VIRTUAL ENERGY AUDIT

Your Power Plant on a desktop computer

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VA:W

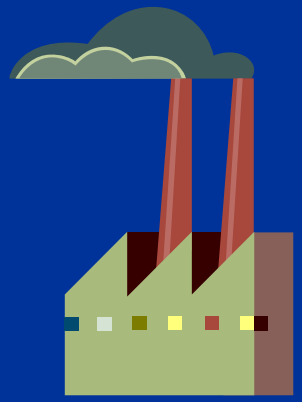
(Value Added by Werner)

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

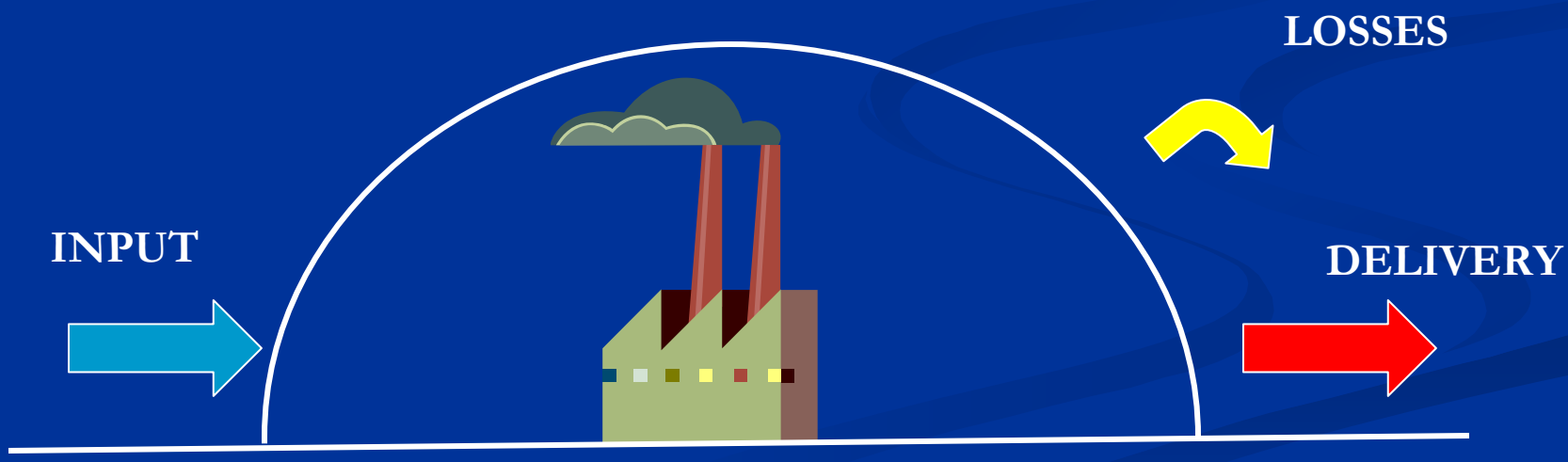
SOLUTION: **The Virtual Energy Audit**

- 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 ⟶ 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

A LITTLE THERMODYNAMICS

- Natural Gas – most uniform
  - $CH_4 + 2\ O_2 \longrightarrow CO_2 + 2\ H_2O$
  - 1 LB MOLE CH_4 = 337,775 BTU/lb mole ±
- OIL - Varies by grade
  - 137,000 – 150,000 BTU/gal
- Wood – Varies by species, moisture, and dirt
  - 8400 – 11,300 BTU/lb (dry), 8750-874 BTU/lb (wet)
- Coal – Varies by type and location
  - 9300 – 14,700 BTU/lb

COMBUSTION SHEET

Flue Gas Calculations

Basis		
Boiler Steam Product	150,000.00	Lb/hr
Flue Gas temperature	562.30	oF
Excess air	15.8%	%
Dry bulb Temperature	400.36	oF
Dew Point Temperature	40.00	oF
Barometric Pressure	14.66	psia
Water Inlet temperature	248.00	oF
Combustion Efficiency	100.00	%
Blow Down	1.50	%
Radiant Heat losses	2.00	%
Boiler Steam Pressure	143.50	psig
Boiler Steam Temperature	362.66	oF

Gas Analysis		%	Higher HV per lbmole	Component Value	Dry Make-Up A	%
1.000	0.00	0.00			N2	0.7809
Oxygen	O2	0.000	0.00	0.00	O2	0.2095
Carbon dioxide	CO2	1.000	0.00	0.00	CO2	0.0003
Arogon	Ar	0.000	0.00	0.00	Ar	0.0093
Carbon Monoxi	CO	0.000	121,759.47	0.00		
Hydrogen	H2	0.000	123,163.85	0.00		
Methane	CH4	95.000	382,955.00	367636.80		
Ethane	C2H6	3.000	671,252.61	20137.58		
		100.00	Higher Heat Value	387,774.38	BTU/lbmole NG	

Boiler Efficiency[Enter]	85%		NG heat	207,282,914.80	BTU/hr
Enthalpy of Steam	1,206.53	BTU/lb	Radiant	4,145,658.30	BTU/hr
Enthalpy of MU water	216.00	BTU/lb	Blowdown	3,109,243.72	BTU/hr
Heat to generate Steam	990.53	BTU/lb			
Heat to generate Sat H2O	146.86	BTU/lb			
Heat for Steam Production	992.76	BTU/lb			
Avail. Heat of Comb. NG	327,089.03	BTU/lbmole NG			
Natural Gas Heat Load		174,843,855.58	BTU/hr		
Mole NG pound of Steam		329.47	#steam/mole NG		
Mole of NG required		534.55	lbmole/hr		

