VIRTUAL ENERGY AUDIT UPDATE – ROUND 2

Your Power Plant on a desktop computer

Alan Werner, P.E.

VA:W

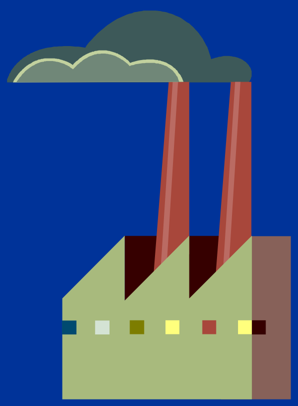
(Value Added by Werner)

COMPLEX ENVIRONMENT

FLUE TEMPERATURES

STEAM DEMAND

MECHANICAL FACTORS



FUEL MANAGEMENT

EXCESS AIR

DRIVER SELECTION

HISTORICAL FACTORS

- OPERATIONS BASED MAINLY ON INTUTION AND EXPERIENCE
- INSTRUMENTS PROVIDE THE MOST IMPORTANT DATA IN A VARIETY OF FORMATS
- ADEQUATE METHODS TO DATE
- NOTHING WRONG – BUT CAN BE IMPROVED

CONSEQUENCES

- INCOMPLETE PICTURE OF THE ENTIRE PLANT OPERATIONS
- RECORDS REFLECT ONLY A PORTION OF THE EQUIPMENT
- FORECASTING, PREDICTIONS, AND ESTIMATIONS ARE EMPIRICAL (BASED ON EXPERIENCE)

VEA

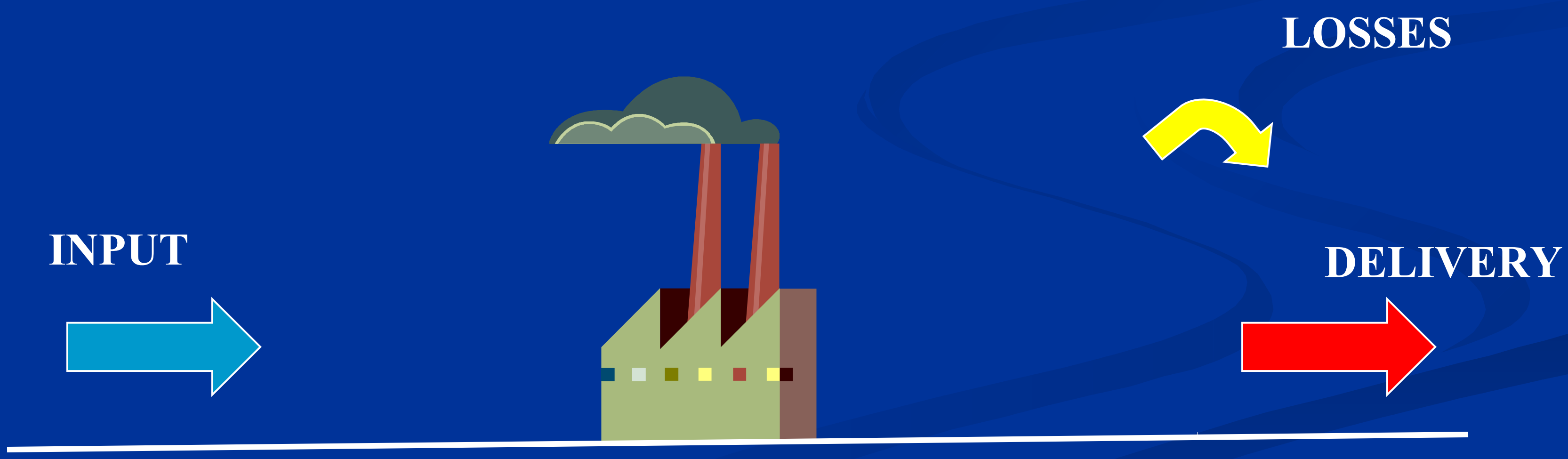
SOLUTION: **The Virtual Energy Audit**

- Whole plant basis – all parts working together
- Calculation with accounting leading to energy balance
- A virtual energy audit (balance) **on demand**
- Uses MS Excel – simple and direct

BASIS

ENERGY IN = ENERGY OUT*

* Product (Delivery) + Losses + Work



FUNDEMENTALS

STOICHIOMETRIC COMBUSTION

(the secret)

- Water at temp + heat $\longrightarrow$ Steam at pressure
- BTU (British Thermal Unit): fixed unit
- Requirements from feed to output in a boiler is known and able to be calculated

FUEL

The fuel shown is natural gas (CH_4 mostly)

