McBurney

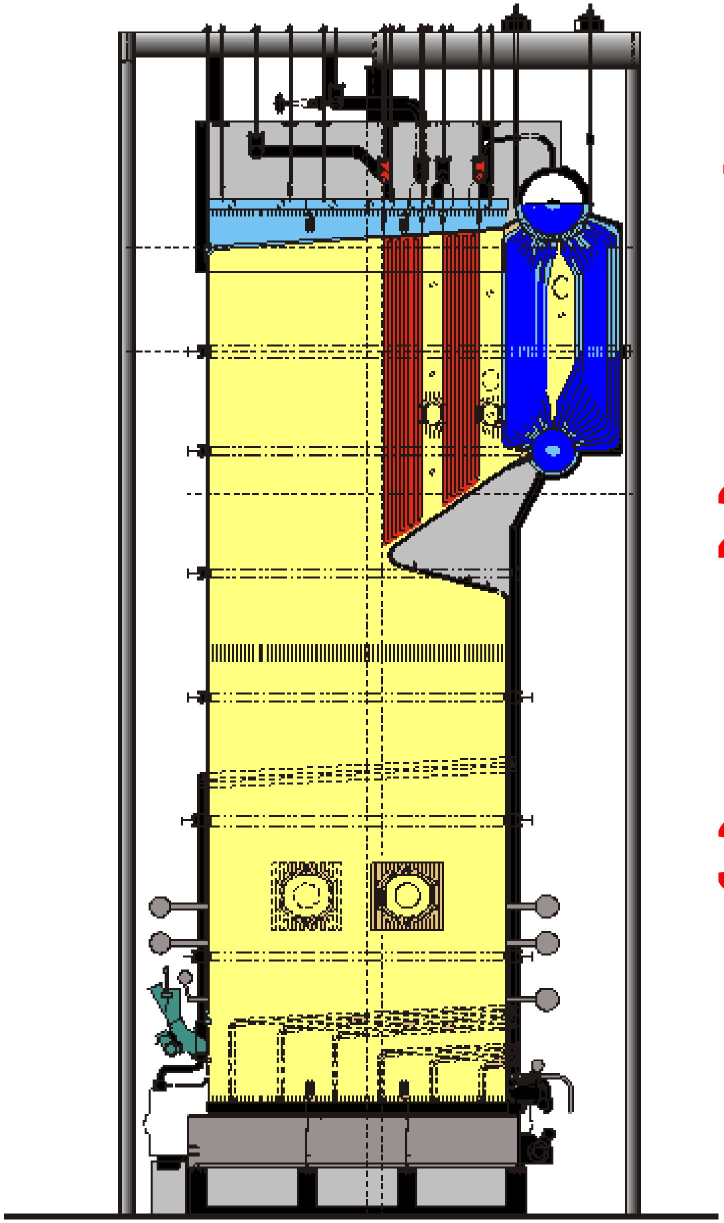
The Relationship Between Fuels, Boiler Design and Environmental Constraints

Presentation to:

CIBO Annual Meeting
Friday, October 24, 2008

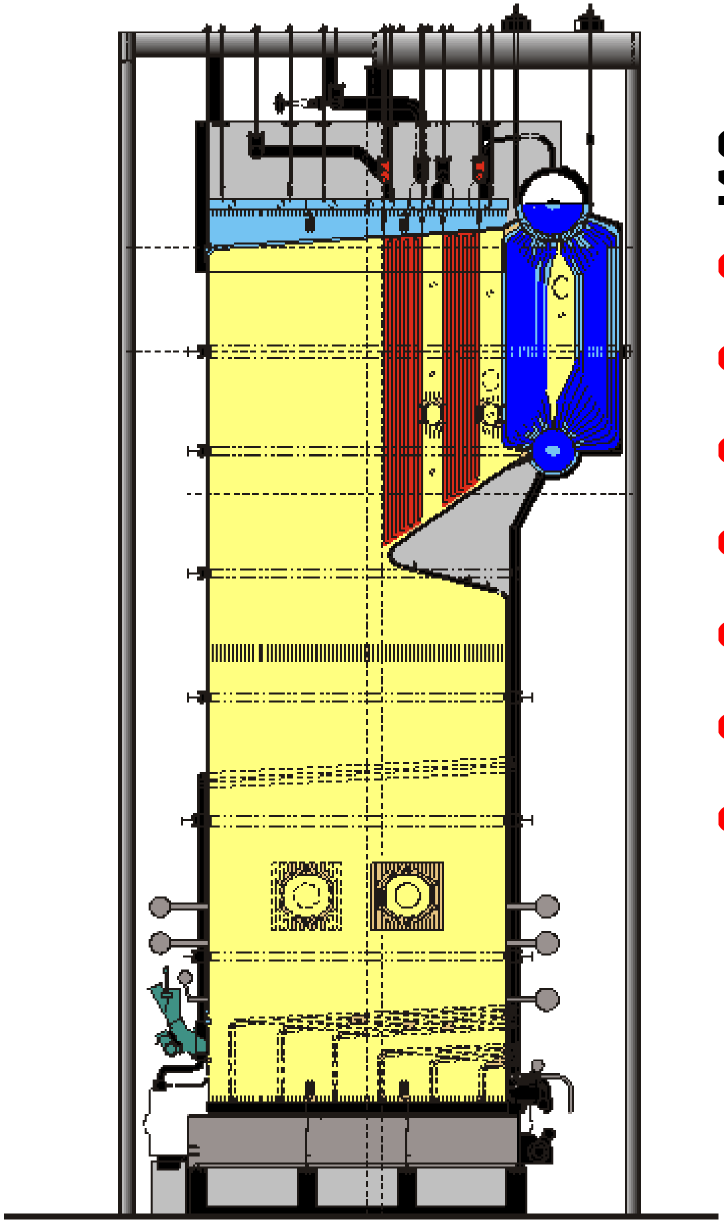
McB

BOILER SYSTEM DESIGN



1. Start with the Fuel
2. Performance Requirements
3. Environmental Factors

BOILER SYSTEM DESIGN



Start with the fuel

- Ultimate analysis
- HHV
- Moisture content
- Particle size distribution
- Particle morphology
- Friability
- Ash % and elemental analysis