BASIS 1 LBMOLE/HR OF METHANE

	Chemical Formula	Molecular Weight	Gross Heat of Combustion BTU/lb	Make-UP Air Mass lb/hr	Make-UP Air Molar lbmole/hr	Make-UP Air Heat BTU/lb	Make-UP Gas Mass lb/hr	Make-UP Gas Molar lbmole/hr	Make-UP Gas Heat BTU/lb	Flue Gas Produced lb/hr	Flue Gas Produced Molar lbmole/hr	Flue Gas Produced Heat BTU/lb	Steam Generated CV lb/hr	Steam Generated Molar lbmole/hr	Steam Generated Heat BTU/lb
Nitrogen	N2	28.013	.000	211.781	7.559991	19,697.996	.280	.010	26.056	212.061	7.569991	28,394.991	.000		.000
Oxygen	O2	31.999	.000	64.900	2.028196	5,378.977	.000	.000	.000	8.846	0.276459	1,055.519	.000		.000
Argon	AR	39.948	.000	3.597	.090034	278.225	.000		.000	3.597	0.090034	400.537	.000		.000
Carbon dioxide	CO2	44.010	.000	.128	.002904	10.554	.440	.010	36.476	45.468	1.032904	5,423.916	.000		.000
Water Vapor	H2O	18.015		1.474	.081821	1,832.341	.000		.000	37.684	2.091821	49,621.934	.000		.000
Carbon Monoxide	CO	28.010	4,347.000	.000		.000	.000	.000	.000	.000	0.000000	.000	.000		.000
Hydrogen	H2	2.016	61,095.000	.000		.000	.000	.000	.000	.000		.000	.000		.000
Methane	CH4	16.040	23,875.000	.000		.000	15.398	.960	3,460.023	.000		.000	.000		.000
Ethane	C2H6	30.070	22,323.000	.000		.000	.902	.030	166.149	.000		.000	.000		.000
	TOTAL	As noted		281.879	9.76295	27,198.133	17.021	1.010	3,688.704	307.647	11.05121	84,896.899	.000		.000
Total Pressure		Psia			14.662			14.696			14.6616				
Partial Press H2O		Psia			.123						2.7727				
Temperature		oF			400.3609215			400.361			562.30				
Volumetric Flow		ACFM			102	54745		10.570			137.88				
Absolute Humidity		#Air/#H2O			0.005256691			.000			.1395				

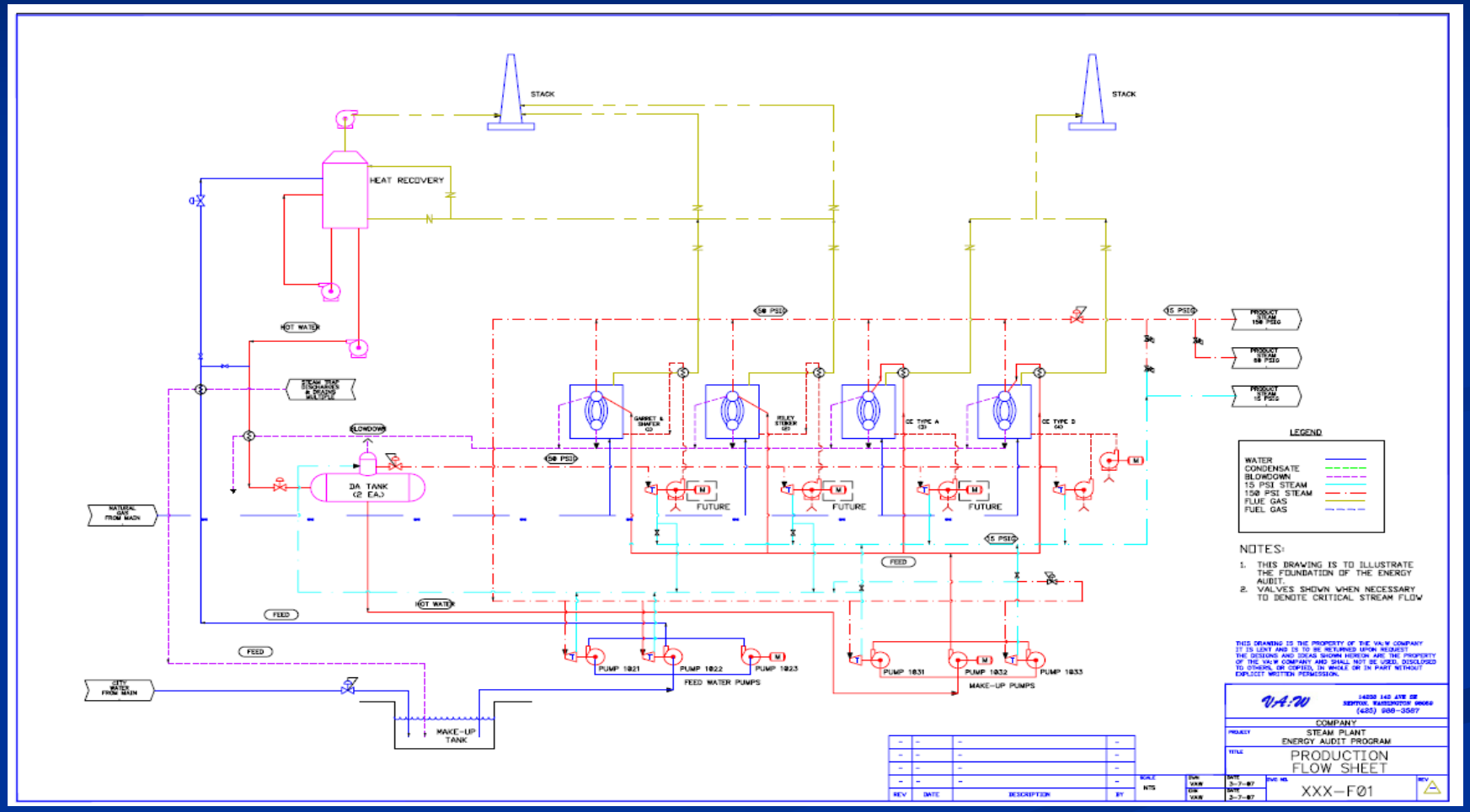
Componnts		Actual Flue Gas lb/hr	Actual Flue Gas lbmole/hr	Actual Flue Gas Btu/hr	Wet Molefraction	Dry Molefraction
Nitrogen	N2	113,366.28	4,046.50	15,178,404.871	68.44%	84.40%
Oxygen	O2	4,726.78	147.78	564,222.475	2.50%	3.08%
Argon	AR	1,922.60	48.13	214,104.949	0.81%	1.00%
Carbon dioxide	CO2	24,299.42	552.13	2,899,329.307	9.34%	11.52%
Water Vapor	H2O	20,143.88	1,118.17	21,371,450.414	18.91%	
Carbon Monoxide	CO	0.00	0.00	.000	0.00%	0.00%
Hydrogen	H2	0.00	0.00	.000	0.00%	0.00%
Methane	CH4	0.00	0.00	.000	0.00%	0.00%
Ethane	C2H6	0.00	0.00	.000	0.00%	0.00%
TOTAL	As noted	164,460.95	5,912.72	40,227,512.02	100.00%	100.00%
Total Pressure	Psia		14.6616			
Partial Press H2O	Psia		2.77			
Temperature	oF		562.30			
Volumetric Flow	ACFM		73,703.99			
Density	lb/ft^3		0.04			
Specific Heat	ft^3/lb		26.89			
Absolute Humidity	#H2O/#Air		0.13959			
Dew Point Temperature	oF		138.274			

