

Main equipment average steady state, required and selected capacity levels

Project Name Case B
Client name LUT Calculation
Location Northern Europe

Target annual production	t/a	1100000	
Target operating days	days	350	
Required average production	ADt/24h	3143	
Design mill capacity	ADt/24h	3490	Overall efficiency 90 %

Fiberline		Balance output	Design Average/D	Calculated design	Selected design
Woodroom	m3sub/d	27433	80%	34291	34300
Digester	ADt/d	3311	90%	3679	3680
Oxygendelignification	ADt/d	3189	90%	3543	3540
Screening	ADt/d	3311	90%	3679	3680
Pulpwashing	ADt/d	3311	90%	3679	3680
Bleaching	ADt/d	3143	90%	3492	3490
Pulpdryer	ADt/d	3143	90%	3492	3490

Recovery					
Evaporation	t H2O/h	1030	90%	1144	1140
- evaporation spill capacity	%		0%		
Recovery boiler	tDS/d	5038	95%	5303	5300
Causticizing	m3WL/d	11675	90%	12973	12970
Lime kiln	t lime/d	972	90%	1080	1080
CTO-prod	t/h		90%	0	0
CNCG-handling	m3/h	1800	90%	2000	2000
DNCG-handling	m3/s	28	90%	31	30

Chemicals					
Chlorine Dioxide	tClO2/24h	113	80%	141	140
Peroxide	tH2O2/24h	31	80%	39	40
Oxygen	tO2/24h	182	80%	227	230
Caustic	tNaOH/24h	88	50%	176	180
Sulphuric acid	tH2SO4/24h	57	50%	113	110

Water and effluent					
Water treatment	m3/d	78257	50%	156514	156500
Effluent treatment	m3/d	65686	50%	131371	131400
Demineralized water	m3/d	1786	50%	3572	3600
Condensate treatment	m3/d	10724	50%	21448	21400

Power generation					
Power boiler	kg/s	88	90%	98	100
Turbogenerator	MW	259	90%	287	290

Case		Joutseno	Kymi	Yonago	SoTu	SkyRec	SkyRec+
		A	B	C	D	E	F
Steam usage							
MP3	kg/s	6.0	6.0	6.0	6.0	8.0	8.0
MP2	kg/s	0.3	0.3	8.5	8.5	8.5	8.5
MP	kg/s	36.8	37.0	37.0	36.9	37.0	37.0
LP	kg/s	115.8	118.3	118.3	118.2	118.3	122.0
LP2	kg/s	0.0	0.0	0.0	0.0	0.0	0.0
LP3	kg/s	0.0	0.0	0.0	0.0	0.0	0.0
Heat	MW	390.1	396.4	417.2	417.1	423.5	432.8
Steams							
Power Boiler	kg/s	84.9	87.9	87.9	87.2	87.9	87.9
Recovery Boiler	kg/s	215.1	226.3	233.6	232.0	224.2	218.6
Condensing tail	kg/s	-113.8	-109.7	-108.1	-105.1	-104.8	-92.6
Spraying	kg/s	1.4	2.0	1.9	1.0	8.5	5.1
To feedwater preheati	kg/s	-28.7	-45.1	-45.6	-45.4	-44.0	-43.6
Case No PB		Joutseno	Kymi	Yonago	SoTu	SkyRec	SkyRec+
		A	B	C	D	E	F
Steam usage							
MP3	kg/s	6.0	6.0	6.0	6.0	8.0	8.0
MP2	kg/s	0.3	0.3	8.5	8.5	8.5	8.5
MP	kg/s	35.2	35.3	35.3	35.3	35.3	35.3
LP	kg/s	112.1	114.4	114.4	114.4	114.4	118.1
LP2	kg/s	0.0	0.0	0.0	0.0	0.0	0.0
LP3	kg/s	0.0	0.0	0.0	0.0	0.0	0.0
Heat	MW	377.4	383.2	404.0	404.0	410.3	419.6
Steams							
Power Boiler	kg/s	0.0	0.0	0.0	0.0	0.0	0.0
Recovery Boiler	kg/s	215.1	226.3	233.6	232.0	224.2	219.0
Condensing tail	kg/s	-41.6	-39.1	-37.4	-34.9	-33.9	-22.2
Spraying	kg/s	1.4	1.9	1.9	0.8	8.2	4.9
To feedwater preheati	kg/s	-21.3	-33.2	-33.9	-33.7	-32.3	-31.9

MILL BALANCE OVERVIEW

Project Name	Case A
Client name	LUT Calculation
Location	Northern Europe

		Balance
Bleached Pulp production	ADt/a	1100000
Operating days		350
Average daily production	ADt/a	3143

1.0 COOKING AND BLEACHING

Bleached Pulp production	ADt/a	1100000
Bleached Pulp production	BDt/a	990000
Pulp moisture	BDt/ADt	90 %
Bleached Pulp Production	BDt/d	2829
	ADt/d	3143
Shrinkage from unbleached to dried pulp	%	3.20 %
Unbleached pulp	ADt/d	1417
Oxygen delignification shrinkage	%	3.0
Screened brown stock	ADt/d	3237
Screening and knotting losses	%	4.5
Unscreened brown stock	ADt/d	3311
Unscreened brown stock	BDt/d	2980
Cooking yield	%	98
Kappa after cooking		30
Kappa after oxygen delignification		12.21428571
Chips to digester	BDt/d	6063
Chips to digester	BDt/a	1066911
Loss in drying machine	%	0.20
Bleached plant yield loss	%	3.00

2.0 WOOD HANDLING**2.1 Wood processing**

Wood species		Softwood
	log length m	2...4
	log diameter cm	10...40
Wood moisture	%	50
Bark content average	%	12
Chips to digester	BDt/d	12220
Days of operation	d/a	350
Annual chip requirement	BDt/a	2122197
Fines	%	2
Fines removed at screening	BDt/a	43310
Chips to screening	BDt/a	2165507
Debris at debarking	%	4
Bark and debris at debarking	BDt/a	400213
Logs to barking drum	BDt/a	2565720
Logs to woodroom	BDt/a	2565720
Woodyard wood intake	BDt/d	14744
Wood density	BDkg/m3sob	451
Woodyard wood intake	m3sob/d	33169
Wood consumption /ADt	m3sob/ADt	5.28
Design factor	%	75 %
Woodyard wood intake, design	m3sob/d	44225
Woodyard wood intake, design	m3sob/h	2764
Chip weight	kgBD/m3l	154
Wood loose/solid	m3l/m3s	3
Woodyard chipping	m3sub/d	27433
Chip storage time	days	14
Chip storage volume	m3	1119000
Wood handling operating time	d/week	7
Wood handling operating time	h/d	16

2.2 Hog fuel processing

Bark and debris at debarking	BDt/a	400213
Fines removed at screening	BDt/a	43310
Losses in the woodyard	%	3
Losses in the woodyard	BDt/a	12006
TOTAL to bark handling	BDt/a	455530
	BDt/d	2592
Bark density	kgBD/m3l	223
Bark volume	m3l/d	15515
Storage time	days	4
Storage volume	m3	62060

3.0 WHITE LIQUOR REQUIREMENTS**3.1 Cooking**

Active alkali charge, as Na ₂ O	%	19 %
Active alkali charge, as NaOH	%	24 %
Chips to digester	BDt/d	6063
Active alkali charge as Na ₂ O	BDt/d	1144
Active alkali charge, as NaOH	BDt/d	1477
Caustic in oxidized white liquor	kg/m ³	133
White liquor flow to cooking plant	m ³ /d	11063
Real chemicals in white liquor	kg/m ³	172
White liquor solids to digester	BDt/d	1910

3.2 Oxygen delignification

Caustic charge	kg NaOH/ADt	19
Oxygen charge	kg O ₂ /ADt	24
Caustic in oxidized white liquor	kg/m ³	99
White liquor flow	m ³ /d	612
Real chemicals in oxidized white liquor	kg/m ³	202
Oxidized white liquor solids to O ₂ reactor	BDt/d	124

3.3 Total white liquor required

White liquor to cooking plant	m ³ /d	0
Oxidized white liquor to ox delignification	m ³ /d	612
Oxidized white liquor to bleaching plant	m ³ /d	0
Oxidized white liquor total	m ³ /d	612
TOTAL	m ³ /d	11675

4.0 BLACK LIQUOR CALCULATION

4.1 Cooking

Chips to digester	BDt/d	0
Cooking yield	%	49
Blown stock	BDt/d	2980
Organic solids generated	BDt/d	3084
White liquor solids to digester	BDt/d	1910
Water loss, as % of inorganic	%	6 %
Water loss	BDt/d	115
White liquor solids to black liquor	BDt/d	1795
Total solids to black liquor	BDt/d	4812

4.2 Oxygen delignification

Pulp to reactor	BDt/d	0
Oxygenated pulp	BDt/d	2889
Organic solids to black liquor	BDt/d	57
Oxidized white liquor solids to O2 reactor	BDt/d	124
Total solids to black liquor	BDt/d	222

4.3 Total solids in Black Liquor

Total solids to black liquor	BDt/d	0
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5.0 BLEACHING CHEMICALS PREPARATION**5.1 Bleaching requirement**

Delignification stage	Kappa in	14
	kappa out	9
O2 delinification stage	kg/ADt	24
Chemical charge DED bleaching	at kappa	8.5
ClO2	kg/ADt	47
NaOH	kg/ADt	14
O2	kg/ADt	4
HCl	kg/ADt	0
hydrogenperoxide, H2O2	kg/ADt	5
NaHSO3	kg/ADt	2
Antichlor as SO2	kg/ADt	0
H2SO4	kg/ADt	9
MgSO4	kg/ADt	0
Talc	kg/ADt	0
Oxidized white liquor to bleaching plant	m3/d	0

5.2 Bleaching chemicals demand

Oxygen for ox delignif and bleaching	BDt/d	182
Oxygen for white liquor oxidation	BDt/d	0
Oxygen total	BDt/d	182
ClO2	BDt/d	113
HCl	BDt/d	0
NaOH for bleaching	BDt/d	88
NaOH for scrubber	BDt/d	0
NaOH required total	BDt/d	88
NaOH produced in balance	BDt/d	139
NaOH in imbalance	BDt/d	-51
NaHSO3	t/d	13
antichlor as SO2	BDt/d	0
H2SO4	t/d	57
MgSO4	t/d	0
Talc	BDt/d	0
hydrogenperoxide	BDt/d	31

Balance report

6.0 RECAUSTICIZING PLANT

Flow of white liquor	m3/d	11675
Sulfidity	%	36 %
Reduction	%	95 %
Causticizing efficiency	%	80 %
Active alkali in white liquor	g/l	135

7.0 LIME REBURNING PLANT

Causticizing power of burnt lime	%	80 %
Kiln product	t/d	972
Burnt lime for waste water neutralization	t/d	0
Kiln product total	t/d	972

8.0 EVAPORATION PLANT

Black liquor dry solids	BDt/d	5038
Weak black liquor conc	%	17 %
Strong black liquor concentration	%	80 %
As fired black liquor concentration	%	82 %
Evaporation capacity	t/h	1023
Spills	t/h	0
Evaporation capacity total	t/h	1023
Total solids to as fired black liquor	tDS/d	5491
Total as fired black liquor	tBL/d	6735
Steam economy with stripper	kg/kg	5.86
MP steam usage	%	19 %
MP Steam requirement	kg/s	9
LP Steam requirement	kg/s	39
Stripper TRS removal efficiency	%	95 %
Stripper methanol removal efficiency	%	90 %

9.0 RECOVERY BOILER

Black liquor solids capacity, as fired	BDt/d	5491
Black liquor solids capacity, virgin	BDt/d	5038
Strong black liquor concentration	%	82 %

Elemental analysis:

Sodium	%	18.7 %
Hydrogen	%	3.6 %
Carbon	%	35.6 %
Oxygen	%	35.1 %
Sulfur	%	4.5 %
Potassium	%	2.0 %
Chloride	%	0.4 %
Nitrogen	%	0.1 %
Silica	%	0.021 %
Aluminium	%	0.002 %
Total inert	%	0.1 %
TOTAL		100 %

Higher heat value	MJ/kgDS	13.60
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Superheated steam

Temperature	C	492
Pressure	bar(a)	94
Steam generation	kg/s/kgDS/s	3.71
Net steam flow	t/h	774
	kg/s	215

Balance report

10.0 POWER BOILER

Continuous rating with hog fuel	t/h	305.6
	kg/s	84.9
Maximum continuous rating with fuel oil	t/h	
	kg/s	

Hog fuel

Hog fuel available	BDt/d	1301.5
Hog fuel steam generation	t steam/h/BDt/h	0.235

11.0 TURBINE GENERATOR

Total power generation	MW	234.44
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12.0 FRESH WATER HANDLING

Design flow	m3/d	150495
	m3/ADt	48
	m3/d	65686
Balance	m3/ADt	21

13.0 WASTE WATER TREATMENT

	m3/ADt	
Effluent from Bleached Plant	14.5	45571
Effluent from Woodhandling	2.9	9114
Pulp Dryer	1	3143
Miscellaneous	6.5	20429
TOTAL	24.9	78257
Balance	m3/ADt	25
Design factor	%	52 %
Waste water treatment, Design	m3/d	150495
	m3/ADt	48

Mill electricity usage and production

Project Name Case A
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1023	1140	94.3	99.7	4.25
Recovery Boiler	tDS/d	5038	5300	43	44	9.30
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					669	87.59
Power Boiler	kg/s	85	120	1000	1207	4.27
Turbine	MW	234	260	30	32	0.31
CIO2 production	tCIO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					729	95.52

Electricity production

Condensing turbine	kg/s	300	300	19315	18757	234.38
Back pressure turbine	kg/s	0	150	14214	14659	0.06
Electricity production total					1790	234.44

Mill steam usage and production

Project Name Case A
 Client name LUT Calculation
 Location Northern Europe

Pulp production
 Softwood 480000 ADt/a
 Hardwood 620000 ADt/a

3142.857

STEAM CONSUMPTION

Department	Unit	Balance	Heat MJ/unit	MJ/ADt	Steam	MP3 kg/s	MP kg/s	LP kg/s	LP2 kg/s	LP3 kg/s	MW	Condensate kg/s	MW
Woodhandling	m3sub/d	27433	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking & O2	ADt/d	3311	2010	2117		0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1
Bleaching	ADt/d	3143	580	580		0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9
Drying	ADt/d	3143	2578	2578		0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2
Evaporation	t H2O/h	1023	117	3278		0.0	9.2	39.3	0.0	0.0	119.2	44.6	14.7
Recovery Boiler	tDS/d	5038	593	951		6.0	4.0	2.3	0.0	0.0	34.6	5.5	1.4
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2
Lime reburning	t lime/d	972	198	61		0.0	0.0	0.6	0.0	0.0	2.2	0.5	0.2
Raw water	m3/d	78257	1	25		0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
NCG	m3/h	45833	10	146				1.8			5.3	5.8	1.1
Auxiliary condenser	ADt/d	3143	10	10				0.1			0.4	0.0	0.0
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1
Pulping steam usage total				10221		6.0	35.0	105.0	0.0	0.0	371.8	122.5	35.1
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8
Power Boiler	kg/s	85	13000	351		0.0	1.6	3.7	0.0	0.0	12.8	5.1	1.9
Steam for heating water								5.0				5.0	
						6.0	36.8	115.8	0.0	0.0			
Pulp mill steam usage total				10725				158.9				134.7	37.7

STEAM PRODUCTION

		Balance	Steam	Heat production		Steam
			kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	85	1.00	2.86	6669	84.9
Recovery Boiler	kgDS/s	58	3.69	10.54	8463	215.1
Condensing tail	kg/s					-113.8
Spraying	kg/s					1.4
To feedwater preheating	kg/s					-28.7
Steam to consumers						158.9

Mill electricity usage and production

Project Name Case A - No PB
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1023	1140	94.3	99.7	4.25
Recovery Boiler	tDS/d	5038	5300	43	44	9.30
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					669	87.59
Power Boiler	kg/s	0	120	1000	0	0.00
Turbine	MW	149	170	30	32	0.20
CIO2 production	tCIO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					696	91.14

Electricity production

Condensing turbine	kg/s	215	220	17378	16661	149.27
Back pressure turbine	kg/s	0	150	14214	14659	0.06
Electricity production total					1140	149.33

Mill steam usage and production

Project Name Case A - No PB
Client name LUT Calculation
Location Northern Europe

Pulp production
Softwood 480000 ADt/a
Hardwood 620000 ADt/a

3142.857

STEAM CONSUMPTION

Department	Unit	Balance	Heat		Steam							Condensate	
			MJ/unit	MJ/ADt		MP3	MP	LP	LP2	LP3	MW	kg/s	MW
						kg/s	kg/s	kg/s	kg/s	kg/s			
Woodhandling	m3sub/d	27433	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking & O2	ADt/d	3311	2010	2117		0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1
Bleaching	ADt/d	3143	580	580		0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9
Drying	ADt/d	3143	2578	2578		0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2
Evaporation	t H2O/h	1023	117	3278		0.0	9.2	39.3	0.0	0.0	119.2	44.6	14.7
Recovery Boiler	tDS/d	5038	593	951		6.0	4.0	2.3	0.0	0.0	34.6	5.5	1.4
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2
Lime reburning	t lime/d	972	198	61		0.0	0.0	0.6	0.0	0.0	2.2	0.5	0.2
Raw water	m3/d	78257	1	25		0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
NCG	m3/h	45833	10	146				1.8			5.3	5.8	1.1
Auxiliary condenser	ADt/d	3143	10	10				0.1			0.4	0.0	0.0
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1
Pulping steam usage total				10221		6.0	35.0	105.0	0.0	0.0	371.8	122.5	35.1
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8
Power Boiler	kg/s	0	13000	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Steam for heating water								5.0				5.0	
						6.0	35.2	112.1	0.0	0.0			
								153.6				129.5	35.8
Pulp mill steam usage total				10374									

STEAM PRODUCTION

		Balance	Steam	Heat production		Steam
			kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	0	1.00	2.86	0	0.0
Recovery Boiler	kgDS/s	58	3.69	10.54	8463	215.1
Condensing tail	kg/s					-41.6
Spraying	kg/s					1.4
To feedwater preheating	kg/s					-21.3
Steam to consumers						153.6

MILL BALANCE OVERVIEW

Project Name	Case B
Client name	LUT Calculation
Location	Northern Europe

		Balance
Bleached Pulp production	ADt/a	1100000
Operating days		350
Average daily production	ADt/a	3143

1.0 COOKING AND BLEACHING

Bleached Pulp production	ADt/a	1100000
Bleached Pulp production	BDt/a	990000
Pulp moisture	BDt/ADt	90 %
Bleached Pulp Production	BDt/d	2829
	ADt/d	3143
Shrinkage from unbleached to dried pulp	%	3.20 %
Unbleached pulp	ADt/d	1417
Oxygen delignification shrinkage	%	3.0
Screened brown stock	ADt/d	3237
Screening and knotting losses	%	4.5
Unscreened brown stock	ADt/d	3311
Unscreened brown stock	BDt/d	2980
Cooking yield	%	98
Kappa after cooking		30
Kappa after oxygen delignification		12
Chips to digester	BDt/d	6063
Chips to digester	BDt/a	1066911
Loss in drying machine	%	0.20
Bleached plant yield loss	%	3.00

2.0 WOOD HANDLING**2.1 Wood processing**

Wood species		Softwood
	log length m	2...4
	log diameter cm	10...40
Wood moisture	%	50
Bark content average	%	12
Chips to digester	BDt/d	12220
Days of operation	d/a	350
Annual chip requirement	BDt/a	2122197
Fines	%	2
Fines removed at screening	BDt/a	43310
Chips to screening	BDt/a	2165507
Debris at debarking	%	4
Bark and debris at debarking	BDt/a	400213
Logs to barking drum	BDt/a	2565720
Logs to woodroom	BDt/a	2565720
Woodyard wood intake	BDt/d	14744
Wood density	BDkg/m3sob	451
Woodyard wood intake	m3sob/d	33169
Wood consumption /ADt	m3sob/ADt	5.28
Design factor	%	75 %
Woodyard wood intake, design	m3sob/d	44225
Woodyard wood intake, design	m3sob/h	2764
Chip weight	kgBD/m3l	154
Wood loose/solid	m3l/m3s	3
Woodyard chipping	m3sub/d	27433
Chip storage time	days	14
Chip storage volume	m3	1119000
Wood handling operating time	d/week	7
Wood handling operating time	h/d	16

2.2 Hog fuel processing

Bark and debris at debarking	BDt/a	400213
Fines removed at screening	BDt/a	43310
Losses in the woodyard	%	3
Losses in the woodyard	BDt/a	12006
TOTAL to bark handling	BDt/a	455530
	BDt/d	2592
Bark density	kgBD/m3l	223
Bark volume	m3l/d	15515
Storage time	days	4
Storage volume	m3	62060

3.0 WHITE LIQUOR REQUIREMENTS

3.1 Cooking

Active alkali charge, as Na ₂ O	%	19 %
Active alkali charge, as NaOH	%	24 %
Chips to digester	BDt/d	6063
Active alkali charge as Na ₂ O	BDt/d	1144
Active alkali charge, as NaOH	BDt/d	1477
Caustic in oxidized white liquor	kg/m ³	133
White liquor flow to cooking plant	m ³ /d	11063
Real chemicals in white liquor	kg/m ³	172
White liquor solids to digester	BDt/d	1910

3.2 Oxygen delignification

Caustic charge	kg NaOH/ADt	19
Oxygen charge	kg O ₂ /ADt	24
Caustic in oxidized white liquor	kg/m ³	99
White liquor flow	m ³ /d	612
Real chemicals in oxidized white liquor	kg/m ³	202
Oxidized white liquor solids to O ₂ reactor	BDt/d	124

3.3 Total white liquor required

White liquor to cooking plant	m ³ /d	0
Oxidized white liquor to ox delignification	m ³ /d	612
Oxidized white liquor to bleaching plant	m ³ /d	0
Oxidized white liquor total	m ³ /d	612
TOTAL	m ³ /d	11675

4.0 BLACK LIQUOR CALCULATION

4.1 Cooking

Chips to digester	BDt/d	0
Cooking yield	%	49
Blown stock	BDt/d	2980
Organic solids generated	BDt/d	3084
White liquor solids to digester	BDt/d	1910
Water loss, as % of inorganic	%	6 %
Water loss	BDt/d	115
White liquor solids to black liquor	BDt/d	1795
Total solids to black liquor	BDt/d	4812

4.2 Oxygen delignification

Pulp to reactor	BDt/d	0
Oxygenated pulp	BDt/d	2889
Organic solids to black liquor	BDt/d	57
Oxidized white liquor solids to O2 reactor	BDt/d	124
Total solids to black liquor	BDt/d	222

4.3 Total solids in Black Liquor

Total solids to black liquor	BDt/d	0
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5.0 BLEACHING CHEMICALS PREPARATION**5.1 Bleaching requirement**

Delignification stage	Kappa in	14
	kappa out	9
O2 delignification stage	kg/ADt	24
Chemical charge DED bleaching	at kappa	8.5
ClO ₂	kg/ADt	47
NaOH	kg/ADt	14
O ₂	kg/ADt	4
HCl	kg/ADt	0
hydrogenperoxide, H ₂ O ₂	kg/ADt	5
NaHSO ₃	kg/ADt	2
Antichlor as SO ₂	kg/ADt	0
H ₂ SO ₄	kg/ADt	9
MgSO ₄	kg/ADt	0
Talc	kg/ADt	0
Oxidized white liquor to bleaching plant	m ³ /d	0

5.2 Bleaching chemicals demand

Oxygen for ox delignif and bleaching	BDt/d	182
Oxygen for white liquor oxidation	BDt/d	0
Oxygen total	BDt/d	182
ClO ₂	BDt/d	113
HCl	BDt/d	0
NaOH for bleaching	BDt/d	88
NaOH for scrubber	BDt/d	0
NaOH required total	BDt/d	88
NaOH produced in balance	BDt/d	139
NaOH in imbalance	BDt/d	-51
NaHSO ₃	t/d	13
antichlor as SO ₂	BDt/d	0
H ₂ SO ₄	t/d	57
MgSO ₄	t/d	0
Talc	BDt/d	0
hydrogenperoxide	BDt/d	31

Balance report

6.0 RECAUSTICIZING PLANT

Flow of white liquor	m3/d	11675
Sulfidity	%	36 %
Reduction	%	95 %
Causticizing efficiency	%	80 %
Active alkali in white liquor	g/l	135

7.0 LIME REBURNING PLANT

Causticizing power of burnt lime	%	80 %
Kiln product	t/d	972
Burnt lime for waste water neutralization	t/d	0
Kiln product total	t/d	972

8.0 EVAPORATION PLANT

Black liquor dry solids	BDt/d	5038
Weak black liquor conc	%	17 %
Strong black liquor concentration	%	84 %
As fired black liquor concentration	%	85 %
Evaporation capacity	t/h	1034
Spills	t/h	0
Evaporation capacity total	t/h	1034
Total solids to as fired black liquor	tDS/d	5491
Total as fired black liquor	tBL/d	6472
Steam economy with stripper	kg/kg	5.86
MP steam usage	%	19 %
MP Steam requirement	kg/s	9
LP Steam requirement	kg/s	40
Stripper TRS removal efficiency	%	95 %
Stripper methanol removal efficiency	%	90 %

Balance report

9.0 RECOVERY BOILER

Black liquor solids capacity, as fired	BDt/d	5491
Black liquor solids capacity, virgin	BDt/d	5038
Strong black liquor concentration	%	85 %
Elemental analysis:		
Sodium	%	18.7 %
Hydrogen	%	3.6 %
Carbon	%	35.6 %
Oxygen	%	35.1 %
Sulfur	%	4.5 %
Potassium	%	2.0 %
Chloride	%	0.4 %
Nitrogen	%	0.1 %
Silica	%	0.021 %
Aluminium	%	0.002 %
Total inert	%	0.1 %
TOTAL		100 %
Higher heat value	MJ/kgDS	13.70
Superheated steam		
Temperature	C	505
Pressure	bar(a)	163
Steam generation	kg/s/kgDS/s	3.93
Net steam flow	t/h	815
	kg/s	226

Balance report

10.0 POWER BOILER

Continuous rating with hog fuel	t/h	316.6
	kg/s	87.9
Maximum continuous rating with fuel oil	t/h	
	kg/s	

Hog fuel

Hog fuel available	BDt/d	1301.5
Hog fuel steam generation	t steam/h/BDt/h	0.243

11.0 TURBINE GENERATOR

Total power generation	MW	252.92
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12.0 FRESH WATER HANDLING

Design flow	m3/d	150495
	m3/ADt	48
	m3/d	65686
Balance	m3/ADt	21

13.0 WASTE WATER TREATMENT

	m3/ADt	
Effluent from Bleached Plant	14.5	45571
Effluent from Woodhandling	2.9	9114
Pulp Dryer	1	3143
Miscellaneous	6.5	20429
TOTAL	24.9	78257
Balance	m3/ADt	25
Design factor	%	52 %
Waste water treatment, Design	m3/d	150495
	m3/ADt	48

Mill electricity usage and production

Project Name Case B
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1034	1150	94.3	99.6	4.29
Recovery Boiler	tDS/d	5038	5300	46	47	9.82
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					673	88.15
Power Boiler	kg/s	88	120	1000	1182	4.33
Turbine	MW	239	270	30	32	0.32
CLO2 production	tClO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					734	96.15

Electricity production

Condensing turbine	kg/s	226	240	15668	15508	146.27
Condensing turbine	kg/s	88	100	25444	25455	93.23
Electricity production total					1829	239.50

Mill steam usage and production

Project Name Case B
Client name LUT Calculation
Location Northern Europe

Pulp production
Softwood 480000 ADt/a
Hardwood 620000 ADt/a

STEAM CONSUMPTION

Department	Unit	Balance	Heat		Steam									Condensate	
			MJ/unit	MJ/ADt		MP3	MP2	MP	LP	LP2	LP3	MW	kg/s	MW	
						kg/s	kg/s	kg/s	kg/s	kg/s	kg/s				
Woodhandling	m3sub/d	27433	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Cooking & O2	ADt/d	3311	2010	2117		0.0	0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1	
Bleaching	ADt/d	3143	580	580		0.0	0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9	
Drying	ADt/d	3143	2578	2578		0.0	0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2	
Evaporation	t H2O/h	1034	127	3597		0.0	0.0	9.3	43.9	0.0	0.0	130.8	48.9	16.1	
Recovery Boiler	tDS/d	5038	493	790		6.0	0.0	4.0	0.0	0.0	0.0	28.7	3.4	0.9	
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2	
Lime reburning	t lime/d	972	198	61		0.0	0.3	0.0	0.6	0.0	0.0	2.2	0.5	0.2	
Raw water	m3/d	78257	1	25		0.0	0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1	
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	
NCG	m3/h	45833	10	146					1.8			5.3	5.8	1.1	
Auxiliary condenser	ADt/d	3143	10	10					0.1			0.4	0.0	0.0	
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1	
Pulping steam usage total					10380	6.0	0.3	35.1	107.3	0.0	0.0	377.6	124.8	35.9	
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8	
Power Boiler	kg/s	88	13000	364		0.0	0.0	1.7	3.8	0.0	0.0	13.2	5.3	2.0	
Steam for heating water									5.0				5.0		
						6.0	0.3	37.0	118.3	0.0	0.0				
Pulp mill steam usage total					10897				161.5				137.1	38.7	

STEAM PRODUCTION

	Balance	Steam	Heat production		Steam
		kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	88	1.00	2.76	87.9
Recovery Boiler	kgDS/s	58	3.88	6669	226.3
Condensing tail	kg/s			10.71	-109.7
Spraying	kg/s				2.0
To feedwater preheating	kg/s				-45.1
Steam to consumers					161.5

Mill electricity usage and production

Project Name Case B No PB
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1034	1150	94.3	99.6	4.29
Recovery Boiler	tDS/d	5038	5300	46	47	9.82
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					673	88.15
Power Boiler	kg/s	0	120	1000	0	0.00
Turbine	MW	154	170	30	32	0.20
CLO2 production	tClO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					700	91.70