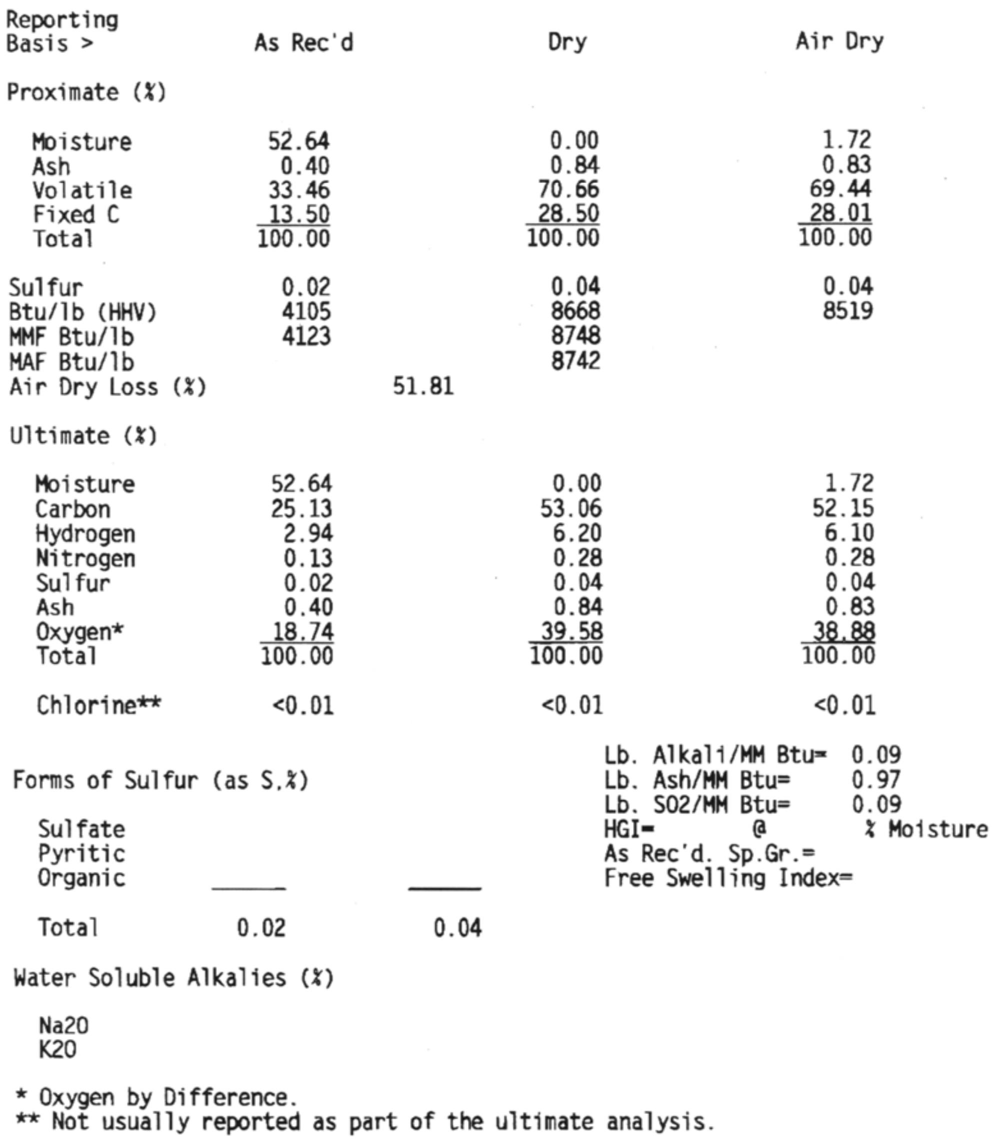
FUEL COSTLY TOO

Table 6
Properties of U.S. Coals

	Anthracite		Pittsburgh #8 HV Bituminous		Illinois #6 HV Bituminous		Upper Freeport MV Bituminous		Spring Creek Subbituminous		Decker Subbituminous		Lignite		Lignite (S. Hallsville)		Lignite (Bryan)		Lignite (San Miguel)	
State	—		Ohio or Pa.		Illinois		Pennsylvania		Wyoming		Montana		North Dakota		Texas		Texas		Texas	
Proximate:																				
Moisture	7.7		5.2		17.6		2.2		24.1		23.4		33.3		37.7		34.1		14.2	
Volatile matter, dry	6.4		40.2		44.2		28.1		43.1		40.8		43.6		45.2		31.5		21.2	
Fixed carbon, dry	83.1		50.7		45.0		58.5		51.2		54.0		45.3		44.4		18.1		10.0	
Ash, dry	10.5		9.1		10.8		13.4		5.7		5.2		11.1		10.4		50.4		68.8	
Heating value, Btu/lb:																				
As-received	11,890		12,540		10,300		12,970		9,190		9,540		7,090		7,080		3,930		2,740	
Dry	12,880		13,230		12,500		13,260		12,110		12,450		10,630		11,360		5,960		3,200	
MAF	14,390		14,550		14,010		15,320		12,840		13,130		11,960		12,680		12,020		10,260	
Ultimate:																				
Carbon	83.7		74.0		69.0		74.9		70.3		72.0		63.3		66.3		33.8		18.4	
Hydrogen	1.9		5.1		4.9		4.7		5.0		5.0		4.5		4.9		3.3		2.3	
Nitrogen	0.9		1.6		1.0		1.27		0.96		0.95		1.0		1.0		0.4		0.29	
Sulfur	0.7		2.3		4.3		0.76		0.35		0.44		1.1		1.2		1.0		1.2	
Ash	10.5		9.1		10.8		13.4		5.7		5.2		11.1		10.4		50.4		68.8	
Oxygen	2.3		7.9		10.0		4.97		17.69		16.41		19.0		16.2		11.1		9.01	
Ash fusion temps, F																				
Reducing/Oxidizing:	Red	Oxid	Red	Oxid	Red	Oxid	Red	Oxid	Red	Oxid	Red	Oxid	Red	Oxid	Red	Oxid	Red	Oxid	Red	Oxid
ID	—	—	2220	2560	1930	2140	2750+	2750+	2100	2180	2120	2420	2030	2160	2000	2210	2370	2470	2730	2750
ST Sp.	—	—	2440	2640	2040	2330	"	"	2160	2300	2250	2470	2130	2190	2060	2250	2580	2670	2750+	"
ST Hsp.	—	—	2470	2650	2080	2400	"	"	2170	2320	2270	2490	2170	2220	2090	2280	2690	2760	"	"
FT 0.0625 in.	—	—	2570	2670	2420	2600	"	"	2190	2360	2310	2510	2210	2280	2220	2350	2900+	2900+	"	"
FT Flat	—	—	2750+	2750+	2490	2700	"	"	2370	2700	2380	2750+	2300	2300	2330	2400	2900+	2900+	"	"
Ash analysis:																				
SiO_2	51.0		50.58		41.68		59.60		32.61		23.77		29.80		23.32		62.4		66.85	
Al_2O_3	34.0		24.62		20.0		27.42		13.38		15.79		10.0		13.0		21.5		23.62	
Fe_2O_3	3.5		17.16		19.0		4.67		7.53		6.41		9.0		22.0		3.0		1.18	
TiO_2	2.4		1.10		0.8		1.34		1.57		1.08		0.4		0.8		0.5		1.46	
CaO	0.6		1.13		8.0		0.62		15.12		21.85		19.0		22.0		3.0		1.76	
MgO	0.3		0.62		0.8		0.75		4.26		3.11		5.0		5.0		1.2		0.42	
Na_2O	0.74		0.39		1.62		0.42		7.41		6.20		5.80		1.05		0.59		1.67	
K_2O	2.65		1.99		1.63		2.47		0.87		0.57		0.49		0.27		0.92		1.57	
P_2O_5	—		0.39		—		0.42		0.44		0.99		—		—		—		—	
SO_3	1.38		1.11		4.41		0.99		14.56		18.85		20.85		9.08		3.50		1.32	

Note: HV = high volatile; MV = medium volatile; ID = initial deformation temp; ST = softening temp; FT = fluid temp; Sp. = spherical; Hsp. = hemispherical.

WOOD WASTE



Reporting Basis >	As Rec'd	Dry	Air Dry
Proximate (%)			
Moisture	52.64	0.00	1.72
Ash	0.40	0.84	0.83
Volatile	33.46	70.66	69.44
Fixed C	13.50	28.50	28.01
Total	100.00	100.00	100.00
Sulfur	0.02	0.04	0.04
Btu/lb (HHV)	4105	8668	8519
MMF Btu/lb	4123	8748	
MAF Btu/lb		8742	
Air Dry Loss (%)	51.81		
Ultimate (%)			
Moisture	52.64	0.00	1.72
Carbon	25.13	53.06	52.15
Hydrogen	2.94	6.20	6.10
Nitrogen	0.13	0.28	0.28
Sulfur	0.02	0.04	0.04
Ash	0.40	0.84	0.83
Oxygen*	18.74	39.58	38.88
Total	100.00	100.00	100.00
Chlorine**	<0.01	<0.01	<0.01

Forms of Sulfur (as S,%)

Sulfate		
Pyritic		
Organic		
Total	0.02	0.04

Lb. Alkali/MM Btu= 0.09
Lb. Ash/MM Btu= 0.97
Lb. SO2/MM Btu= 0.09
HGI= @ % Moisture
As Rec'd. Sp.Gr.=
Free Swelling Index=

Water Soluble Alkalies (%)

Na2O
K2O

* Oxygen by Difference.
** Not usually reported as part of the ultimate analysis.

WOOD WASTE ASH

Elemental Analysis of Ash (%)

SI02	10.03
AL203	2.52
TI02	0.38
FE203	1.50
CAO	33.40
MGO	4.38
NA20	0.91
K20	8.19
P205	2.27
SO3	0.66
CL	0.11
CO2	24.82
Total	94.17

Ash Fusion Temperature (°F)

	Oxidizing Atmosphere	Reducing Atmosphere
Initial		
Softening		
Hemispherical		
Fluid		

FUEL ANALYSIS

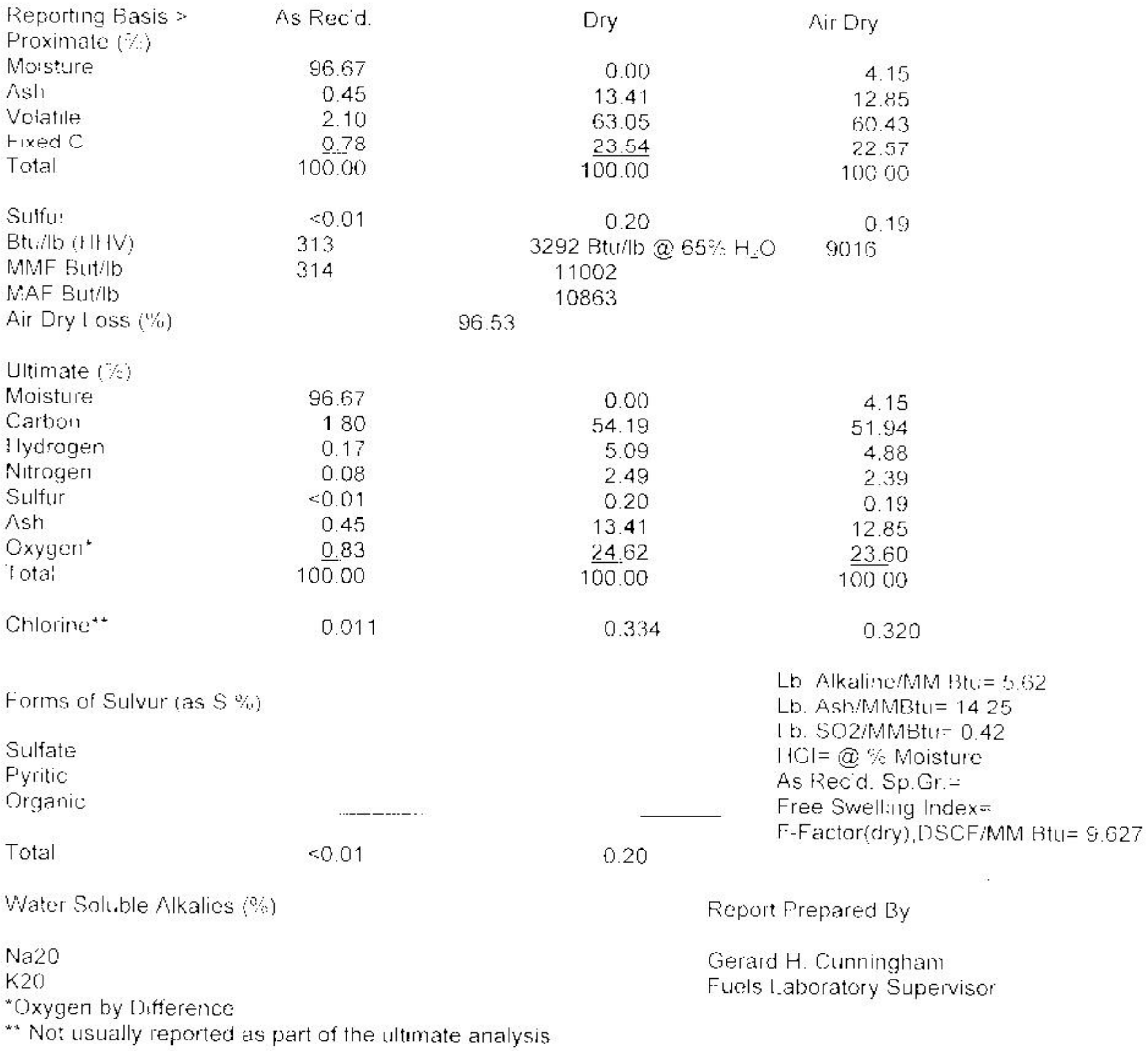
Sample: Wheat Midds

Ultimate Analysis	
Carbon	41.29
Hydrogen	4.98
Oxygen	32.85
Nitrogen	2.52
Sulfur	0.05
Ash	5.14
Moisture	13.17
Total	**100**
HHV	**7,033**

Ash Elemental Analysis	
SiO_2	3.80
$A12O_3$	0.51
TiO_2	0.04
Fe_2O_3	0.51
CaO	2.48
MgO	14.50
Na_2O	0.27
K_2O	24.80
P_2O_5	52.73
SO_3	0.32
Cl	0.01
CO_2	0.17

SAMPLE IDENTIFICATION

Stillage 1 Liter



Reporting Basis >	As Rec'd.	Dry	Air Dry
Proximate (%)			
Moisture	96.67	0.00	4.15
Ash	0.45	13.41	12.85
Volatile	2.10	63.05	60.43
Fixed C	0.78	23.54	22.57
Total	100.00	100.00	100.00
Sulfur	<0.01	0.20	0.19
Btu/lb (HHV)	313	3292 Btu/lb @ 65% H_2O	9016
MMF But/lb	314	11002	
MAF But/lb		10863	
Air Dry Loss (%)		96.53	
Ultimate (%)			
Moisture	96.67	0.00	4.15
Carbon	1.80	54.19	51.94
Hydrogen	0.17	5.09	4.88
Nitrogen	0.08	2.49	2.39
Sulfur	<0.01	0.20	0.19
Ash	0.45	13.41	12.85
Oxygen*	0.83	24.62	23.60
Total	100.00	100.00	100.00
Chlorine**	0.011	0.334	0.320

Lb. Alkaline/MM Btu= 5.62
Lb. Ash/MMBtu= 14.25
Lb. SO2/MMBtu= 0.42
HGI= @ % Moisture
As Rec'd. Sp.Gr.=
Free Swelling Index=
F-Factor(dry),DSCF/MM Btu= 9.627

Forms of Sulvur (as S %)		
Sulfate		
Pyritic		
Organic		
Total	<0.01	0.20

Water Soluble Alkalies (%)

Na20
K20

*Oxygen by Difference
** Not usually reported as part of the ultimate analysis

Report Prepared By

Gerard H. Cunningham
Fuels Laboratory Supervisor

SAMPLE IDENTIFICATION

Stillage 1 Liter

Elemental Analysis of Ash (%)

SI02	24.24
AL203	1.27
TI02	0.11
FE203	0.73
CAO	2.36
MGO	1.98
NA20	6.74
K20	32.70
P205	21.66
SO3	1.70
CL	1.99
CO2	1.68
Total	94.17