STOICHIOMETRIC BENEFITS

- Creates known requirements to heat water, add latent heat, and generate steam conditions
- Calculates combustion environment
  - Air flow
  - Flue conditions
  - Residual O2 ⟶ Excess air
  - Efficiency contribution
- Can accommodate blowdown and radiant heat losses

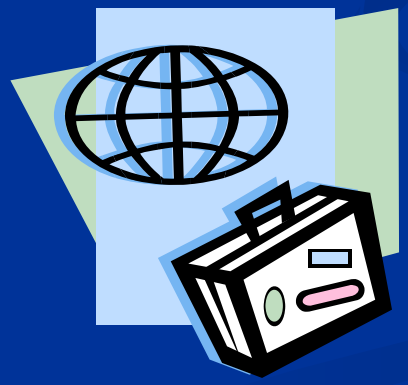
PLANT PROCESS DIAGRAM

THE START

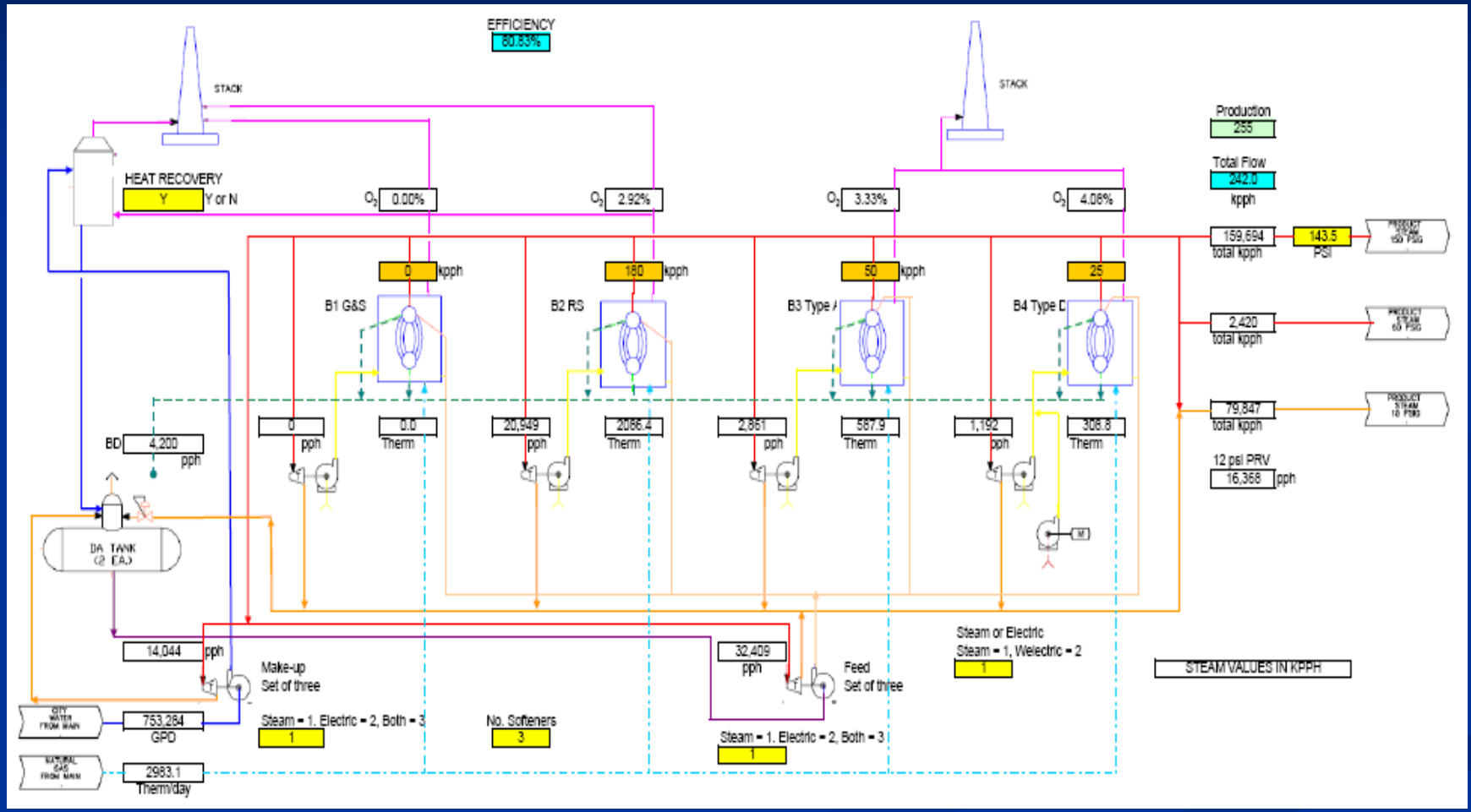


TOUR

- LOOK AT THE INTERNALS OF THE VEA
  - GET A FEEL FOR THE PARTS
    - LEAD TO MORE DETAILED DEMONSTRATION



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: 3/7/2006
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	15,081 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