Electricity production

Condensing turbine	kg/s	226	220	16693	16310	153.75
Condensing turbine	kg/s	0	100	25442	25467	0.11
Electricity production total					1175	153.86

Mill steam usage and production

Project Name Case B No PB
Client name LUT Calculation
Location Northern Europe

Pulp production
Softwood 480000 ADt/a
Hardwood 620000 ADt/a

STEAM CONSUMPTION

Department	Unit	Balance	Heat		Steam							Condensate	
			MJ/unit	MJ/ADt		MP3	MP	LP	LP2	LP3	MW	kg/s	MW
						kg/s	kg/s	kg/s	kg/s	kg/s			
Woodhandling	m3sub/d	27433	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking & O2	ADt/d	3311	2010	2117		0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1
Bleaching	ADt/d	3143	580	580		0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9
Drying	ADt/d	3143	2578	2578		0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2
Evaporation	t H2O/h	1034	127	3597		0.0	9.3	43.9	0.0	0.0	130.8	48.9	16.1
Recovery Boiler	tDS/d	5038	493	790		6.0	4.0	0.0	0.0	0.0	28.7	3.4	0.9
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2
Lime reburning	t lime/d	972	198	61		0.0	0.0	0.6	0.0	0.0	2.2	0.5	0.2
Raw water	m3/d	78257	1	25		0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
NCG	m3/h	45833	10	146				1.8			5.3	5.8	1.1
Auxiliary condenser	ADt/d	3143	10	10				0.1			0.4	0.0	0.0
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1
Pulping steam usage total				10380		6.0	35.1	107.3	0.0	0.0	377.6	124.8	35.9
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8
Power Boiler	kg/s	0	13000	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Steam for heating water								5.0				5.0	
						6.0	35.3	114.4	0.0	0.0			
Pulp mill steam usage total								156.0				131.8	36.7

STEAM PRODUCTION

		Balance	Steam	Heat production		Steam
			kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	0	1.00	2.76	0	0.0
Recovery Boiler	kgDS/s	58	3.88	10.71	8596	226.3
Condensing tail	kg/s					-39.1
Spraying	kg/s					1.9
To feedwater preheating	kg/s					-33.2
Steam to consumers						156.0

MILL BALANCE OVERVIEW

Project Name	Case C
Client name	LUT Calculation
Location	Northern Europe

		Balance
Bleached Pulp production	ADt/a	1100000
Operating days		350
Average daily production	ADt/a	3143

1.0 COOKING AND BLEACHING

Bleached Pulp production	ADt/a	1100000
Bleached Pulp production	BDt/a	990000
Pulp moisture	BDt/ADt	90 %
Bleached Pulp Production	BDt/d	2829
	ADt/d	3143
Shrinkage from unbleached to dried pulp	%	3.20 %
Unbleached pulp	ADt/d	1417
Oxygen delignification shrinkage	%	3.0
Screened brown stock	ADt/d	3237
Screening and knotting losses	%	4.5
Unscreened brown stock	ADt/d	3311
Unscreened brown stock	BDt/d	2980
Cooking yield	%	98
Kappa after cooking		30
Kappa after oxygen delignification		12
Chips to digester	BDt/d	6063
Chips to digester	BDt/a	1066911
Loss in drying machine	%	0.20
Bleached plant yield loss	%	3.00

2.0 WOOD HANDLING**2.1 Wood processing**

Wood species		Softwood
	log length m	2...4
	log diameter cm	10...40
Wood moisture	%	50
Bark content average	%	12
Chips to digester	BDt/d	12220
Days of operation	d/a	350
Annual chip requirement	BDt/a	2122197
Fines	%	2
Fines removed at screening	BDt/a	43310
Chips to screening	BDt/a	2165507
Debris at debarking	%	4
Bark and debris at debarking	BDt/a	400213
Logs to barking drum	BDt/a	2565720
Logs to woodroom	BDt/a	2565720
Woodyard wood intake	BDt/d	14744
Wood density	BDkg/m3sob	451
Woodyard wood intake	m3sob/d	33169
Wood consumption /ADt	m3sob/ADt	5.28
Design factor	%	75 %
Woodyard wood intake, design	m3sob/d	44225
Woodyard wood intake, design	m3sob/h	2764
Chip weight	kgBD/m3l	154
Wood loose/solid	m3l/m3s	3
Woodyard chipping	m3sub/d	27433
Chip storage time	days	14
Chip storage volume	m3	1119000
Wood handling operating time	d/week	7
Wood handling operating time	h/d	16

2.2 Hog fuel processing

Bark and debris at debarking	BDt/a	400213
Fines removed at screening	BDt/a	43310
Losses in the woodyard	%	3
Losses in the woodyard	BDt/a	12006
TOTAL to bark handling	BDt/a	455530
	BDt/d	2592
Bark density	kgBD/m3l	223
Bark volume	m3l/d	15515
Storage time	days	4
Storage volume	m3	62060

3.0 WHITE LIQUOR REQUIREMENTS

3.1 Cooking

Active alkali charge, as Na ₂ O	%	19 %
Active alkali charge, as NaOH	%	24 %
Chips to digester	BDt/d	6063
Active alkali charge as Na ₂ O	BDt/d	1144
Active alkali charge, as NaOH	BDt/d	1477
Caustic in oxidized white liquor	kg/m ³	133
White liquor flow to cooking plant	m ³ /d	11063
Real chemicals in white liquor	kg/m ³	172
White liquor solids to digester	BDt/d	1910

3.2 Oxygen delignification

Caustic charge	kg NaOH/ADt	19
Oxygen charge	kg O ₂ /ADt	24
Caustic in oxidized white liquor	kg/m ³	99
White liquor flow	m ³ /d	612
Real chemicals in oxidized white liquor	kg/m ³	202
Oxidized white liquor solids to O ₂ reactor	BDt/d	124

3.3 Total white liquor required

White liquor to cooking plant	m ³ /d	0
Oxidized white liquor to ox delignification	m ³ /d	612
Oxidized white liquor to bleaching plant	m ³ /d	0
Oxidized white liquor total	m ³ /d	612
TOTAL	m ³ /d	11675

4.0 BLACK LIQUOR CALCULATION

4.1 Cooking

Chips to digester	BDt/d	0
Cooking yield	%	49
Blown stock	BDt/d	2980
Organic solids generated	BDt/d	3084
White liquor solids to digester	BDt/d	1910
Water loss, as % of inorganic	%	6 %
Water loss	BDt/d	115
White liquor solids to black liquor	BDt/d	1795
Total solids to black liquor	BDt/d	4812

4.2 Oxygen delignification

Pulp to reactor	BDt/d	0
Oxygenated pulp	BDt/d	2889
Organic solids to black liquor	BDt/d	57
Oxidized white liquor solids to O2 reactor	BDt/d	124
Total solids to black liquor	BDt/d	222

4.3 Total solids in Black Liquor

Total solids to black liquor	BDt/d	0
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5.0 BLEACHING CHEMICALS PREPARATION**5.1 Bleaching requirement**

Delignification stage	Kappa in	14
	kappa out	9
O2 delignification stage	kg/ADt	24
Chemical charge DED bleaching	at kappa	8.5
ClO ₂	kg/ADt	47
NaOH	kg/ADt	14
O ₂	kg/ADt	4
HCl	kg/ADt	0
hydrogenperoxide, H ₂ O ₂	kg/ADt	5
NaHSO ₃	kg/ADt	2
Antichlor as SO ₂	kg/ADt	0
H ₂ SO ₄	kg/ADt	9
MgSO ₄	kg/ADt	0
Talc	kg/ADt	0
Oxidized white liquor to bleaching plant	m ³ /d	0

5.2 Bleaching chemicals demand

Oxygen for ox delignif and bleaching	BDt/d	182
Oxygen for white liquor oxidation	BDt/d	0
Oxygen total	BDt/d	182
ClO ₂	BDt/d	113
HCl	BDt/d	0
NaOH for bleaching	BDt/d	88
NaOH for scrubber	BDt/d	0
NaOH required total	BDt/d	88
NaOH produced in balance	BDt/d	139
NaOH in imbalance	BDt/d	-51
NaHSO ₃	t/d	13
antichlor as SO ₂	BDt/d	0
H ₂ SO ₄	t/d	57
MgSO ₄	t/d	0
Talc	BDt/d	0
hydrogenperoxide	BDt/d	31

6.0 RECAUSTICIZING PLANT

Flow of white liquor	m ³ /d	11675
Sulfidity	%	36 %
Reduction	%	95 %
Causticizing efficiency	%	80 %
Active alkali in white liquor	g/l	135

7.0 LIME REBURNING PLANT

Causticizing power of burnt lime	%	80 %
Kiln product	t/d	972
Burnt lime for waste water neutralization	t/d	0
Kiln product total	t/d	972

8.0 EVAPORATION PLANT

Black liquor dry solids	BDt/d	5038
Weak black liquor conc	%	17 %
Strong black liquor concentration	%	84 %
As fired black liquor concentration	%	85 %
Evaporation capacity	t/h	1034
Spills	t/h	0
Evaporation capacity total	t/h	1034
Total solids to as fired black liquor	tDS/d	5491
Total as fired black liquor	tBL/d	6472
Steam economy with stripper	kg/kg	5.86
MP steam usage	%	19 %
MP Steam requirement	kg/s	9
LP Steam requirement	kg/s	40
Stripper TRS removal efficiency	%	95 %
Stripper methanol removal efficiency	%	90 %

Balance report

9.0 RECOVERY BOILER

Black liquor solids capacity, as fired	BDt/d	5491
Black liquor solids capacity, virgin	BDt/d	5038
Strong black liquor concentration	%	85 %
Elemental analysis:		
Sodium	%	18.7 %
Hydrogen	%	3.6 %
Carbon	%	35.6 %
Oxygen	%	35.1 %
Sulfur	%	4.5 %
Potassium	%	2.0 %
Chloride	%	0.4 %
Nitrogen	%	0.1 %
Silica	%	0.021 %
Aluminium	%	0.002 %
Total inert	%	0.1 %
TOTAL		100 %
Higher heat value	MJ/kgDS	14.00
Superheated steam		
Temperature	C	515
Pressure	bar(a)	124
Steam generation	kg/s/kgDS/s	4.07
Net steam flow	t/h	841
	kg/s	234

Balance report

10.0 POWER BOILER

Continuous rating with hog fuel	t/h	316.3
	kg/s	87.9
Maximum continuous rating with fuel oil	t/h	
	kg/s	

Hog fuel

Hog fuel available	BDt/d	1301.5
Hog fuel steam generation	t steam/h/BDt/h	0.243

11.0 TURBINE GENERATOR

Total power generation	MW	249.83
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12.0 FRESH WATER HANDLING

Design flow	m3/d	150495
	m3/ADt	48
	m3/d	65686
Balance	m3/ADt	21

13.0 WASTE WATER TREATMENT

	m3/ADt	
Effluent from Bleached Plant	14.5	45571
Effluent from Woodhandling	2.9	9114
Pulp Dryer	1	3143
Miscellaneous	6.5	20429
TOTAL	24.9	78257
Balance	m3/ADt	25
Design factor	%	52 %
Waste water treatment, Design	m3/d	150495
	m3/ADt	48

Mill electricity usage and production

Project Name Case C
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1034	1150	94.3	99.6	4.29
Recovery Boiler	tDS/d	5038	5300	49	50	10.54
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					679	88.87
Power Boiler	kg/s	88	120	1000	1183	4.33
Turbine	MW	250	280	30	32	0.33
CLO2 production	tClO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					740	96.88

Electricity production

Condensing turbine	kg/s	235	240	16358	15946	155.97
Condensing turbine	kg/s	87	90	25960	25981	93.86
Electricity production total					1908	249.83

Mill steam usage and production

Project Name Case C
Client name LUT Calculation
Location Northern Europe

Pulp production
Softwood 480000 ADt/a
Hardwood 620000 ADt/a

STEAM CONSUMPTION

Department	Unit	Balance	Heat		Steam								Condensate	
			MJ/unit	MJ/ADt		MP3	MP2	MP	LP	LP2	LP3	MW	kg/s	MW
Woodhandling	m3sub/d	27433	0	0		kg/s	kg/s	kg/s	kg/s	kg/s	kg/s		kg/s	MW
Cooking & O2	ADt/d	3311	2010	2117		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bleaching	ADt/d	3143	580	580		0.0	0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1
Drying	ADt/d	3143	2578	2578		0.0	0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2
Evaporation	t H2O/h	1034	127	3597		0.0	0.0	9.3	43.9	0.0	0.0	130.8	48.9	16.1
Recovery Boiler	tDS/d	5038	851	1364		6.0	8.2	4.0	0.0	0.0	0.0	49.6	10.8	3.6
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2
Lime reburning	t lime/d	972	198	61		0.0	0.3	0.0	0.6	0.0	0.0	2.2	0.5	0.2
Raw water	m3/d	78257	1	25		0.0	0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
NCG	m3/h	45833	10	146					1.8			5.3	5.8	1.1
Auxiliary condenser	ADt/d	3143	10	10					0.1			0.4	0.0	0.0
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1
Pulping steam usage total				10954		6.0	8.5	35.1	107.3	0.0	0.0	398.5	132.2	38.7
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8
Power Boiler	kg/s	88	13000	363		0.0	0.0	1.7	3.8	0.0	0.0	13.2	5.3	2.0
Steam for heating water									5.0				5.0	
						6.0	8.5	37.0	118.3	0.0	0.0	417.2		
Pulp mill steam usage total				11471					169.7				144.5	41.4

STEAM PRODUCTION

	Balance	Steam	Heat production		Steam
		kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	88	1.00	2.76	87.9
Recovery Boiler	kg/s	58	4.01	11.06	233.6
Condensing tail	kg/s				-108.1
Spraying	kg/s				1.9
To feedwater preheating	kg/s				-45.6
Steam to consumers					169.7

Mill electricity usage and production

Project Name Case C - No PB
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1034	1150	94.3	99.6	4.29
Recovery Boiler	tDS/d	5038	5300	49	50	10.54
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					679	88.87
Power Boiler	kg/s	0	120	1000	0	0.00
Turbine	MW	162	180	30	32	0.21
CLO2 production	tClO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					706	92.43

Electricity production

Condensing turbine	kg/s	233	240	17257	16626	161.74
Condensing turbine	kg/s	0	100	25475	25500	0.11
Electricity production total					1236	161.85

Mill steam usage and production

Project Name Case C - No PB
Client name LUT Calculation
Location Northern Europe

Pulp production
Softwood 480000 ADt/a
Hardwood 620000 ADt/a

STEAM CONSUMPTION

Department	Unit	Balance	Heat		Steam							Condensate	
			MJ/unit	MJ/ADt		MP3	MP	LP	LP2	LP3	MW	kg/s	MW
						kg/s	kg/s	kg/s	kg/s	kg/s			
Woodhandling	m3sub/d	27433	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking & O2	ADt/d	3311	2010	2117		0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1
Bleaching	ADt/d	3143	580	580		0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9
Drying	ADt/d	3143	2578	2578		0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2
Evaporation	t H2O/h	1034	127	3597		0.0	9.3	43.9	0.0	0.0	130.8	48.9	16.1
Recovery Boiler	tDS/d	5038	851	1364		6.0	4.0	0.0	0.0	0.0	49.6	10.8	3.6
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2
Lime reburning	t lime/d	972	198	61		0.0	0.0	0.6	0.0	0.0	2.2	0.5	0.2
Raw water	m3/d	78257	1	25		0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
NCG	m3/h	45833	10	146				1.8			5.3	5.8	1.1
Auxiliary condenser	ADt/d	3143	10	10				0.1			0.4	0.0	0.0
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1
Pulping steam usage total				10954		6.0	35.1	107.3	0.0	0.0	398.5	132.2	38.7
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8
Power Boiler	kg/s	0	13000	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Steam for heating water								5.0				5.0	
						6.0	35.3	114.4	0.0	0.0	404.0		
								164.2				139.2	39.4
Pulp mill steam usage total				11107									

STEAM PRODUCTION

		Balance	Steam	Heat production		Steam
			kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	0	1.00	2.76	0	0.0
Recovery Boiler	kg/s	58	4.01	11.06	8878	233.6
Condensing tail	kg/s					-37.4
Spraying	kg/s					1.9
To feedwater preheating	kg/s					-33.9
Steam to consumers						164.2

MILL BALANCE OVERVIEW

Project Name	Case D
Client name	LUT Calculation
Location	Northern Europe

		Balance
Bleached Pulp production	ADt/a	1100000
Operating days		350
Average daily production	ADt/a	3143

1.0 COOKING AND BLEACHING

Bleached Pulp production	ADt/a	1100000
Bleached Pulp production	BDt/a	990000
Pulp moisture	BDt/ADt	90 %
Bleached Pulp Production	BDt/d	2829
	ADt/d	3143
Shrinkage from unbleached to dried pulp	%	3.20 %
Unbleached pulp	ADt/d	1417
Oxygen delignification shrinkage	%	3.0
Screened brown stock	ADt/d	3237
Screening and knotting losses	%	4.5
Unscreened brown stock	ADt/d	3311
Unscreened brown stock	BDt/d	2980
Cooking yield	%	98
Kappa after cooking		30
Kappa after oxygen delignification		12.21428571
Chips to digester	BDt/d	6063
Chips to digester	BDt/a	1066911
Loss in drying machine	%	0.20
Bleached plant yield loss	%	3.00

2.0 WOOD HANDLING**2.1 Wood processing**

Wood species		Softwood
	log length m	2...4
	log diameter cm	10...40
Wood moisture	%	50
Bark content average	%	12
Chips to digester	BDt/d	12220
Days of operation	d/a	350
Annual chip requirement	BDt/a	2122197
Fines	%	2
Fines removed at screening	BDt/a	43310
Chips to screening	BDt/a	2165507
Debris at debarking	%	4
Bark and debris at debarking	BDt/a	400213
Logs to barking drum	BDt/a	2565720
Logs to woodroom	BDt/a	2565720
Woodyard wood intake	BDt/d	14744
Wood density	BDkg/m3sob	451
Woodyard wood intake	m3sob/d	33169
Wood consumption /ADt	m3sob/ADt	5.28
Design factor	%	75 %
Woodyard wood intake, design	m3sob/d	44225
Woodyard wood intake, design	m3sob/h	2764
Chip weight	kgBD/m3l	154
Wood loose/solid	m3l/m3s	3
Woodyard chipping	m3sub/d	27433
Chip storage time	days	14
Chip storage volume	m3	1119000
Wood handling operating time	d/week	7
Wood handling operating time	h/d	16

2.2 Hog fuel processing

Bark and debris at debarking	BDt/a	400213
Fines removed at screening	BDt/a	43310
Losses in the woodyard	%	3
Losses in the woodyard	BDt/a	12006
TOTAL to bark handling	BDt/a	455530
	BDt/d	2592
Bark density	kgBD/m3l	223
Bark volume	m3l/d	15515
Storage time	days	4
Storage volume	m3	62060

3.0 WHITE LIQUOR REQUIREMENTS

3.1 Cooking

Active alkali charge, as Na ₂ O	%	19 %
Active alkali charge, as NaOH	%	24 %
Chips to digester	BDt/d	6063
Active alkali charge as Na ₂ O	BDt/d	1144
Active alkali charge, as NaOH	BDt/d	1477
Caustic in oxidized white liquor	kg/m ³	133
White liquor flow to cooking plant	m ³ /d	11063
Real chemicals in white liquor	kg/m ³	172
White liquor solids to digester	BDt/d	1910

3.2 Oxygen delignification

Caustic charge	kg NaOH/ADt	19
Oxygen charge	kg O ₂ /ADt	24
Caustic in oxidized white liquor	kg/m ³	99
White liquor flow	m ³ /d	612
Real chemicals in oxidized white liquor	kg/m ³	202
Oxidized white liquor solids to O ₂ reactor	BDt/d	124

3.3 Total white liquor required

White liquor to cooking plant	m ³ /d	0
Oxidized white liquor to ox delignification	m ³ /d	612
Oxidized white liquor to bleaching plant	m ³ /d	0
Oxidized white liquor total	m ³ /d	612
TOTAL	m ³ /d	11675

4.0 BLACK LIQUOR CALCULATION

4.1 Cooking

Chips to digester	BDt/d	0
Cooking yield	%	49
Blown stock	BDt/d	2980
Organic solids generated	BDt/d	3084
White liquor solids to digester	BDt/d	1910
Water loss, as % of inorganic	%	6 %
Water loss	BDt/d	115
White liquor solids to black liquor	BDt/d	1795
Total solids to black liquor	BDt/d	4812

4.2 Oxygen delignification

Pulp to reactor	BDt/d	0
Oxygenated pulp	BDt/d	2889
Organic solids to black liquor	BDt/d	57
Oxidized white liquor solids to O2 reactor	BDt/d	124
Total solids to black liquor	BDt/d	222

4.3 Total solids in Black Liquor

Total solids to black liquor	BDt/d	0
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5.0 BLEACHING CHEMICALS PREPARATION**5.1 Bleaching requirement**

Delignification stage	Kappa in	14
	kappa out	9
O2 delignification stage	kg/ADt	24
Chemical charge DED bleaching	at kappa	8.5
ClO ₂	kg/ADt	47
NaOH	kg/ADt	14
O ₂	kg/ADt	4
HCl	kg/ADt	0
hydrogenperoxide, H ₂ O ₂	kg/ADt	5
NaHSO ₃	kg/ADt	2
Antichlor as SO ₂	kg/ADt	0
H ₂ SO ₄	kg/ADt	9
MgSO ₄	kg/ADt	0
Talc	kg/ADt	0
Oxidized white liquor to bleaching plant	m ³ /d	0

5.2 Bleaching chemicals demand

Oxygen for ox delignif and bleaching	BDt/d	182
Oxygen for white liquor oxidation	BDt/d	0
Oxygen total	BDt/d	182
ClO ₂	BDt/d	113
HCl	BDt/d	0
NaOH for bleaching	BDt/d	88
NaOH for scrubber	BDt/d	0
NaOH required total	BDt/d	88
NaOH produced in balance	BDt/d	139
NaOH in imbalance	BDt/d	-51
NaHSO ₃	t/d	13
antichlor as SO ₂	BDt/d	0
H ₂ SO ₄	t/d	57
MgSO ₄	t/d	0
Talc	BDt/d	0
hydrogenperoxide	BDt/d	31

6.0 RECAUSTICIZING PLANT

Flow of white liquor	m ³ /d	11675
Sulfidity	%	36 %
Reduction	%	95 %
Causticizing efficiency	%	80 %
Active alkali in white liquor	g/l	135

7.0 LIME REBURNING PLANT

Causticizing power of burnt lime	%	80 %
Kiln product	t/d	972
Burnt lime for waste water neutralization	t/d	0
Kiln product total	t/d	972

8.0 EVAPORATION PLANT

Black liquor dry solids	BDt/d	5038
Weak black liquor conc	%	17 %
Strong black liquor concentration	%	84 %
As fired black liquor concentration	%	85 %
Evaporation capacity	t/h	1034
Spills	t/h	0
Evaporation capacity total	t/h	1034
Total solids to as fired black liquor	tDS/d	5491
Total as fired black liquor	tBL/d	6472
Steam economy with stripper	kg/kg	5.86
MP steam usage	%	19 %
MP Steam requirement	kg/s	9
LP Steam requirement	kg/s	40
Stripper TRS removal efficiency	%	95 %
Stripper methanol removal efficiency	%	90 %

Balance report

9.0 RECOVERY BOILER

Black liquor solids capacity, as fired	BDt/d	5491
Black liquor solids capacity, virgin	BDt/d	5038
Strong black liquor concentration	%	85 %

Elemental analysis:

Sodium	%	18.7 %
Hydrogen	%	3.6 %
Carbon	%	35.6 %
Oxygen	%	35.1 %
Sulfur	%	4.5 %
Potassium	%	2.0 %
Chloride	%	0.4 %
Nitrogen	%	0.1 %
Silica	%	0.021 %
Aluminium	%	0.002 %
Total inert	%	0.1 %
TOTAL		100 %

Higher heat value	MJ/kgDS	14.00
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Superheated steam

Temperature	C	540
Pressure	bar(a)	164
Steam generation	kg/s/kgDS/s	4.04
Net steam flow	t/h	835
	kg/s	232

Balance report

10.0 POWER BOILER

Continuous rating with hog fuel	t/h	313.9
	kg/s	87.2
Maximum continuous rating with fuel oil	t/h	
	kg/s	

Hog fuel

Hog fuel available	BDt/d	1301.5
Hog fuel steam generation	t steam/h/BDt/h	0.241

11.0 TURBINE GENERATOR

Total power generation	MW	262.93
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12.0 FRESH WATER HANDLING

Design flow	m3/d	150495
	m3/ADt	48
	m3/d	65686
Balance	m3/ADt	21

13.0 WASTE WATER TREATMENT

	m3/ADt	
Effluent from Bleached Plant	14.5	45571
Effluent from Woodhandling	2.9	9114
Pulp Dryer	1	3143
Miscellaneous	6.5	20429
TOTAL	24.9	78257
Balance	m3/ADt	25
Design factor	%	52 %
Waste water treatment, Design	m3/d	150495
	m3/ADt	48

Mill electricity usage and production

Project Name Case D
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1034	1150	94.3	99.6	4.29
Recovery Boiler	tDS/d	5038	5300	55	57	11.91
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					689	90.24
Power Boiler	kg/s	87	120	1000	1188	4.32
Turbine	MW	263	290	30	32	0.35
CIO2 production	tCIO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					750	98.25

Electricity production

Condensing turbine	kg/s	231	240	17347	17011	163.90
Condensing turbine	kg/s	88	100	27024	27036	99.02
Electricity production total					2008	262.93

Mill steam usage and production

Project Name	Case D				Pulp production									
Client name	LUT Calculation				Softwood	480000 ADt/a								
Location	Northern Europe				Hardwood	620000 ADt/a								
STEAM CONSUMPTION														
Department			Heat		Steam							Condensate		
	Unit	Balance	MJ/unit	MJ/ADt										
					MP3	MP	LP	LP2	LP3					
					kg/s	kg/s	kg/s	kg/s	kg/s	MW		kg/s	MW	
Woodhandling	m3sub/d	27433	0	0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Cooking & O2	ADt/d	3311	2010	2117	0.0	18.8	11.7	0.0	0.0	77.0		21.6	8.1	
Bleaching	ADt/d	3143	580	580	0.0	3.0	5.3	0.0	0.0	21.1		5.1	1.9	
Drying	ADt/d	3143	2578	2578	0.0	0.0	36.3	0.0	0.0	93.8		32.7	6.2	
Evaporation	t H2O/h	1034	127	3597	0.0	9.3	43.9	0.0	0.0	130.8		48.9	16.1	
Recovery Boiler	tDS/d	5038	851	1364	6.0	4.0	0.0	0.0	0.0	49.6		10.8	3.6	
Causticization	m3WL/d	11675	12	46	0.0	0.0	0.7	0.0	0.0	1.7		0.7	0.2	
Lime reburning	t lime/d	972	198	61	0.0	0.0	0.6	0.0	0.0	2.2		0.5	0.2	
Raw water	m3/d	78257	1	25	0.0	0.0	0.4	0.0	0.0	0.9		0.4	0.1	
Effluent treatment	m3/d	65686	0	0	0.0	0.0	0.4	0.0	0.0	0.0		0.0	0.0	
NCG	m3/h	45833	10	146			1.8			5.3		5.8	1.1	
Auxiliary condenser	ADt/d	3143	10	10			0.1			0.4		0.0	0.0	
Auxiliary departments	ADt/d	3143	430	430	0.0	0.0	6.1	0.0	0.0	15.6		5.8	1.1	
Pulping steam usage total					6.0	35.1	107.3	0.0	0.0	398.5		132.2	38.7	
ClO2+O2 Plant	tClO2/d	31	15500	153	0.0	0.2	2.1	0.0	0.0	5.6		2.0	0.8	
Power Boiler	kg/s	87	13000	361	0.0	1.7	3.8	0.0	0.0	13.1		5.3	2.0	
Steam for heating water							5.0					5.0		
					6.0	36.9	118.2	0.0	0.0	417.1				
Pulp mill steam usage total							169.6					144.4	41.4	
STEAM PRODUCTION														
		Balance		Steam	Heat production		Steam							
				kg/s/unit	MJ/unit	MJ/Adt/d	kg/s							
Power Boiler	kg/s	87		1.00	2.78	6669	87.2							
Recovery Boiler	kg/s	58		3.98	11.07	8884	232.0							
Condensing tail	kg/s						-105.1							
Spraying	kg/s						1.0							
To feedwater preheating	kg/s						-45.4							
Steam to consumers							169.6							

Mill electricity usage and production

Project Name Case D - No PB
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1034	1150	94.3	99.6	4.29
Recovery Boiler	tDS/d	5038	5300	55	57	11.91
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					689	90.24
Power Boiler	kg/s	0	120	1000	0	0.00
Turbine	MW	176	200	30	32	0.23
CIO2 production	tCIO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					716	93.82

Electricity production

Condensing turbine	kg/s	232	240	18484	18161	175.45
Condensing turbine	kg/s	0	100	27024	27050	0.11
Electricity production total					1341	175.57