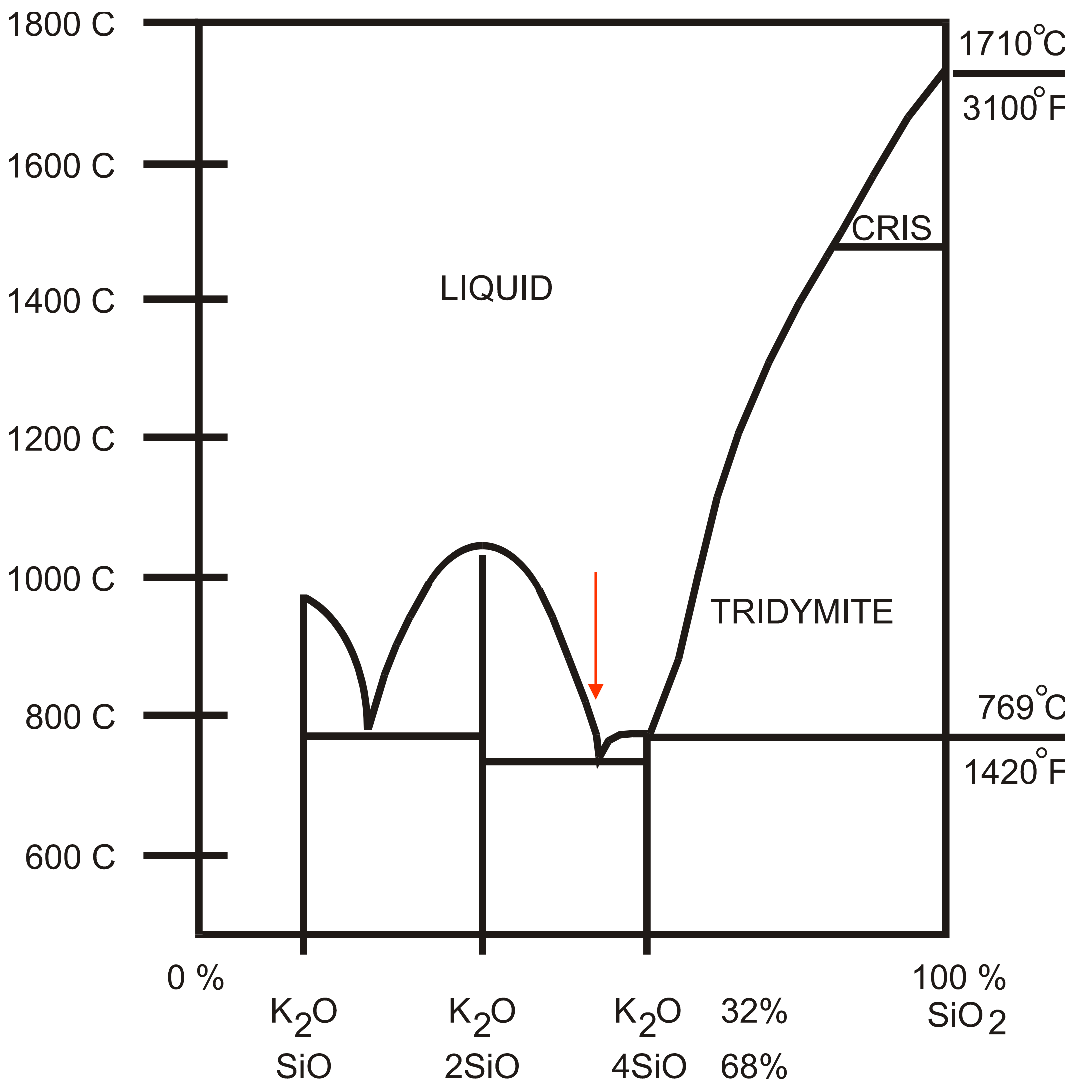
Ash Fusion Temperature (°F)

	Oxidizing Atmosphere	Reducing Atmosphere
Initial	1457	1484
Softening	1507	1549
Hemispherical	1400	1428
Fluid	1588	1600

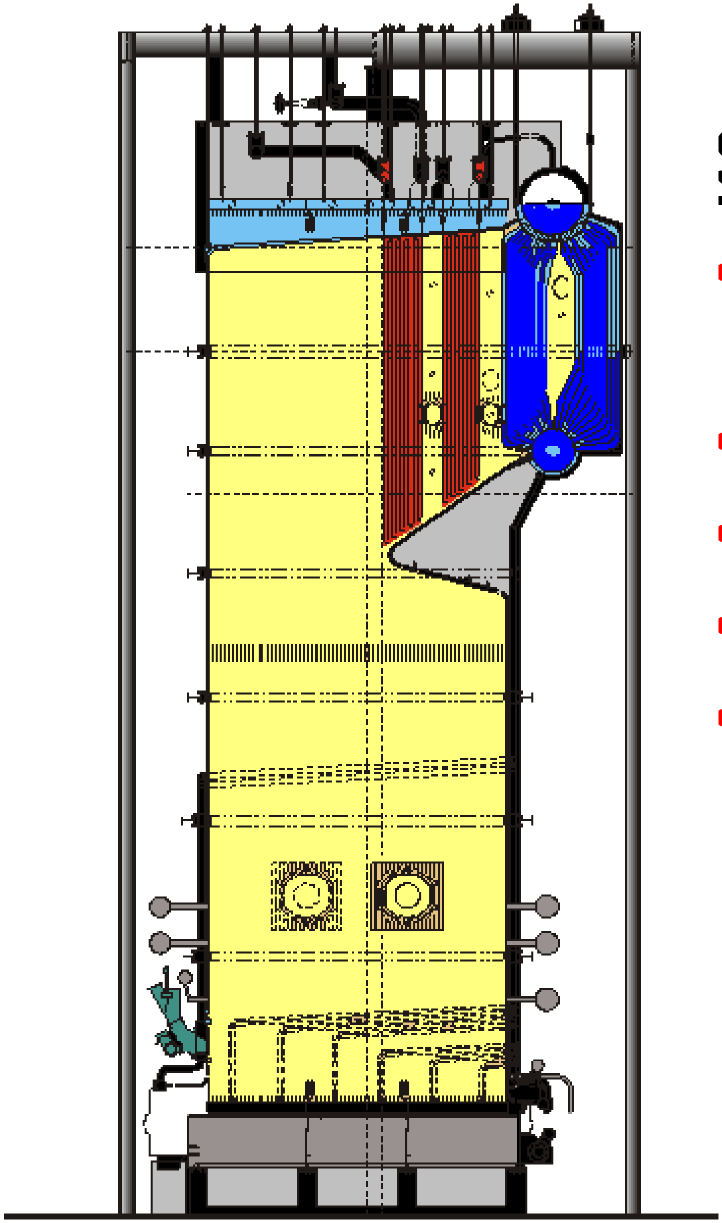
Report Prepared By:
Gerard H. Cunningham
Fuels Laboratory Supervisor

Note: The ash was calcined @ 1110 °F (600 C) prior to analysis.

Phase Diagram for K_2O-SiO_2



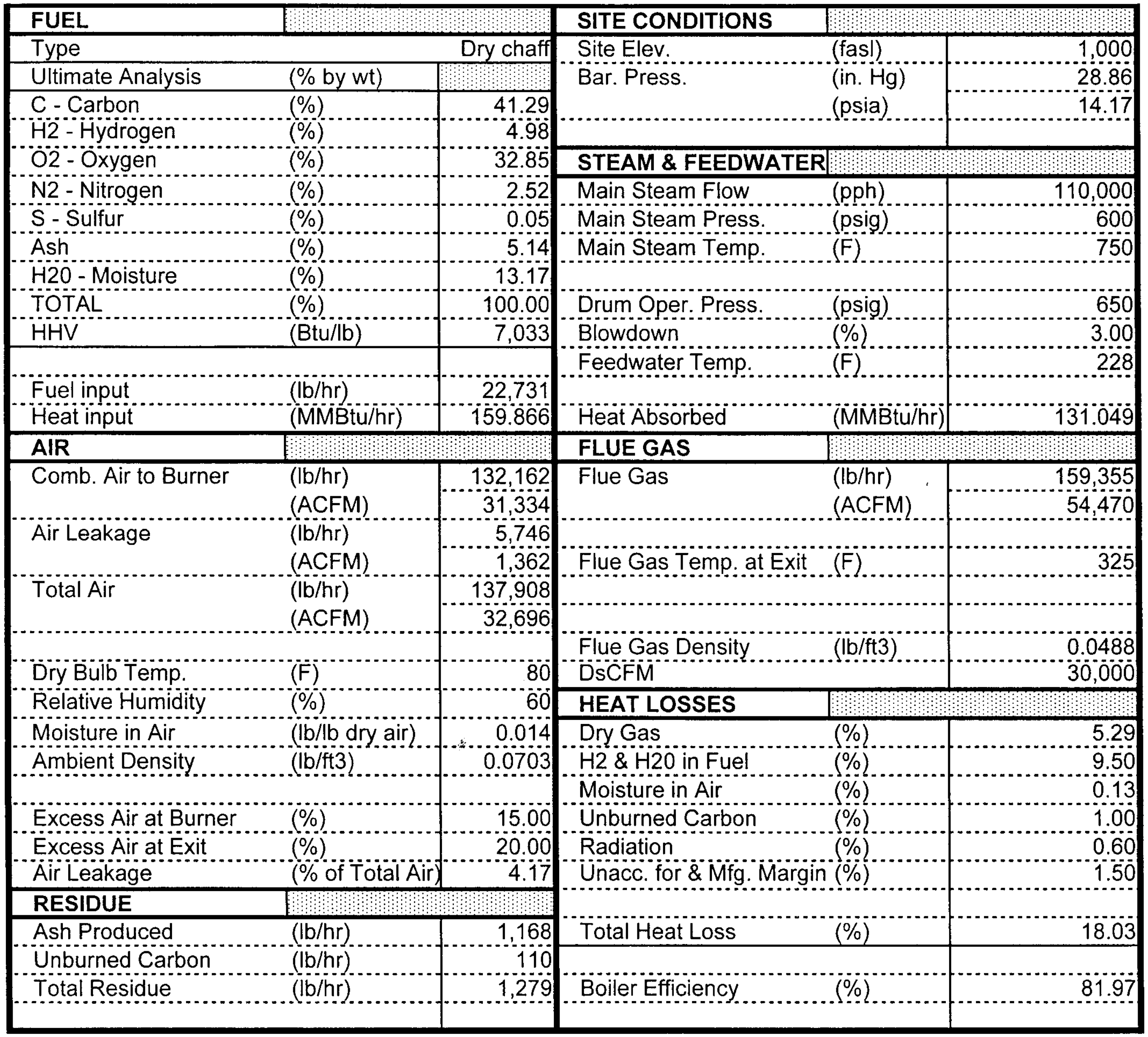
BOILER SYSTEM DESIGN



System Performance

- Steam capacity, Pressure, Temperature
- Thermal efficiency
- Operations / Maintenance
- Reliability / Redundancy
- Emissions limits (NOx, CO, PM, PM-10, PM-2.5, SO2, VOC)

ASME BOILER PERFORMANCE



FUEL		
Type		Dry chaff
Ultimate Analysis	(% by wt)	
C - Carbon	(%)	41.29
H2 - Hydrogen	(%)	4.98
O2 - Oxygen	(%)	32.85
N2 - Nitrogen	(%)	2.52
S - Sulfur	(%)	0.05
Ash	(%)	5.14
H20 - Moisture	(%)	13.17
TOTAL	(%)	100.00
HHV	(Btu/lb)	7,033
Fuel input	(lb/hr)	22,731
Heat input	(MMBtu/hr)	159.866