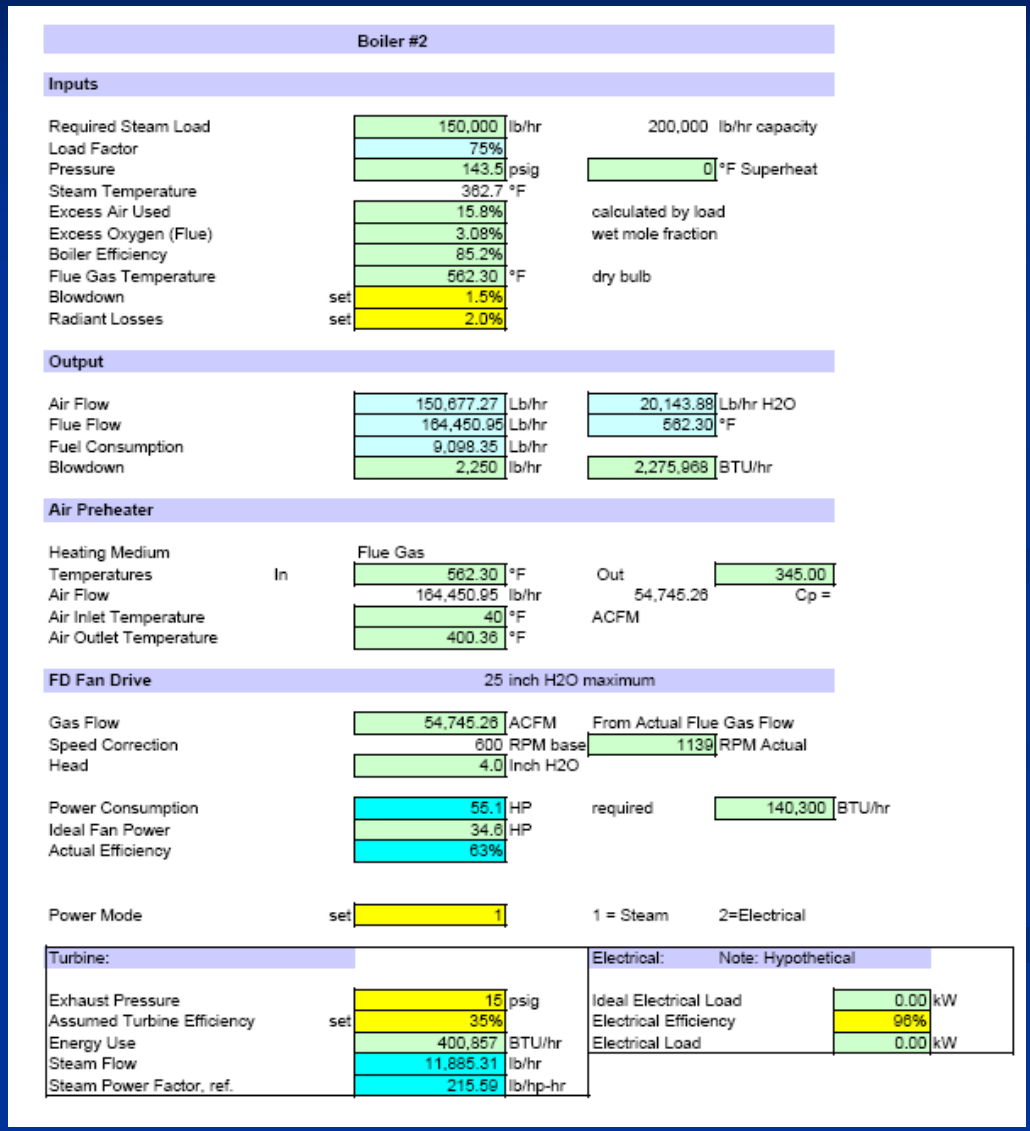
Steam	480.56	MMBTU/hr	produced	Balance 5.74%
Gas	614.83	MMBTU/hr	consumed	
Electricity	0.03	MMBTU/hr	consumed	

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

BOILER #2

TYPICAL FOR INDIVIDUAL UNITS



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:

Exhaust Pressure		15	psig
Assumed Turbine Efficiency	set	35%	
Energy Use		400,857	BTU/hr
Steam Flow		11,885.31	lb/hr
Steam Power Factor, ref.		215.59	lb/hp-hr

Electrical: Note: Hypothetical

Ideal Electrical Load	0.00	kW
Electrical Efficiency	96%	
Electrical Load	0.00	kW

HEAT RECOVERY

CONDENSING ECONOMIZER

Heat Recovery Summary

Gas Flow In	112934.0	ACFM	Temperature	450.19	°F	
Water Flow In	868.83	GPM	Temperature	60.80	°F	
Water Flow Out	904.26	GPM	Temperature	134.76	°F	
Recovered Heat	32,224,230	BTU/Hr				
Recovered Water	35.43	GPM	17,750	lb/Hr.	51,019	GPD