Mill steam usage and production

Project Name Case D - No PB
Client name LUT Calculation
Location Northern Europe

Pulp production
Softwood 480000 ADt/a
Hardwood 620000 ADt/a

STEAM CONSUMPTION

Department	Unit	Balance	Heat		Steam							Condensate	
			MJ/unit	MJ/ADt		MP3	MP	LP	LP2	LP3	MW	kg/s	MW
						kg/s	kg/s	kg/s	kg/s	kg/s			
Woodhandling	m3sub/d	27433	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking & O2	ADt/d	3311	2010	2117		0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1
Bleaching	ADt/d	3143	580	580		0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9
Drying	ADt/d	3143	2578	2578		0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2
Evaporation	t H2O/h	1034	127	3597		0.0	9.3	43.9	0.0	0.0	130.8	48.9	16.1
Recovery Boiler	tDS/d	5038	851	1364		6.0	4.0	0.0	0.0	0.0	49.6	10.8	3.6
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2
Lime reburning	t lime/d	972	198	61		0.0	0.0	0.6	0.0	0.0	2.2	0.5	0.2
Raw water	m3/d	78257	1	25		0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
NCG	m3/h	45833	10	146				1.8			5.3	5.8	1.1
Auxiliary condenser	ADt/d	3143	10	10				0.1			0.4	0.0	0.0
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1
Pulping steam usage total				10954		6.0	35.1	107.3	0.0	0.0	398.5	132.2	38.7
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8
Power Boiler	kg/s	0	13000	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Steam for heating water								5.0				5.0	
						6.0	35.3	114.4	0.0	0.0	404.0		
								164.2				139.2	39.4
Pulp mill steam usage total				11107									

STEAM PRODUCTION

		Balance	Steam	Heat production		Steam
			kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	0	1.00	2.78	0	0.0
Recovery Boiler	kg/s	58	3.98	11.07	8884	232.0
Condensing tail	kg/s					-34.9
Spraying	kg/s					0.8
To feedwater preheating	kg/s					-33.7
Steam to consumers						164.2

MILL BALANCE OVERVIEW

Project Name	Case E
Client name	LUT Calculation
Location	Northern Europe

		Balance
Bleached Pulp production	ADt/a	1100000
Operating days		350
Average daily production	ADt/a	3143

1.0 COOKING AND BLEACHING

Bleached Pulp production	ADt/a	1100000
Bleached Pulp production	BDt/a	990000
Pulp moisture	BDt/ADt	90 %
Bleached Pulp Production	BDt/d	2829
	ADt/d	3143
Shrinkage from unbleached to dried pulp	%	3.20 %
Unbleached pulp	ADt/d	1417
Oxygen delignification shrinkage	%	3.0
Screened brown stock	ADt/d	3237
Screening and knotting losses	%	4.5
Unscreened brown stock	ADt/d	3311
Unscreened brown stock	BDt/d	2980
Cooking yield	%	98
Kappa after cooking		30
Kappa after oxygen delignification		12.21428571
Chips to digester	BDt/d	6063
Chips to digester	BDt/a	1066911
Loss in drying machine	%	0.20
Bleached plant yield loss	%	3.00

2.0 WOOD HANDLING**2.1 Wood processing**

Wood species		Softwood
	log length m	2...4
	log diameter cm	10...40
Wood moisture	%	50
Bark content average	%	12
Chips to digester	BDt/d	12220
Days of operation	d/a	350
Annual chip requirement	BDt/a	2122197
Fines	%	2
Fines removed at screening	BDt/a	43310
Chips to screening	BDt/a	2165507
Debris at debarking	%	4
Bark and debris at debarking	BDt/a	400213
Logs to barking drum	BDt/a	2565720
Logs to woodroom	BDt/a	2565720
Woodyard wood intake	BDt/d	14744
Wood density	BDkg/m3sob	451
Woodyard wood intake	m3sob/d	33169
Wood consumption /ADt	m3sob/ADt	5.28
Design factor	%	75 %
Woodyard wood intake, design	m3sob/d	44225
Woodyard wood intake, design	m3sob/h	2764
Chip weight	kgBD/m3l	154
Wood loose/solid	m3l/m3s	3
Woodyard chipping	m3sub/d	27433
Chip storage time	days	14
Chip storage volume	m3	1119000
Wood handling operating time	d/week	7
Wood handling operating time	h/d	16

2.2 Hog fuel processing

Bark and debris at debarking	BDt/a	400213
Fines removed at screening	BDt/a	43310
Losses in the woodyard	%	3
Losses in the woodyard	BDt/a	12006
TOTAL to bark handling	BDt/a	455530
	BDt/d	2592
Bark density	kgBD/m3l	223
Bark volume	m3l/d	15515
Storage time	days	4
Storage volume	m3	62060

3.0 WHITE LIQUOR REQUIREMENTS

3.1 Cooking

Active alkali charge, as Na ₂ O	%	19 %
Active alkali charge, as NaOH	%	24 %
Chips to digester	BDt/d	6063
Active alkali charge as Na ₂ O	BDt/d	1144
Active alkali charge, as NaOH	BDt/d	1477
Caustic in oxidized white liquor	kg/m ³	133
White liquor flow to cooking plant	m ³ /d	11063
Real chemicals in white liquor	kg/m ³	172
White liquor solids to digester	BDt/d	1910

3.2 Oxygen delignification

Caustic charge	kg NaOH/ADt	19
Oxygen charge	kg O ₂ /ADt	24
Caustic in oxidized white liquor	kg/m ³	99
White liquor flow	m ³ /d	612
Real chemicals in oxidized white liquor	kg/m ³	202
Oxidized white liquor solids to O ₂ reactor	BDt/d	124

3.3 Total white liquor required

White liquor to cooking plant	m ³ /d	0
Oxidized white liquor to ox delignification	m ³ /d	612
Oxidized white liquor to bleaching plant	m ³ /d	0
Oxidized white liquor total	m ³ /d	612
TOTAL	m ³ /d	11675

4.0 BLACK LIQUOR CALCULATION

4.1 Cooking

Chips to digester	BDt/d	0
Cooking yield	%	49
Blown stock	BDt/d	2980
Organic solids generated	BDt/d	3084
White liquor solids to digester	BDt/d	1910
Water loss, as % of inorganic	%	6 %
Water loss	BDt/d	115
White liquor solids to black liquor	BDt/d	1795
Total solids to black liquor	BDt/d	4812

4.2 Oxygen delignification

Pulp to reactor	BDt/d	0
Oxygenated pulp	BDt/d	2889
Organic solids to black liquor	BDt/d	57
Oxidized white liquor solids to O2 reactor	BDt/d	124
Total solids to black liquor	BDt/d	222

4.3 Total solids in Black Liquor

Total solids to black liquor	BDt/d	0
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5.0 BLEACHING CHEMICALS PREPARATION**5.1 Bleaching requirement**

Delignification stage	Kappa in	14
	kappa out	9
O2 delignification stage	kg/ADt	24
Chemical charge DED bleaching	at kappa	8.5
ClO ₂	kg/ADt	47
NaOH	kg/ADt	14
O ₂	kg/ADt	4
HCl	kg/ADt	0
hydrogenperoxide, H ₂ O ₂	kg/ADt	5
NaHSO ₃	kg/ADt	2
Antichlor as SO ₂	kg/ADt	0
H ₂ SO ₄	kg/ADt	9
MgSO ₄	kg/ADt	0
Talc	kg/ADt	0
Oxidized white liquor to bleaching plant	m ³ /d	0

5.2 Bleaching chemicals demand

Oxygen for ox delignif and bleaching	BDt/d	182
Oxygen for white liquor oxidation	BDt/d	0
Oxygen total	BDt/d	182
ClO ₂	BDt/d	113
HCl	BDt/d	0
NaOH for bleaching	BDt/d	88
NaOH for scrubber	BDt/d	0
NaOH required total	BDt/d	88
NaOH produced in balance	BDt/d	139
NaOH in imbalance	BDt/d	-51
NaHSO ₃	t/d	13
antichlor as SO ₂	BDt/d	0
H ₂ SO ₄	t/d	57
MgSO ₄	t/d	0
Talc	BDt/d	0
hydrogenperoxide	BDt/d	31

6.0 RECAUSTICIZING PLANT

Flow of white liquor	m ³ /d	11675
Sulfidity	%	36 %
Reduction	%	95 %
Causticizing efficiency	%	80 %
Active alkali in white liquor	g/l	135

7.0 LIME REBURNING PLANT

Causticizing power of burnt lime	%	80 %
Kiln product	t/d	972
Burnt lime for waste water neutralization	t/d	0
Kiln product total	t/d	972

8.0 EVAPORATION PLANT

Black liquor dry solids	BDt/d	5038
Weak black liquor conc	%	17 %
Strong black liquor concentration	%	84 %
As fired black liquor concentration	%	85 %
Evaporation capacity	t/h	1034
Spills	t/h	0
Evaporation capacity total	t/h	1034
Total solids to as fired black liquor	tDS/d	5491
Total as fired black liquor	tBL/d	6472
Steam economy with stripper	kg/kg	5.86
MP steam usage	%	19 %
MP Steam requirement	kg/s	9
LP Steam requirement	kg/s	40
Stripper TRS removal efficiency	%	95 %
Stripper methanol removal efficiency	%	90 %

Balance report

9.0 RECOVERY BOILER

Black liquor solids capacity, as fired	BDt/d	5491
Black liquor solids capacity, virgin	BDt/d	5038
Strong black liquor concentration	%	85 %

Elemental analysis:

Sodium	%	18.7 %
Hydrogen	%	3.6 %
Carbon	%	35.6 %
Oxygen	%	35.1 %
Sulfur	%	4.5 %
Potassium	%	2.0 %
Chloride	%	0.4 %
Nitrogen	%	0.1 %
Silica	%	0.021 %
Aluminium	%	0.002 %
Total inert	%	0.1 %
TOTAL		100 %

Higher heat value	MJ/kgDS	13.56
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Superheated steam

Temperature	C	515
Pressure	bar(a)	124
Steam generation	kg/s/kgDS/s	3.74
Net steam flow	t/h	807
	kg/s	224

Balance report

10.0 POWER BOILER

Continuous rating with hog fuel	t/h	316.3
	kg/s	87.9
Maximum continuous rating with fuel oil	t/h	
	kg/s	

Hog fuel

Hog fuel available	BDt/d	1301.5
Hog fuel steam generation	t steam/h/BDt/h	0.243

11.0 TURBINE GENERATOR

Total power generation	MW	250.07
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12.0 FRESH WATER HANDLING

Design flow	m3/d	150495
	m3/ADt	48
	m3/d	65686
Balance	m3/ADt	21

13.0 WASTE WATER TREATMENT

	m3/ADt	
Effluent from Bleached Plant	14.5	45571
Effluent from Woodhandling	2.9	9114
Pulp Dryer	1	3143
Miscellaneous	6.5	20429
TOTAL	24.9	78257
Balance	m3/ADt	25
Design factor	%	52 %
Waste water treatment, Design	m3/d	150495
	m3/ADt	48

Mill electricity usage and production

Project Name Case E
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1034	1150	94.3	99.6	4.29
Recovery Boiler	tDS/d	5038	5300	46	47	9.89
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					674	88.21
Power Boiler	kg/s	88	120	1000	1183	4.33
Turbine	MW	250	280	30	32	0.33
CIO2 production	tCIO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					735	96.23

Electricity production

Condensing turbine	kg/s	224	230	16963	16456	153.71
Condensing turbine	kg/s	88	100	25982	26309	96.36
Electricity production total					1910	250.07

Mill steam usage and production

Project Name Case E
Client name LUT Calculation
Location Northern Europe

Pulp production
Softwood 480000 ADt/a
Hardwood 620000 ADt/a

STEAM CONSUMPTION

Department	Unit	Balance	Heat		Steam									Condensate	
			MJ/unit	MJ/ADt		MP3	MP2	MP	LP	LP2	LP3	MW	kg/s	MW	
						kg/s	kg/s	kg/s	kg/s	kg/s	kg/s				
Woodhandling	m3sub/d	27433	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Cooking & O2	ADt/d	3311	2010	2117		0.0	0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1	
Bleaching	ADt/d	3143	580	580		0.0	0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9	
Drying	ADt/d	3143	2578	2578		0.0	0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2	
Evaporation	t H2O/h	1034	127	3597		0.0	0.0	9.3	43.9	0.0	0.0	130.8	48.9	16.1	
Recovery Boiler	tDS/d	5038	958	1536		8.0	8.2	4.0	0.0	0.0	0.0	55.9	10.8	3.6	
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2	
Lime reburning	t lime/d	972	198	61		0.0	0.3	0.0	0.6	0.0	0.0	2.2	0.5	0.2	
Raw water	m3/d	78257	1	25		0.0	0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1	
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	
NCG	m3/h	45833	10	146					1.8			5.3	5.8	1.1	
Auxiliary condenser	ADt/d	3143	10	10					0.1			0.4	0.0	0.0	
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1	
Pulping steam usage total				11126		8.0	8.5	35.1	107.3	0.0	0.0	404.7	132.2	38.7	
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8	
Power Boiler	kg/s	88	13000	363		0.0	0.0	1.7	3.8	0.0	0.0	13.2	5.3	2.0	
Steam for heating water									5.0				5.0		
						8.0	8.5	37.0	118.3	0.0	0.0	423.5			
Pulp mill steam usage total				11642					171.7				144.5	41.4	

STEAM PRODUCTION

	Balance	Steam	Heat production		Steam
		kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	88	1.00	2.76	6669
Recovery Boiler	kg/s	58	3.85	10.62	8521
Condensing tail	kg/s				224.2
Spraying	kg/s				-104.8
To feedwater preheating	kg/s				8.5
Steam to consumers					-44.0
					171.7

Mill electricity usage and production

Project Name Case E - No PB
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood 480000 ADt/a
Hardwood 620000 ADt/a

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit	Electricity MW
Woodhandling	m3sub/d	27433	34300	10	11	12.86
Cooking	ADt/d	3311	3680	35	37	5.10
O2 delignification	ADt/d	3189	3540	25	26	3.50
Screening	ADt/d	3311	3680	30	32	4.37
Washing	ADt/d	3311	3680	19	20	2.77
Bleaching	ADt/d	3143	2862	56	53	7.01
Drying	ADt/d	3143	3490	143	151	19.76
Evaporation	t H2O/h	1034	1150	94.3	99.6	4.29
Recovery Boiler	tDS/d	5038	5300	46	47	9.89
Causticization	m3WL/d	11675	12970	5.1	5.4	2.62
Lime reburning	t lime/d	972	1080	44	46	1.88
Raw water	m3/d	78257	156500	0.3	0.4	1.47
Effluent treatment	m3/d	65686	131400	1.0	1.5	4.11
NCG	m3/h	45833	76386	0.5	0.7	1.27
Cooling towers	MW	242	350	108	132	1.33
Compressed air	m3/h	700	800	40	43	1.25
Miscellaneous	ADt/d	3143	3180	36	36	4.74
Pulping usage total					674	88.21
Power Boiler	kg/s	0	120	1000	0	0.00
Turbine	MW	162	180	30	32	0.21
CIO2 production	tCIO2/d	31	40	120	137	0.18
Oxygen+peroxide	tO2/d	77	85	940	989	3.17
Mill total usage					701	91.78

Electricity production

Condensing turbine	kg/s	224	230	17689	17366	162.16
Condensing turbine	kg/s	0	100	25981	26321	0.11
Electricity production total					1239	162.27

Mill steam usage and production

Project Name Case E - No PB
Client name LUT Calculation
Location Northern Europe

Pulp production
Softwood 480000 ADt/a
Hardwood 620000 ADt/a

STEAM CONSUMPTION

Department		Heat			Steam							Condensate		
	Unit	Balance	MJ/unit	MJ/ADt		MP3	MP2	MP	LP	LP2	LP3			
						kg/s	kg/s	kg/s	kg/s	kg/s	kg/s	MW	kg/s	MW
Woodhandling	m3sub/d	27433	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking & O2	ADt/d	3311	2010	2117		0.0	0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1
Bleaching	ADt/d	3143	580	580		0.0	0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9
Drying	ADt/d	3143	2578	2578		0.0	0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2
Evaporation	t H2O/h	1034	127	3597		0.0	0.0	9.3	43.9	0.0	0.0	130.8	48.9	16.1
Recovery Boiler	tDS/d	5038	958	1536		8.0	8.2	4.0	0.0	0.0	0.0	55.9	10.8	3.6
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2
Lime reburning	t lime/d	972	198	61		0.0	0.3	0.0	0.6	0.0	0.0	2.2	0.5	0.2
Raw water	m3/d	78257	1	25		0.0	0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
NCG	m3/h	45833	10	146					1.8			5.3	5.8	1.1
Auxiliary condenser	ADt/d	3143	10	10					0.1			0.4	0.0	0.0
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1
Pulping steam usage total				11126		8.0	8.5	35.1	107.3	0.0	0.0	404.7	132.2	38.7
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8
Power Boiler	kg/s	0	13000	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Steam for heating water									5.0				5.0	
						8.0	8.5	35.3	114.4	0.0	0.0	410.3		
									166.2				139.2	39.4
Pulp mill steam usage total				11279										

STEAM PRODUCTION

		Balance	Steam	Heat production		Steam
			kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	0	1.00	2.76	0	0.0
Recovery Boiler	kg/s	58	3.85	10.62	8521	224.2
Condensing tail	kg/s					-33.9
Spraying	kg/s					8.2
To feedwater preheating	kg/s					-32.3
Steam to consumers						166.2

MILL BALANCE OVERVIEW

Project Name	Case F
Client name	LUT Calculation
Location	Northern Europe

		Balance
Bleached Pulp production	ADt/a	1100000
Operating days		350
Average daily production	ADt/a	3143

1.0 COOKING AND BLEACHING

Bleached Pulp production	ADt/a	1100000
Bleached Pulp production	BDt/a	990000
Pulp moisture	BDt/ADt	90 %
Bleached Pulp Production	BDt/d	2829
	ADt/d	3143
Shrinkage from unbleached to dried pulp	%	3.20 %
Unbleached pulp	ADt/d	1417
Oxygen delignification shrinkage	%	3.0
Screened brown stock	ADt/d	3237
Screening and knotting losses	%	4.5
Unscreened brown stock	ADt/d	3311
Unscreened brown stock	BDt/d	2980
Cooking yield	%	98
Kappa after cooking		30
Kappa after oxygen delignification		12.21428571
Chips to digester	BDt/d	6063
Chips to digester	BDt/a	1066911
Loss in drying machine	%	0.20
Bleached plant yield loss	%	3.00

2.0 WOOD HANDLING**2.1 Wood processing**

Wood species		Softwood
	log length m	2...4
	log diameter cm	10...40
Wood moisture	%	50
Bark content average	%	12
Chips to digester	BDt/d	12220
Days of operation	d/a	350
Annual chip requirement	BDt/a	2122197
Fines	%	2
Fines removed at screening	BDt/a	43310
Chips to screening	BDt/a	2165507
Debris at debarking	%	4
Bark and debris at debarking	BDt/a	400213
Logs to barking drum	BDt/a	2565720
Logs to woodroom	BDt/a	2565720

Balance report

Woodyard wood intake	BDt/d	14744
Wood density	BDkg/m3sob	451
Woodyard wood intake	m3sob/d	33169
Wood consumption /ADt	m3sob/ADt	5.28
Design factor	%	75 %
Woodyard wood intake, design	m3sob/d	44225
Woodyard wood intake, design	m3sob/h	2764
Chip weight	kgBD/m3l	154
Wood loose/solid	m3l/m3s	3
Woodyard chipping	m3sub/d	27433
Chip storage time	days	14
Chip storage volume	m3	1119000
Wood handling operating time	d/week	7
Wood handling operating time	h/d	16

2.2 Hog fuel processing

Bark and debris at debarking	BDt/a	400213
Fines removed at screening	BDt/a	43310
Losses in the woodyard	%	3
Losses in the woodyard	BDt/a	12006
TOTAL to bark handling	BDt/a	455530
	BDt/d	2592
Bark density	kgBD/m3l	223
Bark volume	m3l/d	15515
Storage time	days	4
Storage volume	m3	62060

3.0 WHITE LIQUOR REQUIREMENTS

3.1 Cooking

Active alkali charge, as Na2O	%	19 %
Active alkali charge, as NaOH	%	24 %
Chips to digester	BDt/d	6063
Active alkali charge as Na2O	BDt/d	1144
Active alkali charge, as NaOH	BDt/d	1477
Caustic in oxidized white liquor	kg/m3	133
White liquor flow to cooking plant	m3/d	11063
Real chemicals in white liquor	kg/m3	172
White liquor solids to digester	BDt/d	1910

3.2 Oxygen delignification

Caustic charge	kg NaOH/ADt	19
Oxygen charge	kg O2/ADt	24
Caustic in oxidized white liquor	kg/m3	99
White liquor flow	m3/d	612
Real chemicals in oxidized white liquor	kg/m3	202
Oxidized white liquor solids to O2 reactor	BDt/d	124

3.3 Total white liquor required

White liquor to cooking plant	m3/d	0
Oxidized white liquor to ox delignification	m3/d	612
Oxidized white liquor to bleaching plant	m3/d	0

Balance report

Oxidized white liquor total	m3/d	612
TOTAL	m3/d	11675

4.0 BLACK LIQUOR CALCULATION

4.1 Cooking

Chips to digester	BDt/d	0
Cooking yield	%	49
Blown stock	BDt/d	2980
Organic solids generated	BDt/d	3084
White liquor solids to digester	BDt/d	1910
Water loss, as % of inorganic	%	6 %
Water loss	BDt/d	115
White liquor solids to black liquor	BDt/d	1795
Total solids to black liquor	BDt/d	4812

4.2 Oxygen delignification

Pulp to reactor	BDt/d	0
Oxygenated pulp	BDt/d	2889
Organic solids to black liquor	BDt/d	57
Oxidized white liquor solids to O2 reactor	BDt/d	124
Total solids to black liquor	BDt/d	222

4.3 Total solids in Black Liquor

Total solids to black liquor	BDt/d	0
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5.0 BLEACHING CHEMICALS PREPARATION

5.1 Bleaching requirement

Delignification stage	Kappa in	14
	kappa out	9
O2 delignification stage	kg/ADt	24
Chemical charge DED bleaching	at kappa	8.5
ClO2	kg/ADt	47
NaOH	kg/ADt	14
O2	kg/ADt	4
HCl	kg/ADt	0
hydrogenperoxide, H2O2	kg/ADt	5
NaHSO3	kg/ADt	2
Antichlor as SO2	kg/ADt	0
H2SO4	kg/ADt	9
MgSO4	kg/ADt	0
Talc	kg/ADt	0
Oxidized white liquor to bleaching plant	m3/d	0

5.2 Bleaching chemicals demand

Oxygen for ox delignif and bleaching	BDt/d	182
Oxygen for white liquor oxidation	BDt/d	0

Balance report

Oxygen total	BDt/d	182
ClO ₂	BDt/d	113
HCl	BDt/d	0
NaOH for bleaching	BDt/d	88
NaOH for scrubber	BDt/d	0
NaOH required total	BDt/d	88
NaOH produced in balance	BDt/d	139
NaOH in imbalance	BDt/d	-51
NaHSO ₃	t/d	13
antichlor as SO ₂	BDt/d	0
H ₂ SO ₄	t/d	57
MgSO ₄	t/d	0
Talc	BDt/d	0
hydrogenperoxide	BDt/d	31

6.0 RECAUSTICIZING PLANT

Flow of white liquor	m ³ /d	11675
Sulfidity	%	36 %
Reduction	%	95 %
Causticizing efficiency	%	80 %
Active alkali in white liquor	g/l	135

7.0 LIME REBURNING PLANT

Causticizing power of burnt lime	%	80 %
Kiln product	t/d	972
Burnt lime for waste water neutralization	t/d	0
Kiln product total	t/d	972

8.0 EVAPORATION PLANT

Black liquor dry solids	BDt/d	5038
Weak black liquor conc	%	17 %
Strong black liquor concentration	%	84 %
As fired black liquor concentration	%	85 %
Evaporation capacity	t/h	1034
Spills	t/h	0
Evaporation capacity total	t/h	1034
Total solids to as fired black liquor	tDS/d	5491
Total as fired black liquor	tBL/d	6472
Steam economy with stripper	kg/kg	5.86
MP steam usage	%	19 %
MP Steam requirement	kg/s	9
LP Steam requirement	kg/s	40
Stripper TRS removal efficiency	%	95 %
Stripper methanol removal efficiency	%	90 %

9.0 RECOVERY BOILER

Black liquor solids capacity, as fired	BDt/d	5491
Black liquor solids capacity, virgin	BDt/d	5038
Strong black liquor concentration	%	85 %

Balance report

Elemental analysis:

Sodium	%	18.7 %
Hydrogen	%	3.6 %
Carbon	%	35.6 %
Oxygen	%	35.1 %
Sulfur	%	4.5 %
Potassium	%	2.0 %
Chloride	%	0.4 %
Nitrogen	%	0.1 %
Silica	%	0.021 %
Aluminium	%	0.002 %
Total inert	%	0.1 %
TOTAL		100 %

Higher heat value	MJ/kgDS	13.27
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Superheated steam

Temperature	C	540
Pressure	bar(a)	260
Steam generation	kg/s/kgDS/s	3.64
Net steam flow	t/h	788
	kg/s	219

10.0 POWER BOILER

Continuous rating with hog fuel	t/h	316.6
	kg/s	87.9
Maximum continuous rating with fuel oil	t/h	
	kg/s	

Hog fuel

Hog fuel available	BDt/d	1301.5
Hog fuel steam generation	t steam/h/BDt/h	0.243

11.0 TURBINE GENERATOR

Total power generation	MW	279.35
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12.0 FRESH WATER HANDLING

Design flow	m3/d	150495
	m3/ADt	48
	m3/d	65686
Balance	m3/ADt	21

13.0 WASTE WATER TREATMENT

	m3/ADt	
Effluent from Bleached Plant	14.5	45571
Effluent from Woodhandling	2.9	9114

Balance report

Pulp Dryer	1	3143
Miscellaneous	6.5	20429
TOTAL	24.9	78257
Balance	m3/ADt	25
Design factor	%	52 %
Waste water treatment, Design	m3/d	150495
	m3/ADt	48

Mill electricity usage and production

Project Name Case F
Client name LUT Calculation
Location Northern Europe

Pulp production

Softwood
Hardwood
Eucalyptus

Department usage

	unit	Balance units/d	Design units/d	Design kWh/unit	Actual kWh/unit
Woodhandling	m3sub/d	27433	34300	10	11
Cooking	ADt/d	3311	3680	35	37
O2 delignification	ADt/d	3189	3540	25	26
Screening	ADt/d	3311	3680	30	32
Washing	ADt/d	3311	3680	19	20
Bleaching	ADt/d	3143	2862	56	53
Drying	ADt/d	3143	3490	143	151
Evaporation	t H2O/h	1034	1150	94.3	99.6
Recovery Boiler	tDS/d	5038	5300	46	47
Causticization	m3WL/d	11675	12970	5.1	5.4
Lime reburning	t lime/d	972	1080	44	46
Raw water	m3/d	78257	156500	0.3	0.4
Effluent treatment	m3/d	65686	131400	1.0	1.5
NCG	m3/h	45833	76386	0.5	0.7
Cooling towers	MW	242	350	108	132
Compressed air	m3/h	700	800	40	43
Miscellaneous	ADt/d	3143	3180	36	36
Pulping usage total					674

Power Boiler	kg/s	88	120	1000	1182
Turbine	MW	279	310	30	32
CIO2 production	tCIO2/d	31	40	120	137
Oxygen+peroxide	tO2/d	77	85	940	989

Mill total usage **735**

Electricity production

Condensing turbine	kg/s	219	210	20941	20379
Condensing turbine	kg/s	88	100	25477	25487

Electricity production total **2133**

Mill steam usage and production

Project Name	Case F	Pulp production	
Client name	LUT Calculation	Softwood	480000 ADt/a
Location	Northern Europe		

STEAM CONSUMPTION

Department	Unit	Balance	Heat		LP	Steam	MP3	MP2	MP	LP	LP2	LP3	MW	Condensate	
			MJ/unit	MJ/ADt	kg/s									kg/s	MW
Woodhandling	m3sub/d	27433	0	0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking & O2	ADt/d	3311	2010	2117	11.7		0.0	0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1
Bleaching	ADt/d	3143	580	580	5.3		0.0	0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9
Drying	ADt/d	3143	2578	2578	36.3		0.0	0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2
Evaporation	t H2O/h	1034	127	3597	43.9		0.0	0.0	9.3	43.9	0.0	0.0	130.8	48.9	16.1
Recovery Boiler	tDS/d	5038	1118	1792	3.7		8.0	8.2	4.0	3.7	0.0	0.0	65.2	14.1	4.5
Causticization	m3WL/d	11675	12	46	0.7		0.0	0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2
Lime reburning	t lime/d	972	198	61	0.6		0.0	0.3	0.0	0.6	0.0	0.0	2.2	0.5	0.2
Raw water	m3/d	78257	1	25	0.4		0.0	0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1
Effluent treatment	m3/d	65686	0	0	0.4		0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
NCG	m3/h	45833	10	146	1.8					1.8			5.3	5.8	1.1
Auxiliary condenser	ADt/d	3143	10	10	0.1					0.1			0.4	0.0	0.0
Auxiliary departments	ADt/d	3143	430	430	6.1		0.0	0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1
Pulping steam usage total				11382	111.0		8.0	8.5	35.1	111.0	0.0	0.0	414.0	135.5	39.5
ClO2+O2 Plant	tClO2/d	31	15500	153	2.1		0.0	0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8
Power Boiler	kg/s	88	13000	364	3.8		0.0	0.0	1.7	3.8	0.0	0.0	13.2	5.3	2.0
Steam for heating water					5.0					5.0				5.0	
					122.0		8.0	8.5	37.0	122.0	0.0	0.0	432.8		
Pulp mill steam usage total				11899	173.4					175.4				147.8	42.3

STEAM PRODUCTION

	Balance	Steam	Heat production		Steam
		kg/s/unit	MJ/unit	MJ/Adt/d	kg/s
Power Boiler	kg/s	88	1.00	2.76	87.9
Recovery Boiler	kg/s	58	3.75	10.01	218.6
Condensing tail	kg/s				-92.6
Spraying	kg/s				5.1
To feedwater preheating	kg/s				-43.6
Steam to consumers					175.4