AIR		
Comb. Air to Burner	(lb/hr)	132,162
	(ACFM)	31,334
Air Leakage	(lb/hr)	5,746
	(ACFM)	1,362
Total Air	(lb/hr)	137,908
	(ACFM)	32,696
Dry Bulb Temp.	(F)	80
Relative Humidity	(%)	60
Moisture in Air	(lb/lb dry air)	0.014
Ambient Density	(lb/ft3)	0.0703
Excess Air at Burner	(%)	15.00
Excess Air at Exit	(%)	20.00
Air Leakage	(% of Total Air)	4.17

RESIDUE		
Ash Produced	(lb/hr)	1,168
Unburned Carbon	(lb/hr)	110
Total Residue	(lb/hr)	1,279

SITE CONDITIONS		
Site Elev.	(fasl)	1,000
Bar. Press.	(in. Hg)	28.86
	(psia)	14.17

STEAM & FEEDWATER		
Main Steam Flow	(pph)	110,000
Main Steam Press.	(psig)	600
Main Steam Temp.	(F)	750
Drum Oper. Press.	(psig)	650
Blowdown	(%)	3.00
Feedwater Temp.	(F)	228
Heat Absorbed	(MMBtu/hr)	131.049

FLUE GAS		
Flue Gas	(lb/hr)	159,355
	(ACFM)	54,470
Flue Gas Temp. at Exit	(F)	325
Flue Gas Density	(lb/ft3)	0.0488
DsCFM		30,000

HEAT LOSSES		
Dry Gas	(%)	5.29
H2 & H20 in Fuel	(%)	9.50
Moisture in Air	(%)	0.13
Unburned Carbon	(%)	1.00
Radiation	(%)	0.60
Unacc. for & Mfg. Margin	(%)	1.50
Total Heat Loss	(%)	18.03
Boiler Efficiency	(%)	81.97

FURNACE / BOILER DESIGN CRITERIA

- Time, temperature and turbulence in the furnace are optimized for good combustion.
- Low volume heat release rate for sufficient retention time—maximizes carbon burnout and minimizes NOx and CO emissions (longer residence time).
- Longer residence time promotes good burnout and minimizes carryover of air borne fuel particles.
- Low velocities through boiler convection sections to minimize erosion.
- NOx emissions vary directly with fuel bound nitrogen content and excess air.
- CO emissions vary directly with biomass fuel moisture content and excess air.

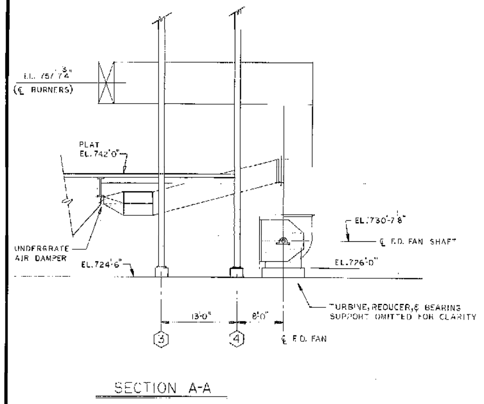
HEAT RELEASE RATE

- Coal – Bituminous
  Grate – 750,000 Btu/sq.ft. (approx)
  Volumetric – 20,000 – 25,000 Btu/cu.ft.

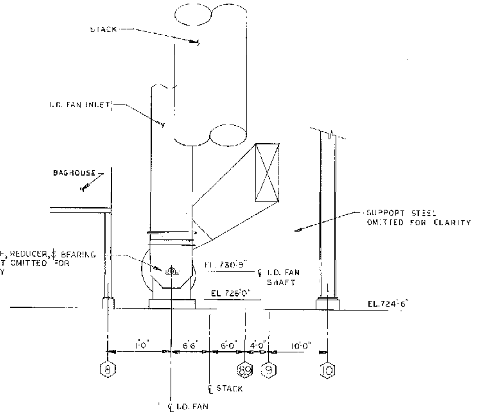
- Biomass – Wood Wastes
  Grate 0 850,000 – 1,000,000 Btu/sq.ft.
  Volumetric – 15,000 – 20,000 Btu/cu.ft.

BILL OF MATERIAL

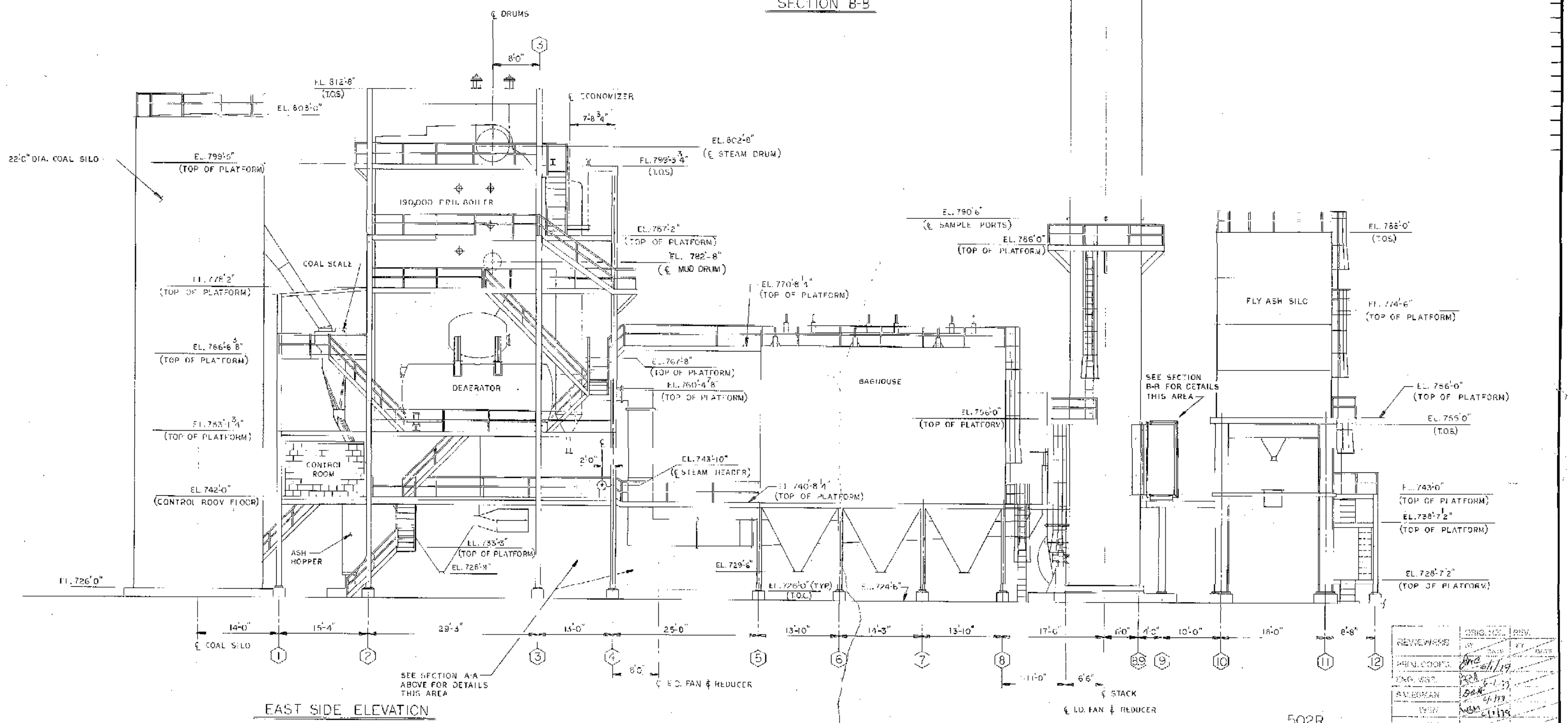
ITEM	QUAN.	DWG. OR PART NO.	DESCRIPTION	FT.	IN.	REMARKS	CO



SECTION A-A



SECTION B-B



EAST SIDE ELEVATION

502R

REVIEWERS	ORIG. DOC. BY	DATE	REV. BY	DATE
PRIN. COORD.	JMC	6/1/79		
ENG. SUP.	DCA	6-1-79		
SALESMAN	DAK	6/1/79		
MGM	WBM	6/1/79		
LAW				

NO.	DRWN.	DATE	APPVD.	REVISIONS
1	C.H.	10-10-79	JMC	GENERAL REVISION - PLATFORMING

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CRA, INC.
DIVISION OF
FARMLAND INDUSTRIES
COFFEYVILLE, KANSAS

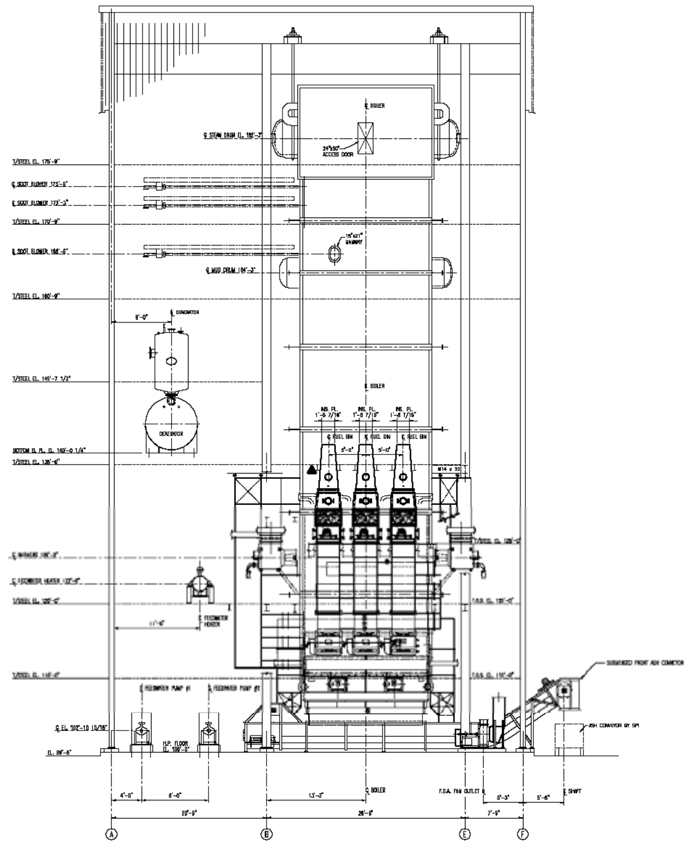
		MFG. REV.
DATE	2-23-79	A
DRAWN BY	D.C.A.	B
CHKD BY	DCA 6/1/79	C
APPVD BY	JMC 6/1/79	D
SCALE	1/8" = 1'-0"	E
		F