Recirculation Pump	Flow	1303.24	GPM	Head	80.00	Ft. H2O
	Power	44.65	HP	Electricity	33.31	kW
Transfer Pump	Flow	904.26	GPM	Head	62.9	Ft. H2O
	Power	131.72	HP	Electricity	98.26	kW

PLANT USES 1

PLANT USES

Plant uses come from 15 psig and 150 psig steam headers

15 psig Steam

Steam Pressure	15	psig	29.696 psia
Steam Enthalpy	1,161.42	BTU/lb	
Latent Heat	970.2	BTU/lb	
Steam Temperature	249.7	°F	saturated
Net Plant Consumption	16,053.93	Lb/hr	
Header equivalent enthalpy	1,173.59	BTU/lb	29.696 psia
Header Temperature	277.10	°F	
Superheat	27.35	°F	

60 psig Steam

Steam Pressure	60	psig	74.696 psia
Steam Enthalpy	1,181.97	BTU/lb	
Steam Temperature	307.3	°F	saturated
Header equivalent enthalpy	1,195.15	BTU/lb	74.696 psia
Header Temperature	329.91	°F	
Superheat	22.59	°F	

150 psig Steam

Steam Pressure	143.5	psig	158.2 psia
Steam Enthalpy	1,195.15	BTU/lb	
Steam Temperature	362.7	°F	saturated
Net Plant Consumption	103,367.45	Lb/hr	

Barometric Pressure	14.696	psia

THERMODYNAMIC PARAMETERS

PLANT USES 2

COMMON EQUIPMENT

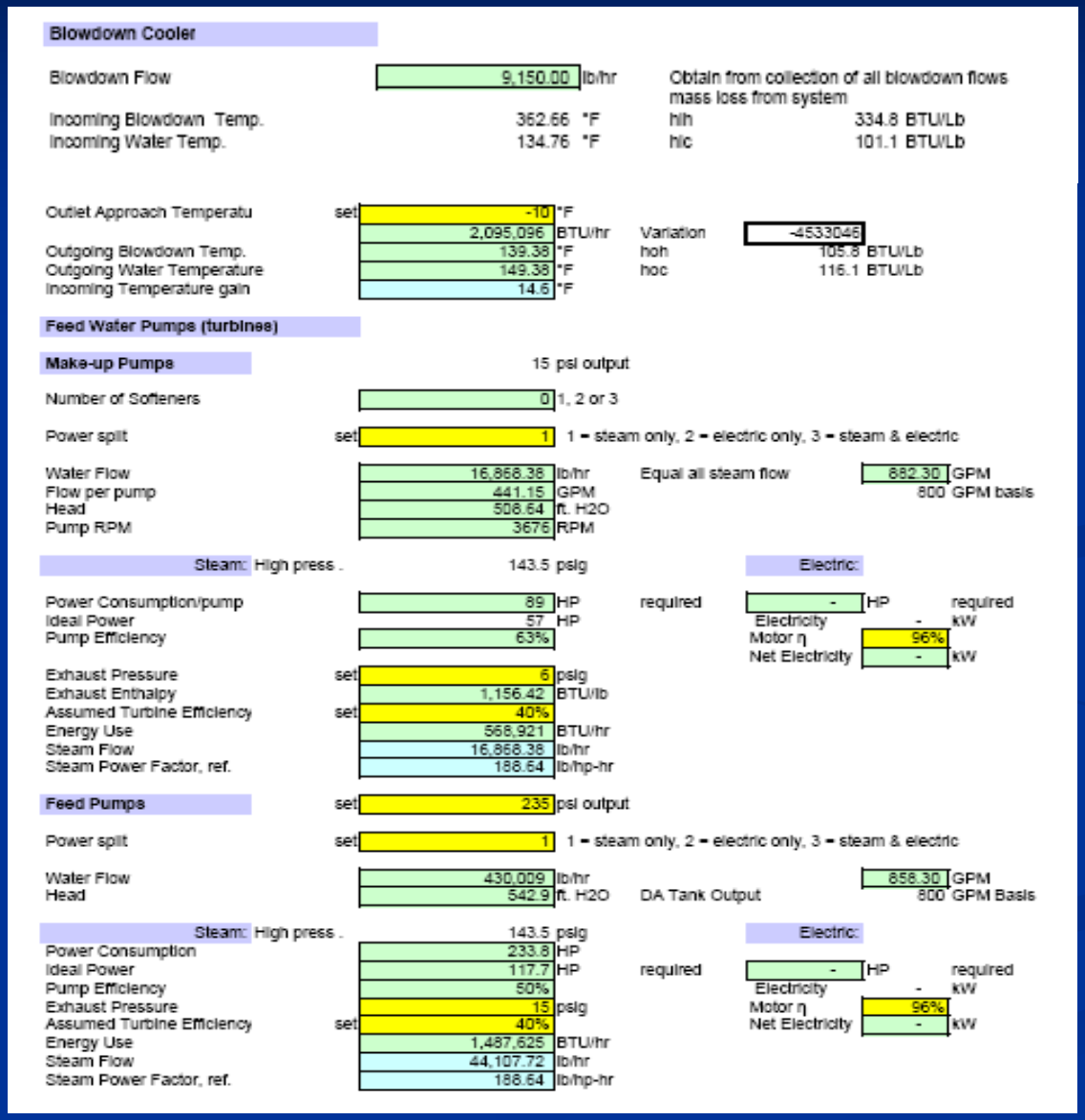
Plant Peripheral Equipment Values

Deaerator	Oper. Press.		5	psig			
Flow			34,922	Lb/hr	water flow		
Temperature In			149.38	°F			
Temperature out			226.99	°F			
ΔT through cooler		set	80	°F			
Required Heat			40,368,386	BTU/hr			
Return from Condensate			0	lb/hr			
Total Steam Flow			34,922.31	lb/hr			
Steam Flow Split	6 psi		16,868.38	lb/hr	15 psi PRV	18,053.93	lb/hr
Equivalent Heating Loss			15,080.90	lb/hr	14,630,969	BTU/hr	
Vent Loss			2,880.00	lb/hr	mass loss from system		
			2,991,157	BTU/hr			