Mill steam usage and production

Project Name Case F
 Client name LUT Calculation
 Location Northern Europe

Pulp production
 Softwood 480000 ADt/a

STEAM CONSUMPTION

Department	Unit	Balance	Heat MJ/unit	MJ/ADt	Steam	MP3 kg/s	MP2 kg/s	MP kg/s	LP kg/s	LP2 kg/s	LP3 kg/s	MW	Condensate kg/s	MW		
Woodhandling	m3sub/d	27433	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking & O2	ADt/d	3311	2010	2117		0.0	0.0	18.8	11.7	0.0	0.0	77.0	21.6	8.1	18.8	11.7
Bleaching	ADt/d	3143	580	580		0.0	0.0	3.0	5.3	0.0	0.0	21.1	5.1	1.9	3.0	5.3
Drying	ADt/d	3143	2578	2578		0.0	0.0	0.0	36.3	0.0	0.0	93.8	32.7	6.2	0.0	36.3
Evaporation	t H2O/h	1034	127	3597		0.0	0.0	9.3	43.9	0.0	0.0	130.8	48.9	16.1	9.3	43.9
Recovery Boiler	tDS/d	5038	1118	1792		8.0	8.2	4.0	3.7	0.0	0.0	65.2	14.1	4.5	4.0	3.7
Causticization	m3WL/d	11675	12	46		0.0	0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.2	0.0	0.7
Lime reburning	t lime/d	972	198	61		0.0	0.3	0.0	0.6	0.0	0.0	2.2	0.5	0.2	0.0	0.6
Raw water	m3/d	78257	1	25		0.0	0.0	0.0	0.4	0.0	0.0	0.9	0.4	0.1	0.0	0.4
Effluent treatment	m3/d	65686	0	0		0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4
NCG	m3/h	45833	10	146					1.8			5.3	5.8	1.1		1.8
Auxiliary condenser	ADt/d	3143	10	10					0.1			0.4	0.0	0.0		0.1
Auxiliary departments	ADt/d	3143	430	430		0.0	0.0	0.0	6.1	0.0	0.0	15.6	5.8	1.1	0.0	6.1
Pulping steam usage total				11382		8.0	8.5	35.1	111.0	0.0	0.0	414.0	135.5	39.5	35.1	111.0
ClO2+O2 Plant	tClO2/d	31	15500	153		0.0	0.0	0.2	2.1	0.0	0.0	5.6	2.0	0.8	0.2	2.1
Power Boiler	kg/s	0	13000	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Steam for heating water									5.0				5.0			5.0
						8.0	8.5	35.3	118.1	0.0	0.0	419.6				
Pulp mill steam usage total				11535					169.9				142.5	40.3		

STEAM PRODUCTION

	Balance	Steam kg/s/unit	Heat production MJ/unit MJ/Adt/d	Steam kg/s
Power Boiler	kg/s	0	2.76 0	0.0
Recovery Boiler	kg/s	58	10.02 8046	219.0
Condensing tail	kg/s			-22.2
Spraying	kg/s			4.9
To feedwater preheatin	kg/s			-31.9
Steam to consumers				169.9

INPUT

BY: **ESV**
DATE: **8.8.2009**

1. NAME

Case F

2. CAPACITY (as fired) **5500** tds/d
5005 tds/d (virgin)

3. BLACK LIQUOR (to furnace)

- Dry solid content		83.8	85	%
- Higher heating value		14.29	13	MJ/kgds
	LHV	13.49	12.28	
		virgin	as fired	
- Analysis	C	35.140	32.10	%
	H	3.626	3.30	%
	N	0.110	0.10	%
	S	4.523	5.80	%
	Na	19.092	20.00	%
	K	1.555	2.00	%
	Cl	0.387	0.50	%
	B	0.000	0.00	%
	Inerts	0.000	0.00	%
	O2	35.566	36.20	%
	TOTAL	100.000	100.000	%

- Temperature Before heating **140** °C
Liquor guns **140** °C

4. LIQUOR HEATING: (Direct = 0, Indirect = 1)
- enthalpies for direct heating:
-- steam in p(bar) **12.00** 2814.4 kJ/kg
-- water out (h' in bl T) T(°C) **200.00** 589.1 kJ/kg

5. MAKE-UP SALTCAKE
- Make-up flow **0** g/kg ds
- Make-up T **20** °C
- Make-up cp **1.05** kJ/kg°C

6. RECYCLE ASH
- Flow as percentage of as fired liquor flow **9.00** % of as fired
28.3 g/m3n,dry

7. AUXILIARY FUEL DATA
- auxiliary fuel flow 52.76 MJ/kg (HHV) **0** kg/s
- auxiliary fuel lower heating value 0 MW **47.93** MJ/kg
- Analysis
C **76.71** w-%
H **21.99** w-%
O **1.15** w-%
N **0.15** w-%
S **0.00** w-%
H2O **0.00** w-%
100.00

8. COMBUSTION AIR
- Ambient air temperature **30.00** °C
- H2O in the air moisture **13.50** g/kg da
- Excess air O2 in dry flue gas 2.771 % **15.00** %
- Infiltration air 12.6 m3n/s **6.00** %
- Primary air percentage 43.5 m3n/s **22.00** %
- Primary air temperature **190.00** °C
- Secondary air percentage 106.7 m3n/s **54.00** %
- Secondary air temperature **190.00** °C
- Tertiary air percentage 23.7 m3n/s **12.00** %
- Tertiary air temperature **190.00** °C
- Quaternary air percentage 23.7 m3n/s **12.00** %
- Quaternary air temperature **190.00** °C
- Total air percentage **100.00** %
- Total air temperature **190.00** °C

9. REDUCTION EFFICIENCY
- Reduction as mole ratio of Na2S/(Na2S+Na2SO4) **96.00** %
- Reduction as mole ratio of Na3BO3/(BNaO2+Na3BO3) **80.00** %

10. GASEOUS EMISSIONS IN FLUE GAS
- SO2 in dry flue gas (3% O2) **0.10** ppm
S/(NA2+K2) in liquor (recycle excluded) **32.43** %
- HCl in dry flue gas (3% O2) **0.00** ppm
- H2S in dry flue gas (3% O2) **0.00** ppm
- Dust loss in stack 52.5 mg/m3n,dry **0.17** g/kg ds
- Flue gas temperature **197.00** °C

11. MAIN STEAM									
- pressure				260.00	bar(a)				
- temperature				540.00	°C				
12. FEED WATER									
- pressure				290.00	bar(a)				
- temperature				148.00	°C				
13. BLOWDOWN									
- mass flow		0 % of FW		0.00	kg/s	0.0 %			
		1423.5 kJ/kg		103.60	bar(a)				
14. SOOTBLOWING: (Outside=0,Inside=1)									
- mass flow		2.7 % of FW		6.00	kg/s	10.4 %			
- pressure for indirect				26.00	bar(a)				
- temperature for indirect		2969.6 kJ/kg		285.00	°C				
15. DNCG BURNING: (In air = 0, Separate = 1)									
- DNCG flow (wet)		0.00 kg/s		0.00	m3n/s				
- DNCG saturated temperature		0.12 kPa		50.00	°C				
- DNCG inlet temperature		0 kg(dry)/s		90.00	°C				
- Sulfur in wet DNCG				200.00	mg/m3n				
16. CNCG+ETC BURNING									
- CNCG flow (wet)		19.28 MJ/kg (HHV)		0.50	kg/s				
- CNCG saturated temperature		17.78 MJ/kg (LHV)		60.00	°C				
- CNCG inlet temperature		12.14 w-% water		82.00	°C				
- CNCG ejector steam		0.439 kg(dry)/s		0.00	kg/s				
- methanol flow		20.4 MJ/kg (HHV)		0.00	kg/s				
- water in methanol flow		16.1 MJ/kg (LHV)		8.00	w-%				
- turpentine flow		38.3 MJ/kg (HHV)		0.00	kg/s				
- water in turpentine flow		32.6 MJ/kg (LHV)		7.90	w-%				
		Methanol	Turpentine	CNCG					
- Analysis	C	32.82	80.77	16.57	w-%				
	H	10.98	10.87	5.48	w-%				
	O	42.12	0.00	4.17	w-%				
	N	3.57	0.19	21.31	w-%				
3.1681 g/kgds	S	2.61	0.17	40.33	w-%				
	H2O	7.90	8.00	12.14	w-%				
		100	100	100					
17. DISSOLVING TANK VENT GASES: (In air = 0, Separate = 1)									
- DTVG flow (wet)		23.24 kg/s		0.30	m3n/s /kgds				
- DTVG saturated temperature		12.34 kPa		50.00	°C				
18. ENERGY BALANCE									
- Reference air temperature				0	°C				
- radiation & convection		5.604 MW		0.560	%-of heat input				
- unburnt and other losses		8.907 MW		0.890	%-of heat input				
- manufacturers margin		13.410 MW		1.340	%-of heat input				
19. ASH DATA									
- flow		Make-up	Dust loss	Recycle	g/kgds (as fired)				
		0.0	0.2	90.0					
- Analysis	Na	32.4	29.2	29.2	w-%	137.554363			
	K	0.0	6.5	6.5	w-%				
	Cl	0.3	1.6	1.6	w-%				
	CO3	0.0	6.8	6.8	w-%				
	S	0.0	0.1	0.1	w-%				
	BO2	0.0	0.0	0.0	w-%				
	SO4	67.2	55.8	55.8	w-%				
20. MP FW PREHEATING									
- FW temperature HP heater in				200.00	°C				
- FW temperature HP heater out				220.00	°C				
- Added enthalpy				88.00 kJ/kg FW					
21. REHEATER									
- Inlet pressure				54.00	bar(a)				
- Inlet temperature				337.00	°C				
- Outlet pressure				52.00	bar(a)				
- Outlet temperature				460.00	°C				
- Reheat flow				201.86	kg/s				
- Added enthalpy				313.52 kJ/kg FW					

EXCESS AIR, TOTAL FLUE GAS AND SOOTBLOWING STEAM AMOUNTS / KGDS

Excess air	%	15	O ₂ ,dry	O ₂ ,wet	2.206					
AIR	mol	m3n	g	Flue gas	mol	m3n	g			
excess O2	3.941	0.088	126.114	Theor.dryFG	123.442	2.762	3845.804			
excess N2	14.866	0.333	416.430	excess dry air	18.812	0.421	542.793			
excess CO2	0.006	0.000	0.248							
excess H2O	0.407	0.009	7.328	Dry flue gas	142.254	3.184	4388.596			
				H2O comb	28.084	0.629	505.943			
Excess wet air	19.219	0.431	550.120	H2O air	3.118	0.070	56.180			
Stoich.wet air	128.128	2.870	3667.510							
				H2O sum	31.203	0.699	562.122			
Total wet air	147.347	3.301	4217.630							
					173.457	3.883	4950.718 (w/o sootblowing steam)			
H2O in stoich. air	2.712	0.061	48.852	Sootbl.s.	5.232	0.117	94.255	0.204		
H2O in excess air	0.407	0.009	7.328							
					178.689	4.000	5044.973 (with sootblowing steam)			
Water in air	3.118	0.070	56.180	DCE	0.000	0.000	0.000			
Total dry air	144.229	3.231	4161.450	Wet FG	178.689	4.000	5044.973 (with DCE+STBLS)			
Composition of FG	Theoretical dry FG			Theoretical wet FG		Dry FG		Wetl FG no sootb.		Wet FG
	mol	vol	mol	vol	mol	vol	mol	vol	mol	vol
CO2	19.64	19.54	15.45	15.36	17.05	16.96	13.98	13.90	13.57	13.50
H2O	0.00	0.00	21.35	21.37	0.00	0.00	17.99	18.01	20.39	20.41
SO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2	80.36	80.46	63.20	63.26	80.19	80.28	65.77	65.82	63.84	63.90
O2	0.00	0.00	0.00	0.00	2.77	2.77	2.27	2.27	2.21	2.22
TOTAL	100.00	100.00	100.00	100.00	100.01	100.01	100.01	100.01	100.01	100.01
AIR AND FLUE GAS FLOWS					Air		Dry FG		WetFG	
with DS capacity of:			63.66	kgds/s	210.119	m3n/s	202.660	m3n/s	254.631	m3n/s
					268.483	kg/s	279.367	kg/s	321.150	kg/s

HEAT BALANCE MODERN

Case F

Ref temp °C

0

Black liquor:	MJ/kgds	13.00000	Enthalpies:			
HHV	kJ/kgds	13000	- steam	kJ/kg	pressure	temperature
NHV (Adams)	kJ/kgds	10524.532	- RH steam out	3292.3	260.0	540.0
NHV (Balance)	kJ/kgds	10917.6076	- RH steam in	3338.2	52.00	460.00
NHV (KCL)	kJ/kgds	10444.5	- feed water	3024.7	54.00	337.00
			- steam at fg out temp	641.8	290.0	148.0
T from evap	°C	140	- continuous blow down	2873.3	0.20	197.0
T at guns	°C	140	- steam at air in temp.	1423.5	103.6	
Liquor cp	kJ/kg°C	2.64072581	- fwah ent difference	2842.1	0.0	180.4
			- auxiliary sootb. steam	0		
Combustion air:			- latent heat at ref. T	2969.6	26.0	285.0
Ambient	°C	30		2501.6		
Enthalpy	kJ/m3n	38.9682158	Losses of heat input			
Heated	°C	190	- rad&conv	%	0.56	
Enthalpy	kJ/m3n	248.404397	- unburnt	%	0.89	
Infiltr. air	%	6	- margin	%	1.34	
Ref enthalpy	kJ/m3n	1.4478E-05				
Smelt temperatur	°C	850	Wet flue gas:			
			- temperature	°C	197	
			- enthalpy	kJ/m3n	277.743536	
			- ref enthalpy	kJ/m3n	0.00	

INPUT			kJ/kgds	%	OUTPUT		kJ/kgds	%
BL LHV (I=2440)		12280.4		(92.9)	Smelt	(Na2+K2)S	155.9	1.2
Correction to ref. temperature		0.0		(0.0)		(Na2+K2)SO4	10.3	0.1
H2O in BL	0.17647059	-430.6		(-3.3)		(Na2+K2)CO3	415.6	3.1
Black liquor heating value			11849.8	89.7		(Na+K)Cl	7.7	0.1
Auxiliary fuel			0.0	0.0		Na3BO3+NaBO2	0.0	0.0
BL sensible heat			434.9	3.3	Others		0.0	0.0
Indirect			0.0	0.0	Reduction	Na2S	1293.4	9.8
Direct			0.0	0.0		SO2	0.0	0.0
Dry air:						K2S	64.3	0.5
Unheated			118.3	0.9		Na3BO3	0.0	0.0
Heated			636.1	4.8				
Infiltration			7.6	0.1	red+smelt		1947.2	14.7
Moist in air	0.056		20.8	0.2				
CNCG			139.6	1.1	wet fg	4.000	1111.0	8.4
Methanol			0.0	0.0	r/c loss	% 0.56	74.0	0.6
Turpentine			0.0	0.0	unburnt	% 0.89	117.5	0.9
Outside sootblowing steam			9.1	0.1	margin	% 1.34	177.0	1.3
Heat input			13216.2	100.0	losses total		3426.7	25.9
						kg/kgds	kJ/kg	
					fwah	3.432	0.0	0.0
					sb	0.094	0.0	0.0
Feedwater preheating			302.0		cbd	0.000	1423.5	0.0
					reheat	3.171	313.5	7.5
Feedwater	3.432	641.8	2202.9	16.7	steam	3.432	3292.3	85.5
Total			15721.1	119.0	Total		15721.1	119.0
Net heat to steam			9789.5		Boiler efficiency (LHV)		74.07	%
					Boiler efficiency (LHV+reduction)		84.35	%
Free heat in furnace			10974.5		Boiler efficiency (NHV)		87.96	%
Steam production			3.4323	kg/kgds	218.492	kg/s	786.6	t/h
Sootblowing steam	Outside		0.0943	kg/kgds	6.000	kg/s	21.6	t/h
Continuous blowdown			0.0000	kg/kgds	0.000	kg/s	0.0	t/h
Feed water flow			3.4323	kg/kgds	218.492	kg/s	786.6	t/h

MASS BALANCE

Case F

IN	g/kgds	kg/s	OUT	g/kgds	kg/s
Black liquor (wet)	1176.471	74.891	Smelt	390.824	24.879
DNCG	0.000	0.000	Recycle ash	90.000	5.729
CNCG	7.856	0.500	Dust loss	0.167	0.011
Methanol	0.000	0.000			
Turpentine	0.000	0.000			
Diss.&mix tank gases	29.753	1.894			
Sootblowing steam	94.255	6.000			
Auxiliary fuel	0.000	0.000			
Air (wet)	4217.630	268.483	Flue gas	5044.973	321.150
Total	5525.96	351.769		5525.964	351.769

HEAT BALANCE

Net heat to steam 9789.52

STEAM

Steam production		Modern
Sootblowing steam	Outside	218.492
Continuous blowdown		6.000
Feed water flow		0.000
		218.492

INPUT

BY: **ESV**
DATE: **22.11.2009**

1. NAME

Case E

2. CAPACITY (as fired) **5500** tds/d
5005 tds/d (virgin)

3. BLACK LIQUOR (to furnace)

- Dry solid content		83.8	85	%
- Higher heating value		14.29	13	MJ/kgds
	LHV	13.49	12.28	
		virgin	as fired	
- Analysis	C	35.140	32.10	%
	H	3.626	3.30	%
	N	0.110	0.10	%
	S	4.523	5.80	%
	Na	19.092	20.00	%
	K	1.555	2.00	%
	Cl	0.387	0.50	%
	B	0.000	0.00	%
	Inerts	0.000	0.00	%
	O2	35.566	36.20	%
	TOTAL	100.000	100.000	%

- Temperature Before heating **140** °C
Liquor guns **140** °C

4. LIQUOR HEATING: (Direct = 0, Indirect = 1)
- enthalpies for direct heating:
-- steam in p(bar) **12.00** 2814.4 kJ/kg
-- water out (h' in bl T) T(°C) **200.00** 589.1 kJ/kg

5. MAKE-UP SALTCAKE
- Make-up flow **0** g/kg ds
- Make-up T **20** °C
- Make-up cp **1.05** kJ/kg°C

6. RECYCLE ASH
- Flow as percentage of as fired liquor flow **9.00** % of as fired
28.3 g/m3n,dry

7. AUXILIARY FUEL DATA
- auxiliary fuel flow 52.76 MJ/kg (HHV) **0** kg/s
- auxiliary fuel lower heating value 0 MW **47.93** MJ/kg
- Analysis
C **76.71** w-%
H **21.99** w-%
O **1.15** w-%
N **0.15** w-%
S **0.00** w-%
H2O **0.00** w-%
100.00

8. COMBUSTION AIR
- Ambient air temperature **30.00** °C
- H2O in the air moisture **13.50** g/kg da
- Excess air O2 in dry flue gas 2.771 % **15.00** %
- Infiltration air 12.6 m3n/s **6.00** %
- Primary air percentage 43.5 m3n/s **22.00** %
- Primary air temperature **190.00** °C
- Secondary air percentage 106.7 m3n/s **54.00** %
- Secondary air temperature **190.00** °C
- Tertiary air percentage 23.7 m3n/s **12.00** %
- Tertiary air temperature **190.00** °C
- Quaternary air percentage 23.7 m3n/s **12.00** %
- Quaternary air temperature **190.00** °C
- Total air percentage **100.00** %
- Total air temperature **190.00** °C

9. REDUCTION EFFICIENCY
- Reduction as mole ratio of Na2S/(Na2S+Na2SO4) **96.00** %
- Reduction as mole ratio of Na3BO3/(BNaO2+Na3BO3) **80.00** %

10. GASEOUS EMISSIONS IN FLUE GAS
- SO2 in dry flue gas (3% O2) **0.10** ppm
S/(NA2+K2) in liquor (recycle excluded) **32.43** %
- HCl in dry flue gas (3% O2) **0.00** ppm
- H2S in dry flue gas (3% O2) **0.00** ppm
- Dust loss in stack 52.5 mg/m3n,dry **0.17** g/kg ds
- Flue gas temperature **197.00** °C

11. MAIN STEAM									
- pressure				160.00	bar(a)				
- temperature				515.00	°C				
12. FEED WATER									
- pressure				290.00	bar(a)				
- temperature				148.00	°C				
13. BLOWDOWN									
- mass flow		0 % of FW		0.00	kg/s	0.0 %			
		1423.5 kJ/kg		103.60	bar(a)				
14. SOOTBLOWING: (Outside=0,Inside=1)									
- mass flow		2.7 % of FW		6.00	kg/s	10.4 %			
- pressure for indirect				26.00	bar(a)				
- temperature for indirect		2969.6 kJ/kg		285.00	°C				
15. DNCG BURNING: (In air = 0, Separate = 1)									
- DNCG flow (wet)		0.00 kg/s		0.00	m3n/s				
- DNCG saturated temperature		0.12 kPa		50.00	°C				
- DNCG inlet temperature		0 kg(dry)/s		90.00	°C				
- Sulfur in wet DNCG				200.00	mg/m3n				
16. CNCG+ETC BURNING									
- CNCG flow (wet)		19.28 MJ/kg (HHV)		0.50	kg/s				
- CNCG saturated temperature		17.78 MJ/kg (LHV)		60.00	°C				
- CNCG inlet temperature		12.14 w-% water		82.00	°C				
- CNCG ejector steam		0.439 kg(dry)/s		0.00	kg/s				
- methanol flow		20.4 MJ/kg (HHV)		0.00	kg/s				
- water in methanol flow		16.1 MJ/kg (LHV)		8.00	w-%				
- turpentine flow		38.3 MJ/kg (HHV)		0.00	kg/s				
- water in turpentine flow		32.6 MJ/kg (LHV)		7.90	w-%				
		Methanol	Turpentine	CNCG					
- Analysis	C	32.82	80.77	16.57	w-%				
	H	10.98	10.87	5.48	w-%				
	O	42.12	0.00	4.17	w-%				
	N	3.57	0.19	21.31	w-%				
3.1681 g/kgds	S	2.61	0.17	40.33	w-%				
	H2O	7.90	8.00	12.14	w-%				
		100	100	100					
17. DISSOLVING TANK VENT GASES: (In air = 0, Separate = 1)									
- DTVG flow (wet)		23.24 kg/s		0.30	m3n/s /kgds				
- DTVG saturated temperature		12.34 kPa		50.00	°C				
18. ENERGY BALANCE									
- Reference air temperature				0	°C				
- radiation & convection		5.614 MW		0.560	%-of heat input				
- unburnt and other losses		8.922 MW		0.890	%-of heat input				
- manufacturers margin		13.432 MW		1.340	%-of heat input				
19. ASH DATA									
- flow		Make-up	Dust loss	Recycle	g/kgds (as fired)				
		0.0	0.2	90.0					
- Analysis	Na	32.4	29.2	29.2	w-%	137.554363			
	K	0.0	6.5	6.5	w-%				
	Cl	0.3	1.6	1.6	w-%				
	CO3	0.0	6.8	6.8	w-%				
	S	0.0	0.1	0.1	w-%				
	BO2	0.0	0.0	0.0	w-%				
	SO4	67.2	55.8	55.8	w-%				
20. MP FW PREHEATING									
- FW temperature HP heater in				200.00	°C				
- FW temperature HP heater out				220.00	°C				
- Added enthalpy				88.00 kJ/kg FW					
21. REHEATER									
- Inlet pressure				36.00	bar(a)				
- Inlet temperature				310.00	°C				
- Outlet pressure				34.00	bar(a)				
- Outlet temperature				400.00	°C				
- Reheat flow				210.00	kg/s				
- Added enthalpy				223.18 kJ/kg FW					

Dry solid amount	tds/d	5500	Reduction eff. %			96							
DS content virgin	%	83.76	S/(Na2+K2) in BLDS, mol-%			32.4268803 (as fired)					B/(Na3+K3), mol-%		
DS content as fired	%	85	S/(Na2+K2) in smelt, mol-%			34.9086389 => SO2 in dry (ppm)					0.11096035 B/Na, mol-%		
As fired	g/kgds	H2O 176.47	C 321	H2 33	O2 362	N2 1	S 58	Na2 200	K2 20	Cl 5	B 0	Inerts 0	
Molar weight		18.0152	12.0110	2.0158	31.9988	28.0134	32.0600	45.9795	78.1966	35.4530	10.8110	-	
		mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	g/kgds	
Virgin black liquor	1086.5	9.796	26.623	16.371	10.115	0.036	1.284	3.779	0.181	0.099	0.000	0.000	
Water & chemical loss in DCE	0.0	-	-	-	-	-	-	-	-	-	-	-	
Recycle ash	90.0	-	0.102	-	1.198	-	0.525	0.571	0.075	0.042	0.000	-	
Salt cake make-up	0.0	-	0.000	-	0.000	-	0.000	0.000	0.000	0.000	0.000	-	
Liquor to recovery boiler	1176.5	9.796	26.726	16.371	11.313	0.036	1.809	4.350	0.256	0.141	0.000	0.000	
Steam to preheater	0.0	0.000	-	-	-	-	-	-	-	-	-	-	
As fired liquor to furnace	1176.5	9.796	26.726	16.371	11.313	0.036	1.809	4.350	0.256	0.141	0.000	0.000	
DNCG	0.0	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	
CNCG	7.9	0.053	0.108	0.213	0.010	0.060	0.099	-	-	-	-	-	
Methanol	0.0	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	
Turpentine	0.0	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	
Dissolving tank vent	29.8	1.652	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	
Auxiliary fuel	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	0.000	-	
Recycle ash	-90.0	-	-0.102	-	-1.198	-	-0.525	-0.571	-0.075	-0.042	-	-	
Chem. loss to stack	-0.2	-	0.000	-	-0.002	-	-0.001	-0.001	0.000	0.000	0.000	-	
To smelt and flue gas	1094.2	11.500	26.731	16.584	10.123	0.095	1.382	3.778	0.181	0.099	0.000	0.000	
Na2S (78.0395)	98.8	-	-	-	-	-	1.266	1.266	-	-	-	-	
Na2SO4 (142.0371)	7.5	-	-	-	0.105	-	0.053	0.053	-	-	-	-	
Na2CO3 (105.9887)	255.6	-	2.411	-	3.617	-	-	2.411	-	-	-	-	
K2S (110.2566)	6.7	-	-	-	-	-	0.061	-	0.061	-	-	-	
K2SO4 (174.2542)	0.4	-	-	-	0.005	-	0.003	-	0.003	-	-	-	
K2CO3 (138.2058)	16.0	-	0.115	-	0.173	-	-	-	0.115	-	-	-	
NaCl (58.4428)	5.5	-	-	-	-	-	-	0.047	-	0.095	-	-	
KCl (74.5513)	0.3	-	-	-	-	-	-	-	0.002	0.005	-	-	
Na3BO3 (127.7785)	0.0	-	-	-	0.000	-	-	0.000	-	-	0.000	-	
NaBO2 (65.7996)	0.0	-	-	-	0.000	-	-	0.000	-	-	0.000	-	
Other	0.0	-	-	-	-	-	-	-	-	-	-	0.000	
Total to smelt	390.8	-	2.527	-	3.901	-	1.382	3.778	0.181	0.099	0.000	0.000</	

	Air			Dry gas			Water vapour				
	mol	m3n	g		mol	m3n	g		mol	m3n	g
C	24.204	-	-	CO2	24.204	0.539	1065.231	H2O	11.500	0.258	207.177
S	0.000	-	-	SO2	0.000	0.000	0.001		-	-	-
H2	16.584	-	-		-	-	-	H2	16.584	0.372	298.766
O2-required	32.496	-	-		-	-	-				
O2 in BLDS	6.222	-	-		-	-	-				
O2 from air	26.275	0.588	840.760	O2	0.000	0.000	0.000				
N2 in BLDS	0.095	0.002	2.674	-	-	-	-				
N2 from air	99.104	2.220	2776.242	N2	99.200	2.222	2778.915				
CO2 from air	0.038	0.001	1.656	CO2	0.038	0.001	1.656	DCE	0.000	0.000	0.000
H2O from air	2.712	0.061	48.852					From air	2.712	0.061	48.852
Stoichiom. wet air	128.128	2.870	3667.510	Dry flue gas	123.442	2.762	3845.804	H2O in FG	30.796	0.690	554.795

Excess air	%	15	O2,dry	O2,wet	2.206				
AIR	mol	m3n	g	Flue gas	mol	m3n	g		
excess O2	3.941	0.088	126.114	Theor.dryFG	123.442	2.762	3845.804		
excess N2	14.866	0.333	416.430	excess dry air	18.812	0.421	542.793		
excess CO2	0.006	0.000	0.248						
excess H2O	0.407	0.009	7.328	Dry flue gas	142.254	3.184	4388.596		
				H2O comb	28.084	0.629	505.943		
Excess wet air	19.219	0.431	550.120	H2O air	3.118	0.070	56.180		
Stoich.wet air	128.128	2.870	3667.510						
				H2O sum	31.203	0.699	562.122		
Total wet air	147.347	3.301	4217.630						
					173.457	3.883	4950.718 (w/o sootblowing steam)		
H2O in stoich. air	2.712	0.061	48.852	Sootbl.s.	5.232	0.117	94.255	0.204	
H2O in excess air	0.407	0.009	7.328						
					178.689	4.000	5044.973 (with sootblowing steam)		
Water in air	3.118	0.070	56.180	DCE	0.000	0.000	0.000		
Total dry air	144.229	3.231	4161.450	Wet FG	178.689	4.000	5044.973 (with DCE+STBLS)		
Composition of FG	Theoretical dry FG		Theoretical wet FG		Dry FG		Wet FG no sootb.		Wet FG
	mol	vol	mol	vol	mol	vol	mol	vol	mol
CO2	19.64	19.54	15.45	15.36	17.05	16.96	13.98	13.90	13.57
H2O	0.00	0.00	21.35	21.37	0.00	0.00	17.99	18.01	20.39
SO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2	80.36	80.46	63.20	63.26	80.19	80.28	65.77	65.82	63.84
O2	0.00	0.00	0.00	0.00	2.77	2.77	2.27	2.27	2.21
TOTAL	100.00	100.00	100.00	100.00	100.01	100.01	100.01	100.01	100.01
AIR AND FLUE GAS FLOWS					Air	Dry FG	WetFG		
with DS capacity of:			63.66	kgds/s	210.119	202.660	254.631		
					268.483	279.367	321.150		
					kg/s	kg/s	kg/s		