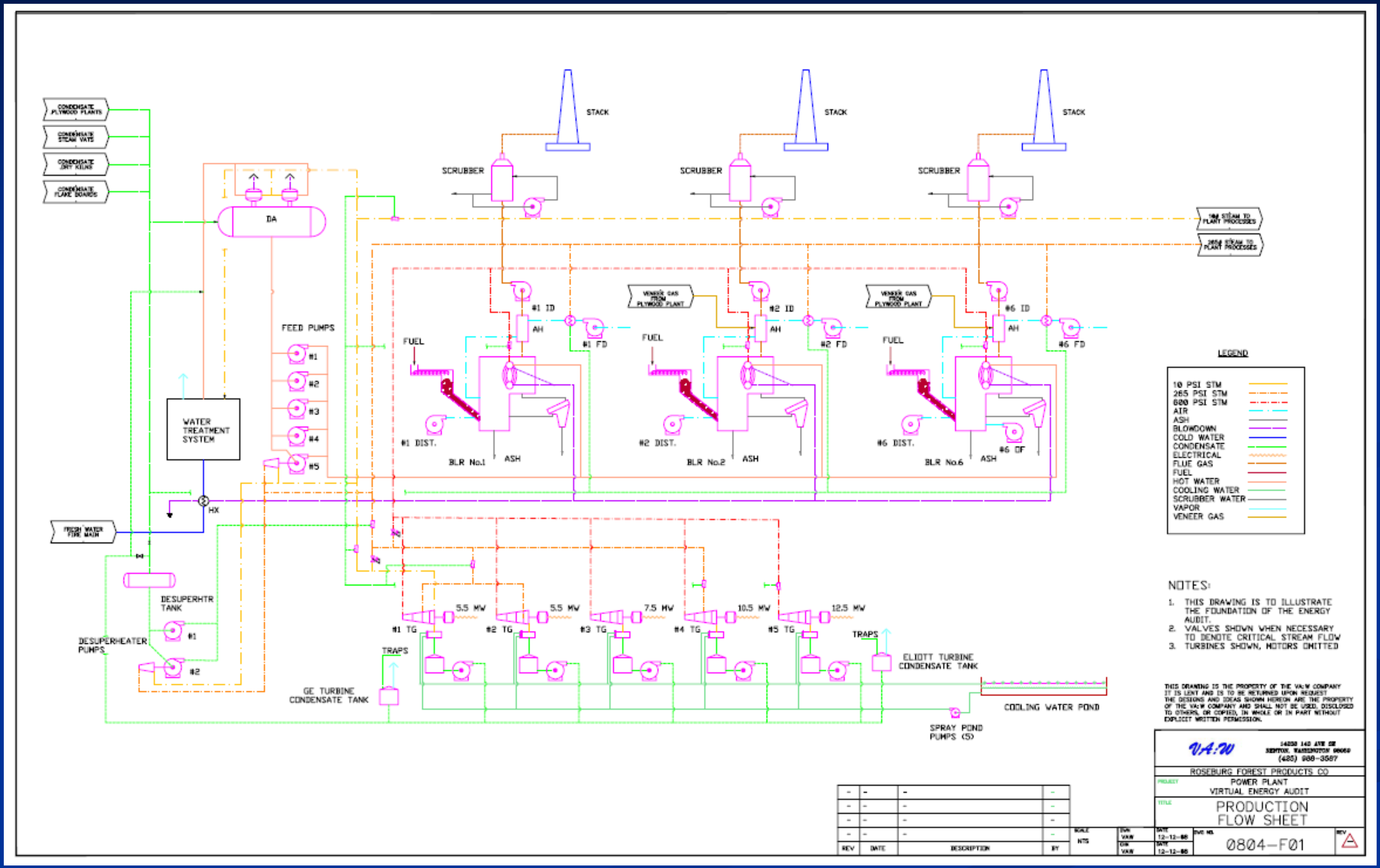
Solid Fuel (wood) given local data

Coal is common

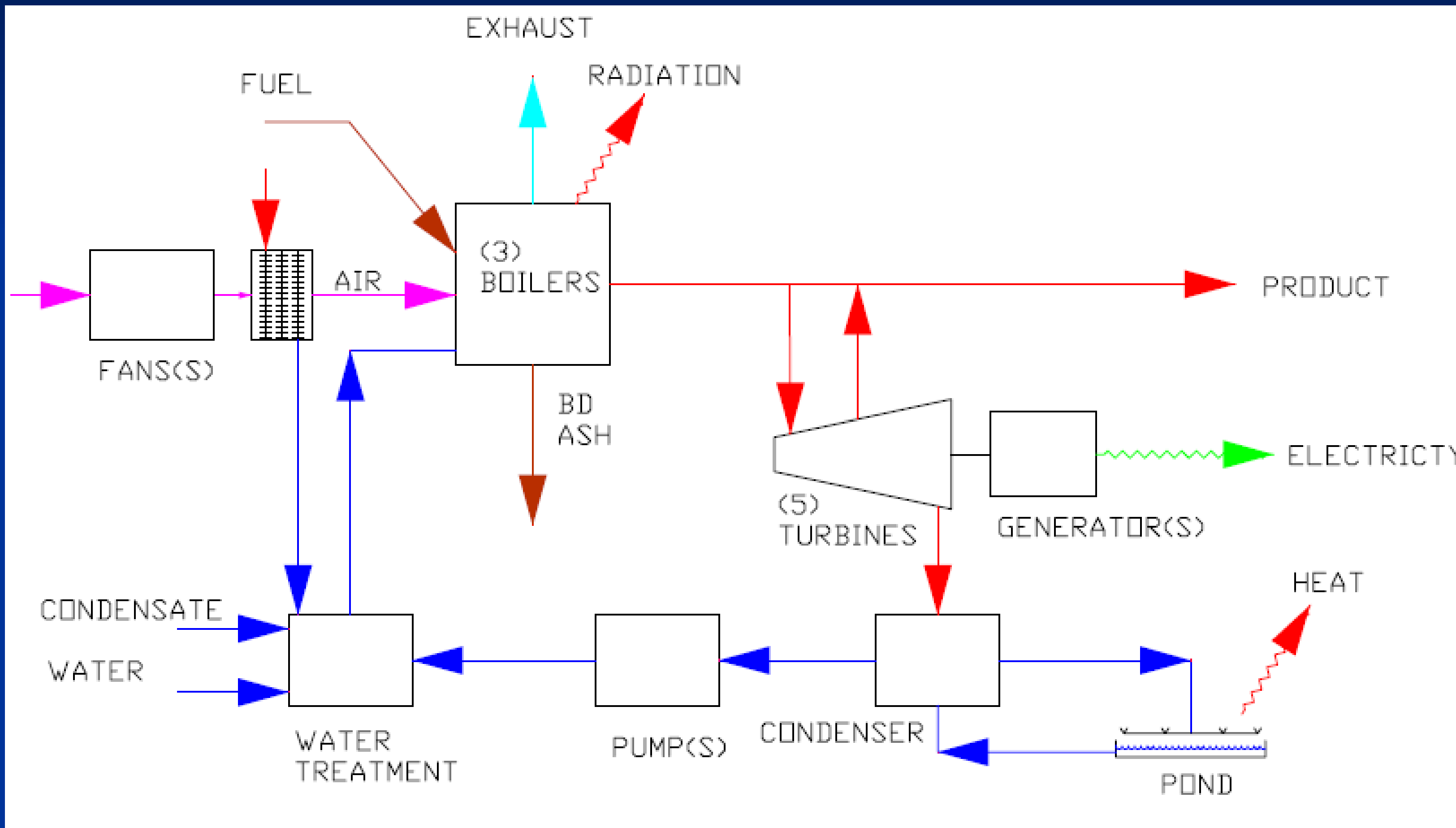
Oil fuel given characteristics

Key: heating value at firing conditions

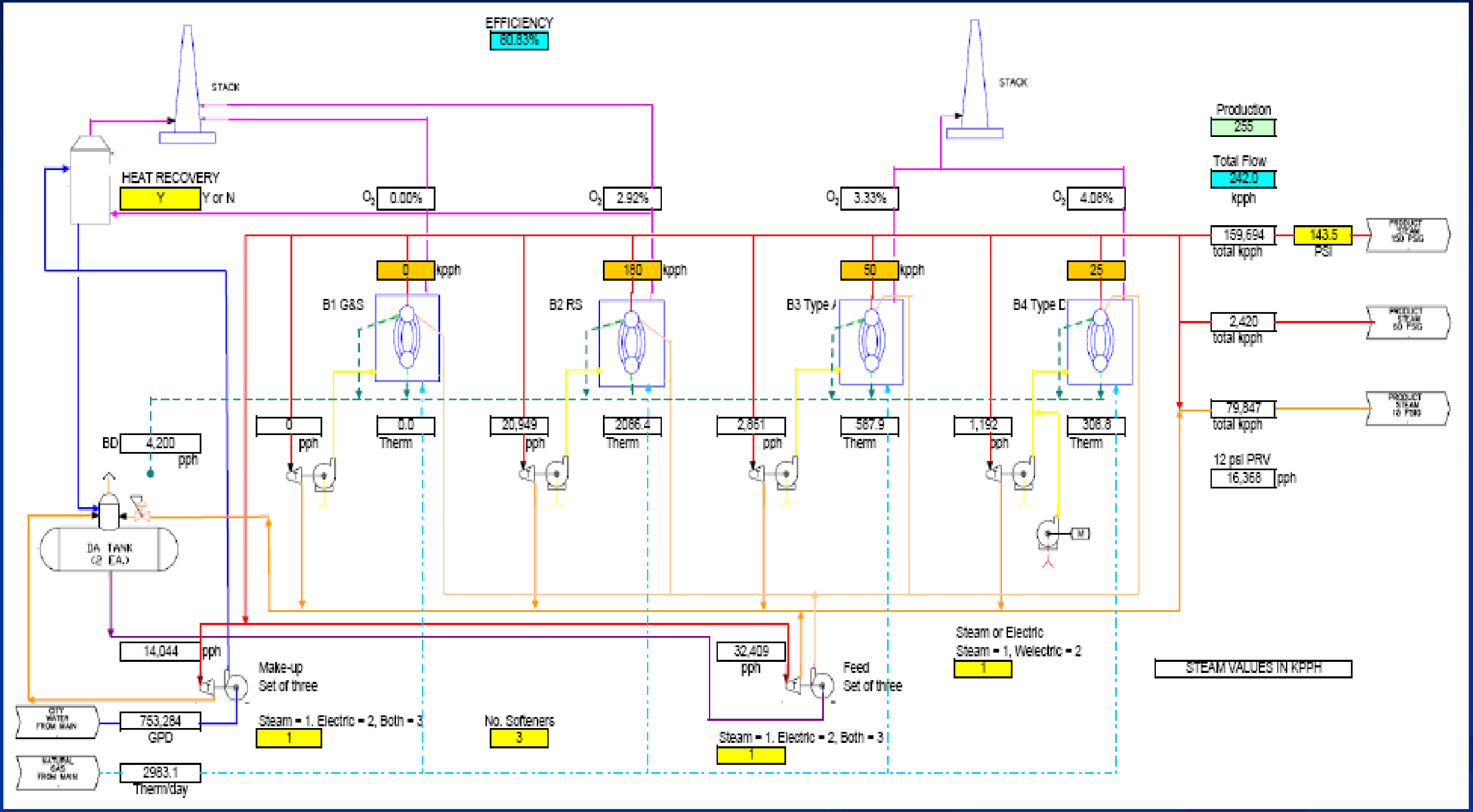
PLANT SCHEMATIC



SIMPLIFIED DIAGRAM



SCHEMATIC SHEET



GOLD AND YELLOW BOXES = INPUT

OPERATOR LOG

Plant Operational Log — 3/7/2008 10:35

Plant Load Total	kpph	404.5	kpph delivered	430	kpph produced	
High Pressure	set	143.5	psig			

		Boiler 1	Boiler 2	Boiler 3	Boiler 4
Load	kpph	100	150	100	80
Boiler Load Factor		63%	75%	63%	67%
Plant Load Factor		23%	35%	23%	19%
Flue Gas O2	%				
Flue Gas Temp	°F				
Flue Gas Flow	%				
	CFM				
Fan Speed	RPM				
Delta Pressure	in H2O				
Inlet Air Temp	°F				
Inlet Water Temp	°F				

Water Temp	°F	55	(required input)		
Heat Recovery Inlet	°F				
Heat Recovery Outlet	°F		Heat Recovery Op.	Y	Y or N
Deaerator Inlet Temp	°F				
Number of Softeners					
Make-up Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric		
Feed Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric		
Blowdown Waste Temp	°F				
Plant Efficiency	%	78.7%			
Balance		5.74%			

OVERALL

OVERALL PLANT OPERATION

Date: 3/7/2008
Run ID: Working

Set Overall Plant Operation Values

Net Steam Load	430,000	Lb/hr	Delivery	404,497	Lb/Hr	Proportioning		
15 Psi Header	133,484	Lb/hr	High Pressure	266,968	Lb/hr	Load		404,497 pph
60 Psi Header	4,045	Lb/hr	High Pressure	143.5	psig	HP	66%	266,968 pph
						MP	1%	4,045 pph