High Pressure Trap Cooler

Flow			1,135	lb/hr			
Incoming Trap Temperature			362.7	°F	hlh	334.8	BTU/Lb
Incoming Water Temp			55.0	°F	hlc	23.1	BTU/Lb
Outlet Approach Temperatu		set	-5	°F			
Heat Exchanged			352,978	BTU/hr	Variation	-1025	
Outgoing Trap Temperature			50.61	°F	hoh	18.9	BTU/Lb
Outgoing Water Temperature			55.815	°F	hoc	23.9	BTU/Lb
Incoming Temperature gain			0.8	°F			

PLANT USES 3



Blowdown Cooler

Blowdown Flow	9,150.00	lb/hr	Obtain from collection of all blowdown flows mass loss from system		
Incoming Blowdown Temp.	362.66	°F	hih	334.8	BTU/Lb
Incoming Water Temp.	134.76	°F	hic	101.1	BTU/Lb
Outlet Approach Temperatu set	-10	°F			
	2,095,096	BTU/hr	Variation	-4533046	
Outgoing Blowdown Temp.	139.38	°F	hoh	105.8	BTU/Lb
Outgoing Water Temperature	149.38	°F	hoc	116.1	BTU/Lb
Incoming Temperature gain	14.6	°F			

Feed Water Pumps (turbines)

Make-up Pumps — 15 psi output

Number of Softeners	0	1, 2 or 3			
Power split set	1	1 = steam only, 2 = electric only, 3 = steam & electric			
Water Flow	16,868.38	lb/hr	Equal all steam flow	882.30	GPM
Flow per pump	441.15	GPM		800	GPM basis
Head	506.64	ft. H2O			
Pump RPM	3676	RPM			

Steam: High press . — 143.5 psig — Electric:

Power Consumption/pump	89	HP	required	-	HP required
Ideal Power	57	HP		Electricity -	kW
Pump Efficiency	63%			Motor η 96%	
				Net Electricity -	kW
Exhaust Pressure set	6	psig			
Exhaust Enthalpy	1,156.42	BTU/lb			
Assumed Turbine Efficiency set	40%				
Energy Use	568,921	BTU/hr			
Steam Flow	16,868.38	lb/hr			
Steam Power Factor, ref.	188.64	lb/hp-hr			

Feed Pumps set 235 psi output

Power split set	1	1 = steam only, 2 = electric only, 3 = steam & electric			
Water Flow	430,009	lb/hr		858.30	GPM
Head	542.9	ft. H2O	DA Tank Output	800	GPM Basis

Steam: High press . — 143.5 psig — Electric:

Power Consumption	233.8	HP			
Ideal Power	117.7	HP	required	-	HP required
Pump Efficiency	50%			Electricity -	kW
Exhaust Pressure	15	psig		Motor η 96%	
Assumed Turbine Efficiency set	40%			Net Electricity -	kW
Energy Use	1,487,625	BTU/hr			
Steam Flow	44,107.72	lb/hr			
Steam Power Factor, ref.	188.64	lb/hp-hr			

COMMON EQUIPMENT

MASS BALANCE

Mass Balance

Produced Steam	#1	#2	#3	#4	Net	
150 psig	100,000	150,000	100,000	80,000	430,000	pph

Delivered Steam		
15 psig	133,484	pph
60 psig	4,045	pph
150 psig	266,968	pph
Net	404,497	pph

Steam Uses	6 PSI	!5 PSI	140 PSI				
6 psig exhaust	16,868			pph	#1 FD	16,219	lb/hr
15 psig exhaust		42,391		pph	#2 FD	11,885	lb/hr
Fan Turbines			(42,391)	pph	#3 FD	8,211	lb/hr
Make-Up Pump		16,868	(16,868)	pph	#4 FD	6,076	lb/hr
Feed Pump		44,108	(44,108)	pph			
Deaerator (15 psi letdown)		(18,054)		pph			
Deaerator (6 psi feed)	(16,868)						
Net	-	85,314	(103,367)				

Losses		
Blowdown	9,150	pph
Vent	2,880	pph
	12,030	

PRV	48,170	pph

Reconciliation	15 PSI	140 PSI	
Produced	-	430,000	pph
Used	85,314	(103,367)	pph
PRV (140 to 15, less 60)	48,170	(44,126)	pph
Losses		(12,030)	pph
Net	133,484	270,477	pph
Variation	-	3,509	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	$\dot{\eta}$ =	78.2% Basic Thermal Efficiency
	5.74%		$\dot{\eta}'$ =	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