HEAT BALANCE MODERN

Case E

Ref temp °C

0

Black liquor:	MJ/kgds	13.00000	Enthalpies:			
HHV	kJ/kgds	13000	- steam	kJ/kg	pressure	temperature
NHV (Adams)	kJ/kgds	10524.532	- RH steam out	3340.4	160.0	515.0
NHV (Balance)	kJ/kgds	10917.6076	- RH steam in	3225.9	34.00	400.00
NHV (KCL)	kJ/kgds	10444.5	- feed water	3002.7	36.00	310.00
			- steam at fg out temp	641.8	290.0	148.0
T from evap	°C	140	- continuous blow down	2873.3	0.20	197.0
T at guns	°C	140	- steam at air in temp.	1423.5	103.6	
Liquor cp	kJ/kg°C	2.64072581	- fwah ent difference	2842.1	0.0	180.4
			- auxiliary sootb. steam	0		
Combustion air:			- latent heat at ref. T	2969.6	26.0	285.0
Ambient	°C	30		2501.6		
Enthalpy	kJ/m3n	38.9682158	Losses of heat input			
Heated	°C	190	- rad&conv	%	0.56	
Enthalpy	kJ/m3n	248.404397	- unburnt	%	0.89	
Infiltr. air	%	6	- margin	%	1.34	
Ref enthalpy	kJ/m3n	1.4478E-05				
Smelt temperatur	°C	850	Wet flue gas:			
			- temperature	°C	197	
			- enthalpy	kJ/m3n	277.743536	
			- ref enthalpy	kJ/m3n	0.00	

INPUT			kJ/kgds	%	OUTPUT		kJ/kgds	%
BL LHV (I=2440)		12280.4		(92.9)	Smelt	(Na2+K2)S	155.9	1.2
Correction to ref. temperature		0.0		(0.0)		(Na2+K2)SO4	10.3	0.1
H2O in BL	0.17647059	-430.6		(-3.3)		(Na2+K2)CO3	415.6	3.1
Black liquor heating value			11849.8	89.7		(Na+K)Cl	7.7	0.1
Auxiliary fuel			0.0	0.0		Na3BO3+NaBO2	0.0	0.0
BL sensible heat			434.9	3.3	Others		0.0	0.0
Indirect			0.0	0.0	Reduction	Na2S	1293.4	9.8
Direct			0.0	0.0		SO2	0.0	0.0
Dry air:						K2S	64.3	0.5
Unheated			118.3	0.9		Na3BO3	0.0	0.0
Heated			636.1	4.8				
Infiltration			7.6	0.1	red+smelt		1947.2	14.7
Moist in air	0.056		20.8	0.2				
CNCG			139.6	1.1	wet fg	4.000	1111.0	8.4
Methanol			0.0	0.0	r/c loss	% 0.56	74.0	0.6
Turpentine			0.0	0.0	unburnt	% 0.89	117.5	0.9
Outside sootblowing steam			9.1	0.1	margin	% 1.34	177.0	1.3
Heat input			13216.2	100.0	losses total		3426.7	25.9
						kg/kgds	kJ/kg	
					fwah	3.468	0.0	0.0
					sb	0.094	0.0	0.0
Feedwater preheating			305.2		cbd	0.000	1423.5	0.0
					reheat	3.299	223.2	5.6
Feedwater	3.468	641.8	2225.7	16.8	steam	3.468	3340.4	11584.1
								87.7
Total			15747.1	119.1	Total		15747.1	119.1
Net heat to steam			9789.5		Boiler efficiency (LHV)		74.07	%
					Boiler efficiency (LHV+reduction)		84.35	%
Free heat in furnace			10974.5		Boiler efficiency (NHV)		87.96	%
Steam production			3.4679	kg/kgds	220.755	kg/s	794.7	t/h
Sootblowing steam	Outside		0.0943	kg/kgds	6.000	kg/s	21.6	t/h
Continuous blowdown			0.0000	kg/kgds	0.000	kg/s	0.0	t/h
Feed water flow			3.4679	kg/kgds	220.755	kg/s	794.7	t/h

MASS BALANCE

Case E

IN	g/kgds	kg/s	OUT	g/kgds	kg/s
Black liquor (wet)	1176.471	74.891	Smelt	390.824	24.879
DNCG	0.000	0.000	Recycle ash	90.000	5.729
CNCG	7.856	0.500	Dust loss	0.167	0.011
Methanol	0.000	0.000			
Turpentine	0.000	0.000			
Diss.&mix tank gases	29.753	1.894			
Sootblowing steam	94.255	6.000			
Auxiliary fuel	0.000	0.000			
Air (wet)	4217.630	268.483	Flue gas	5044.973	321.150
Total	5525.96	351.769		5525.964	351.769

HEAT BALANCE

Net heat to steam	9789.52
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STEAM

Steam production	Modern	220.755
Sootblowing steam	Outside	6.000
Continuous blowdown		0.000
Feed water flow		220.755

INPUT

BY: **ESV**
DATE: **7.8.2009**

1. NAME

Case E

2. CAPACITY (as fired) **5500** tds/d
5005 tds/d (virgin)

3. BLACK LIQUOR (to furnace)

- Dry solid content		83.8	85	%
- Higher heating value		14.29	13	MJ/kgds
	LHV	13.49	12.28	
		virgin	as fired	
- Analysis	C	35.140	32.10	%
	H	3.626	3.30	%
	N	0.110	0.10	%
	S	4.523	5.80	%
	Na	19.092	20.00	%
	K	1.555	2.00	%
	Cl	0.387	0.50	%
	B	0.000	0.00	%
	Inerts	0.000	0.00	%
	O2	35.566	36.20	%
	TOTAL	100.000	100.000	%

- Temperature Before heating **140** °C
Liquor guns **140** °C

4. LIQUOR HEATING: (Direct = 0, Indirect = 1)
- enthalpies for direct heating:
-- steam in p(bar) **12.00** 2814.4 kJ/kg
-- water out (h' in bl T) T(°C) **200.00** 589.1 kJ/kg

5. MAKE-UP SALTCAKE
- Make-up flow **0** g/kg ds
- Make-up T **20** °C
- Make-up cp **1.05** kJ/kg°C

6. RECYCLE ASH
- Flow as percentage of as fired liquor flow **9.00** % of as fired
28.3 g/m3n,dry

7. AUXILIARY FUEL DATA
- auxiliary fuel flow 52.76 MJ/kg (HHV) **0** kg/s
- auxiliary fuel lower heating value 0 MW **47.93** MJ/kg
- Analysis
C **76.71** w-%
H **21.99** w-%
O **1.15** w-%
N **0.15** w-%
S **0.00** w-%
H2O **0.00** w-%
100.00

8. COMBUSTION AIR
- Ambient air temperature **30.00** °C
- H2O in the air moisture **13.50** g/kg da
- Excess air O2 in dry flue gas 2.771 % **15.00** %
- Infiltration air 12.6 m3n/s **6.00** %
- Primary air percentage 43.5 m3n/s **22.00** %
- Primary air temperature **190.00** °C
- Secondary air percentage 106.7 m3n/s **54.00** %
- Secondary air temperature **190.00** °C
- Tertiary air percentage 23.7 m3n/s **12.00** %
- Tertiary air temperature **190.00** °C
- Quaternary air percentage 23.7 m3n/s **12.00** %
- Quaternary air temperature **190.00** °C
- Total air percentage **100.00** %
- Total air temperature **190.00** °C

9. REDUCTION EFFICIENCY
- Reduction as mole ratio of Na2S/(Na2S+Na2SO4) **96.00** %
- Reduction as mole ratio of Na3BO3/(BNaO2+Na3BO3) **80.00** %

10. GASEOUS EMISSIONS IN FLUE GAS
- SO2 in dry flue gas (3% O2) **0.10** ppm
S/(NA2+K2) in liquor (recycle excluded) **32.43** %
- HCl in dry flue gas (3% O2) **0.00** ppm
- H2S in dry flue gas (3% O2) **0.00** ppm
- Dust loss in stack 52.5 mg/m3n,dry **0.17** g/kg ds
- Flue gas temperature **197.00** °C

11. MAIN STEAM					
- pressure			120.00	bar(a)	
- temperature			515.00	°C	
12. FEED WATER					
- pressure			290.00	bar(a)	
- temperature			148.00	°C	
13. BLOWDOWN					
- mass flow	0 % of FW		0.00	kg/s	0.0 %
	1423.5 kJ/kg		103.60	bar(a)	
14. SOOTBLOWING: (Outside=0,Inside=1)					
- mass flow	2.7 % of FW		6.00	kg/s	10.4 %
- pressure for indirect			26.00	bar(a)	
- temperature for indirect	2969.6 kJ/kg		285.00	°C	
15. DNCG BURNING: (In air = 0, Separate = 1)					
- DNCG flow (wet)	0.00 kg/s		0.00	m3n/s	
- DNCG saturated temperature	0.12 kPa		50.00	°C	
- DNCG inlet temperature	0 kg(dry)/s		90.00	°C	
- Sulfur in wet DNCG			200.00	mg/m3n	
16. CNCG+ETC BURNING					
- CNCG flow (wet)	19.28 MJ/kg (HHV)		0.50	kg/s	
- CNCG saturated temperature	17.78 MJ/kg (LHV)		60.00	°C	
- CNCG inlet temperature	12.14 w-% water		82.00	°C	
- CNCG ejector steam	0.439 kg(dry)/s		0.00	kg/s	
- methanol flow	20.4 MJ/kg (HHV)		0.00	kg/s	
- water in methanol flow	16.1 MJ/kg (LHV)		8.00	w-%	
- turpentine flow	38.3 MJ/kg (HHV)		0.00	kg/s	
- water in turpentine flow	32.6 MJ/kg (LHV)		7.90	w-%	
	Methanol	Turpentine	CNCG		
- Analysis	C	32.82	80.77	16.57	w-%
	H	10.98	10.87	5.48	w-%
	O	42.12	0.00	4.17	w-%
	N	3.57	0.19	21.31	w-%
3.1681 g/kgds	S	2.61	0.17	40.33	w-%
	H2O	7.90	8.00	12.14	w-%
		100	100	100	
17. DISSOLVING TANK VENT GASES: (In air = 0, Separate = 1)					
- DTVG flow (wet)	23.24 kg/s		0.30	m3n/s /kgds	
- DTVG saturated temperature	12.34 kPa		50.00	°C	
18. ENERGY BALANCE					
- Reference air temperature			0	°C	
- radiation & convection	5.627 MW		0.560	%-of heat input	
- unburnt and other losses	8.942 MW		0.890	%-of heat input	
- manufacturers margin	13.464 MW		1.340	%-of heat input	
19. ASH DATA					
- flow	Make-up	Dust loss	Recycle	g/kgds (as fired)	
	0.0	0.2	90.0		
- Analysis	Na	32.4	29.2	29.2	w-%
	K	0.0	6.5	6.5	w-%
	Cl	0.3	1.6	1.6	w-%
	CO3	0.0	6.8	6.8	w-%
	S	0.0	0.1	0.1	w-%
	BO2	0.0	0.0	0.0	w-%
	SO4	67.2	55.8	55.8	w-%
20. MP FW PREHEATING					
- FW temperature HP heater in			200.00	°C	
- FW temperature HP heater out			220.00	°C	
- Added enthalpy			88.00 kJ/kg FW		
21. REHEATER					
- Inlet pressure			36.00	bar(a)	
- Inlet temperature			346.00	°C	
- Outlet pressure			34.00	bar(a)	
- Outlet temperature			400.00	°C	
- Reheat flow			210.00	kg/s	
- Added enthalpy			131.41 kJ/kg FW		

Case F

STOICHIOMETRIC AIR, DRY FLUE GAS AND WATER VAPOUR / KGDS

	Air			Dry gas			Water vapour				
	mol	m3n	g		mol	m3n	g		mol	m3n	g
C	24.204	-	-	CO2	24.204	0.539	1065.231	H2O	11.500	0.258	207.177
S	0.000	-	-	SO2	0.000	0.000	0.001		-	-	-
H2	16.584	-	-		-	-	-	H2	16.584	0.372	298.766
O2-required	32.496	-	-		-	-	-				
O2 in BLDS	6.222	-	-		-	-	-				
O2 from air	26.275	0.588	840.760	O2	0.000	0.000	0.000				
N2 in BLDS	0.095	0.002	2.674	-	-	-	-				
N2 from air	99.104	2.220	2776.242	N2	99.200	2.222	2778.915				
CO2 from air	0.038	0.001	1.656	CO2	0.038	0.001	1.656	DCE	0.000	0.000	0.000
H2O from air	2.712	0.061	48.852					From air	2.712	0.061	48.852
Stoichiom. wet air	128.128	2.870	3667.510	Dry flue gas	123.442	2.762	3845.804	H2O in FG	30.796	0.690	554.795

Excess air	%	15	O2,dry	O2,wet	2.206				
AIR	mol	m3n	g	Flue gas	mol	m3n	g		
excess O2	3.941	0.088	126.114	Theor.dryFG	123.442	2.762	3845.804		
excess N2	14.866	0.333	416.430	excess dry air	18.812	0.421	542.793		
excess CO2	0.006	0.000	0.248						
excess H2O	0.407	0.009	7.328	Dry flue gas	142.254	3.184	4388.596		
				H2O comb	28.084	0.629	505.943		
Excess wet air	19.219	0.431	550.120	H2O air	3.118	0.070	56.180		
Stoich.wet air	128.128	2.870	3667.510						
				H2O sum	31.203	0.699	562.122		
Total wet air	147.347	3.301	4217.630						
					173.457	3.883	4950.718 (w/o sootblowing steam)		
H2O in stoich. air	2.712	0.061	48.852	Sootbl.s.	5.232	0.117	94.255	0.204	
H2O in excess air	0.407	0.009	7.328						
					178.689	4.000	5044.973 (with sootblowing steam)		
Water in air	3.118	0.070	56.180	DCE	0.000	0.000	0.000		
Total dry air	144.229	3.231	4161.450	Wet FG	178.689	4.000	5044.973 (with DCE+STBLS)		
Composition of FG	Theoretical dry FG		Theoretical wet FG		Dry FG		Wet FG no sootb.		Wet FG
	mol	vol	mol	vol	mol	vol	mol	vol	mol
CO2	19.64	19.54	15.45	15.36	17.05	16.96	13.98	13.90	13.57
H2O	0.00	0.00	21.35	21.37	0.00	0.00	17.99	18.01	20.39
SO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2	80.36	80.46	63.20	63.26	80.19	80.28	65.77	65.82	63.84
O2	0.00	0.00	0.00	0.00	2.77	2.77	2.27	2.27	2.21
TOTAL	100.00	100.00	100.00	100.00	100.01	100.01	100.01	100.01	100.01
AIR AND FLUE GAS FLOWS					Air		Dry FG		WetFG
with DS capacity of:		63.66	kgds/s		210.119	m3n/s	202.660	m3n/s	254.631
					268.483	kg/s	279.367	kg/s	321.150
									m3n/s
									kg/s

HEAT BALANCE MODERN

Case E

Ref temp °C

0

Black liquor:	MJ/kgds	13.00000	Enthalpies:			
HHV	kJ/kgds	13000	- steam	kJ/kg	pressure	temperature
NHV (Adams)	kJ/kgds	10524.532	- RH steam out	3389.2	120.0	515.0
NHV (Balance)	kJ/kgds	10917.6076	- RH steam in	3225.9	34.00	400.00
NHV (KCL)	kJ/kgds	10444.5	- feed water	3094.4	36.00	346.00
			- steam at fg out temp	641.8	290.0	148.0
T from evap	°C	140	- continuous blow down	2873.3	0.20	197.0
T at guns	°C	140	- steam at air in temp.	1423.5	103.6	
Liquor cp	kJ/kg°C	2.64072581	- fwah ent difference	2842.1	0.0	180.4
			- auxiliary sootb. steam	0		
Combustion air:			- latent heat at ref. T	2969.6	26.0	285.0
Ambient	°C	30		2501.6		
Enthalpy	kJ/m3n	38.9682158	Losses of heat input			
Heated	°C	190	- rad&conv	%	0.56	
Enthalpy	kJ/m3n	248.404397	- unburnt	%	0.89	
Infiltr. air	%	6	- margin	%	1.34	
Ref enthalpy	kJ/m3n	1.4478E-05				
Smelt temperatur	°C	850	Wet flue gas:			
			- temperature	°C	197	
			- enthalpy	kJ/m3n	277.743536	
			- ref enthalpy	kJ/m3n	0.00	

INPUT				OUTPUT			
BL LHV (I=2440)	12280.4		%	Smelt		kJ/kgds	%
Correction to ref. temperature	0.0		(92.9)		(Na2+K2)S	155.9	1.2
H2O in BL	0.17647059	-430.6	(0.0)		(Na2+K2)SO4	10.3	0.1
Black liquor heating value		11849.8	(-3.3)		(Na2+K2)CO3	415.6	3.1
Auxiliary fuel		0.0	89.7		(Na+K)Cl	7.7	0.1
BL sensible heat		434.9	0.0	Others	Na3BO3+NaBO2	0.0	0.0
Indirect		0.0	3.3	Reduction	Na2S	1293.4	9.8
Direct		0.0	0.0		SO2	0.0	0.0
Dry air:			0.0		K2S	64.3	0.5
Unheated		118.3	0.9		Na3BO3	0.0	0.0
Heated		636.1	4.8				
Infiltration		7.6	0.1	red+smelt		1947.2	14.7
Moist in air	0.056	20.8	0.2				
CNCG		139.6	1.1	wet fg	4.000	1111.0	8.4
Methanol		0.0	0.0	r/c loss	% 0.56	74.0	0.6
Turpentine		0.0	0.0	unburnt	% 0.89	117.5	0.9
Outside sootblowing steam		9.1	0.1	margin	% 1.34	177.0	1.3
Heat input		13216.2	100.0	losses total		3426.7	25.9
				kg/kgds	kJ/kg		
				fwah	3.518	0.0	0.0
				sb	0.094	0.0	0.0
Feedwater preheating		309.6		cbd	0.000	1423.5	0.0
Feedwater	3.518	641.8	2257.9	reheat	3.299	131.4	433.5
			17.1	steam	3.518	3389.2	11923.5
Total		15783.7	119.4	Total		15783.7	119.4
Net heat to steam		9789.5		Boiler efficiency (LHV)		74.07	%
Free heat in furnace		10974.5		Boiler efficiency (LHV+reduction)		84.35	%
				Boiler efficiency (NHV)		87.96	%
Steam production		3.5181	kg/kgds	223.951	kg/s	806.2	t/h
Sootblowing steam	Outside	0.0943	kg/kgds	6.000	kg/s	21.6	t/h
Continuous blowdown		0.0000	kg/kgds	0.000	kg/s	0.0	t/h
Feed water flow		3.5181	kg/kgds	223.951	kg/s	806.2	t/h

MASS BALANCE

Case E

IN	g/kgds	kg/s	OUT	g/kgds	kg/s
Black liquor (wet)	1176.471	74.891	Smelt	390.824	24.879
DNCG	0.000	0.000	Recycle ash	90.000	5.729
CNCG	7.856	0.500	Dust loss	0.167	0.011
Methanol	0.000	0.000			
Turpentine	0.000	0.000			
Diss.&mix tank gases	29.753	1.894			
Sootblowing steam	94.255	6.000			
Auxiliary fuel	0.000	0.000			
Air (wet)	4217.630	268.483	Flue gas	5044.973	321.150
Total	5525.96	351.769		5525.964	351.769

HEAT BALANCE

Net heat to steam	9789.52
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STEAM

Steam production	Modern	223.951
Sootblowing steam	Outside	6.000
Continuous blowdown		0.000
Feed water flow		223.951

INPUT

BY: **ESV**
DATE: **20.4.2009**

1. NAME

Case C

2. CAPACITY (as fired) **5500** tds/d
5005 tds/d (virgin)

3. BLACK LIQUOR (to furnace)

- Dry solid content		83.8	85	%
- Higher heating value		14.29	13	MJ/kgds
	LHV	13.49	12.28	
		virgin	as fired	
- Analysis	C	35.140	32.10	%
	H	3.626	3.30	%
	N	0.110	0.10	%
	S	4.523	5.80	%
	Na	19.092	20.00	%
	K	1.555	2.00	%
	Cl	0.387	0.50	%
	B	0.000	0.00	%
	Inerts	0.000	0.00	%
	O2	35.566	36.20	%
	TOTAL	100.000	100.000	%

- Temperature Before heating **140** °C
Liquor guns **140** °C

4. LIQUOR HEATING: (Direct = 0, Indirect = 1)
- enthalpies for direct heating:
-- steam in p(bar) **12.00** 2814.4 kJ/kg
-- water out (h' in bl T) T(°C) **200.00** 589.1 kJ/kg

5. MAKE-UP SALTCAKE
- Make-up flow **0** g/kg ds
- Make-up T **20** °C
- Make-up cp **1.05** kJ/kg°C

6. RECYCLE ASH
- Flow as percentage of as fired liquor flow **9.00** % of as fired
28.3 g/m3n,dry

7. AUXILIARY FUEL DATA
- auxiliary fuel flow 52.76 MJ/kg (HHV) **0** kg/s
- auxiliary fuel lower heating value 0 MW **47.93** MJ/kg
- Analysis
C **76.71** w-%
H **21.99** w-%
O **1.15** w-%
N **0.15** w-%
S **0.00** w-%
H2O **0.00** w-%
100.00

8. COMBUSTION AIR
- Ambient air temperature **30.00** °C
- H2O in the air moisture **13.50** g/kg da
- Excess air O2 in dry flue gas 2.771 % **15.00** %
- Infiltration air 12.6 m3n/s **6.00** %
- Primary air percentage 43.5 m3n/s **22.00** %
- Primary air temperature **190.00** °C
- Secondary air percentage 106.7 m3n/s **54.00** %
- Secondary air temperature **190.00** °C
- Tertiary air percentage 23.7 m3n/s **12.00** %
- Tertiary air temperature **190.00** °C
- Quaternary air percentage 23.7 m3n/s **12.00** %
- Quaternary air temperature **190.00** °C
- Total air percentage **100.00** %
- Total air temperature **190.00** °C

9. REDUCTION EFFICIENCY
- Reduction as mole ratio of Na2S/(Na2S+Na2SO4) **96.00** %
- Reduction as mole ratio of Na3BO3/(BNaO2+Na3BO3) **80.00** %

10. GASEOUS EMISSIONS IN FLUE GAS
- SO2 in dry flue gas (3% O2) **0.10** ppm
S/(NA2+K2) in liquor (recycle excluded) **32.43** %
- HCl in dry flue gas (3% O2) **0.00** ppm
- H2S in dry flue gas (3% O2) **0.00** ppm
- Dust loss in stack 52.5 mg/m3n,dry **0.17** g/kg ds
- Flue gas temperature **197.00** °C

11. MAIN STEAM					
- pressure			160.00	bar(a)	
- temperature			540.00	°C	
12. FEED WATER					
- pressure			180.00	bar(a)	
- temperature			148.00	°C	
13. BLOWDOWN					
- mass flow	0 % of FW		0.00	kg/s	0.0 %
	1423.5 kJ/kg		103.60	bar(a)	
14. SOOTBLOWING: (Outside=0,Inside=1)					
- mass flow	2.6 % of FW		6.00	kg/s	10.4 %
- pressure for indirect			26.00	bar(a)	
- temperature for indirect	2969.6 kJ/kg		285.00	°C	
15. DNCG BURNING: (In air = 0, Separate = 1)					
- DNCG flow (wet)	0.00 kg/s		0.00	m3n/s	
- DNCG saturated temperature	0.12 kPa		50.00	°C	
- DNCG inlet temperature	0 kg(dry)/s		90.00	°C	
- Sulfur in wet DNCG			200.00	mg/m3n	
16. CNCG+ETC BURNING					
- CNCG flow (wet)	19.28 MJ/kg (HHV)		0.50	kg/s	
- CNCG saturated temperature	17.78 MJ/kg (LHV)		60.00	°C	
- CNCG inlet temperature	12.14 w-% water		82.00	°C	
- CNCG ejector steam	0.439 kg(dry)/s		0.00	kg/s	
- methanol flow	20.4 MJ/kg (HHV)		0.00	kg/s	
- water in methanol flow	16.1 MJ/kg (LHV)		8.00	w-%	
- turpentine flow	38.3 MJ/kg (HHV)		0.00	kg/s	
- water in turpentine flow	32.6 MJ/kg (LHV)		7.90	w-%	
	Methanol	Turpentine	CNCG		
- Analysis	C	32.82	80.77	16.57	w-%
	H	10.98	10.87	5.48	w-%
	O	42.12	0.00	4.17	w-%
	N	3.57	0.19	21.31	w-%
3.1681 g/kgds	S	2.61	0.17	40.33	w-%
	H2O	7.90	8.00	12.14	w-%
		100	100	100	
17. DISSOLVING TANK VENT GASES: (In air = 0, Separate = 1)					
- DTVG flow (wet)	23.24 kg/s		0.30	m3n/s /kgds	
- DTVG saturated temperature	12.34 kPa		50.00	°C	
18. ENERGY BALANCE					
- Reference air temperature			0	°C	
- radiation & convection	5.536 MW		0.560	%-of heat input	
- unburnt and other losses	8.798 MW		0.890	%-of heat input	
- manufacturers margin	13.246 MW		1.340	%-of heat input	
19. ASH DATA					
- flow	Make-up	Dust loss	Recycle	g/kgds (as fired)	
	0.0	0.2	90.0		
- Analysis	Na	32.4	29.2	29.2	w-%
	K	0.0	6.5	6.5	w-%
	Cl	0.3	1.6	1.6	w-%
	CO3	0.0	6.8	6.8	w-%
	S	0.0	0.1	0.1	w-%
	BO2	0.0	0.0	0.0	w-%
	SO4	67.2	55.8	55.8	w-%
20. MP FW PREHEATING					
- FW temperature HP heater in			200.00	°C	
- FW temperature HP heater out			220.00	°C	
- Added enthalpy			89.10 kJ/kg FW		
21. REHEATER					
- Inlet pressure			56.00	bar(a)	
- Inlet temperature			320.00	°C	
- Outlet pressure			56.00	bar(a)	
- Outlet temperature			320.00	°C	

137.554363

Dry solid amount	tds/d		5500	Reduction eff. %						96							
DS content virgin	%		83.76	S/(Na2+K2) in BLDS, mol-%						32.4268803 (as fired)							B/(Na3+K3), mol-%
DS content as fired	%		85	S/(Na2+K2) in smelt, mol-%						34.9086389 => SO2 in dry (ppm)							0.11096035 B/N a, mol-%
As fired	g/kgds	H2O 176.47	C 321	H2 33	O2 362	N2 1	S 58	Na2 200	K2 20	Cl 5	B 0	Inerts 0					
Molar weight		18.0152	12.0110	2.0158	31.9988	28.0134	32.0600	45.9795	78.1966	35.4530	10.8110	-					
		mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds					
Virgin black liquor	1086.5	9.796	26.623	16.371	10.115	0.036	1.284	3.779	0.181	0.099	0.000	0.000					
Water & chemical loss in DCE	0.0	-	-	-	-	-	-	-	-	-	-	-					
Recycle ash	90.0	-	0.102	-	1.198	-	0.525	0.571	0.075	0.042	0.000	-					
Salt cake make-up	0.0	-	0.000	-	0.000	-	0.000	0.000	0.000	0.000	0.000	-					
Liquor to recovery boiler	1176.5	9.796	26.726	16.371	11.313	0.036	1.809	4.350	0.256	0.141	0.000	0.000					
Steam to preheater	0.0	0.000	-	-	-	-	-	-	-	-	-	-					
As fired liquor to furnace	1176.5	9.796	26.726	16.371	11.313	0.036	1.809	4.350	0.256	0.141	0.000	0.000					
DNCG	0.0	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-					
CNCG	7.9	0.053	0.108	0.213	0.010	0.060	0.099	-	-	-	-	-					
Methanol	0.0	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-					
Turpentine	0.0	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-					
Dissolving tank vent	29.8	1.652	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-					
Auxiliary fuel	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-					
Recycle ash	-90.0	-	-0.102	-	-1.198	-	-0.525	-0.571	-0.075	-0.042	-	-					
Chem. loss to stack	-0.2	-	0.000	-	-0.002	-	-0.001	-0.001	0.000	0.000	0.000	-					
To smelt and flue gas	1094.2	11.500	26.731	16.584	10.123	0.095	1.382	3.778	0.181	0.099	0.000	0.000					
Na2S (78.0395)	98.8	-	-	-	-	-	1.266	1.266	-	-	-	-					
Na2SO4 (142.0371)	7.5	-	-	-	0.105	-	0.053	0.053	-	-	-	-					
Na2CO3 (105.9887)	255.6	-	2.411	-	3.617	-	-	2.411	-	-	-	-					
K2S (110.2566)	6.7	-	-	-	-	-	0.061	-	0.061	-	-	-					
K2SO4 (174.2542)	0.4	-	-	-	0.005	-	0.003	-	0.003	-	-	-					
K2CO3 (138.2058)	16.0	-	0.115	-	0.173	-	-	-	0.115	-	-	-					
NaCl (58.4428)	5.5	-	-	-	-	-	-	0.047	-	0.095	-	-					
KCl (74.5513)	0.3	-	-	-	-	-	-	-	0.002	0.005	-	-					
Na3BO3 (127.7785)	0.0	-	-	-	0.000	-	-	0.000	-	-	0.000	-					
NaBO2 (65.7996)	0.0	-	-	-	0.000	-	-	0.000	-	-	0.000	-					
Other	0.0	-	-	-	-	-	-	-	-	-	-	0.000					
Total to smelt	390.8	-	2.527	-	3.901	-	1.382	3.778	0.181	0.099	0.000	0.000					
Total to flue gas	703.3	11.500	24.204	16.584	6.222	0.095	0.000	0.000	0.000	0.000	0.000	-					
Gaseous loss (SO2)	0.0	-	-	-	0.000												