						LP	33%	133,484 pph

Boiler Set Up:

		Load Factor		
Boiler # 1	100,000	23%	160,000.00	lb/hr max
Boiler # 2	150,000	35%	200,000.00	lb/hr max
Boiler # 3	100,000	23%	160,000.00	lb/hr max
Boiler # 4	80,000	19%	120,000.00	lb/hr max
		100%	640,000.00	lb/hr max

Barometric Pressure	14.696	psia	Outside Atmospheric Temp	40	°F
Feed Water Temp	55	°F	Inside Ambient Temperature	75	°F
Deaerator Temp Out	226.99	°F			
Deaerator Temp Data	226.99	°F			

Utility Unit Costs:	Set values below				
Natural Gas	$ 1.00	per therm	Electricity	$ 0.07	per kWh

Heat Recovery Used: Y — Y or N
Set Heat Recovery to N for Type A or Type D only

Plant Output Values

PRV Flow		48,170.50	Lb/hr	-		
Superheat Values	60 psi Header	22.59	°F	15 psi Header	27.35	°F

Natural Gas Consumption	6,148.28	Therms/hr					
Electricity Consumption	131.6	kW/Hr.	For production purposes only				
Feed Water Consumption	442,030	lb/hr	882.30	GPM	1,270,505	GPD	
Basic Overall Steam Load	442,030	lb/hr	Steam Losses	12,030	lb/hr		
			Equiv. Loss	15,061	lb/hr		
Mass Loss Index	1.0630		Factor	1.0630			

Costs:

Natural Gas	$ 6,148.28	per hour	Electricity	$ 9.21	per hour
	$ 147,558.82	per day (1)		$ 221.04	per day (1)

(1) based on uniform load

Efficiencies

Steam	480.56	MMBTU/hr	produced	Balance	5.74%
Gas	614.83	MMBTU/hr	consumed		
Electricity	0.03	MMBTU/hr	consumed		

Steam η =	97.3%	Ratio of Steam delivered to steam used
Basic η =	78.2%	Ratio of steam produced to NG energy consumed
Plant η =	78.7%	Ratio of steam produced to output