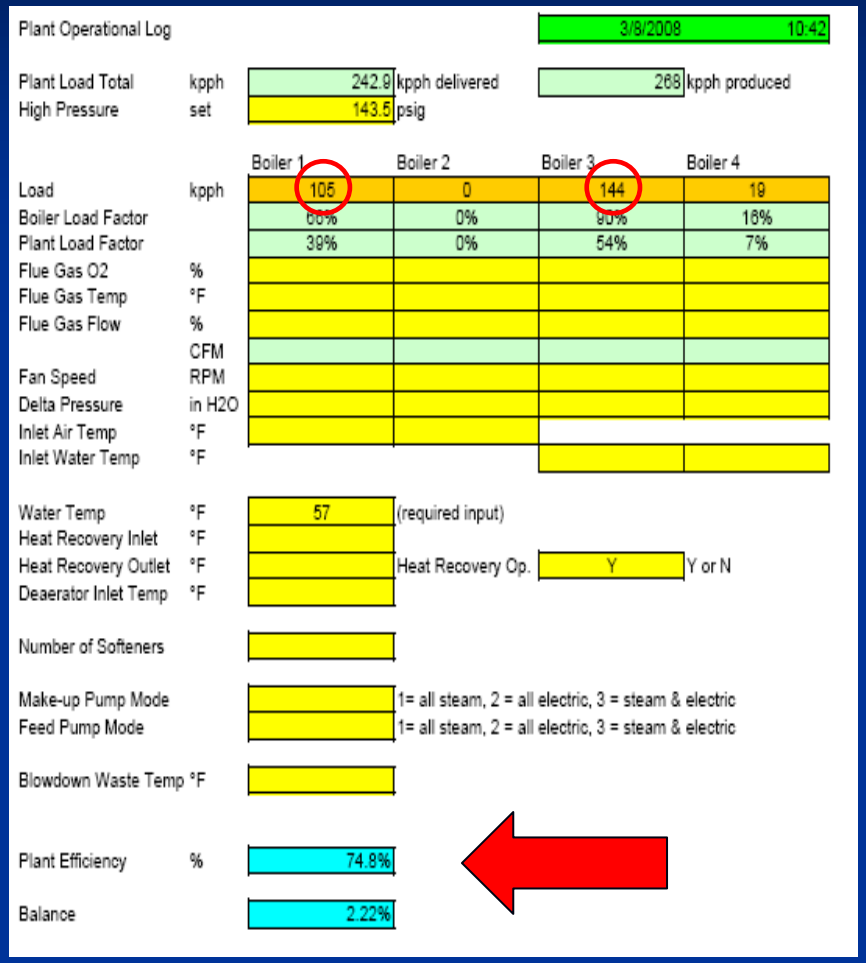
- Stand-alone program or integrated into an automated control program
- Adaptable to future changes to remain unique to a specific plant
- Operates in many modes (see later)
- Accounts for all significant equipment

  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

OPERATING EFFICIENCY



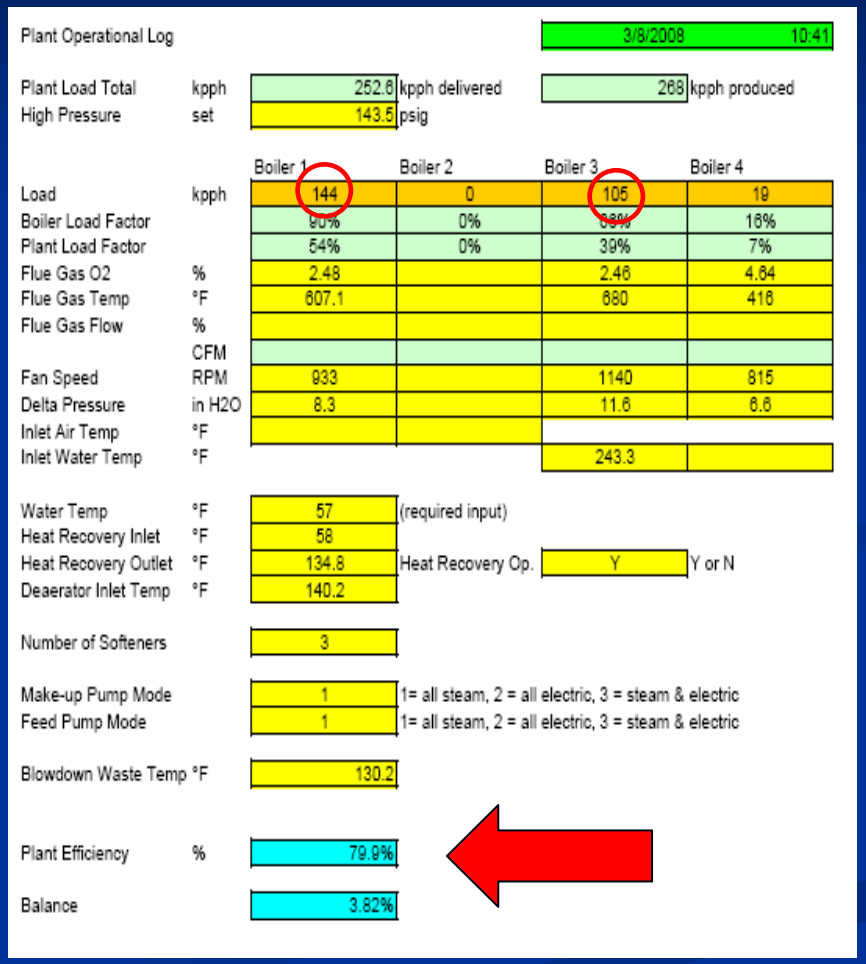
Plant Operational Log					3/8/2008	10:42
Plant Load Total	kpph	242.9	kpph delivered	268	kpph produced	
High Pressure	set	143.5	psig			

		Boiler 1	Boiler 2	Boiler 3	Boiler 4
Load	kpph	105	0	144	19
Boiler Load Factor		66%	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

$\dot{\eta} = 74.8\%$



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%	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	%	79.9%			
Balance		3.82%			