	Air			Dry gas			Water vapour				
	mol	m3n	g		mol	m3n	g		mol	m3n	g
C	24.204	-	-	CO2	24.204	0.539	1065.231	H2O	11.500	0.258	207.177
S	0.000	-	-	SO2	0.000	0.000	0.001		-	-	-
H2	16.584	-	-		-	-	-	H2	16.584	0.372	298.766
O2-required	32.496	-	-		-	-	-				
O2 in BLDS	6.222	-	-		-	-	-				
O2 from air	26.275	0.588	840.760	O2	0.000	0.000	0.000				
N2 in BLDS	0.095	0.002	2.674	-	-	-	-				
N2 from air	99.104	2.220	2776.242	N2	99.200	2.222	2778.915				
CO2 from air	0.038	0.001	1.656	CO2	0.038	0.001	1.656	DCE	0.000	0.000	0.000
H2O from air	2.712	0.061	48.852					From air	2.712	0.061	48.852
Stoichiom. wet air	128.128	2.870	3667.510	Dry flue gas	123.442	2.762	3845.804	H2O in FG	30.796	0.690	554.795

Excess air	%	15	O2,dry	O2,wet	2.206				
AIR	mol	m3n	g	Flue gas	mol	m3n	g		
excess O2	3.941	0.088	126.114	Theor.dryFG	123.442	2.762	3845.804		
excess N2	14.866	0.333	416.430	excess dry air	18.812	0.421	542.793		
excess CO2	0.006	0.000	0.248						
excess H2O	0.407	0.009	7.328	Dry flue gas	142.254	3.184	4388.596		
				H2O comb	28.084	0.629	505.943		
Excess wet air	19.219	0.431	550.120	H2O air	3.118	0.070	56.180		
Stoich.wet air	128.128	2.870	3667.510						
				H2O sum	31.203	0.699	562.122		
Total wet air	147.347	3.301	4217.630						
					173.457	3.883	4950.718 (w/o sootblowing steam)		
H2O in stoich. air	2.712	0.061	48.852	Sootbl.s.	5.232	0.117	94.255	0.204	
H2O in excess air	0.407	0.009	7.328						
					178.689	4.000	5044.973 (with sootblowing steam)		
Water in air	3.118	0.070	56.180	DCE	0.000	0.000	0.000		
Total dry air	144.229	3.231	4161.450	Wet FG	178.689	4.000	5044.973 (with DCE+STBLS)		
Composition of FG	Theoretical dry FG		Theoretical wet FG		Dry FG		Wet FG no sootb.		Wet FG
	mol	vol	mol	vol	mol	vol	mol	vol	mol
CO2	19.64	19.54	15.45	15.36	17.05	16.96	13.98	13.90	13.57
H2O	0.00	0.00	21.35	21.37	0.00	0.00	17.99	18.01	20.39
SO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2	80.36	80.46	63.20	63.26	80.19	80.28	65.77	65.82	63.84
O2	0.00	0.00	0.00	0.00	2.77	2.77	2.27	2.27	2.21
TOTAL	100.00	100.00	100.00	100.00	100.01	100.01	100.01	100.01	100.01
AIR AND FLUE GAS FLOWS					Air		Dry FG		WetFG
with DS capacity of:		63.66	kgds/s		210.119	m3n/s	202.660	m3n/s	254.631
					268.483	kg/s	279.367	kg/s	321.150
									m3n/s
									kg/s

HEAT BALANCE MODERN

Case C

Ref temp °C

0

Black liquor:	MJ/kgds	13.00000	Enthalpies:	kJ/kg	pressure	temperature
HHV	kJ/kgds	13000	- steam	3410.3	160.0	540.0
NHV (Adams)	kJ/kgds	10524.532	- feed water	634.7	180.0	148.0
NHV (Balance)	kJ/kgds	10917.6076	- steam at fg out temp	2873.3	0.20	197.0
NHV (KCL)	kJ/kgds	10444.5	- continuous blow down	1423.5	103.6	
			- steam at air in temp.	2842.1	0.0	180.4
T from evap	°C	140	- fwah ent difference	0		
T at guns	°C	140	- auxiliary sootb. steam	2969.6	26.0	285.0
Liquor cp	kJ/kg°C	2.64072581	- latent heat at ref. T	2501.6		
Combustion air:			Losses of heat input			
Ambient	°C	30	- rad&conv	%	0.56	
Enthalpy	kJ/m3n	38.9682158	- unburnt	%	0.89	
Heated	°C	190	- margin	%	1.34	
Enthalpy	kJ/m3n	248.404397	Wet flue gas:			
Infiltr. air	%	6	- temperature	°C	197	
Ref enthalpy	kJ/m3n	1.4478E-05	- enthalpy	kJ/m3n	277.743536	
Smelt temperatur	°C	850	- ref enthalpy	kJ/m3n	-2.794E-10	

INPUT		kJ/kgds	%	OUTPUT		kJ/kgds	%
BL LHV (I=2440)	12280.4		(92.9)	Smelt	(Na2+K2)S	155.9	1.2
Correction to ref. temperature	0.0		(0.0)		(Na2+K2)SO4	10.3	0.1
H2O in BL	0.17647059	-430.6	(-3.3)		(Na2+K2)CO3	415.6	3.1
Black liquor heating value		11849.8	89.7		(Na+K)Cl	7.7	0.1
Auxiliary fuel		0.0	0.0		Na3BO3+NaBO2	0.0	0.0
BL sensible heat		434.9	3.3	Others		0.0	0.0
Indirect		0.0	0.0	Reduction	Na2S	1293.4	9.8
Direct		0.0	0.0		SO2	0.0	0.0
Dry air:					K2S	64.3	0.5
Unheated		118.3	0.9		Na3BO3	0.0	0.0
Heated		636.1	4.8				
Infiltration		7.6	0.1	red+smelt		1947.2	14.7
Moist in air	0.056	20.8	0.2				
CNCG		139.6	1.1	wet fg	4.000	1111.0	8.4
Methanol		0.0	0.0	r/c loss	%	0.56	74.0
Turpentine		0.0	0.0	unburnt	%	0.89	117.5
Outside sootblowing steam		9.1	0.1	margin	%	1.34	177.0
Heat input		13216.2	100.0	losses total		3426.7	25.9
				kg/kgds	kJ/kg		
				fwah	3.644	0.0	0.0
				fpreheat	3.644	-89.1	-324.7
				sb	0.094	0.0	0.0
				cbd	0.000	1423.5	0.0
Feedwater	3.644	634.7	2312.6	17.5	steam	3.644	3410.3
						12426.8	94.0
Total		15528.8	117.5	Total		15528.8	117.5
Net heat to steam		9789.5		Boiler efficiency (LHV)		74.07	%
Free heat in furnace		10974.5		Boiler efficiency (LHV+reduction)		84.35	%
				Boiler efficiency (NHV)		87.96	%
Steam production		3.6439	kg/kgds	231.958	kg/s	835.0	t/h
Sootblowing steam	Outside	0.0943	kg/kgds	6.000	kg/s	21.6	t/h
Continuous blowdown		0.0000	kg/kgds	0.000	kg/s	0.0	t/h
Feed water flow		3.6439	kg/kgds	231.958	kg/s	835.0	t/h

MASS BALANCE

Case C

IN	g/kgds	kg/s	OUT	g/kgds	kg/s
Black liquor (wet)	1176.471	74.891	Smelt	390.824	24.879
DNCG	0.000	0.000	Recycle ash	90.000	5.729
CNCG	7.856	0.500	Dust loss	0.167	0.011
Methanol	0.000	0.000			
Turpentine	0.000	0.000			
Diss.&mix tank gases	29.753	1.894			
Sootblowing steam	94.255	6.000			
Auxiliary fuel	0.000	0.000			
Air (wet)	4217.630	268.483	Flue gas	5044.973	321.150
Total	5525.96	351.769		5525.964	351.769

HEAT BALANCE

Net heat to steam	9789.52
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STEAM

Steam production	Modern	231.958
Sootblowing steam	Outside	6.000
Continuous blowdown		0.000
Feed water flow		231.958

INPUT

BY: **ESV**
DATE: **2.8.2009**

1. NAME

Case C

2. CAPACITY (as fired) **5500** tds/d
5005 tds/d (virgin)

3. BLACK LIQUOR (to furnace)

- Dry solid content		83.8	85	%
- Higher heating value		14.29	13	MJ/kgds
	LHV	13.49	12.28	
		virgin	as fired	
- Analysis	C	35.140	32.10	%
	H	3.626	3.30	%
	N	0.110	0.10	%
	S	4.523	5.80	%
	Na	19.092	20.00	%
	K	1.555	2.00	%
	Cl	0.387	0.50	%
	B	0.000	0.00	%
	Inerts	0.000	0.00	%
	O2	35.566	36.20	%
	TOTAL	100.000	100.000	%

- Temperature Before heating **140** °C
Liquor guns **140** °C

4. LIQUOR HEATING: (Direct = 0, Indirect = 1)
- enthalpies for direct heating:
-- steam in p(bar) **12.00** 2814.4 kJ/kg
-- water out (h' in bl T) T(°C) **200.00** 589.1 kJ/kg

5. MAKE-UP SALTCAKE
- Make-up flow **0** g/kg ds
- Make-up T **20** °C
- Make-up cp **1.05** kJ/kg°C

6. RECYCLE ASH
- Flow as percentage of as fired liquor flow **9.00** % of as fired
28.3 g/m3n,dry

7. AUXILIARY FUEL DATA
- auxiliary fuel flow 52.76 MJ/kg (HHV) **0** kg/s
- auxiliary fuel lower heating value 0 MW **47.93** MJ/kg
- Analysis
C **76.71** w-%
H **21.99** w-%
O **1.15** w-%
N **0.15** w-%
S **0.00** w-%
H2O **0.00** w-%
100.00

8. COMBUSTION AIR
- Ambient air temperature **30.00** °C
- H2O in the air moisture 0 % **13.50** g/kg da
- Excess air O2 in dry flue gas 2.771 % **15.00** %
- Infiltration air 12.6 m3n/s **6.00** %
- Primary air percentage 43.5 m3n/s **22.00** %
- Primary air temperature **190.00** °C
- Secondary air percentage 106.7 m3n/s **54.00** %
- Secondary air temperature **190.00** °C
- Tertiary air percentage 23.7 m3n/s **12.00** %
- Tertiary air temperature **190.00** °C
- Quaternary air percentage 23.7 m3n/s **12.00** %
- Quaternary air temperature **190.00** °C
- Total air percentage **100.00** %
- Total air temperature **190.00** °C

9. REDUCTION EFFICIENCY
- Reduction as mole ratio of Na2S/(Na2S+Na2SO4) **96.00** %
- Reduction as mole ratio of Na3BO3/(BNaO2+Na3BO3) **80.00** %

10. GASEOUS EMISSIONS IN FLUE GAS
- SO2 in dry flue gas (3% O2) **0.10** ppm
S/(NA2+K2) in liquor (recycle excluded) **32.43** %
- HCl in dry flue gas (3% O2) **0.00** ppm
- H2S in dry flue gas (3% O2) **0.00** ppm
- Dust loss in stack 52.5 mg/m3n,dry **0.17** g/kg ds
- Flue gas temperature **197.00** °C

11. MAIN STEAM									
- pressure						120.00		bar(a)	
- temperature						515.00		°C	
12. FEED WATER									
- pressure						146.00		bar(a)	
- temperature						148.00		°C	
13. BLOWDOWN									
- mass flow		0 % of FW				0.00		kg/s	0.0 %
		1423.5 kJ/kg				103.60		bar(a)	
14. SOOTBLOWING: (Outside=0,Inside=1)									
- mass flow		2.6 % of FW				6.00		kg/s	10.4 %
- pressure for indirect						26.00		bar(a)	
- temperature for indirect		2969.6 kJ/kg				285.00		°C	
15. DNCG BURNING: (In air = 0, Separate = 1)									
- DNCG flow (wet)		0.00 kg/s				0.00		m3n/s	
- DNCG saturated temperature		0.12 kPa				50.00		°C	
- DNCG inlet temperature		0 kg(dry)/s				90.00		°C	
- Sulfur in wet DNCG						200.00		mg/m3n	
16. CNCG+ETC BURNING									
- CNCG flow (wet)		19.28 MJ/kg (HHV)				0.50		kg/s	
- CNCG saturated temperature		17.78 MJ/kg (LHV)				60.00		°C	
- CNCG inlet temperature		12.14 w-% water				82.00		°C	
- CNCG ejector steam		0.439 kg(dry)/s				0.00		kg/s	
- methanol flow		20.4 MJ/kg (HHV)				0.00		kg/s	
- water in methanol flow		16.1 MJ/kg (LHV)				8.00		w-%	
- turpentine flow		38.3 MJ/kg (HHV)				0.00		kg/s	
- water in turpentine flow		32.6 MJ/kg (LHV)				7.90		w-%	
		Methanol	Turpentine			CNCG			
- Analysis	C	32.82	80.77			16.57		w-%	
	H	10.98	10.87			5.48		w-%	
	O	42.12	0.00			4.17		w-%	
	N	3.57	0.19			21.31		w-%	
3.1681 g/kgds	S	2.61	0.17			40.33		w-%	
	H2O	7.90	8.00			12.14		w-%	
		100	100			100			
17. DISSOLVING TANK VENT GASES: (In air = 0, Separate = 1)									
- DTVG flow (wet)		23.24 kg/s				0.30		m3n/s /kgds	
- DTVG saturated temperature		12.34 kPa				50.00		°C	
18. ENERGY BALANCE									
- Reference air temperature						0		°C	
- radiation & convection		5.539 MW				0.560		%-of heat input	
- unburnt and other losses		8.803 MW				0.890		%-of heat input	
- manufacturers margin		13.254 MW				1.340		%-of heat input	
19. ASH DATA									
- flow		Make-up	Dust loss			Recycle		g/kgds (as fired)	
		0.0	0.2			90.0			
- Analysis	Na	32.4	29.2			29.2		w-%	137.554363
	K	0.0	6.5			6.5		w-%	
	Cl	0.3	1.6			1.6		w-%	
	CO3	0.0	6.8			6.8		w-%	
	S	0.0	0.1			0.1		w-%	
	BO2	0.0	0.0			0.0		w-%	
	SO4	67.2	55.8			55.8		w-%	
20. MP FW PREHEATING									
- FW temperature HP heater in						200.00		°C	
- FW temperature HP heater out						220.00		°C	
- Added enthalpy						89.47 kJ/kg FW			
21. REHEATER									
- Inlet pressure						56.00		bar(a)	
- Inlet temperature						320.00		°C	
- Outlet pressure						56.00		bar(a)	
- Outlet temperature						320.00		°C	

BALANCE CALCULATIONS Case C

Dry solid amount	tds/d	5500	Reduction eff. %				96							
DS content virgin	%	83.76	S/(Na2+K2) in BLDS, mol-%				32.4268803 (as fired)		B/(Na3+K3), mol-%					0
DS content as fired	%	85	S/(Na2+K2) in smelt, mol-%				34.9086389 => SO2 in dry (ppm)		0.11096035 B/Na, mol-%					0
As fired	g/kgds	g/kgds	H2O	C	H2	O2	N2	S	Na2	K2	Cl	B	Inerts	
		1176.5	176.47	321	33	362	1	58	200	20	5	0	0	
	Molar weight		18.0152	12.0110	2.0158	31.9988	28.0134	32.0600	45.9795	78.1966	35.4530	10.8110	-	
		mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	g/kgds	
Virgin black liquor	1086.5	9.796	26.623	16.371	10.115	0.036	1.284	3.779	0.181	0.099	0.000	0.000	0.000	
Water & chemical loss in DCE	0.0	-	-	-	-	-	-	-	-	-	-	-	-	
Recycle ash	90.0	-	0.102	-	1.198	-	0.525	0.571	0.075	0.042	0.000	-	-	
Salt cake make-up	0.0	-	0.000	-	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-	
Liquor to recovery boiler	1176.5	9.796	26.726	16.371	11.313	0.036	1.809	4.350	0.256	0.141	0.000	0.000	0.000	
Steam to preheater	0.0	0.000	-	-	-	-	-	-	-	-	-	-	-	
As fired liquor to furnace	1176.5	9.796	26.726	16.371	11.313	0.036	1.809	4.350	0.256	0.141	0.000	0.000	0.000	
DNCG	0.0	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
CNCG	7.9	0.053	0.108	0.213	0.010	0.060	0.099	0.099	0.099	0.099	0.099	0.099	0.099	
Methanol	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Turpentine	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Dissolving tank vent	29.8	1.652	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Auxiliary fuel	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Recycle ash	-90.0	-	-0.102	-	-1.198	-	-0.525	-0.571	-0.075	-0.042	-	-	-	
Chem. loss to stack	-0.2	-	0.000	-	-0.002	-	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	
To smelt and flue gas	1094.2	11.500	26.731	16.584	10.123	0.095	1.382	3.778	0.181	0.099	0.000	0.000	0.000	
Na2S (78.0395)	98.8	-	-	-	-	-	1.266	1.266	-	-	-	-	-	
Na2SO4 (142.0371)	7.5	-	-	-	0.105	-	0.053	0.053	-	-	-	-	-	
Na2CO3 (105.9887)	255.6	-	2.411	-	3.617	-	-	2.411	-	-	-	-	-	
K2S (110.2566)	6.7	-	-	-	-	-	0.061	-	0.061	-	-	-	-	
K2SO4 (174.2542)	0.4	-	-	-	0.005	-	0.003	-	0.003	-	-	-	-	
K2CO3 (138.2058)	16.0	-	0.115	-	0.173	-	-	-	0.115	-	-	-	-	
NaCl (58.4428)	5.5	-	-	-	-	-	-	0.047	-	0.095	-	-	-	
KCl (74.5513)	0.3	-	-	-	-	-	-	-	0.002	0.005	-	-	-	
Na3BO3 (127.7785)	0.0	-	-	-	0.000	-	-	0.000	-	-	0.000	-	-	
NaBO2 (65.7996)	0.0	-	-	-	0.000	-	-	0.000	-	-	0.000	-	-	
Other	0.0	-	-	-	-	-	-	-	-	-	-	-	0.000	
Total to smelt	390.8	-	2.527	-	3.901	-	1.382	3.778	0.181	0.099	0.000	0.000	0.000	
Total to flue gas	703.3	11.500	24.204	16.584	6.222	0.095	0.000	0.000	0.000	0.000	0.000	0.000	-	
Gaseous loss (SO2)	0.0	-	-	-	0.000	-	0.000	-	-	-	0.000	-	-	
Gaseous loss (HCl)	0.0	-	-	-	0.000	-	0.000	-	-	-	-	-	-	
Gaseous loss (H2S)	0.0	-	-	-	0.000	-	0.000	-	-	-	-	-	-	

STOICHIOMETRIC AIR, DRY FLUE GAS AND WATER VAPOUR / KGDS

	Air			Dry gas			Water vapour		
	mol	m3n	g	mol	m3n	g	mol	m3n	g
C	24.204	-	-	CO2	24.204	0.539	H2O	11.500	0.258
S	0.000	-	-	SO2	0.000	0.001		-	-
H2	16.584	-	-		-	-	H2	16.584	0.372
O2-required	32.496	-	-		-	-		-	-
O2 in BLDS	6.222	-	-		-	-		-	-
O2 from air	26.275	0.588	840.760	O2	0.000	0.000		-	-
N2 in BLDS	0.095	0.002	2.674		-	-		-	-
N2 from air	99.104	2.220	2776.242	N2	99.200	2.222		-	-
CO2 from air	0.038	0.001	1.656	CO2	0.038	0.001		-	-
H2O from air	2.712	0.061	48.852		-	-	DCE	0.000	0.000
							From air	2.712	0.061
Stoichiomet. wet air	128.128	2.870	3667.510	Dry flue gas	123.442	2.762	H2O in FG	30.796	0.690

EXCESS AIR, TOTAL FLUE GAS AND SOOTBLOWING STEAM AMOUNTS / KGDS

Excess air	%	15	O ₂ ,dry	O ₂ ,wet	2.206						
AIR	mol	m3n	g	Flue gas	mol	m3n	g				
excess O ₂	3.941	0.088	126.114	Theor.dryFG	123.442	2.762	3845.804				
excess N ₂	14.866	0.333	416.430	excess dry air	18.812	0.421	542.793				
excess CO ₂	0.006	0.000	0.248								
excess H ₂ O	0.407	0.009	7.328	Dry flue gas	142.254	3.184	4388.596				
				H ₂ O comb	28.084	0.629	505.943				
Excess wet air	19.219	0.431	550.120	H ₂ O air	3.118	0.070	56.180				
Stoich.wet air	128.128	2.870	3667.510								
				H ₂ O sum	31.203	0.699	562.122				
Total wet air	147.347	3.301	4217.630								
					173.457	3.883	4950.718 (w/o sootblowing steam)				
H ₂ O in stoich. air	2.712	0.061	48.852	Sootbl.s.	5.232	0.117	94.255	0.204			
H ₂ O in excess air	0.407	0.009	7.328								
					178.689	4.000	5044.973 (with sootblowing steam)				
Water in air	3.118	0.070	56.180	DCE	0.000	0.000	0.000				
Total dry air	144.229	3.231	4161.450	Wet FG	178.689	4.000	5044.973 (with DCE+STBLS)				
Composition of FG	Theoretical dry FG			Theoretical wet FG		Dry FG		Wet FG no sootb.		Wet FG	
	mol	vol	mol	vol	mol	vol	mol	vol	mol	vol	mol
CO ₂	19.64	19.54	15.45	15.36	17.05	16.96	13.98	13.90	13.57	13.50	13.50
H ₂ O	0.00	0.00	21.35	21.37	0.00	0.00	17.99	18.01	20.39	20.41	20.41
SO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N ₂	80.36	80.46	63.20	63.26	80.19	80.28	65.77	65.82	63.84	63.90	63.90
O ₂	0.00	0.00	0.00	0.00	2.77	2.77	2.27	2.27	2.21	2.21	2.21
TOTAL	100.00	100.00	100.00	100.00	100.01	100.01	100.01	100.01	100.01	100.01	100.01
AIR AND FLUE GAS FLOWS				Air		Dry FG		WetFG			
with DS capacity of:				63.66	kgds/s	210.119	m3n/s	202.660	m3n/s	254.631	m3n/s
						268.483	kg/s	279.367	kg/s	321.150	kg/s

HEAT BALANCE MODERN

Case C

Ref temp °C 0

Black liquor:	MJ/kgds	13.00000	Enthalpies:	kJ/kg	pressure	temperature
HHV	kJ/kgds	13000	- steam	3389.2	120.0	515.0
NHV (Adams)	kJ/kgds	10524.532	- feed water	632.5	146.0	148.0
NHV (Balance)	kJ/kgds	10917.6076	- steam at fg out temp	2873.3	0.20	197.0
NHV (KCL)	kJ/kgds	10444.5	- continuous blow down	1423.5	103.6	
			- steam at air in temp.	2842.1	0.0	180.4
T from evap	°C	140	- fwah ent difference	0		
T at guns	°C	140	- auxiliary sootb. steam	2969.6	26.0	285.0
Liquor cp	kJ/kg°C	2.64072581	- latent heat at ref. T	2501.6		
Combustion air:			Losses of heat input			
Ambient	°C	30	- rad&conv	%	0.56	
Enthalpy	kJ/m3n	38.9682158	- unburnt	%	0.89	
Heated	°C	190	- margin	%	1.34	
Enthalpy	kJ/m3n	248.404397	Wet flue gas:			
Infiltr. air	%	6	- temperature	°C	197	
Ref enthalpy	kJ/m3n	1.4478E-05	- enthalpy	kJ/m3n	277.743536	
Smelt temperatur	°C	850	- ref enthalpy	kJ/m3n	-2.794E-10	

INPUT		kJ/kgds	%	OUTPUT		kJ/kgds	%
BL LHV (I=2440)	12280.4		(92.9)	Smelt	(Na2+K2)S	155.9	1.2
Correction to ref. temperature	0.0		(0.0)		(Na2+K2)SO4	10.3	0.1
H2O in BL	0.17647059	-430.6	(-3.3)		(Na2+K2)CO3	415.6	3.1
Black liquor heating value		11849.8	89.7		(Na+K)Cl	7.7	0.1
Auxiliary fuel		0.0	0.0		Na3BO3+NaBO2	0.0	0.0
BL sensible heat		434.9	3.3	Others		0.0	0.0
Indirect		0.0	0.0	Reduction	Na2S	1293.4	9.8
Direct		0.0	0.0		SO2	0.0	0.0
Dry air:					K2S	64.3	0.5
Unheated		118.3	0.9		Na3BO3	0.0	0.0
Heated		636.1	4.8				
Infiltration		7.6	0.1	red+smelt		1947.2	14.7
Moist in air	0.056	20.8	0.2				
CNCG		139.6	1.1	wet fg	4.000	1111.0	8.4
Methanol		0.0	0.0	r/c loss	%	0.56	74.0
Turpentine		0.0	0.0	unburnt	%	0.89	117.5
Outside sootblowing steam		9.1	0.1	margin	%	1.34	177.0
Heat input		13216.2	100.0	losses total		3426.7	25.9
				kg/kgds	kJ/kg		
				fwah	3.670	0.0	0.0
				fpreheat	3.670	-89.5	-328.4
				sb	0.094	0.0	0.0
				cbd	0.000	1423.5	0.0
Feedwater	3.670	632.5	2321.3	17.6	steam	3.670	3389.2
						12439.2	94.1
Total		15537.6	117.6	Total		15537.6	117.6
Net heat to steam		9789.5		Boiler efficiency (LHV)		74.07	%
Free heat in furnace		10974.5		Boiler efficiency (LHV+reduction)		84.35	%
				Boiler efficiency (NHV)		87.96	%
Steam production		3.6702	kg/kgds	233.638	kg/s	841.1	t/h
Sootblowing steam	Outside	0.0943	kg/kgds	6.000	kg/s	21.6	t/h
Continuous blowdown		0.0000	kg/kgds	0.000	kg/s	0.0	t/h
Feed water flow		3.6702	kg/kgds	233.638	kg/s	841.1	t/h

0.0178

MASS BALANCE

Case C

IN	g/kgds	kg/s	OUT	g/kgds	kg/s
Black liquor (wet)	1176.471	74.891	Smelt	390.824	24.879
DNCG	0.000	0.000	Recycle ash	90.000	5.729
CNCG	7.856	0.500	Dust loss	0.167	0.011
Methanol	0.000	0.000			
Turpentine	0.000	0.000			
Diss.&mix tank gases	29.753	1.894			
Sootblowing steam	94.255	6.000			
Auxiliary fuel	0.000	0.000			
Air (wet)	4217.630	268.483	Flue gas	5044.973	321.150
Total	5525.96	351.769		5525.964	351.769

HEAT BALANCE

Net heat to steam	9789.52
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STEAM

Steam production	Modern	233.638
Sootblowing steam	Outside	6.000
Continuous blowdown		0.000
Feed water flow		233.638

INPUT

BY: **ESV**
DATE: **8.8.2009**

1. NAME

Case B

2. CAPACITY (as fired) **5500** tds/d
5005 tds/d (virgin)

3. BLACK LIQUOR (to furnace)

- Dry solid content		83.8	85	%
- Higher heating value		14.29	13	MJ/kgds
	LHV	13.49	12.28	
		virgin	as fired	
- Analysis	C	35.140	32.10	%
	H	3.626	3.30	%
	N	0.110	0.10	%
	S	4.523	5.80	%
	Na	19.092	20.00	%
	K	1.555	2.00	%
	Cl	0.387	0.50	%
	B	0.000	0.00	%
	Inerts	0.000	0.00	%
	O2	35.566	36.20	%
	TOTAL	100.000	100.000	%

- Temperature Before heating **140** °C
Liquor guns **140** °C

4. LIQUOR HEATING: (Direct = 0, Indirect = 1) **0**
- enthalpies for direct heating:
-- steam in p(bar) **12.00** 2814.4 kJ/kg
-- water out (h' in bl T) T(°C) **200.00** 589.1 kJ/kg

5. MAKE-UP SALTCAKE
- Make-up flow **0** g/kg ds
- Make-up T **20** °C
- Make-up cp **1.05** kJ/kg°C

6. RECYCLE ASH
- Flow as percentage of as fired liquor flow **9.00** % of as fired
28.3 g/m3n,dry

7. AUXILIARY FUEL DATA
- auxiliary fuel flow 52.76 MJ/kg (HHV) **0** kg/s
- auxiliary fuel lower heating value 0 MW **47.93** MJ/kg
- Analysis
C **76.71** w-%
H **21.99** w-%
O **1.15** w-%
N **0.15** w-%
S **0.00** w-%
H2O **0.00** w-%
100.00

8. COMBUSTION AIR
- Ambient air temperature **30.00** °C
- H2O in the air moisture **13.50** g/kg da
- Excess air O2 in dry flue gas 2.771 % **15.00** %
- Infiltration air 12.6 m3n/s **6.00** %
- Primary air percentage 43.5 m3n/s **22.00** %
- Primary air temperature **190.00** °C
- Secondary air percentage 106.7 m3n/s **54.00** %
- Secondary air temperature **190.00** °C
- Tertiary air percentage 23.7 m3n/s **12.00** %
- Tertiary air temperature **190.00** °C
- Quaternary air percentage 23.7 m3n/s **12.00** %
- Quaternary air temperature **190.00** °C
- Total air percentage **100.00** %
- Total air temperature **190.00** °C

9. REDUCTION EFFICIENCY
- Reduction as mole ratio of Na2S/(Na2S+Na2SO4) **96.00** %
- Reduction as mole ratio of Na3BO3/(BNaO2+Na3BO3) **80.00** %

10. GASEOUS EMISSIONS IN FLUE GAS
- SO2 in dry flue gas (3% O2) **0.10** ppm
S/(NA2+K2) in liquor (recycle excluded) **32.43** %
- HCl in dry flue gas (3% O2) **0.00** ppm
- H2S in dry flue gas (3% O2) **0.00** ppm
- Dust loss in stack 52.5 mg/m3n,dry **0.17** g/kg ds
- Flue gas temperature **197.00** °C