JMC 6/1/79

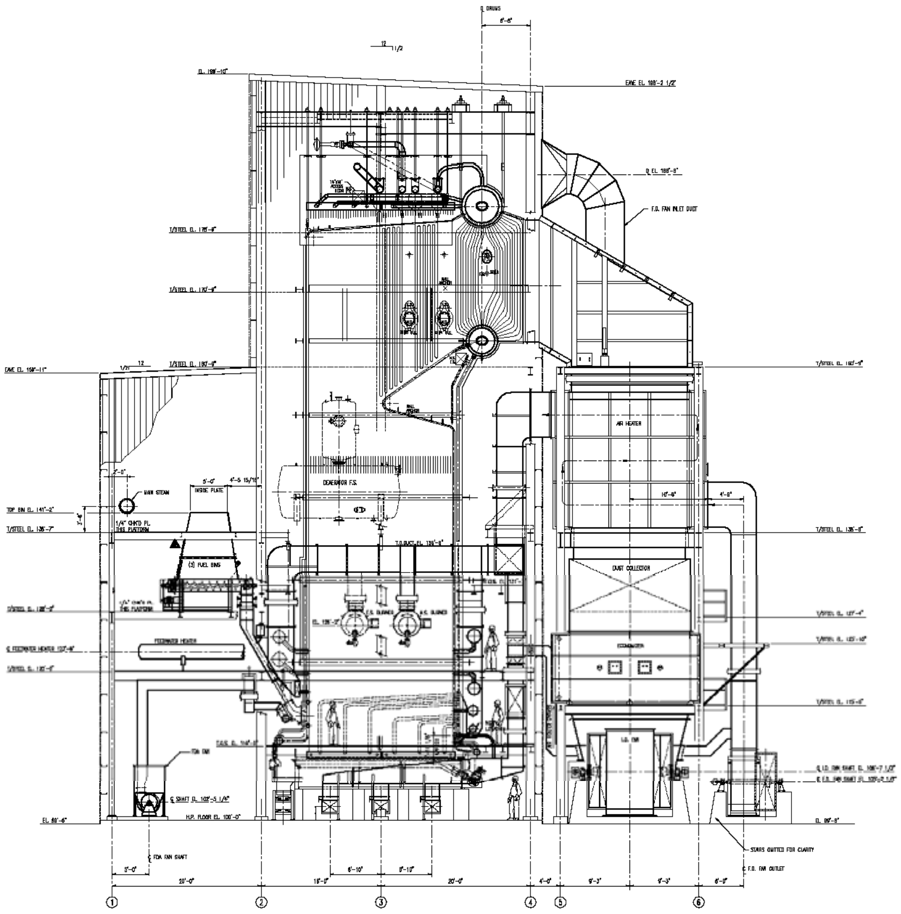
THE McBURNEY CORPORATION
ATLANTA, GEORGIA

GENERAL ARRANGEMENT-ELEVATION

JOB NO. 7838 E
DWG. NO. 100
REV. NO. 1



FRONT ELEVATION



RIGHT SIDE ELEVATION

NO.	DRWN.	CHKD.	APPVD.	DATE	REVISION DESCRIPTION
0	SFA	TJK	TJK	9/21/04	RELEASED FOR CONSTRUCTION
1	SFA	TJK	TJK	12/29/04	RELOCATED FEEDWATER HEATER
2	SFA	TJK		1/24/05	RELOCATED PLATFORM STEEL AT EL 138'-7" TO CLEAR FUEL BIN

CAD FILE NAME: 705001_1103E_2
DRAWING SCALE: 3/16"=1'-0"

SIERRA PACIFIC INDUSTRIES

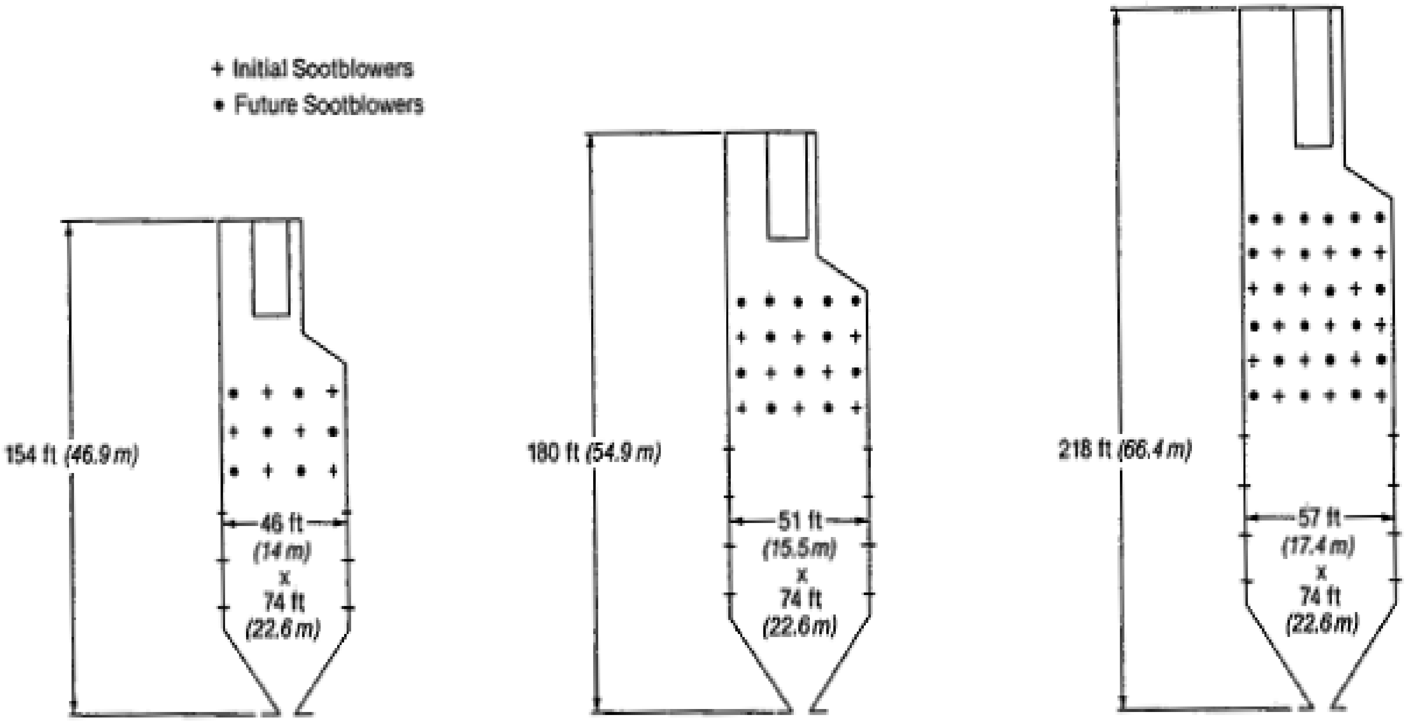
LINCOLN, CALIFORNIA

McBurney®

McBurney Corporation of California

170,000 PPH WOOD FIRED BOILER
GENERAL ARRANGEMENT
FRONT AND RIGHT SIDE ELEVATIONS

JOB NO. 705001
DWG. NO. 1103
REV. 2



(a)

Bituminous
Low/Med Slagging

(b)

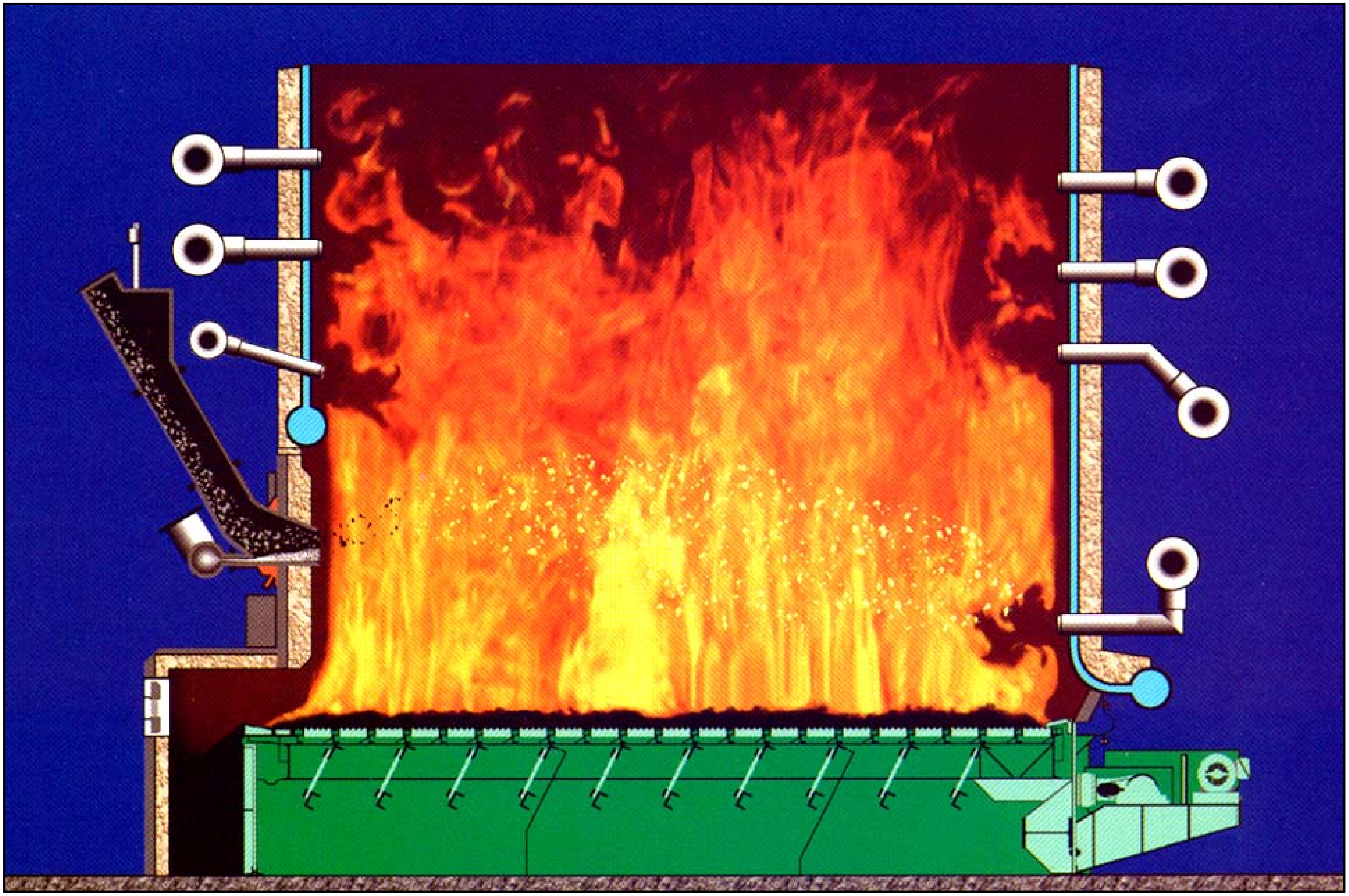
Subbituminous
High Slagging

(c)

Lignite
Severe Slagging

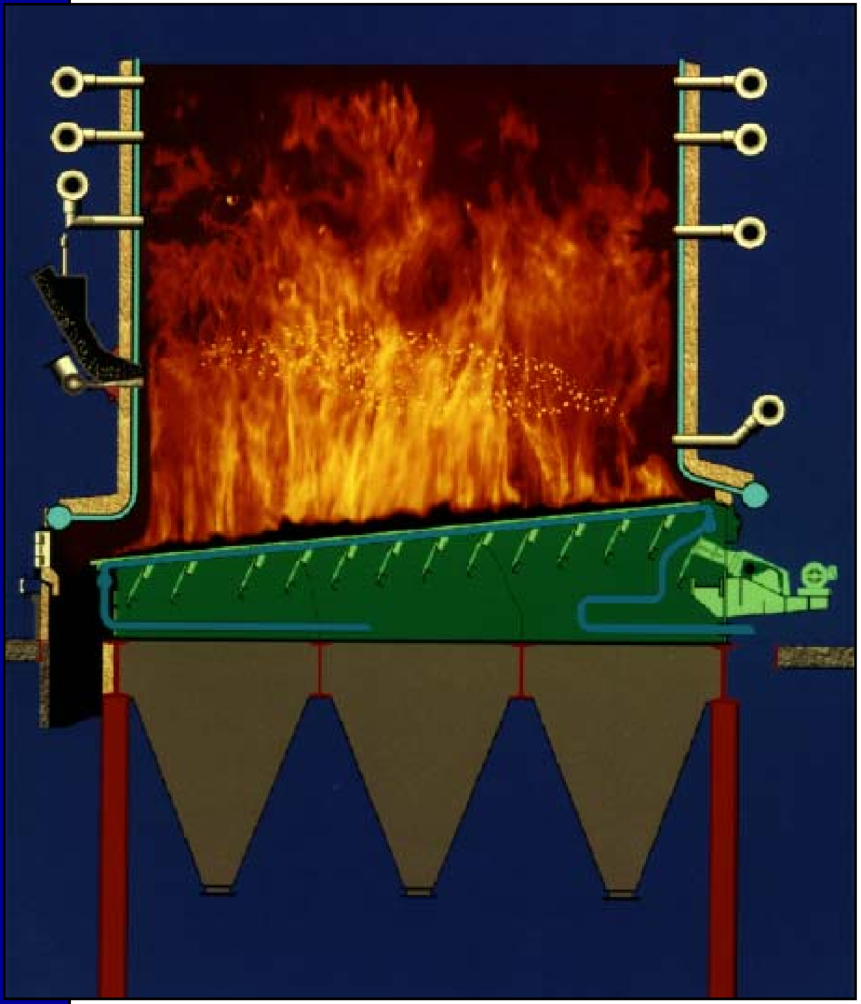
Fig. 19 Influence of slagging potential on furnace size. (See Table 6.)