Case 2 – documented

$\dot{\eta} = 79.9\%$

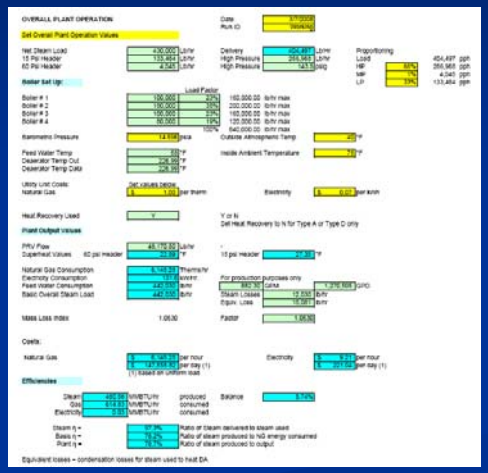
TRAINING TOOL

Plant Operational Log

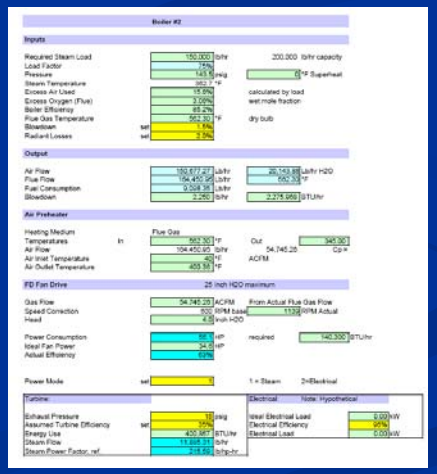
				3/7/2008	10:35
Plant Load Total	kpph	404.5	kpph delivered	430	kpph produced
High Pressure	set	143.5	psig		

		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%			



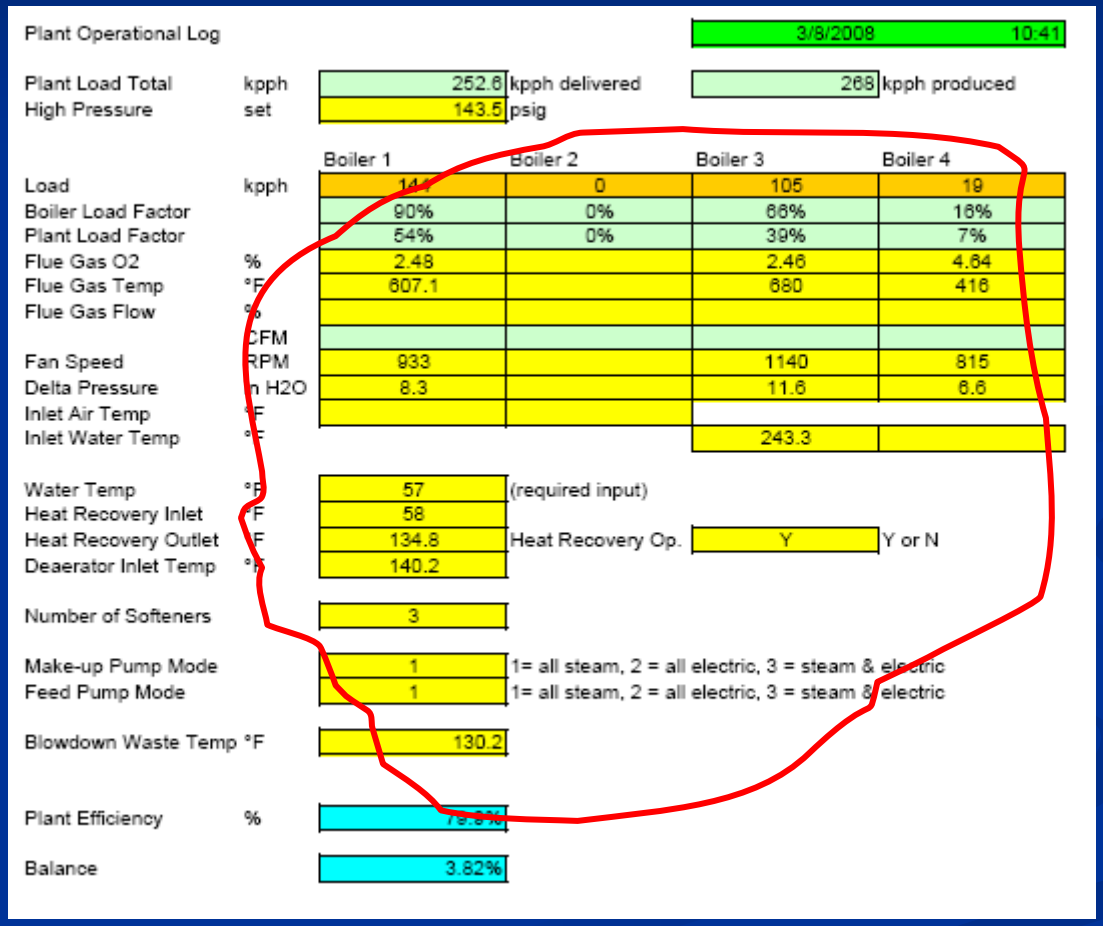
Overall



Specific Component

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

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
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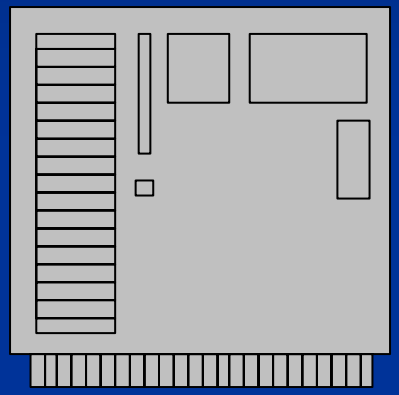
Flue Gas Temp	°F	607.1		680	416
Flue Gas Flow	%				
	CFM				
Fan Speed	RPM	933		1140	815
Delta Pressure	in H2O	8.3		11.6	6.6
Inlet Air Temp	°F				
Inlet Water Temp	°F			243.3	

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%			

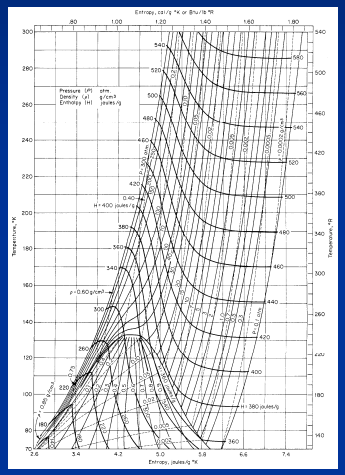
VEA

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

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)

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