11. MAIN STEAM					
- pressure			103.00	bar(a)	
- temperature			505.00	°C	
12. FEED WATER					
- pressure			121.00	bar(a)	
- temperature			148.00	°C	
13. BLOWDOWN					
- mass flow	0 % of FW		0.00	kg/s	0.0 %
	1423.5 kJ/kg		103.60	bar(a)	
14. SOOTBLOWING: (Outside=0,Inside=1)					
- mass flow	2.7 % of FW		6.00	kg/s	10.4 %
- pressure for indirect			26.00	bar(a)	
- temperature for indirect	2969.6 kJ/kg		285.00	°C	
15. DNCG BURNING: (In air = 0, Separate = 1)					
- DNCG flow (wet)	0.00 kg/s		0.00	m3n/s	
- DNCG saturated temperature	0.12 kPa		50.00	°C	
- DNCG inlet temperature	0 kg(dry)/s		90.00	°C	
- Sulfur in wet DNCG			200.00	mg/m3n	
16. CNCG+ETC BURNING					
- CNCG flow (wet)	19.28 MJ/kg (HHV)		0.50	kg/s	
- CNCG saturated temperature	17.78 MJ/kg (LHV)		60.00	°C	
- CNCG inlet temperature	12.14 w-% water		82.00	°C	
- CNCG ejector steam	0.439 kg(dry)/s		0.00	kg/s	
- methanol flow	20.4 MJ/kg (HHV)		0.00	kg/s	
- water in methanol flow	16.1 MJ/kg (LHV)		8.00	w-%	
- turpentine flow	38.3 MJ/kg (HHV)		0.00	kg/s	
- water in turpentine flow	32.6 MJ/kg (LHV)		7.90	w-%	
	Methanol	Turpentine	CNCG		
- Analysis	C	32.82	80.77	16.57	w-%
	H	10.98	10.87	5.48	w-%
	O	42.12	0.00	4.17	w-%
	N	3.57	0.19	21.31	w-%
3.1681 g/kgds	S	2.61	0.17	40.33	w-%
	H2O	7.90	8.00	12.14	w-%
		100	100	100	
17. DISSOLVING TANK VENT GASES: (In air = 0, Separate = 1)					
- DTVG flow (wet)	23.24 kg/s		0.30	m3n/s /kgds	
- DTVG saturated temperature	12.34 kPa		50.00	°C	
18. ENERGY BALANCE					
- Reference air temperature			0	°C	
- radiation & convection	5.511 MW		0.560	%-of heat input	
- unburnt and other losses	8.759 MW		0.890	%-of heat input	
- manufacturers margin	13.187 MW		1.340	%-of heat input	
19. ASH DATA					
- flow	Make-up	Dust loss	Recycle	g/kgds (as fired)	
	0.0	0.2	90.0		
- Analysis	Na	32.4	29.2	29.2	w-%
	K	0.0	6.5	6.5	w-%
	Cl	0.3	1.6	1.6	w-%
	CO3	0.0	6.8	6.8	w-%
	S	0.0	0.1	0.1	w-%
	BO2	0.0	0.0	0.0	w-%
	SO4	67.2	55.8	55.8	w-%
20. MP FW PREHEATING					
- FW temperature HP heater in			200.00	°C	
- FW temperature HP heater out			200.00	°C	
- Added enthalpy			0.00	kJ/kg FW	
21. REHEATER					
- Inlet pressure			56.00	bar(a)	
- Inlet temperature			320.00	°C	
- Outlet pressure			56.00	bar(a)	
- Outlet temperature			320.00	°C	

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EXCESS AIR, TOTAL FLUE GAS AND SOOTBLOWING STEAM AMOUNTS / KGDS

Excess air	%	15	O ₂ ,dry	O ₂ ,wet	2.206					
AIR	mol	m3n	g	Flue gas	mol	m3n	g			
excess O ₂	3.941	0.088	126.114	Theor.dryFG	123.442	2.762	3845.804			
excess N ₂	14.866	0.333	416.430	excess dry air	18.812	0.421	542.793			
excess CO ₂	0.006	0.000	0.248							
excess H ₂ O	0.407	0.009	7.328	Dry flue gas	142.254	3.184	4388.596			
				H ₂ O comb	28.084	0.629	505.943			
Excess wet air	19.219	0.431	550.120	H ₂ O air	3.118	0.070	56.180			
Stoich.wet air	128.128	2.870	3667.510							
				H ₂ O sum	31.203	0.699	562.122			
Total wet air	147.347	3.301	4217.630							
					173.457	3.883	4950.718 (w/o sootblowing steam)			
H ₂ O in stoich. air	2.712	0.061	48.852	Sootbl.s.	5.232	0.117	94.255	0.204		
H ₂ O in excess air	0.407	0.009	7.328							
					178.689	4.000	5044.973 (with sootblowing steam)			
Water in air	3.118	0.070	56.180	DCE	0.000	0.000	0.000			
Total dry air	144.229	3.231	4161.450	Wet FG	178.689	4.000	5044.973 (with DCE+STBLS)			
Composition of FG	Theoretical dry FG		Theoretical wet FG		Dry FG		Wetl FG no sootb.		Wet FG	
	mol	vol	mol	vol	mol	vol	mol	vol	mol	vol
CO ₂	19.64	19.54	15.45	15.36	17.05	16.96	13.98	13.90	13.57	13.50
H ₂ O	0.00	0.00	21.35	21.37	0.00	0.00	17.99	18.01	20.39	20.41
SO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N ₂	80.36	80.46	63.20	63.26	80.19	80.28	65.77	65.82	63.84	63.90
O ₂	0.00	0.00	0.00	0.00	2.77	2.77	2.27	2.27	2.21	2.21
TOTAL	100.00	100.00	100.00	100.00	100.01	100.01	100.01	100.01	100.01	100.01
AIR AND FLUE GAS FLOWS					Air	Dry FG		WetFG		
with DS capacity of:			63.66	kgds/s	210.119	m3n/s	202.660	m3n/s	254.631	m3n/s
					268.483	kg/s	279.367	kg/s	321.150	kg/s

HEAT BALANCE MODERN

Case B

Ref temp °C

0

Black liquor:	MJ/kgds	13.00000	Enthalpies:	kJ/kg	pressure	temperature
HHV	kJ/kgds	13000	- steam	3383.7	103.0	505.0
NHV (Adams)	kJ/kgds	10524.532	- feed water	630.9	121.0	148.0
NHV (Balance)	kJ/kgds	10917.6076	- steam at fg out temp	2873.3	0.20	197.0
NHV (KCL)	kJ/kgds	10444.5	- continuous blow down	1423.5	103.6	
			- steam at air in temp.	2842.1	0.0	180.4
T from evap	°C	140	- fwah ent difference	0		
T at guns	°C	140	- auxiliary sootb. steam	2969.6	26.0	285.0
Liquor cp	kJ/kg°C	2.64072581	- latent heat at ref. T	2501.6		
Combustion air:			Losses of heat input			
Ambient	°C	30	- rad&conv	%	0.56	
Enthalpy	kJ/m3n	38.9682158	- unburnt	%	0.89	
Heated	°C	190	- margin	%	1.34	
Enthalpy	kJ/m3n	248.404397	Wet flue gas:			
Infiltr. air	%	6	- temperature	°C	197	
Ref enthalpy	kJ/m3n	1.4478E-05	- enthalpy	kJ/m3n	277.743536	
Smelt temperatur	°C	850	- ref enthalpy	kJ/m3n	-2.794E-10	

INPUT		kJ/kgds	%	OUTPUT		kJ/kgds	%
BL LHV (I=2440)	12280.4		(92.9)	Smelt	(Na2+K2)S	155.9	1.2
Correction to ref. temperature	0.0		(0.0)		(Na2+K2)SO4	10.3	0.1
H2O in BL	0.17647059	-430.6	(-3.3)		(Na2+K2)CO3	415.6	3.1
Black liquor heating value		11849.8	89.7		(Na+K)Cl	7.7	0.1
Auxiliary fuel		0.0	0.0		Na3BO3+NaBO2	0.0	0.0
BL sensible heat		434.9	3.3	Others		0.0	0.0
Indirect		0.0	0.0	Reduction	Na2S	1293.4	9.8
Direct		0.0	0.0		SO2	0.0	0.0
Dry air:					K2S	64.3	0.5
Unheated		118.3	0.9		Na3BO3	0.0	0.0
Heated		636.1	4.8				
Infiltration		7.6	0.1	red+smelt		1947.2	14.7
Moist in air	0.056	20.8	0.2				
CNCG		139.6	1.1	wet fg	4.000	1111.0	8.4
Methanol		0.0	0.0	r/c loss	%	0.56	74.0
Turpentine		0.0	0.0	unburnt	%	0.89	117.5
Outside sootblowing steam		9.1	0.1	margin	%	1.34	177.0
Heat input		13216.2	100.0	losses total		3426.7	25.9
				kg/kgds	kJ/kg		
				fwah	3.556	0.0	0.0
				sb	0.094	0.0	0.0
				cbd	0.000	1423.5	0.0
				steam	3.556	3383.7	12033.0
Feedwater	3.556	630.9	2243.5	17.0			91.0
Total		15459.7	117.0	Total		15459.7	117.0
Net heat to steam		9789.5		Boiler efficiency (LHV)		74.07	%
Free heat in furnace		10974.5		Boiler efficiency (LHV+reduction)		84.35	%
				Boiler efficiency (NHV)		87.96	%
Steam production		3.5562	kg/kgds	226.377	kg/s	815.0	t/h
Sootblowing steam	Outside	0.0943	kg/kgds	6.000	kg/s	21.6	t/h
Continuous blowdown		0.0000	kg/kgds	0.000	kg/s	0.0	t/h
Feed water flow		3.5562	kg/kgds	226.377	kg/s	815.0	t/h

MASS BALANCE

Case B

IN	g/kgds	kg/s	OUT	g/kgds	kg/s
Black liquor (wet)	1176.471	74.891	Smelt	390.824	24.879
DNCG	0.000	0.000	Recycle ash	90.000	5.729
CNCG	7.856	0.500	Dust loss	0.167	0.011
Methanol	0.000	0.000			
Turpentine	0.000	0.000			
Diss.&mix tank gases	29.753	1.894			
Sootblowing steam	94.255	6.000			
Auxiliary fuel	0.000	0.000			
Air (wet)	4217.630	268.483	Flue gas	5044.973	321.150
Total	5525.96	351.769		5525.964	351.769

HEAT BALANCE

Net heat to steam	9789.52
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STEAM

Steam production	Modern	226.377
Sootblowing steam	Outside	6.000
Continuous blowdown		0.000
Feed water flow		226.377

INPUT

BY: **ESV**
DATE: **12.4.2009**

1. NAME

Case A

2. CAPACITY (as fired) **5500** tds/d
5005 tds/d (virgin)

3. BLACK LIQUOR (to furnace)

- Dry solid content		80.6	82	%
- Higher heating value		14.29	13	MJ/kgds
	LHV	13.70	12.46	
		virgin	as fired	
- Analysis	C	35.140	32.10	%
	H	3.626	3.30	%
	N	0.110	0.10	%
	S	4.523	5.80	%
	Na	19.092	20.00	%
	K	1.555	2.00	%
	Cl	0.387	0.50	%
	B	0.000	0.00	%
	Inerts	0.000	0.00	%
	O2	35.566	36.20	%
	TOTAL	100.000	100.000	%

- Temperature Before heating **140** °C
Liquor guns **140** °C

4. LIQUOR HEATING: (Direct = 0, Indirect = 1)
- enthalpies for direct heating:
-- steam in p(bar) **12.00** 2814.4 kJ/kg
-- water out (h' in bl T) T(°C) **200.00** 589.1 kJ/kg

5. MAKE-UP SALTCAKE
- Make-up flow **0** g/kg ds
- Make-up T **20** °C
- Make-up cp **1.05** kJ/kg°C

6. RECYCLE ASH
- Flow as percentage of as fired liquor flow **9.00** % of as fired
28.2 g/m3n,dry

7. AUXILIARY FUEL DATA
- auxiliary fuel flow 52.76 MJ/kg (HHV) **0** kg/s
- auxiliary fuel lower heating value 0 MW **47.93** MJ/kg
- Analysis
C **76.71** w-%
H **21.99** w-%
O **1.15** w-%
N **0.15** w-%
S **0.00** w-%
H2O **0.00** w-%
100.00

8. COMBUSTION AIR
- Ambient air temperature **30.00** °C
- H2O in the air moisture **13.50** g/kg da
- Excess air O2 in dry flue gas 2.771 % **15.00** %
- Infiltration air 20.0 m3n/s **9.53** %
- Primary air percentage 43.8 m3n/s **23.00** %
- Primary air temperature **150.00** °C
- Secondary air percentage 95.1 m3n/s **50.00** %
- Secondary air temperature **120.00** °C
- Tertiary air percentage 51.4 m3n/s **27.00** %
- Tertiary air temperature **30.00** °C
- Quaternary air percentage 0.0 m3n/s **0.00** %
- Quaternary air temperature **30.00** °C
- Total air percentage **100.00** %
- Total air temperature **102.60** °C

9. REDUCTION EFFICIENCY
- Reduction as mole ratio of Na2S/(Na2S+Na2SO4) **95.00** %
- Reduction as mole ratio of Na3BO3/(BNaO2+Na3BO3) **80.00** %

10. GASEOUS EMISSIONS IN FLUE GAS
- SO2 in dry flue gas (3% O2) **0.10** ppm
S/(NA2+K2) in liquor (recycle excluded) **32.43** %
- HCl in dry flue gas (3% O2) **0.00** ppm
- H2S in dry flue gas (3% O2) **0.00** ppm
- Dust loss in stack 52.4 mg/m3n,dry **0.17** g/kg ds
- Flue gas temperature **155.00** °C

11. MAIN STEAM					
- pressure			91.00	bar(a)	
- temperature			490.00	°C	
12. FEED WATER					
- pressure			110.00	bar(a)	
- temperature			120.00	°C	
13. BLOWDOWN					
- mass flow	0 % of FW		0.00	kg/s	0.0 %
	1423.5 kJ/kg		103.60	bar(a)	
14. SOOTBLOWING: (Outside=0,Inside=1)					
- mass flow	2.8 % of FW		6.00	kg/s	10.4 %
- pressure for indirect			26.00	bar(a)	
- temperature for indirect	3056.0 kJ/kg		320.00	°C	
15. DNCG BURNING: (In air = 0, Separate = 1)					
- DNCG flow (wet)	0.00 kg/s		0.00	m3n/s	
- DNCG saturated temperature	0.12 kPa		50.00	°C	
- DNCG inlet temperature	0 kg(dry)/s		90.00	°C	
- Sulfur in wet DNCG			200.00	mg/m3n	
16. CNCG+ETC BURNING					
- CNCG flow (wet)	19.28 MJ/kg (HHV)		0.50	kg/s	
- CNCG saturated temperature	17.78 MJ/kg (LHV)		60.00	°C	
- CNCG inlet temperature	12.14 w-% water		82.00	°C	
- CNCG ejector steam	0.439 kg(dry)/s		0.00	kg/s	
- methanol flow	20.4 MJ/kg (HHV)		0.00	kg/s	
- water in methanol flow	16.1 MJ/kg (LHV)		8.00	w-%	
- turpentine flow	38.3 MJ/kg (HHV)		0.00	kg/s	
- water in turpentine flow	32.6 MJ/kg (LHV)		7.90	w-%	
	Methanol	Turpentine	CNCG		
- Analysis	C	32.82	80.77	16.57	w-%
	H	10.98	10.87	5.48	w-%
	O	42.12	0.00	4.17	w-%
	N	3.57	0.19	21.31	w-%
3.1681 g/kgds	S	2.61	0.17	40.33	w-%
	H2O	7.90	8.00	12.14	w-%
		100	100	100	
17. DISSOLVING TANK VENT GASES: (In air = 0, Separate = 1)					
- DTVG flow (wet)	23.24 kg/s		0.30	m3n/s /kgds	
- DTVG saturated temperature	12.34 kPa		50.00	°C	
18. ENERGY BALANCE					
- Reference air temperature			0	°C	
- radiation & convection	5.176 MW		0.560	%-of heat input	
- unburnt and other losses	8.226 MW		0.890	%-of heat input	
- manufacturers margin	12.385 MW		1.340	%-of heat input	
19. ASH DATA					
- flow	Make-up	Dust loss	Recycle	g/kgds (as fired)	
	0.0	0.2	90.0		
- Analysis	Na	32.4	29.2	29.2	w-%
	K	0.0	6.5	6.5	w-%
	Cl	0.3	1.6	1.6	w-%
	CO3	0.0	6.8	6.8	w-%
	S	0.0	0.1	0.1	w-%
	BO2	0.0	0.0	0.0	w-%
	SO4	67.2	55.8	55.8	w-%
20. MP FW PREHEATING					
- FW temperature HP heater in			200.00	°C	
- FW temperature HP heater out			200.00	°C	
- Added enthalpy			0.00	kJ/kg FW	
21. REHEATER					
- Inlet pressure			56.00	bar(a)	
- Inlet temperature			320.00	°C	
- Outlet pressure			56.00	bar(a)	
- Outlet temperature			320.00	°C	

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BALANCE CALCULATIONS Case A

Dry solid amount	tds/d	5500	Reduction eff. %				95								
DS content virgin	%	80.57	S/(Na2+K2) in BLDS, mol-%				32.4268803 (as fired)				B/(Na3+K3), mol-%				0
DS content as fired	%	82	S/(Na2+K2) in smelt, mol-%				34.9086389 ==> SO2 in dry (ppm)				0.11086367 B/Na, mol-%				0
As fired	g/kgds	g/kgds	H2O	C	H2	O2	N2	S	Na2	K2	Cl	B	Inerts		
			219.51	321	33	362	1	58	200	20	5	0	0		
	Molar weight		18.0152	12.0110	2.0158	31.9988	28.0134	32.0600	45.9795	78.1966	35.4530	10.8110	-		
		mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	mol/kgds	g/kgds		
Virgin black liquor	1129.5	12.185	26.623	16.371	10.115	0.036	1.284	3.779	0.181	0.099	0.000	0.000	0.000		
Water & chemical loss in DCE	0.0	-	-	-	-	-	-	-	-	-	-	-	-		
Recycle ash	90.0	-	0.102	-	1.198	-	0.525	0.571	0.075	0.042	0.000	-	-		
Salt cake make-up	0.0	-	0.000	-	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-		
Liquor to recovery boiler	1219.5	12.185	26.726	16.371	11.313	0.036	1.809	4.350	0.256	0.141	0.000	0.000	0.000		
Steam to preheater	0.0	0.000	-	-	-	-	-	-	-	-	-	-	-		
As fired liquor to furnace	1219.5	12.185	26.726	16.371	11.313	0.036	1.809	4.350	0.256	0.141	0.000	0.000	0.000		
DNCG	0.0	0.000	-	0.000	0.000	0.000	0.000	-	-	-	-	-	-		
CNCG	7.9	0.053	0.108	0.213	0.010	0.060	0.099	-	-	-	-	-	-		
Methanol	0.0	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	-		
Turpentine	0.0	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	-		
Dissolving tank vent	29.8	1.652	-	0.000	0.000	0.000	0.000	-	-	-	-	-	-		
Auxiliary fuel	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-		
Recycle ash	-90.0	-	-0.102	-	-1.198	-	-0.525	-0.571	-0.075	-0.042	-	-	-		
Chem. loss to stack	-0.2	-	0.000	-	-0.002	-	-0.001	-0.001	0.000	0.000	0.000	0.000	-		
To smelt and flue gas	1137.2	13.889	26.731	16.584	10.123	0.095	1.382	3.778	0.181	0.099	0.000	0.000	0.000		
Na2S (78.0395)	97.8	-	-	-	-	-	1.253	1.253	-	-	-	-	-		
Na2SO4 (142.0371)	9.4	-	-	-	0.132	-	0.066	0.066	-	-	-	-	-		
Na2CO3 (105.9887)	255.6	-	2.411	-	3.617	-	-	2.411	-	-	-	-	-		
K2S (110.2566)	6.6	-	-	-	-	-	0.060	-	0.060	-	-	-	-		
K2SO4 (174.2542)	0.5	-	-	-	0.006	-	0.003	-	0.003	-	-	-	-		
K2CO3 (138.2058)	16.0	-	0.115	-	0.173	-	-	-	0.115	-	-	-	-		
NaCl (58.4428)	5.5	-	-	-	-	-	-	0.047	-	0.095	-	-	-		
KCl (74.5513)	0.3	-	-	-	-	-	-	-	0.002	0.005	-	-	-		
Na3BO3 (127.7785)	0.0	-	-	-	0.000	-	-	0.000	-	-	0.000	-	-		
NaBO2 (65.7996)	0.0	-	-	-	0.000	-	-	0.000	-	-	0.000	-	-		
Other	0.0	-	-	-	-	-	-	-	-	-	-	-	0.000		
Total to smelt	391.7	-	2.527	-	3.929	-	1.382	3.778	0.181	0.099	0.000	0.000	0.000		
Total to flue gas	745.5	13.889	24.204	16.584	6.194	0.095	0.000	0.000	0.000	0.000	0.000	0.000	-		
Gaseous loss (SO2)	0.0	-	-	-	0.000	-	0.000	-	-	-	0.000	-	-		
Gaseous loss (HCl)	0.0	-	-	-	0.000	-	0.000	-	-	-	-	-	-		
Gaseous loss (H2S)	0.0	-	-	-	0.000	-	0.000	-	-	-	-	-	-		

STOICHIOMETRIC AIR, DRY FLUE GAS AND WATER VAPOUR / KGDS

	Air			Dry gas			Water vapour		
	mol	m3n	g	mol	m3n	g	mol	m3n	g
C	24.204	-	-	CO2	24.204	0.539	H2O	13.889	0.311
S	0.000	-	-	SO2	0.000	0.001		-	-
H2	16.584	-	-		-	-	H2	16.584	0.372
O2-required	32.496	-	-		-	-		-	-
O2 in BLDS	6.194	-	-		-	-		-	-
O2 from air	26.302	0.589	841.645	O2	0.000	0.000		-	-
N2 in BLDS	0.095	0.002	2.674		-	-		-	-
N2 from air	99.208	2.223	2779.162	N2	99.304	2.225		-	-
CO2 from air	0.038	0.001	1.658	CO2	0.038	0.001		-	-
H2O from air	2.715	0.061	48.903		-	-	DCE	0.000	0.000
							From air	2.715	0.061
Stoichiomet. wet air	128.263	2.873	3671.367	Dry flue gas	123.546	2.765	H2O in FG	33.188	0.744

Excess air	%	15	O2,dry	O2,wet	2.178				
AIR	mol	m3n	g	Flue gas	mol	m3n	g		
excess O2	3.945	0.088	126.247	Theor.dryFG	123.546	2.765	3848.725		
excess N2	14.881	0.333	416.868	excess dry air	18.832	0.422	543.364		
excess CO2	0.006	0.000	0.249						
excess H2O	0.407	0.009	7.335	Dry flue gas	142.378	3.186	4392.089		
				H2O comb	30.473	0.683	548.984		
Excess wet air	19.239	0.431	550.699	H2O air	3.122	0.070	56.239		
Stoich.wet air	128.263	2.873	3671.367						
				H2O sum	33.595	0.753	605.223		
Total wet air	147.502	3.304	4222.066						
					175.973	3.939	4997.312	(w/o sootblowing steam)	
H2O in stoich. air	2.715	0.061	48.903	Sootbl.s.	5.232	0.117	94.255	0.214	
H2O in excess air	0.407	0.009	7.335						
					181.205	4.056	5091.566	(with sootblowing steam)	
Water in air	3.122	0.070	56.239	DCE	0.000	0.000	0.000		
Total dry air	144.381	3.234	4165.827	Wet FG	181.205	4.056	5091.566	(with DCE+STBLS)	
Composition of FG	Theoretical dry FG		Theoretical wet FG		Dry FG		Wet FG no sooth.		Wet FG
	mol	vol	mol	vol	mol	vol	mol	vol	mol
CO2	19.62	19.52	15.20	15.12	17.03	16.94	13.78	13.70	13.38
H2O	0.00	0.00	22.52	22.54	0.00	0.00	19.09	19.11	21.43
SO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2	80.38	80.48	62.28	62.34	80.21	80.30	64.90	64.95	63.02
O2	0.00	0.00	0.00	0.00	2.77	2.77	2.24	2.24	2.18
TOTAL	100.00	100.00	100.00	100.00	100.01	100.01	100.01	100.01	100.00
AIR AND FLUE GAS FLOWS					Air		Dry FG		WetFG
with DS capacity of:		63.66	kgds/s		210.340	m3n/s	202.837	m3n/s	258.221
					268.766	kg/s	279.589	kg/s	324.116
									m3n/s
									kg/s

HEAT BALANCE MODERN

Case A

Ref temp °C

0

Black liquor:	MJ/kgds	13.00000	Enthalpies:	kJ/kg	pressure	temperature
HHV	kJ/kgds	13000	- steam	3360.5	91.0	490.0
NHV (Adams)	kJ/kgds	10542.7694	- feed water	511.3	110.0	120.0
NHV (Balance)	kJ/kgds	10931.7504	- steam at fg out temp	2791.9	0.21	155.0
NHV (KCL)	kJ/kgds	10444.5	- continuous blow down	1423.5	103.6	
			- steam at air in temp.	2680.3	0.0	95.7
T from evap	°C	140	- fwah ent difference	0		
T at guns	°C	140	- auxiliary sootb. steam	3056.0	26.0	320.0
Liquor cp	kJ/kg°C	2.71780772	- latent heat at ref. T	2501.6		
Combustion air:			Losses of heat input			
Ambient	°C	30	- rad&conv	%	0.56	
Enthalpy	kJ/m3n	38.9682158	- unburnt	%	0.89	
Heated	°C	102.6	- margin	%	1.34	
Enthalpy	kJ/m3n	133.537315	Wet flue gas:			
Infiltr. air	%	9.53	- temperature	°C	155	
Ref enthalpy	kJ/m3n	1.4478E-05	- enthalpy	kJ/m3n	217.205152	
Smelt temperatur	°C	844	- ref enthalpy	kJ/m3n	-2.794E-10	

INPUT		kJ/kgds	%	OUTPUT		kJ/kgds	%
BL LHV (I=2440)	12280.4		(96.0)	Smelt	(Na2+K2)S	153.1	1.2
Correction to ref. temperature	0.0		(0.0)		(Na2+K2)SO4	12.8	0.1
H2O in BL	0.2195122	-535.6	(-4.2)		(Na2+K2)CO3	412.7	3.2
Black liquor heating value		11744.8	91.8		(Na+K)Cl	7.7	0.1
Auxiliary fuel		0.0	0.0		Na3BO3+NaBO2	0.0	0.0
BL sensible heat		464.0	3.6	Others		0.0	0.0
Indirect		0.0	0.0	Reduction	Na2S	1279.9	10.0
Direct		0.0	0.0		SO2	0.0	0.0
Dry air:					K2S	63.6	0.5
Unheated		114.0	0.9		Na3BO3	0.0	0.0
Heated		276.7	2.2				
Infiltration		12.0	0.1	red+smelt		1929.9	15.1
Moist in air	0.056	15.7	0.1				
CNCG		139.6	1.1	wet fg	4.056	881.1	6.9
Methanol		0.0	0.0	r/c loss	%	0.56	71.5
Turpentine		0.0	0.0	unburnt	%	0.89	113.6
Outside sootblowing steam		24.9	0.2	margin	%	1.34	171.1
Heat input		12791.8	100.0	losses total		3167.2	24.8
				kg/kgds	kJ/kg		
				fwah	3.378	0.0	0.0
				sb	0.094	0.0	0.0
				cbd	0.000	1423.5	0.0
				steam	3.378	3360.5	11352.0
Feedwater	3.378	511.3	1727.4	13.5			88.7
Total		14519.2	113.5	Total		14519.2	113.5
Net heat to steam		9624.6		Boiler efficiency (LHV)		75.24	%
Free heat in furnace		10577.2		Boiler efficiency (LHV+reduction)		85.74	%
				Boiler efficiency (NHV)		89.59	%
Steam production		3.3781	kg/kgds	215.039	kg/s	774.1	l/h
Sootblowing steam	Outside	0.0943	kg/kgds	6.000	kg/s	21.6	l/h
Continuous blowdown		0.0000	kg/kgds	0.000	kg/s	0.0	l/h
Feed water flow		3.3781	kg/kgds	215.039	kg/s	774.1	l/h

MASS BALANCE

Case A

IN	g/kgds	kg/s	OUT	g/kgds	kg/s
Black liquor (wet)	1219.512	77.631	Smelt	391.708	24.935
DNCG	0.000	0.000	Recycle ash	90.000	5.729
CNCG	7.856	0.500	Dust loss	0.167	0.011
Methanol	0.000	0.000			
Turpentine	0.000	0.000			
Diss.&mix tank gases	29.753	1.894			
Sootblowing steam	94.255	6.000			
Auxiliary fuel	0.000	0.000			
Air (wet)	4222.066	268.766	Flue gas	5091.566	324.116
Total	5573.44	354.791		5573.442	354.791

HEAT BALANCE

Net heat to steam	9624.60
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STEAM

Steam production	Modern	215.039
Sootblowing steam	Outside	6.000
Continuous blowdown		0.000
Feed water flow		215.039

APPENDIX Flowsheet diagrams and properties dialogs for Sky Case F APROS model

The developed APROS model is divided into three flowsheet diagrams:

- Recovery boiler model
- Boundary conditions (input values)
- Simulation control and control of thermohydraulics

The diagrams are presented in this appendix with the corresponding data at 100 % and 80 % loads.