Equivalent losses = condensation losses for steam used to heat DA

THE SOURCE

FUEL ANALYSIS

Wood Fuel Analysis

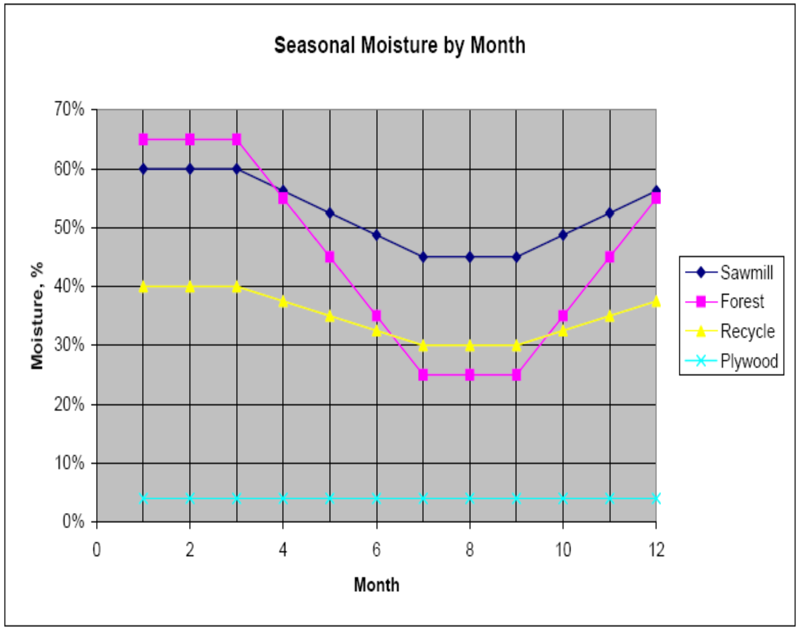
Month: 12

Sawmill Residuals			Forest Grindings			Recycle			Plywood Trim		
Ratio		54%	Ratio		23%	Ratio		10%	Ratio		13%
Moisture		56%	Moisture		55%	Moisture		38%	Moisture		4%
DFB	50%	8200	DFB	40%	8500	Urban	100%	7500	Trim	100%	8250
HFB	40%	8200	HFB	40%	8200						
Other	10%	7600	HB	20%	7200						
Composite, dry		8140			8120			7500			8250
Composit, wet		3218.125			3307.5			4218.75			7900

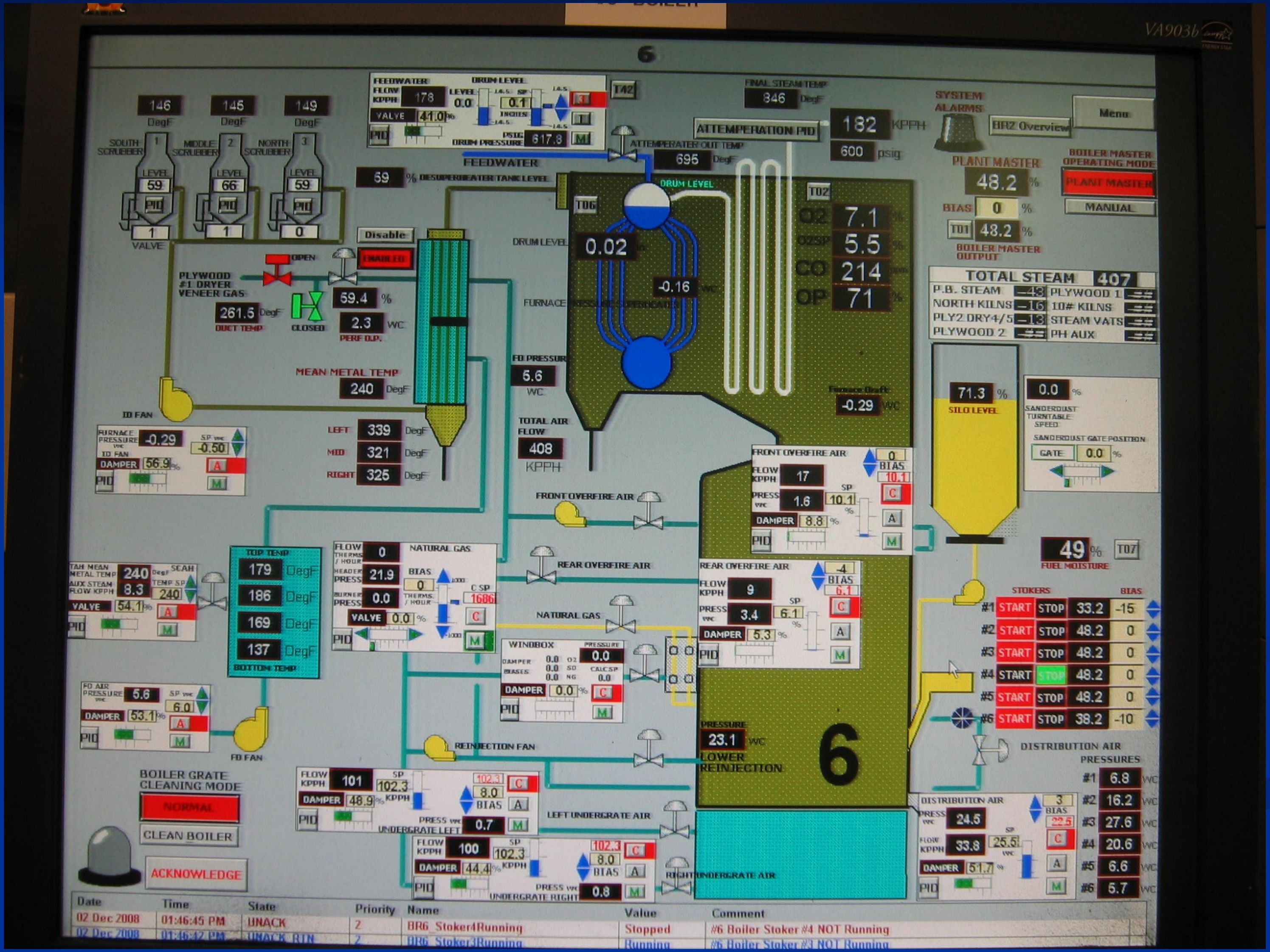
Net HHV: 3947.4 BTU/lb   Net Moist. 47.3%

DFB	Douglas Fir Bark
HFB	Hemlock Bark
Other	Cedar, et al
HB	Hardwood bark

Seasonal Moisture		Sawmill	Forest	Recycle	Plywood
January	1	60%	65%	40%	4%
February	2	60%	65%	40%	4%
March	3	60%	65%	40%	4%
April	4	56%	55%	38%	4%
May	5	53%	45%	35%	4%
June	6	49%	35%	33%	4%
July	7	45%	25%	30%	4%
August	8	45%	25%	30%	4%
September	9	45%	25%	30%	4%
October	10	49%	35%	33%	4%
November	11	53%	45%	35%	4%
December	12	56%	55%	38%	4%