DETROIT VCG STOKER (1 of 2)



DETROIT VCG STOKER (2 of 2)

DETROIT HYDROGRATE STOKER (1 of 3)



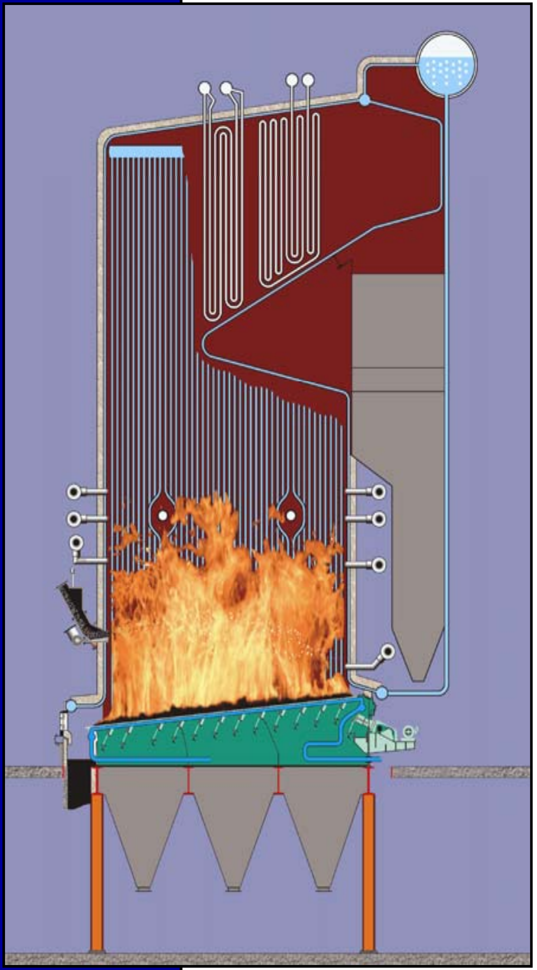
- Water-cooled grate surface is tightly interlocked to reduce tramp air flow and cool the grate castings properly.

- No moving surfaces between grate castings.

- High combustion air temperature capability in order to burn high moisture biomass without concern for damaging grates.

- 68 units in operation

DETROIT HYDROGRATE STOKER (2 of 3)

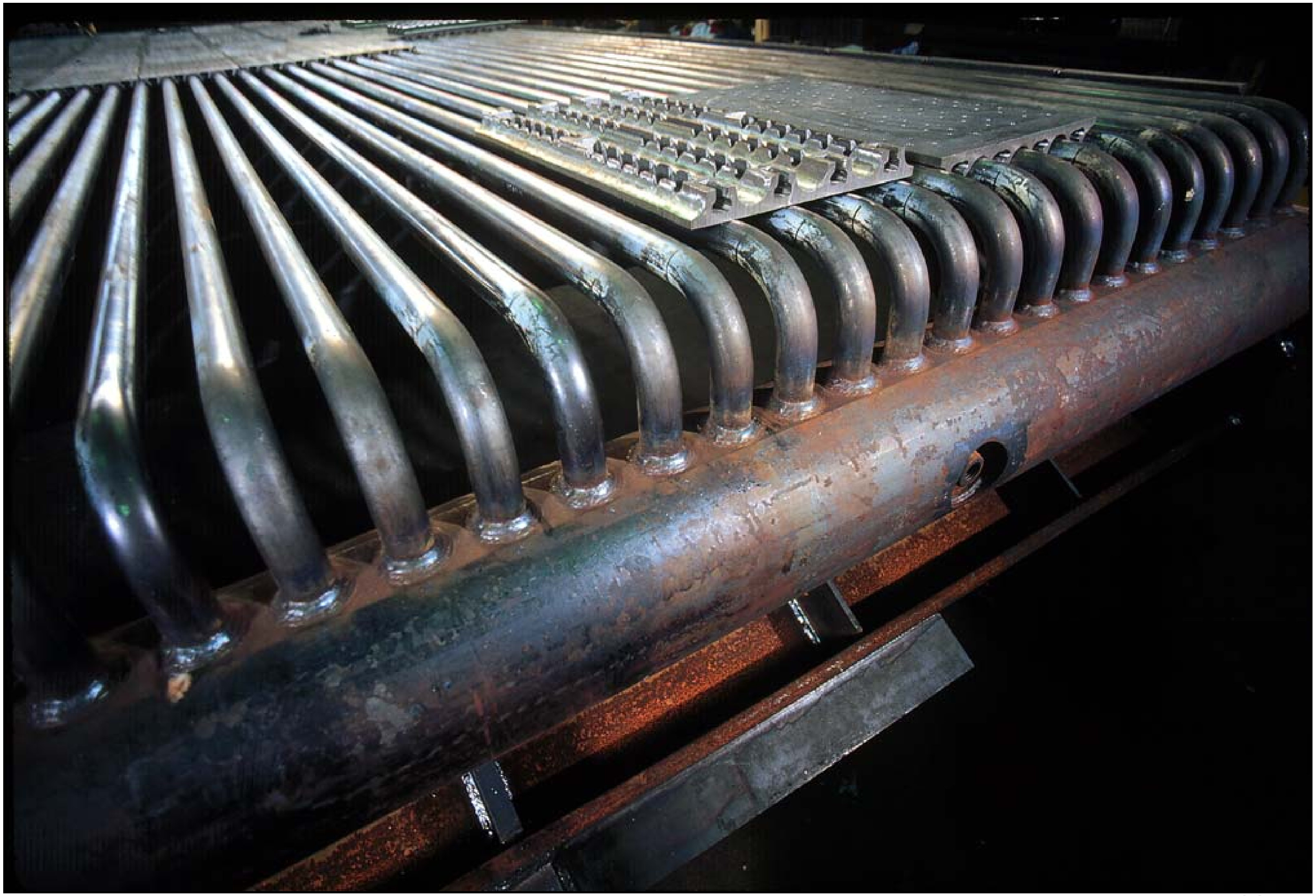


WATER COOLED GRATE ADVANTAGES:

- Dryer (sanderdust and TDF) and finer biomass fuels can be fired without risk of damaging the grate surface.
- Auxiliary Gas, Oil, or PC burners can be used without additional grate protection.
- Best against catastrophic failure. If the undergrate air flow is stopped, the cooling is maintained by the water. If the cooling water were to stop the grate can be temporarily cooled by the increase of undergrate air.
- Capable of withstanding higher undergrate air temperatures to fire higher moisture fuels.

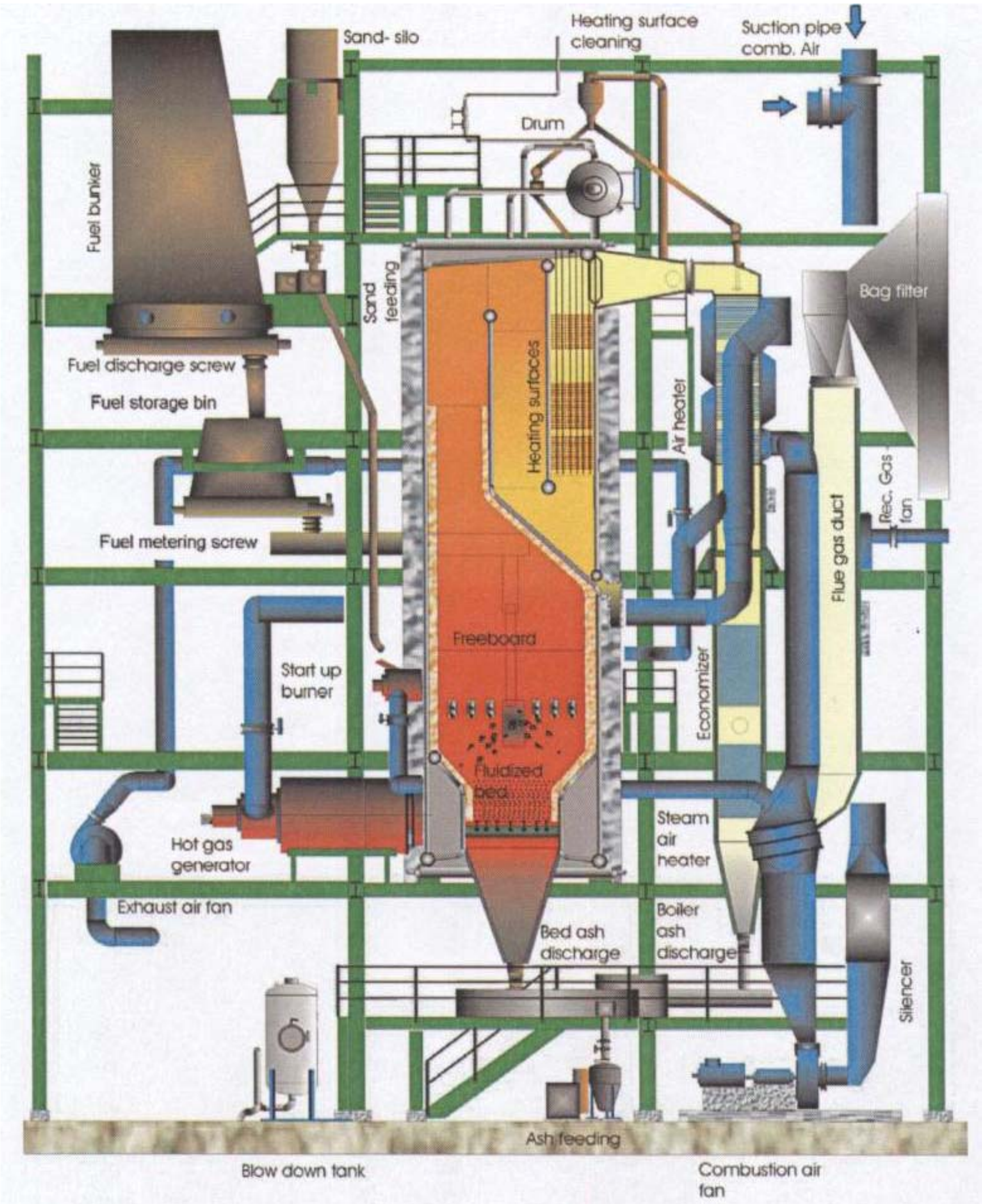
DETROIT HYDROGRATE STOKER (3 of 3)

