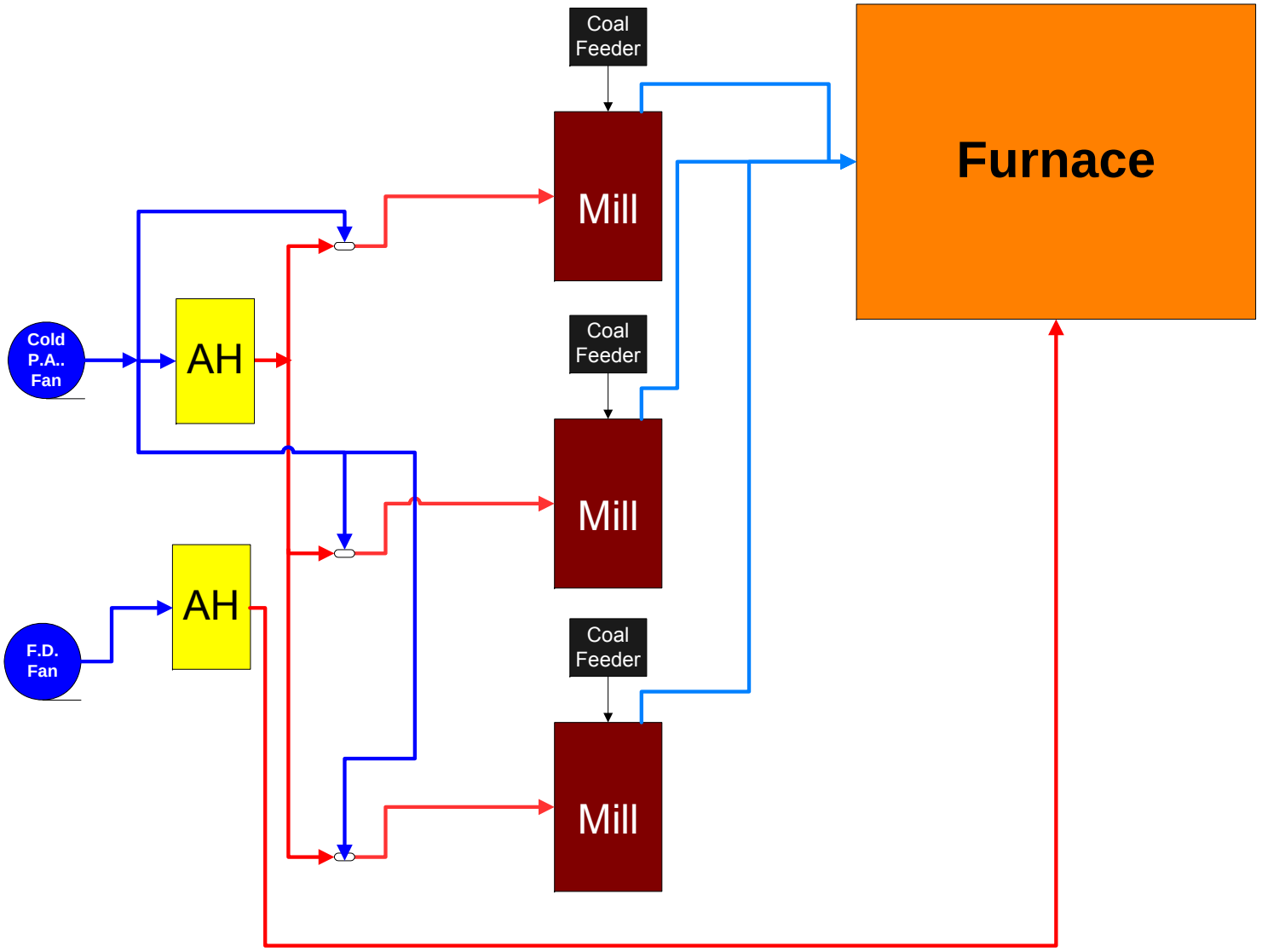
Pulverizer System with Exhausters



Cold Primary Air System



Cold Primary Air System with Bisector AH



Converting Coal Fired Boilers to Gas Firing

Summary

Bituminous Coal to Natural Gas Conversion

ALSTOM

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

PRB/Lignite to Natural Gas Conversions

ALSTOM

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

PRB/Lignite to Natural Gas Conversions

ALSTOM

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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