HEAT CREATION



BOILER PERFORMANCE

BOILER 1							
Inputs							
Required Steam Load		129,000	lb/hr	150,000	lb/hr capacity		
				86.0%			
Pressure		600	psig				
Steam Temperature		850.0	°F	361.1623037	°F Superheat		
Flue Gas Temperature		720.29	°F	dry bulb			
Excess Air		30.6%					
Residual Flue O_2		4.45%					
Boiler Efficiency		86.0%					
Blowdown	set	1.50%		1935	lb/hr		
Boiler Losses	set	2.5%					
Output							
Air Flow		89,314.66	Lb/hr				
Flue Flow		113,998.52	Lb/hr	340.41	°F	14,531.57	Lb/hr H2O
Fuel Consumption, Wet		38,033.96	Lb/hr	19.02	Tons/hr	199,112,523	BTU/hr
Steam Coil Air Heater							
Air Flow		208,860.21	lb/hr				
Inlet Temperature		51	°F				
Outlet Temperature		91.2	°F				
Approach Temperature	set value	50	°F				
Condensate Outlet		195	°F		ho	163.0	BTU/lb
Steam Flow		5,004.86	lb/hr	194,915	BTU/hr		
Static Pressure Drop		22.09	in. WG	question			
Air Heater							
Gas Temp In		725.3	°F				
Gas Temp Out		340.4	°F				
Air Temp In		91.2	°F				
Air Temp Out		556.4	°F				
Air Flow		208,860.21	lb/hr	89,138.49	ACFM		

FAN PERFORMANCE

Force Draft Fan

Make-up Air Gas Flow	208,860.21	lb/hr	From Actual Make-up Air Flow			400	RPM min
	89,314.66	ACFM		51 °F		1400	RPM max
Head	13.1	inch H_2O					
Power Consumption	330.5	HP				83%	full load rati
Ideal Fan Power	184	HP					
Fan efficiency	56%						
Electrical:							
Ideal Electrical Load	246.22	kW			Full Load	300	HP
Electrical Efficiency	98.63%				Rated Speed	1770	RPM
Electrical Load	249.63	kW	851,946.76	BTU/hr			

Induced Draft Fan

Flue Gas Flow	233,055.92	lb/hr	From Actual Flue Gas Flow				
	113,998.52	ACFM		340.4 °F			
	114.00	KACFM					
Head	12.2	inch H_2O					
Power Consumption	307.0	HP					
Ideal Fan Power	219	HP					
Fan efficiency	71%						
Electrical:							
						44%	full load rati
Ideal Electrical Load	228.70	kW			Full Load	700	HP
Electrical Efficiency	99.47%				Rated Speed	885	RPM
Electrical Load	229.92	kW	784,659.14	BTU/hr			

Distribution Fan

Air Flow	16,082.24	lb/hr	proportional from FD flow				
	6,863.64	ACFM		556.4 °F			
	6.86	KACFM					
Head	26.2	inch H_2O					
Power Consumption	28.4	HP					
Ideal Fan Power	27	HP					
Fan efficiency	96%						
Electrical:							
Ideal Electrical Load	21.18	kW			Full Load	75	HP
Electrical Efficiency	99.85%				Rated Speed	1780	RPM
Electrical Load	21.21	kW	72,396.91	BTU/hr			

Turbine-Generator

TURBINES

Turbine Generator #3

W =	3.000	MW	Electrical Generation	
Mechanical Efficiency	91.53%	Proportion	13.1%	
m1	600 psi load			
m2	vacuum pressure exhaust		87.8	°F Hood Temperature
			1099.1	BTU/lb

Computation				η Computation	
m1 =	27,993	lb/hr	600 psi steam	m1 =	27,993
w1 =	10,238,622	BTU/hr		w1 =	9,370,908
Required	10,238,622	BTU/hr		Required	10,238,622
Variance	-	BTU/hr	1	η =	0.915250895
Error %	0.00%				

Turbine Generator #4

W =	9.200	MW	Electrical Generation	
Mechanical Efficiency	84.70%	Proportion	40.2%	
m1	600 psi load			
m2	265 psi extraction			
m3	vacuum pressure exhaust		102.6	°F Hood Temperature
			1105.5	BTU/lb

Computation				Computation		
m1 =	200,995	lb/hr	600 psi steam	m1 =	200,995	lb/hr
m2 =	145,000	lb/hr	265 psi extraction	m2 =	145,000	lb/hr
w1 =	8,203,960	BTU/hr		w1 =	8,203,960	BTU/hr
w2 =	18,389,013	BTU/hr		w2 =	18,389,013	BTU/hr
Net	31,398,441	BTU/hr		Net	26,592,974	BTU/hr
Required	31,398,441	BTU/hr		Required	31,398,441	BTU/hr
Variance	-	BTU/hr		η =	0.846952047	
Error %	0.00%					

CONDENSERS

Turbine Generator Condenser Calculation							
Cooling Pond Flow	Return	45000	GPM	@	69.02	°F	
Condenser 1		18%	8100	GPM			
Condenser 2		18%	8100	GPM			
Condenser 3		18%	8100	GPM			
Condenser 4		23%	10350	GPM			
Condenser 5		23%	10350	GPM			
		100%	45000				
			Outlet to Pond		97.04	°F	
Condenser 1							
Flow	Hot	72,806	lb/hr	Hood to Hot Well			
	Cold	4,058,100	lb/hr	Cooling Pond in and out			
TC1 Hood Temperature		104.2	°F	hih	1106.22	BTU/Lb	
Incoming Cooling Pond Temp		69.02	°F	hic	37.06	BTU/Lb	
Outlet Approach Temperature		17	°F				
Heat Exchanged		75,255,585.11	BTU/hr	Variation	#NAME?		
Condenser 1 Hot Well Temp		104.589	°F	hoh	72.5731576	BTU/Lb	
Outgoing Cooling Pond Temp		87.589	°F	hoc	55.6003576	BTU/Lb	
Cooling Pond Temperature gain		18.57	°F				
Condenser 2							
Flow	Hot	24,832.67	lb/hr		Hood to Hot Well		
	Cold	4,058,100.00	lb/hr		Cooling Pond in and out		
TC2 Hood Temperature		96.01	°F	hih	1102.64	BTU/Lb	
Incoming Cooling Pond Temp		69.02	°F	hic	37.06	BTU/Lb	
Outlet Approach Temperature		6.00	°F				
Heat Exchanged		26,152,399	BTU/hr	Variation2	1,139.88		
Condenser 2 Hot Well Temp		81.47	°F	hoh	49.49	BTU/Lb	
Outgoing Cooling Pond Temp		75.47	°F	hoc	43.50	BTU/Lb	
Cooling Pond Temperature gain		6.45	°F				
Condenser 3							
Flow	Hot	27,993.31	lb/hr		Hood to Hot Well		
	Cold	4,058,100.00	lb/hr		Cooling Pond in and out		
TC3 Hood Temperature		87.83	°F	hih	1099.13	BTU/Lb	
Incoming Cooling Pond Temp		69.02	°F	hic	37.06	BTU/Lb	
Outlet Approach Temperature		10.00	°F				
Heat Exchanged		29,249,830	BTU/hr	Variation3	3,143.91		
Condenser 3 Hot Well Temp		86.23	°F	hoh	54.25	BTU/Lb	
Outgoing Cooling Pond Temp		76.23	°F	hoc	44.26	BTU/Lb	
Cooling Pond Temperature gain		7.21	°F				