WATER COOLED GRATE SURFACE:



SUSPENSION BURNERS

VERA Plant Hamburg



BIOMASS COMBUSTION SYSTEM OPTIONS

1. Fluid Bed Technologies

- Bubbling Fluid Bed (BFB)
- Circulating Fluid Bed (BFB)

2. Stoker Technologies

- Mass Feed/Reciprocating Stoker
- Spreader Stoker
  - Stationary air cooled grate
  - Stationary water cooled grate
  - Air cooled traveling grate
  - Air-cooled vibrating grate
  - Water-cooled vibrating grate

TECHNOLOGY COMPARISON

Bubbling Fluid Bed	Spreader Stoker
Capital Cost: Generally higher due to more complex fuel and ash systems	Capital Cost: Lower capital cost
Operating Costs: Higher Operating Costs – up to 60” static for FD fans	Operating Costs: Lower – FD fan static is lower resulting in reduced fan operating HP requirements
Availability: <85% in some cases depending on fuels	Availability: >98%
Complexity: More operator training required	Complexity: Less operator training required
Fuel flexibility: Somewhat limited to high moisture, high ash fuels	Fuel flexibility: Very flexible, but not preferred for fine dry material
Emissions: NOx 0.15-0.25 CO 0.20-0.40	Emissions: NOx <0.20-0.25 CO 0.20-0.40

TECHNOLOGY COMPARISON

Suspension Firing	Gasification
Capital Cost: Moderately higher than stoker due to fuel preparation system	Capital Cost: Very high capital cost due to flue gas clean-up and cost of gasifier
Operating Costs: Higher Operating Costs – up to 60” static for FD fans	Operating Costs: High Operating Costs due to fan HP requirements and unburned carbon in the bottom ash
Availability: >95%	Availability: Developing technology, limited proven experience
Complexity: More operator training required	Complexity: More operator training required
Fuel flexibility: Limited to dry fine fuels	Fuel flexibility: Very flexible
Emissions: NOx 0.15-0.25 CO 0.20-0.40	Emissions: Very low theoretically

STOKER SYSTEM DESIGN (1 of 4)

Mass Feed Stoker	Spreader Stoker
Fuel Moisture: 40% to 60%	Fuel Moisture: 10% to 60%
Fuel Bed: Thick stable fuel bed, which assists with boiler turndown, but has poor load response characteristics	Fuel Bed: Thin fuel bed with high burning rates and semi-suspension mode of firing. •Fine particles → suspension. •Heavier fuel → grate. The combination of suspension firing and a fast burning fuel bed makes this method of firing extremely responsive to changes in load demand.
Load Response: Slow: <5% per minute	Load Response: Fast: >30% per minute

STOKER SYSTEM DESIGN (2 of 4)

Mass Feed Stoker	Spreader Stoker
Grate Heat Release: GHR 1.1 – 1.3 MW/m² (HHV) 0.7 – 1.0 MW/m² (LHV)	Grate Heat Release: GHR 2.3 – 2.6 MW/m² (HHV) 1.2 – 2.0 MW/m² (LHV)
Stoker/Grate Operation: Continuous operation with several grate sections moving within the heat zone.	Stoker/Grate Operation: (3) vibrating grate sections with intermittent vibration. The vibrating grate only vibrates for 2 to 3 seconds every 8 to 10 minutes.
Maintenance Requirements: >$40,000 (US) per year for grate bars and refractory.	Maintenance Requirements: <$15,000 (US) per year for grate bars and refractory.
Drive Type: Hydraulic	Drive Type: 7.5 HP electric motors coupled to an eccentric drive per stoker module.

STOKER SYSTEM DESIGN (3 of 4)

Mass Feed Stoker	Spreader Stoker
Lubrication Requirements: Lubrication is required for the hydraulic drives, bearings, shafts and cylinders in the hot combustion air zones.	Lubrication Requirements: None required since there are no bearings or shafts in the hot combustion air zones.
Excess Air: 50%-100%	Excess Air: 25%-40%
Grate Side Seals: The seal between the moving grate and the furnace have to be maintained.	Grate Side Seals: The effective air seal design between the stationary and moving surfaces of the spreader stoker results in better air control and lower excess air requirements. The ability to operate at lower levels of excess air reduces emissions and improves boiler efficiency.

STOKER SYSTEM DESIGN (4 of 4)

Mass Feed Stoker	Spreader Stoker
Grate Bar Material: Cast or ductile iron, which limits the combustion air temperature.	Grate Bar Material: Water-cooled ductile iron or stainless steel, which allows hotter combustion air temperatures to be used to assist with the combustion of wet wood fuel.
Undergrate/Overfire Air Ratio: 80/20 (more undergrate air is required due to the thicker fuel bed)	Undergrate/Overfire Air Ratio: 50/50 and can be designed for 35/65 depending on fuel type
Assembly Requirements: Reciprocating grate stoker is shipped loose in many pieces requiring additional construction costs.	Assembly Requirements: Vibrating grate stokers are shop assembled and shipped in modules, which reduces construction costs.

SPREADER FIRING OVERVIEW

Technology Separates Fuel for Proper Combustion

- Large Particles for Grate Firing / Small Particles for Suspension Firing

Grate Firing

- Larger particles are higher in mass, high moisture, therefore need more time to dry and volatilize.
- As particles dry / volatilize - size and density decrease
- Terminal velocity is reduced which reintroduces particles into the suspension fired combustion zone.
- Larger particle size naturally have increased residence time-burn slower and help sustain combustion.

Suspension Firing

- Smaller particles with lower terminal velocities dry/volatize in suspension over the bed flame.
- Smaller particles are less dense with lower mass of moisture.
- Smaller particles have higher surface area ⇨ burn quickly, help dry/volatilize higher moisture particles.

BENEFITS OF VIBRATING GRATE STOKER

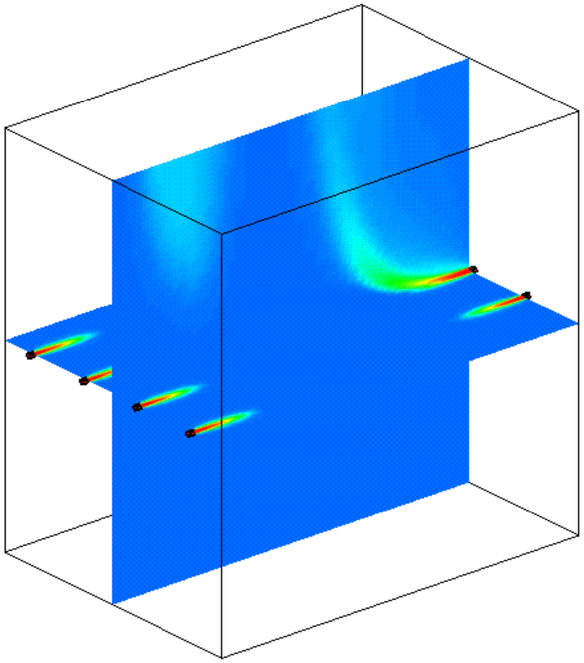
- Vibrating surface simplifies grate cooling.
- Automatic ash discharge for continuous operation.
- High availability with low maintenance costs.
- High boiler steam capacities.
- Vibrating bed reduces fuel piling and improves fuel distribution.
- Low leakage resulting in lower operating levels of excess air.

OVERFIRE AIR

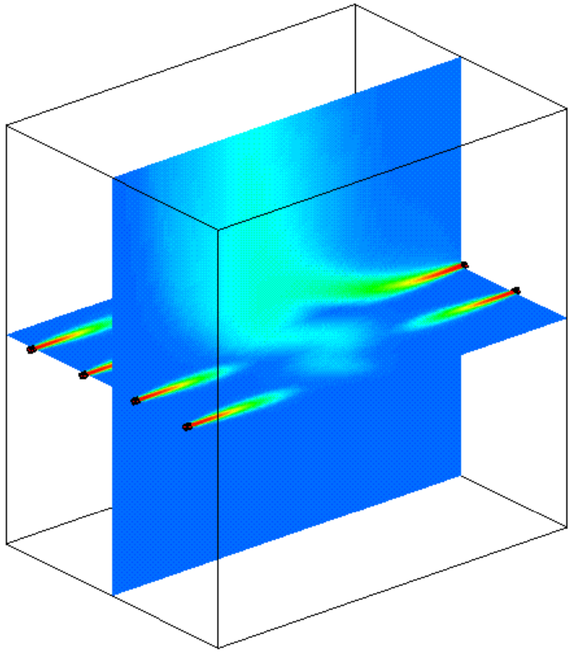
- Proper turbulence in upper furnace assures good fuel/air mixing (minimizes CO and VOC emissions).
- Staged combustion reduces NOx emissions.
- Select Radial and Axial Jet Velocities to Match Vertical Cross Flow and Buoyancy Effects
- Interlaced (Staggered) Design to provide an Effective Curtain of Combustion Air