THE POND

THE WORKING END

COOLING POND - NUMBERS

Cooling Pond Heat Balance

Ambient Temperature	51	°F	0	432.24
Wet Bulb Temperature	47.24	°F	0.5	76.45
Ambient Wind Speed	5	MPH	1	72.28
			2	21.61
Circulating Flow	46000	GPM	5	49.64
	23,046,000	Lb/Hr	10	1339.72
Incoming Temperature	87	°F	20	177.30
			50	-1656.40

Heat Lost in Sprays	18.1	°F			
Surface Temperature	68.89	°F	hs =	36.92	BTUlbm
Heat Lost From Surface	49.64	BTU/hr-Sq.Ft.			
	5,886,959	BTU/Hr.			
Pond Volume	7,096,844	gallons	Heat1	2,188,003,884	BTU
			Heat2	2,182,116,925	BTU
Returning Temperature	68.82	°F	hw	36.86	BTUlbm

Wet Bulb Calculations

Temperature	10.56	°C	
	247.86	°K	
Relative Humidity	75.2%		
Saturated Vapor Press.	1.2748	kPa	
Vapor Pressure	0.9591	kPa	
Dew Point	6.36	°C	
	43.45	°F	
Gamma	0.066890		factor
Delta	0.066199		factor
Wet bulb Temp	8.47	°C	
	47.24	°F	

MASS BALANCE

Mass Balance

Produced Steam	B1	B2	B3	Net	
600 psig	129,000	109,000	219,000	457,000	pph

Delivered Steam		
10 psig	117,722	pph
265 psig	49,260	pph

Steam Uses						
	600 psi		265 psi		10 psi	
T1 Load	72,806	pph	-	pph	38,000	pph
T2 Load	24,833	pph	-	pph		
T3 Load	27,993	pph				
T4 Load	200,995	pph	145,000	pph		
T5 Load	26,025	pph				
Turbine Total	352,652					
Feed Pump, Turbine				pph		
Desuperheat Pump, Turbine				pph		
Deaerator						pph
Preheaters						pph

Losses		
Blowdown	4,235	pph
Vent	5,160	pph

PRV 10		pph
PRV 265		pph

ENERGY BALANCE
The Bottom Line

Plant Energy Balance

In			Out	Energy			Mass		
Natural Gas	614.83	MMBTU/hr	150 psi Steam	319.07	MMBTU/hr		266.97	KPPH	
Air	12.96	MMBTU/hr	60 psi Steam	4.83	MMBTU/hr		4.04	KPPH	
Water	10.17	MMBTU/hr	15 psi Steam	156.66	MMBTU/hr	480.56	133.48	KPPH	
			#1 Fan Turbine	0.55	MMBTU/hr				
			#2 Fan Turbine	0.40	MMBTU/hr				
			#3 Fan Turbine	0.28	MMBTU/hr				
			#4 Fan Turbine	0.20	MMBTU/hr				
			MU Pump	0.57	MMBTU/hr				
			FW Pump	1.49	MMBTU/hr	3.49			
			DA Heating	14.63	MMBTU/hr				
			DA vent	-	MMBTU/hr		0.00	KPPH	
			Steam Trap Cond.	1.37	MMBTU/hr				
			BD	13.09	MMBTU/hr		9.15	KPPH	
			Radiant Losses	9.56	MMBTU/hr	38.65			
			Flue Gas 1 & 2	17.14	MMBTU/hr				
			Flue Gas 3 & 4	61.48	MMBTU/hr	78.62			
							404.50	KPPH	Delivery
Total	638	MMBTU/hr		601	MMBTU/hr		9.15	KPPH	Losses

Balance	37	MMBTU/hr
	5.74%	

ή =	78.2%	Basic Thermal Efficiency
ή' =	78.7%	Overall Plant Efficiency
Losses	19.1%	

PAUSE

SO, WHAT WAYS WOULD YOU SEE TO MAKE THE VEA WORK FOR YOU?

(There is no quiz, therefore there is no pressure.)

FEATURES

- Stand-alone program or integrated into an automated control program
- Adaptable to future changes to remain unique to a specific plant
- Operates in many modes (see later)
- Accounts for all significant equipment

  Fans, Pumps, Deaerator-heaters, Pre-heaters, Economizers, Heat Recovery, Generators, Hot wells, Turbines/motors, chillers, pulverizers, and more…

TOOLS

- OPTIMIZER – FORECASTING OPERATING EFFICIENCY
- DOCUMENTATION – RECORDS FOR TOTAL PLANT EQUIPMENT
- MODIFICATIONS – RESEARCH W/ O HIGH COST
- AUTOMATION
- TRAINING TOOL
- REPORT GENERATION

OPERATING EFFICIENCY

Plant Operational Log					
				3/8/2008	10:42
Plant Load Total	kpph	242.9	kpph delivered	268	kpph produced
High Pressure	set	143.5	psig		

		Boiler 1	Boiler 2	Boiler 3	Boiler 4
Load	kpph	105	0	144	19
Boiler Load Factor		60%	0%	90%	16%
Plant Load Factor		39%	0%	54%	7%
Flue Gas O2	%				
Flue Gas Temp	°F				
Flue Gas Flow	%				
	CFM				
Fan Speed	RPM				
Delta Pressure	in H2O				
Inlet Air Temp	°F				
Inlet Water Temp	°F				

Water Temp	°F	57	(required input)		
Heat Recovery Inlet	°F				
Heat Recovery Outlet	°F		Heat Recovery Op.	Y	Y or N
Deaerator Inlet Temp	°F				
Number of Softeners					
Make-up Pump Mode			1= all steam, 2 = all electric, 3 = steam & electric		
Feed Pump Mode			1= all steam, 2 = all electric, 3 = steam & electric		
Blowdown Waste Temp	°F				
Plant Efficiency	%	74.8%			
Balance		2.22%			

Case 1

ή = 74.8%

Plant Operational Log					
				3/8/2008	10:41
Plant Load Total	kpph	252.6	kpph delivered	268	kpph produced
High Pressure	set	143.5	psig		

		Boiler 1	Boiler 2	Boiler 3	Boiler 4
Load	kpph	144	0	105	19
Boiler Load Factor		90%	0%	60%	16%
Plant Load Factor		54%	0%	39%	7%
Flue Gas O2	%	2.48		2.46	4.84
Flue Gas Temp	°F	807.1		680	416
Flue Gas Flow	%				
	CFM				
Fan Speed	RPM	933		1140	815
Delta Pressure	in H2O	8.3		11.6	6.6
Inlet Air Temp	°F				
Inlet Water Temp	°F			243.3	

Water Temp	°F	57	(required input)		
Heat Recovery Inlet	°F	58			
Heat Recovery Outlet	°F	134.8	Heat Recovery Op.	Y	Y or N
Deaerator Inlet Temp	°F	140.2			
Number of Softeners		3			
Make-up Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric		
Feed Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric		
Blowdown Waste Temp	°F	130.2			
Plant Efficiency	%	79.9%			
Balance		3.82%			

Case 2 – documented

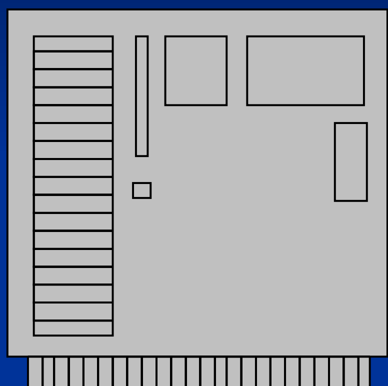
ή = 79.9%

DOCUMENTATION

Plant Operational Log				3/8/2008	10:41	
Plant Load Total	kpph	252.6	kpph delivered	268	kpph produced	
High Pressure	set	143.5	psig			
		Boiler 1	Boiler 2	Boiler 3	Boiler 4	
Load	kpph	144	0	105	19	
Boiler Load Factor		90%	0%	66%	16%	
Plant Load Factor		54%	0%	39%	7%	
Flue Gas O2	%	2.48		2.46	4.64	
Flue Gas Temp	°F	607.1		680	416	
Flue Gas Flow	%					
	CFM					
Fan Speed	RPM	933		1140	815	
Delta Pressure	in H2O	8.3		11.6	6.6	
Inlet Air Temp	°F					
Inlet Water Temp	°F			243.3		
Water Temp	°F	57	(required input)			
Heat Recovery Inlet	°F	58				
Heat Recovery Outlet	°F	134.8	Heat Recovery Op.	Y	Y or N	
Deaerator Inlet Temp	°F	140.2				
Number of Softeners		3				
Make-up Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric			
Feed Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric			
Blowdown Waste Temp	°F	130.2				
Plant Efficiency	%	79.8%				
Balance		3.82%				

Record and document specific plant conditions with all details

AUTOMATION



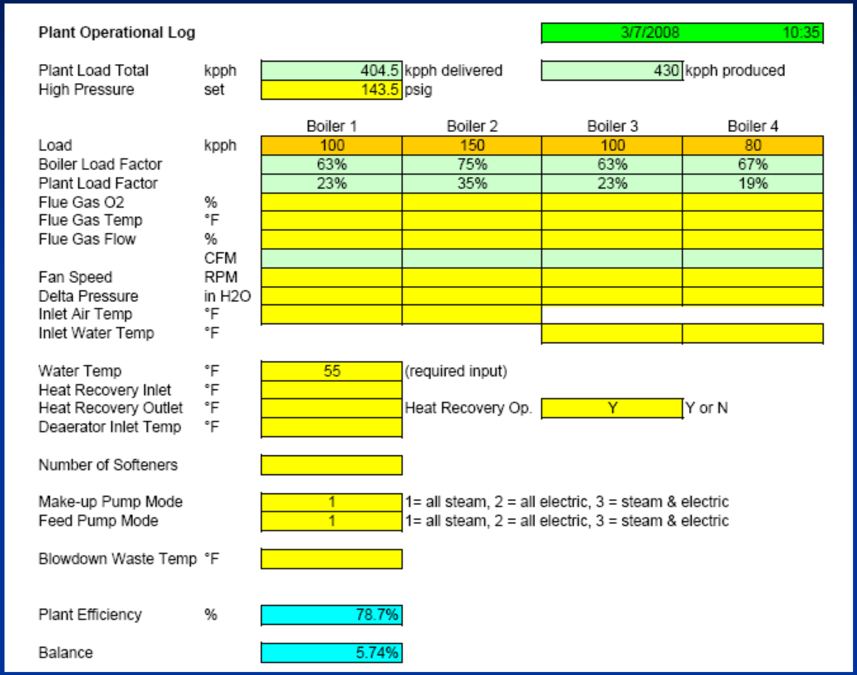
SERVER

Plant Operational Log				3/7/2008	10:35
Plant Load Total	kpph	404.5	kpph delivered	430	kpph produced
High Pressure	set	143.5	psig		
		Boiler 1	Boiler 2	Boiler 3	Boiler 4
Load	kpph	100	150	100	80
Boiler Load Factor		63%	75%	63%	67%
Plant Load Factor		23%	35%	23%	19%
Flue Gas O2	%				
Flue Gas Temp	°F				
Flue Gas Flow	%				
	CFM				
Fan Speed	RPM				
Delta Pressure	in H2O				
Inlet Air Temp	°F				
Inlet Water Temp	°F				
Water Temp	°F	55	(required input)		
Heat Recovery Inlet	°F				
Heat Recovery Outlet	°F		Heat Recovery Op.	Y	Y or N
Deaerator Inlet Temp	°F				
Number of Softeners					
Make-up Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric		
Feed Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric		
Blowdown Waste Temp	°F				
Plant Efficiency	%	78.7%			
Balance		5.74%			

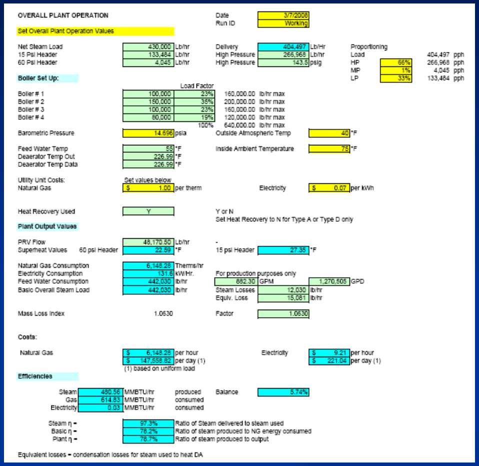
VEA

TIE-IN BETWEEN SYSTEM AUTOMATION AND VEA TO ENABLE SPECIFIC DATA RETREIVAL AND OPTIMIZATION.