OVERFIRE AIR—CFD

4” diameter nozzles @ 5” and 20” w.g. pressure



Nozzle Pressure = 5 inches H_2O



Nozzle Pressure = 20 inches H_2O

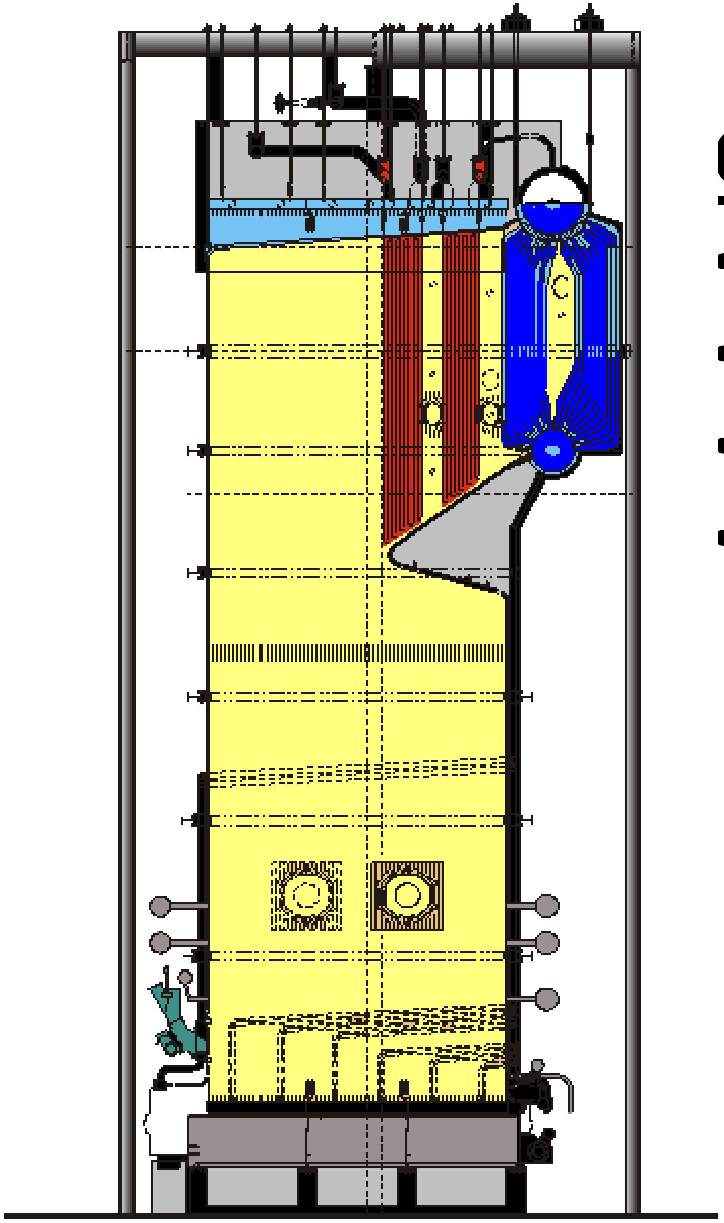
21%

O_2 concentration

0%

Detroit Stoker

BOILER SYSTEM DESIGN



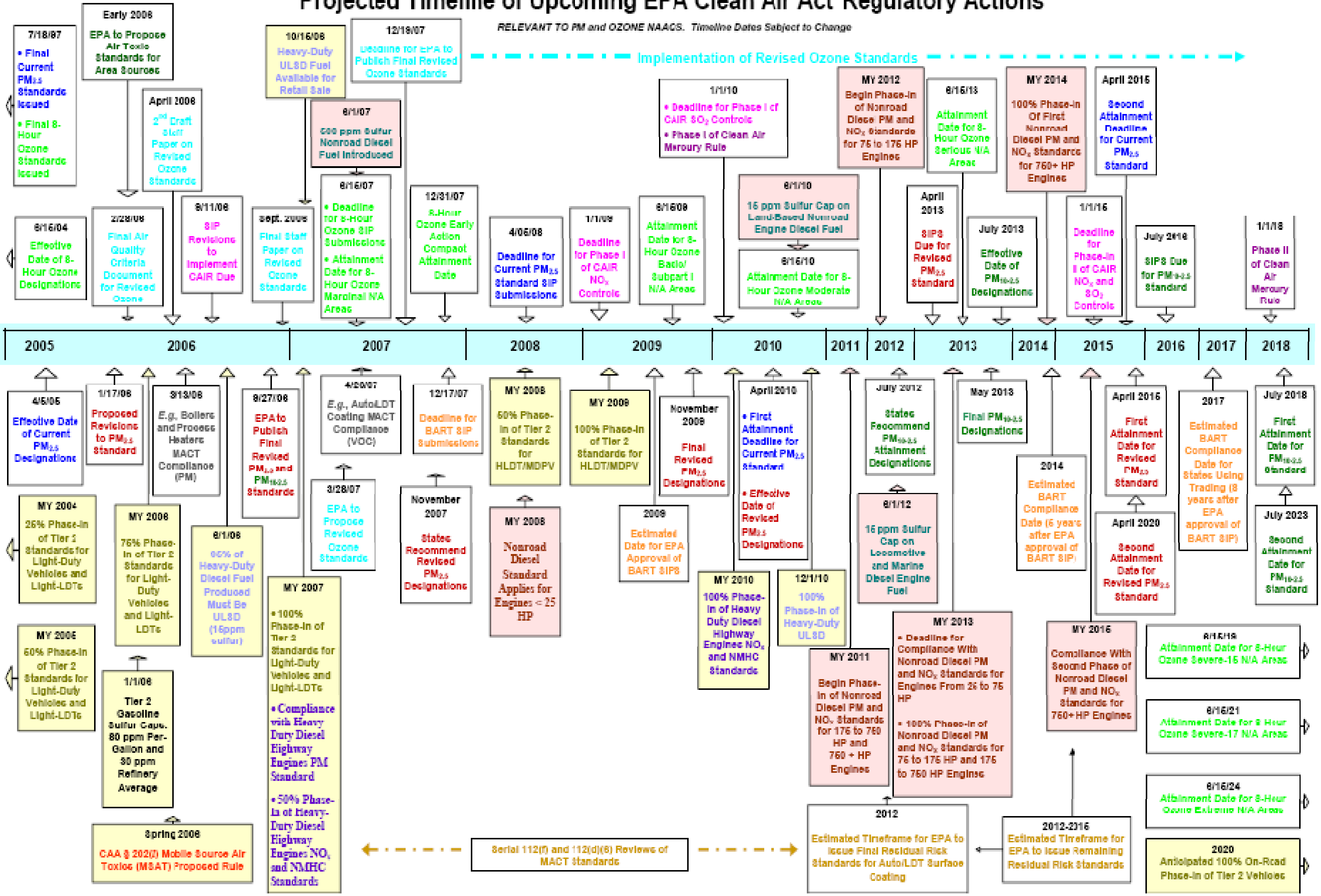
Other Factors

- Process controls
- Auxiliary fuel(s)
- Space limitations
- Future plans
  - Plant expansion
  - Tighter emissions
  - Other fuels

Projected Timeline of Upcoming EPA Clean Air Act Regulatory Actions

Alliance of Automobile Manufacturers DRAFT 4/7/06

RELEVANT TO PM and OZONE NAACS. Timeline Dates Subject to Change



7/18/97
- Final Current $PM_{2.5}$ Standards Issued
- Final 8-Hour Ozone Standards Issued

Early 2006
EPA to Propose Air Toxic Standards for Area Sources

April 2006
2^{nd} Draft Staff Paper on Revised Ozone Standards

10/15/06
Heavy-Duty ULSD Fuel Available for Retail Sale

12/19/07
Deadline for EPA to Publish Final Revised Ozone Standards

Implementation of Revised Ozone Standards

6/1/07
500 ppm Sulfur Nonroad Diesel Fuel Introduced

6/15/04
Effective Date of 8-Hour Ozone Designations

2/28/06
Final Air Quality Criteria Document for Revised Ozone

9/11/06
SIP Revisions to Implement CAIR Due

Sept. 2006
Final Staff Paper on Revised Ozone Standards

6/15/07
- Deadline for 8-Hour Ozone SIP Submissions
- Attainment Date for 8-Hour Ozone Marginal N/A Areas

12/31/07
8-Hour Ozone Early Action Compact Attainment Date

4/06/08
Deadline for Current $PM_{2.5}$ Standard SIP Submissions

1/1/09
Deadline for Phase I of CAIR NO_x Controls

6/15/09
Attainment Date for 8-Hour Ozone Basic/ Subpart I N/A Areas

1/1/10
- Deadline for Phase I of CAIR SO_2 Controls
- Phase I of Clean Air Mercury Rule

6/1/10
15 ppm Sulfur Cap on Land-Based Nonroad Engine Diesel Fuel

6/15/10
Attainment Date for 8-Hour Ozone Moderate N/A Areas

MY 2012
Begin Phase-in of Nonroad Diesel PM and NO_x Standards for 75 to 175 HP Engines

April 2013
SIPS Due for Revised $PM_{2.5}$ Standard

6/15/13
Attainment Date for 8-Hour Ozone Serious N/A Areas

July 2013
Effective Date of $PM_{10-2.5}$ Designations

MY 2014
100% Phase-in Of First Nonroad Diesel PM and NO_x Standards for 750+ HP Engines

1/1/15
Deadline for Phase-In II of CAIR NO_x and SO_2 Controls

April 2015
Second Attainment Deadline for Current $PM_{2.5}$ Standard

July 2016
SIPS Due for $PM_{10-2.5}$ Standard

1/1/18
Phase II of Clean Air Mercury Rule

2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018

4/5/05
Effective Date of Current $PM_{2.5}$ Designations

1/17/06
Proposed Revisions to $PM_{2.5}$ Standard

9/13/06
E.g., Boilers and Process Heaters MACT Compliance (PM)

9/27/06
EPA to Publish Final Revised $PM_{2.5}$ and $PM_{10-2.5}$ Standards

4/20/07
E.g., Auto/LDT Coating MACT Compliance (VOC)

12/17/07
Deadline for BART SIP Submissions

MY 2004
25% Phase-In of Tier 2 Standards for Light-Duty Vehicles and Light-LDTs

MY 2006
75% Phase-In of Tier 2 Standards for Light-Duty Vehicles and Light-LDTs

6/1/06
95% of Heavy-Duty Diesel Fuel Produced Must Be ULSD (15ppm sulfur)

3/28/07
EPA to Propose Revised Ozone Standards

November 2007
States Recommend Revised $PM_{2.5}$ Designations

MY 2005
50% Phase-In of Tier 2 Standards for Light-Duty Vehicles and Light-LDTs

1/1/06
Tier 2 Gasoline Sulfur Caps. 80 ppm Per-Gallon and 30 ppm Refinery Average

MY 2007
- 100% Phase-In of Tier 2 Standards for Light-Duty Vehicles and Light-LDTs
- Compliance with Heavy Duty Diesel Highway Engines PM Standard
- 50% Phase-In of Heavy-Duty Diesel Highway Engines NO_x and NMHC Standards

Spring 2006
CAA § 202(l) Mobile Source Air Toxics (MSAT) Proposed Rule

MY 2008
50% Phase-In of Tier 2 Standards for HLDT/MDPV

MY 2008
Nonroad Diesel Standard Applies for Engines < 25 HP

MY 2009
100% Phase-In of Tier 2 Standards for HLDT/MDPV

November 2009
Final Revised $PM_{2.5}$ Designations

2009
Estimated Date for EPA Approval of BART SIPS

April 2010
- First Attainment Deadline for Current $PM_{2.5}$ Standard
- *Effective* Date of Revised $PM_{2.5}$ Designations

MY 2010
100% Phase-In of Heavy Duty Diesel Highway Engines NO_x and NMHC Standards

12/1/10
100% Phase-In of Heavy-Duty ULSD

July 2012
States Recommend $PM_{10-2.5}$ Attainment Designations

6/1/12
15 ppm Sulfur Cap on Locomotive and Marine Diesel Engine Fuel

May 2013
Final $PM_{10-2.5}$ Designations

MY 2011
Begin Phase-In of Nonroad Diesel PM and NO_x Standards for 175 to 750 HP and 750 + HP Engines

MY 2013
- Deadline for Compliance With Nonroad Diesel PM and NO_x Standards for Engines From 25 to 75 HP
- 100% Phase-in of Nonroad Diesel PM and NO_x Standards for 75 to 175 HP and 175 to 750 HP Engines

Serial 112(f) and 112(d)(6) Reviews of MACT Standards

2012
Estimated Timeframe for EPA to Issue Final Residual Risk Standards for Auto/LDT Surface Coating

2014
Estimated BART Compliance Date (5 years after EPA approval of BART SIP)

April 2015
First Attainment Date for Revised $PM_{2.5}$ Standard

April 2020
Second Attainment Date for Revised $PM_{2.5}$ Standard

2017
Estimated BART Compliance Date for States Using Trading (8 years after EPA approval of BART SIP)

July 2018
First Attainment Date for $PM_{10-2.5}$ Standard

July 2023
Second Attainment Date for $PM_{10-2.5}$ Standard

MY 2015
Compliance With Second Phase of Nonroad Diesel PM and NO_x Standards for 750+ HP Engines

2012-2015
Estimated Timeframe for EPA to Issue Remaining Residual Risk Standards

6/15/19
Attainment Date for 8-Hour Ozone Severe-15 N/A Areas

6/15/21
Attainment Date for 8-Hour Ozone Severe-17 N/A Areas

6/15/24
Attainment Date for 8-Hour Ozone Extreme N/A Areas

2020
Anticipated 100% On-Road Phase-In of Tier 2 Vehicles

SUMMARY / CONCLUSION

START WITH THE FUEL