TRAINING TOOL

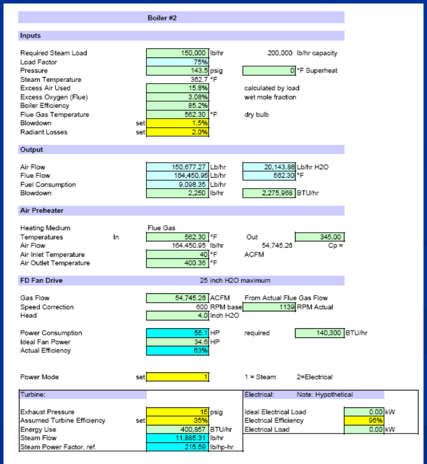


Plant Operational Log					3/7/2008	10:35
Plant Load Total	kpph	404.5	kpph delivered		430	kpph produced
High Pressure	set	143.5	psig			
		Boiler 1	Boiler 2	Boiler 3	Boiler 4	
Load	kpph	100	150	100	80	
Boiler Load Factor		63%	75%	63%	67%	
Plant Load Factor		23%	35%	23%	19%	
Flue Gas O2	%					
Flue Gas Temp	°F					
Flue Gas Flow	%					
	CFM					
Fan Speed	RPM					
Delta Pressure	in H2O					
Inlet Air Temp	°F					
Inlet Water Temp	°F					
Water Temp	°F	55	(required input)			
Heat Recovery Inlet	°F					
Heat Recovery Outlet	°F		Heat Recovery Op.	Y	Y or N	
Deaerator Inlet Temp	°F					
Number of Softeners						
Make-up Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric			
Feed Pump Mode		1	1= all steam, 2 = all electric, 3 = steam & electric			
Blowdown Waste Temp	°F					
Plant Efficiency	%	78.7%				
Balance		5.74%				



OVERALL PLANT OPERATION				Date	3/7/2008				
				Run ID	Working				
Set Overall Plant Operation Values									
Net Steam Load	430,000		Lb/hr	Delivery	404,497	Lb/Hr	Proportioning		
15 Psi Header	133,484		Lb/hr	High Pressure	266,968	Lb/hr	Load		404,497 pph
60 Psi Header	4,045		Lb/hr	High Pressure	143.5	psig	HP	66%	266,968 pph
							MP	1%	4,045 pph
Boiler Set Up:							LP	33%	133,484 pph
		Load Factor							
Boiler # 1	100,000	23%	160,000.00 lb/hr max						
Boiler # 2	150,000	35%	200,000.00 lb/hr max						
Boiler # 3	100,000	23%	160,000.00 lb/hr max						
Boiler # 4	80,000	19%	120,000.00 lb/hr max						
		100%	640,000.00 lb/hr max						
Barometric Pressure	14.696		psia	Outside Atmospheric Temp	40	°F			
Feed Water Temp	55		°F	Inside Ambient Temperature	75	°F			
Deaerator Temp Out	226.99		°F						
Deaerator Temp Data	226.99		°F						
Utility Unit Costs:	Set values below								
Natural Gas	$ 1.00		per therm	Electricity	$ 0.07	per kWh			
Heat Recovery Used	Y			Y or N					
				Set Heat Recovery to N for Type A or Type D only					
Plant Output Values									
PRV Flow	48,170.50		Lb/hr	-					
Superheat Values 60 psi Header	22.59		°F	15 psi Header	27.35	°F			
Natural Gas Consumption	6,148.28		Therms/hr						
Electricity Consumption	131.6		kW/Hr.	For production purposes only					
Feed Water Consumption	442,030		lb/hr	882.30 GPM	1,270,505	GPD			
Basic Overall Steam Load	442,030		lb/hr	Steam Losses	12,030	lb/hr			
				Equiv. Loss	15,081	lb/hr			
Mass Loss Index	1.0630			Factor	1.0630				
Costs:									
Natural Gas	$ 6,148.28		per hour	Electricity	$ 9.21	per hour			
	$ 147,558.82		per day (1)		$ 221.04	per day (1)			
	(1) based on uniform load								
Efficiencies									
Steam	480.56	MMBTU/hr	produced	Balance	5.74%				
Gas	614.83	MMBTU/hr	consumed						
Electricity	0.03	MMBTU/hr	consumed						
Steam η =	97.3%		Ratio of Steam delivered to steam used						
Basic η =	78.2%		Ratio of steam produced to NG energy consumed						
Plant η =	78.7%		Ratio of steam produced to output						
Equivalent losses = condensation losses for steam used to heat DA									

Overall



Boiler #2					
Inputs					
Required Steam Load		150,000	lb/hr	200,000	lb/hr capacity
Load Factor		75%			
Pressure		143.5	psig	0	°F Superheat
Steam Temperature		362.7	°F		
Excess Air Used		15.8%		calculated by load	
Excess Oxygen (Flue)		3.08%		wet mole fraction	
Boiler Efficiency		85.2%			
Flue Gas Temperature		562.30	°F	dry bulb	
Blowdown	set	1.5%			
Radiant Losses	set	2.0%			
Output					
Air Flow		150,677.27	Lb/hr	20,143.88	Lb/hr H2O
Flue Flow		164,450.95	Lb/hr	562.30	°F
Fuel Consumption		9,098.35	Lb/hr		
Blowdown		2,250	lb/hr	2,275,968	BTU/hr
Air Preheater					
Heating Medium		Flue Gas			
Temperatures	In	562.30	°F	Out	345.00
Air Flow		164,450.95	lb/hr	54,745.26	Cp =
Air Inlet Temperature		40	°F	ACFM	
Air Outlet Temperature		400.36	°F		
FD Fan Drive		25 inch H2O maximum			
Gas Flow		54,745.26	ACFM	From Actual Flue Gas Flow	
Speed Correction		600	RPM base	1139	RPM Actual
Head		4.0	Inch H2O		
Power Consumption		55.1	HP	required	140,300 BTU/hr
Ideal Fan Power		34.6	HP		
Actual Efficiency		63%			
Power Mode	set	1		1 = Steam	2=Electrical
Turbine:				Electrical:	Note: Hypothetical
Exhaust Pressure		15	psig	Ideal Electrical Load	0.00 kW
Assumed Turbine Efficiency	set	35%		Electrical Efficiency	96%
Energy Use		400,857	BTU/hr	Electrical Load	0.00 kW
Steam Flow		11,885.31	lb/hr		
Steam Power Factor, ref.		215.59	lb/hp-hr		

Specific

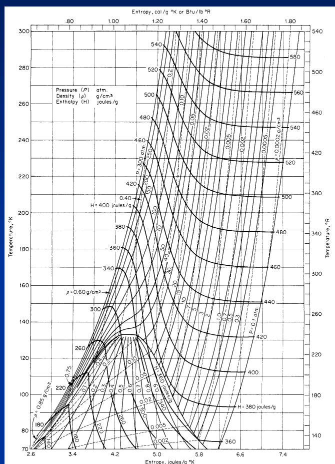
Component

Customized simulation of the specific power plant to learn how to operate and optimize quickly and without actual operation.

MODIFICATIONS

- COMPARE TWO (OR MORE) MODIFICATIONS
- DETERMINE EFFECT ON PLANT OPERATIONS – WITHOUT ACTUAL CHANGES
- CONDUCT FEASIBILITY ANALYSIS

Contact Data



VA:W

(Value Added by Werner)

Alan Werner, P.E. Principal

aawerner@comcast.net

(425) 988-3587

www.virtenergy.com