At 100 % load, properties dialogs are given for the selected components in the recovery boiler model (the names of the component types in APROS are given in parentheses):

- Flue gas at superheater 3A (POINT)
- Upper furnace (HEAT_PIPE)
- Heat transfer between flue gas at SH 3A and upper furnace (HEAT_TRANS)
- Calculation level component of radiation heat transfer between flue gas at SH 3A and upper furnace (HEAT_RADIATION)
- Calculation level component of convective heat transfer between flue gas at SH 3A and upper furnace (HEAT_TRANSFER)
- Superheater 3A (HEAT_PIPE)
- Heat transfer between flue gas and SH 3A (HEAT_TRANS)
- Calculation level component of radiation heat transfer between flue gas and SH 3A (HEAT_RADIATION)
- Calculation level component of convective heat transfer between flue gas and SH 3A (HEAT_TRANSFER)
- Piping between spray attemperator DSH2 and superheater 3A (PIPE)
- Main steam stop valve (CONTROL_VALVE)
- High-pressure turbine (TURBINE_SECTION)

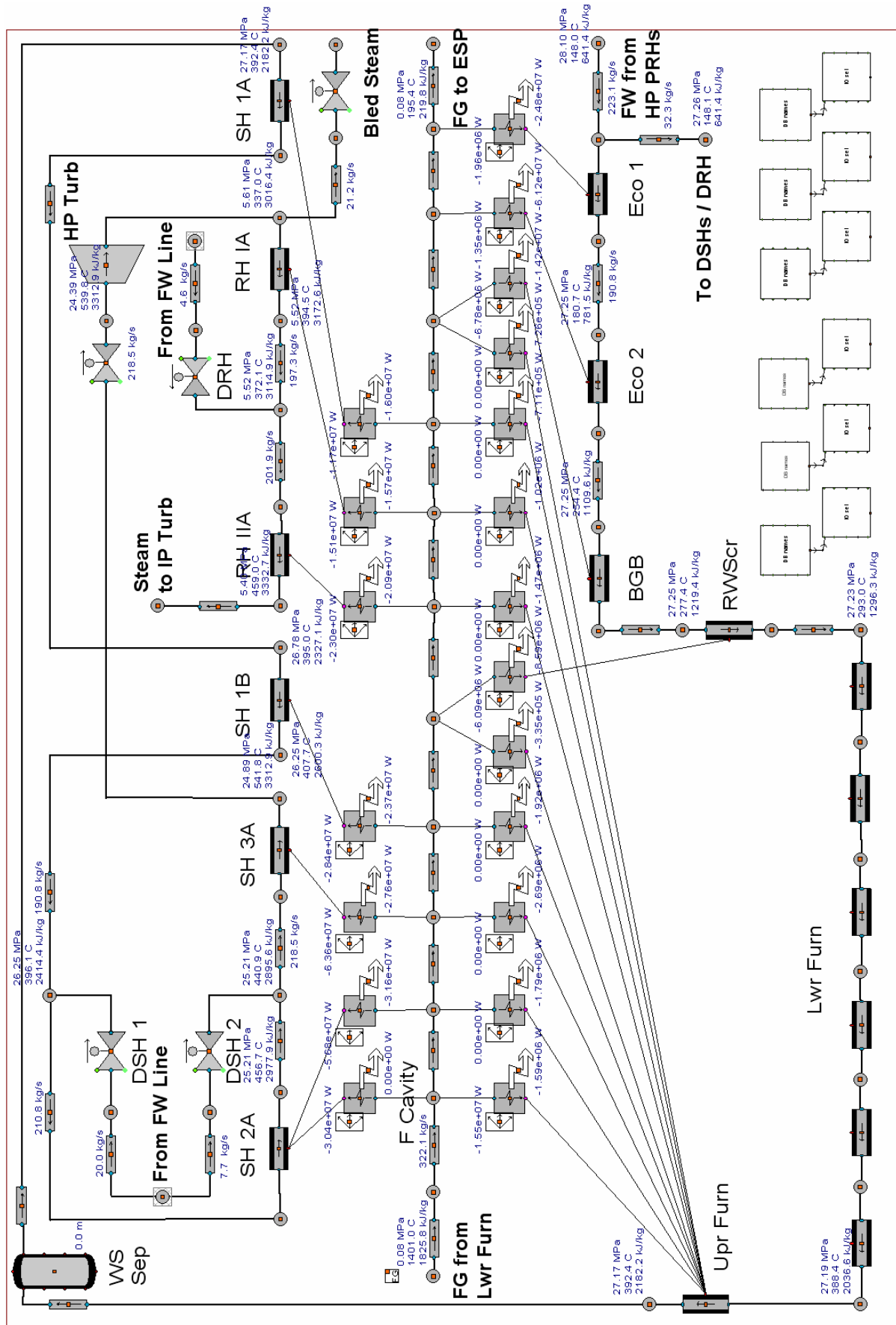


Figure 1, Recovery boiler model: steady-state operating values at 100 % load.

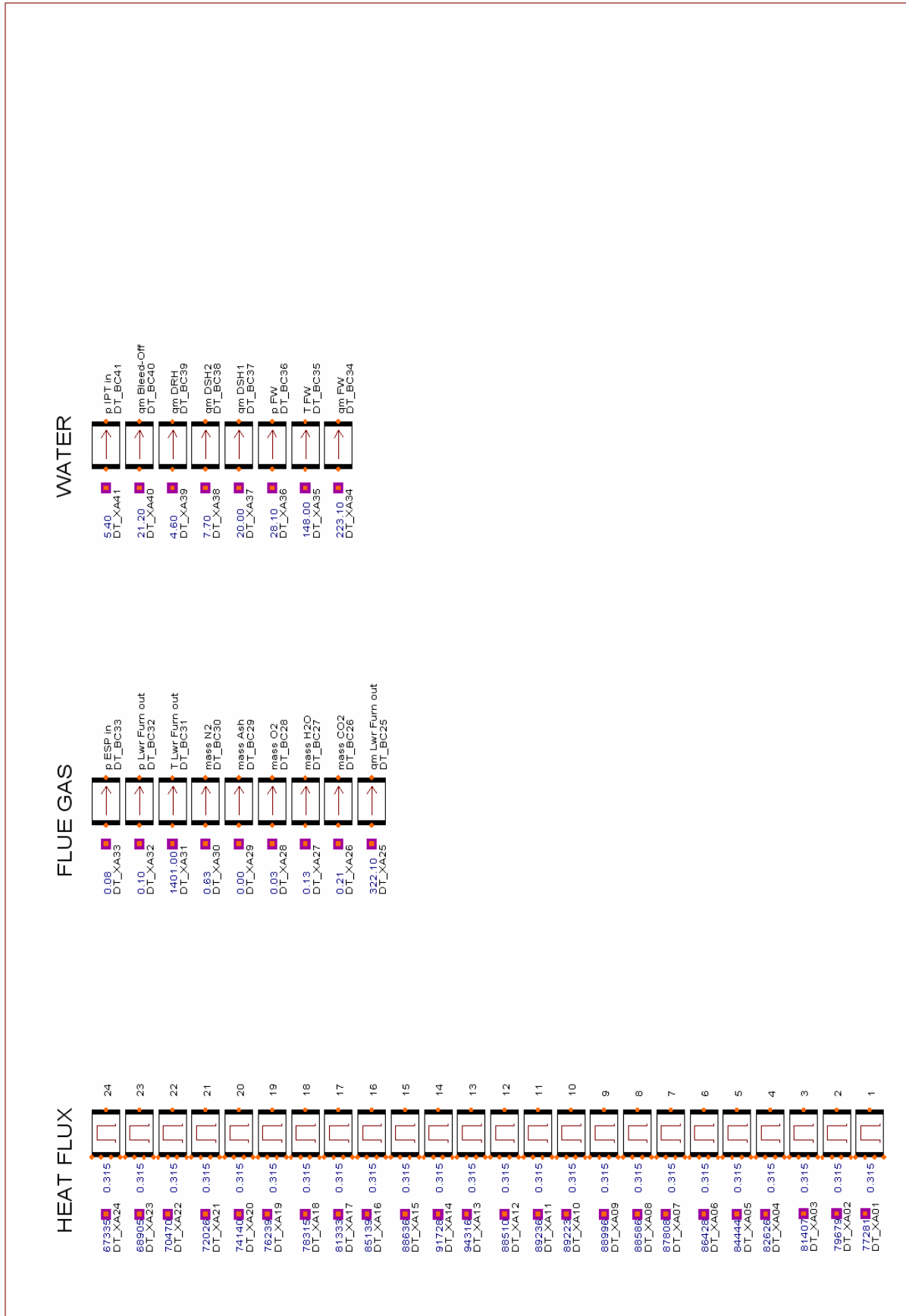


Figure 2, Boundary conditions: input values at 100 % load.

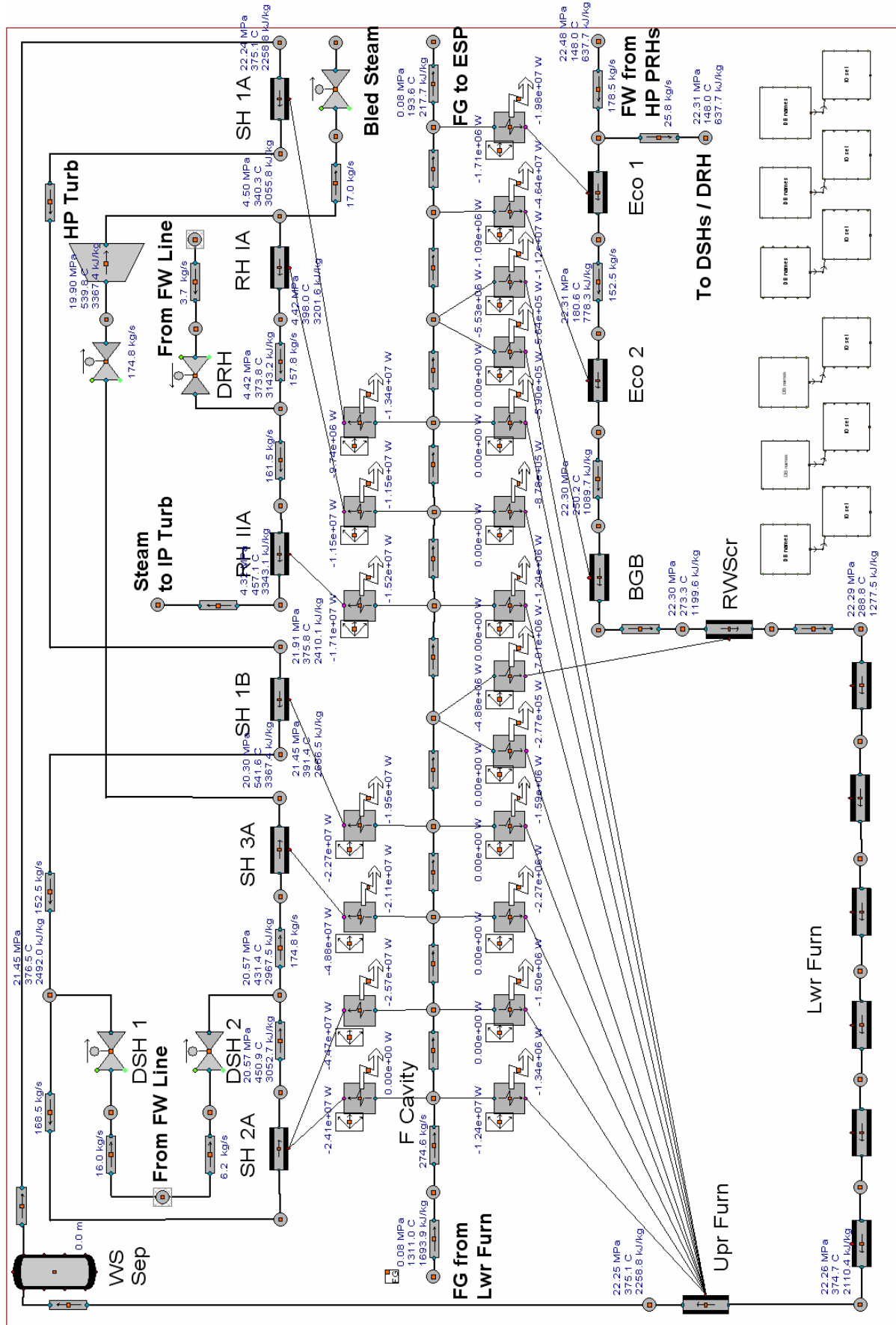


Figure 3, Recovery boiler model: steady-state operating values at 80 % load.

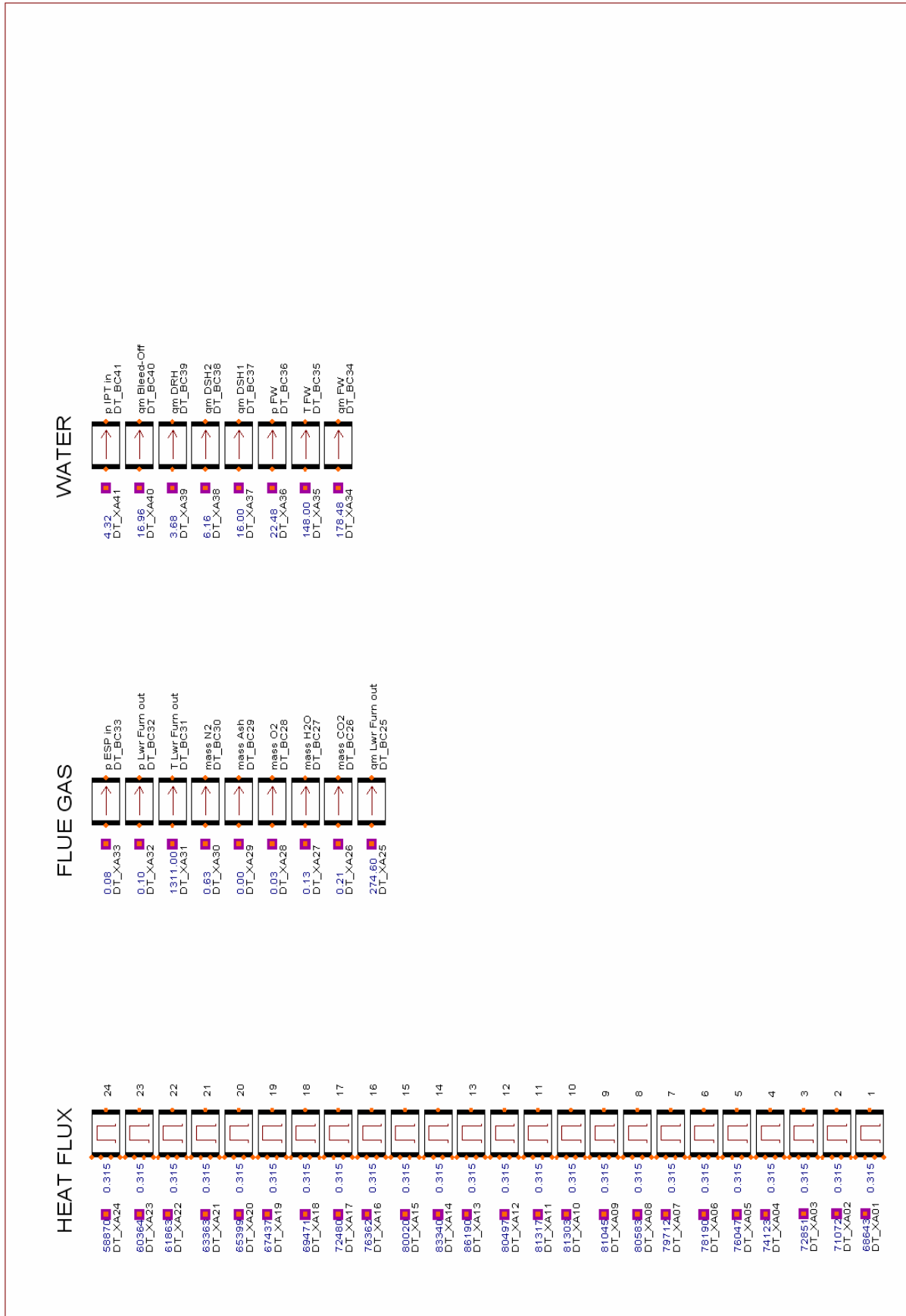


Figure 4, Boundary conditions: input values at 80 % load.

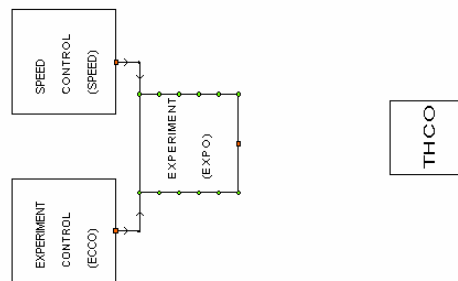


Figure 5, Simulation control and control of thermohydraulics.

Field	Value	Min	Max	Unit
Module type	POINT			
Module name	BO_PO24			
Label				
Flow model	2			
Name of fluid	FG			
Is temperature given as input	T			
Pressure	0.080017231	-1.7e+308	1.7e+308	MPa
Temperature	895.9923	-1.7e+308	1.7e+308	C
Enthalpy	1106.787	-1.7e+308	1.7e+308	kJ/kg
Void fraction	1	0	1	
Elevation from reference level	0	-1.7e+308	1.7e+308	m
Angle between flow direction and horizontal	99	-1.7e+308	1.7e+308	deg
Is pressure solved	1			
Is enthalpy solved	1			
Are concentrations solved	1			
Calculation of material properties	1			
Is flow incompressible	0			
Updating direction	1			
Liquid enthalpy	0	-1.7e+308	1.7e+308	kJ/kg
Gas enthalpy	1106.787	-1.7e+308	1.7e+308	kJ/kg
Boron concentration	0	-1.7e+308	1.7e+308	ppm
Prandtl number	0.7052652	-1.7e+308	1.7e+308	

OK Cancel

Figure 6, Properties dialog for flue gas at superheater 3A (100 % load).

Field	Value	Min	Max	Unit
Module type	HEAT_PIPE			
Module name	BO_HP03			
Label				
Mass flow	190.8	-1.7e+308	1.7e+308	kg/s
Flow length of pipe	23.5	-1.7e+308	1.7e+308	m
Inside radius	24.98	-1.7e+308	1.7e+308	mm
Thickness of first layer in the wall	6.77	0	1.7e+308	mm
Thickness of second layer in the wall	0	0	1.7e+308	mm
Thickness of third layer in the wall	0	0	1.7e+308	mm
Flow area	0	-1.7e+308	1.7e+308	m ²
Hydraulic diameter	0	-1.7e+308	1.7e+308	m
Number of parallel pipes	602	1	1.7e+308	
Material number of first layer in the wall	5			
Material number of second layer in the wall	0			
Material number of third layer in the wall	0			
Heating power of the wall	0	-1.7e+308	1.7e+308	MW
Relative roughness	0.0012000001	1e-07	1.7e+308	
Form loss coefficient	500	0	1.7e+308	
Extra pressure loss	0	0	1.7e+308	%
Is momentum transferred in beginning of pipe	T			
Is momentum transferred in the end of pipe	F			
Number of calculation nodes inside the pipe	1			
Number of nodes in first layer of the wall	2			
Number of nodes in second layer of the wall	0			
Number of nodes in third layer of the wall	0			
Is heat transferred to connection points	F			
Is axial heat conduction solved	0			
Explicit connection	0			
Is flow incompressible	0			
Discretization method of concentrations	0			
Convection constant	1	0	1.7e+308	
Radiation constant	0	0	1	
Name of external point	NULL			
Liquid mass flow	0	-1.7e+308	1.7e+308	kg/s
Gas mass flow	190.8	-1.7e+308	1.7e+308	kg/s
Mole flow	0	-1.7e+308	1.7e+308	mol/s
Name of inlet connection point	BO_PO06			
Name of outlet connection point	BO_PO07			
Flow model	2			
Name of fluid	WS			
Name of generated heat point	BO_HP03_HP1			

OK Cancel

Figure 7, Properties dialog for upper furnace (100 % load).

Field	Value	Min	Max	Unit
Module type	HEAT_TRANS			
Module name	BO_HTR06			
Label				
Hydraulic diameter	0	-1.7e+308	1.7e+308	m
Is heat transfer coefficient given	0			
Heat transfer coefficient	0	0	1.7e+308	W/(m2C)
Heat transfer coefficient of liquid	0	0	1.7e+308	W/(m2C)
Heat transfer coefficient of gas	0	0	1.7e+308	W/(m2C)
Convection constant	0.059999999	0	1.7e+308	
Radiation constant	0	0	1	
Efficiency of heat transfer	100	0	1.7e+308	%
Number of gas heat transfer correlation	0			
Name of connection point	BO_PO24			
Name of connection heat point	BO_HP03_HP1			

OK Cancel

Figure 8, Properties dialog for heat transfer between flue gas at SH 3A and upper furnace (100 % load).

Field	Value	Min	Max	Unit
Module type	HEAT_RADIATION			
Module name	BO_HTR06_HR1			
Label				
Emissivity * view factor	0	-1.7e+308	1.7e+308	
Heat transfer coefficient	0	-1.7e+308	1.7e+308	W/m2/K4
Heat flow from heat structure to th node	0	-1.7e+308	1.7e+308	W
Name of thermohydraulic node	BO_PO24_NO1			
Name of heat structure node	BO_HP03_HN2			

OK Cancel

Figure 9, Properties dialog for calculation level component of radiation heat transfer between flue gas at SH 3A and upper furnace (100 % load).

Field	Value	Min	Max	Unit
Module type	HEAT_TRANSFER			
Module name	BO_HTR06_HT1			
Label				
Hydraulic diameter	0	-1.7e+308	1.7e+308	m
Is heat transfer coefficient given	0			
Heat transfer coefficient	1.91842905273343	0	1.7e+308	W/m2/C
Convection constant for flue gas	0.059999999	0	1.7e+308	
Increase of heat trans coeff (wavy surface)	1	1	1.7e+308	
Efficiency of heat transfer	1	0	1.7e+308	
Relaxation coefficient for heat transfer	1	0.001	1	
Direction of heat transfer	0			
Heat flow from heat structure to th node	-2692043.66218381	-1.7e+308	1.7e+308	W
Heat transfer area	4.68804191543087	-1.7e+308	1.7e+308	m2
Reynolds number	1863.32901765012	-1.7e+308	1.7e+308	
Name of thermohydraulic node	BO_PO24_NO1			
Name of heat structure node	BO_HP03_HN2			

OK Cancel

Figure 10, Properties dialog for calculation level component of convective heat transfer between flue gas at SH 3A and upper furnace (100 % load).

Field	Value	Min	Max	Unit
Module type	HEAT_PIPE			
Module name	BO_HP06			
Label				
Mass flow	218.5	-1.7e+308	1.7e+308	kg/s
Flow length of pipe	219.6	-1.7e+308	1.7e+308	m
Inside radius	24.65	-1.7e+308	1.7e+308	mm
Thickness of first layer in the wall	7.1	0	1.7e+308	mm
Thickness of second layer in the wall	0	0	1.7e+308	mm
Thickness of third layer in the wall	0	0	1.7e+308	mm
Flow area	0	-1.7e+308	1.7e+308	m ²
Hydraulic diameter	0	-1.7e+308	1.7e+308	m
Number of parallel pipes	152	1	1.7e+308	
Material number of first layer in the wall	5			
Material number of second layer in the wall	0			
Material number of third layer in the wall	0			
Heating power of the wall	0	-1.7e+308	1.7e+308	MW
Relative roughness	0.0012000001	1e-07	1.7e+308	
Form loss coefficient	5	0	1.7e+308	
Extra pressure loss	0	0	1.7e+308	%
Is momentum transferred in beginning of pipe	F			
Is momentum transferred in the end of pipe	F			
Number of calculation nodes inside the pipe	1			
Number of nodes in first layer of the wall	2			
Number of nodes in second layer of the wall	0			
Number of nodes in third layer of the wall	0			
Is heat transferred to connection points	F			
Is axial heat conduction solved	0	☒		
Explicit connection	0	☒		
Is flow incompressible	0	☒		
Discretization method of concentrations	0	☒		
Convection constant	1	0	1.7e+308	
Radiation constant	0	0	1	
Name of external point	NULL			
Liquid mass flow	0	-1.7e+308	1.7e+308	kg/s
Gas mass flow	218.5	-1.7e+308	1.7e+308	kg/s
Mole flow	0	-1.7e+308	1.7e+308	mol/s
Name of inlet connection point	BO_PO14			
Name of outlet connection point	BO_PO15			
Flow model	2			
Name of fluid	WS			
Name of generated heat point	BO_HP06_HP1			

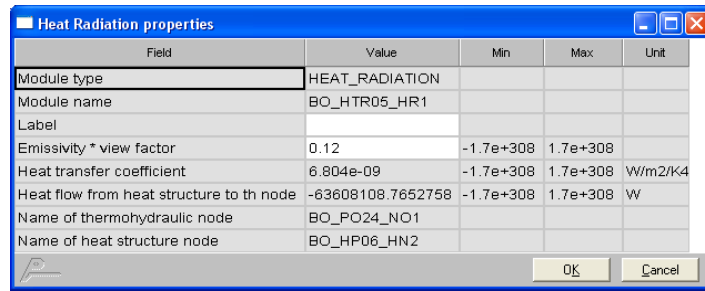
OK Cancel

Figure 11, Properties dialog for superheater 3A (100 % load).

Field	Value	Min	Max	Unit
Module type	HEAT_TRANS			
Module name	BO_HTR05			
Label				
Hydraulic diameter	0	-1.7e+308	1.7e+308	m
Is heat transfer coefficient given	0	☒		
Heat transfer coefficient	0	0	1.7e+308	W/(m ² C)
Heat transfer coefficient of liquid	0	0	1.7e+308	W/(m ² C)
Heat transfer coefficient of gas	0	0	1.7e+308	W/(m ² C)
Convection constant	0.377	0	1.7e+308	
Radiation constant	0.12	0	1	
Efficiency of heat transfer	100	0	1.7e+308	%
Number of gas heat transfer correlation	0	☒		
Name of connection point	BO_PO24			
Name of connection heat point	BO_HP06_HP1			

OK Cancel

Figure 12, Properties dialog for heat transfer between flue gas and SH 3A (100 % load).

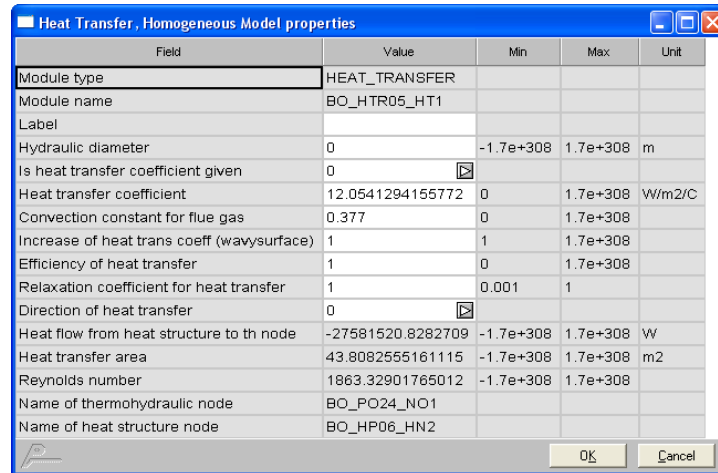


Heat Radiation properties

Field	Value	Min	Max	Unit
Module type	HEAT_RADIATION			
Module name	BO_HTR05_HR1			
Label				
Emissivity * view factor	0.12	-1.7e+308	1.7e+308	
Heat transfer coefficient	6.804e-09	-1.7e+308	1.7e+308	W/m2/K4
Heat flow from heat structure to th node	-63608108.7652758	-1.7e+308	1.7e+308	W
Name of thermohydraulic node	BO_PO24_NO1			
Name of heat structure node	BO_HP06_HN2			

OK Cancel

Figure 13, Properties dialog for calculation level component of radiation heat transfer between flue gas and SH 3A (100 % load).



Heat Transfer, Homogeneous Model properties

Field	Value	Min	Max	Unit
Module type	HEAT_TRANSFER			
Module name	BO_HTR05_HT1			
Label				
Hydraulic diameter	0	-1.7e+308	1.7e+308	m
Is heat transfer coefficient given	☒			
Heat transfer coefficient	12.0541294155772	0	1.7e+308	W/m2/C
Convection constant for flue gas	0.377	0	1.7e+308	
Increase of heat trans coeff (wavysurface)	1	1	1.7e+308	
Efficiency of heat transfer	1	0	1.7e+308	
Relaxation coefficient for heat transfer	1	0.001	1	
Direction of heat transfer	0 ☒			
Heat flow from heat structure to th node	-27581520.8282709	-1.7e+308	1.7e+308	W
Heat transfer area	43.8082555161115	-1.7e+308	1.7e+308	m2
Reynolds number	1863.32901765012	-1.7e+308	1.7e+308	
Name of thermohydraulic node	BO_PO24_NO1			
Name of heat structure node	BO_HP06_HN2			

OK Cancel

Figure 14, Properties dialog for calculation level component of convective heat transfer between flue gas and SH 3A (100 % load).

Field	Value	Min	Max	Unit
Module type	PIPE			
Module name	BO_PIP09			
Label				
Mass flow	218.5	-1.7e+308	1.7e+308	kg/s
Flow length of pipe	1	-1.7e+308	1.7e+308	m
Diameter of pipe	0	-1.7e+308	1.7e+308	mm
Flow area	2	-1.7e+308	1.7e+308	m2
Hydraulic diameter	0	-1.7e+308	1.7e+308	m
Relative roughness	9.9999997e-06	1e-07	1.7e+308	
Form loss coefficient	1	0	1.7e+308	
Extra pressure loss	0	0	1.7e+308	%
Discharge coefficient	0.75	-1.7e+308	1.7e+308	
Relaxation coefficient of mass flow	1	0.001	1	
Is momentum transferred in beginning of pipe	F			
Is momentum transferred in the end of pipe	F			
Number of calculation nodes inside the pipe	1			
Is flow solved	1	☒		
Is pipe included in pressure solution	1	☒		
Is pipe included in enthalpy solution	1	☒		
Explicit connection	0	☒		
Connection between two experiments	0	☒		
Calculation of material properties	1	☒		
Is flow incompressible	0	☒		
Discretization method of concentrations	0	☒		
Updating direction	1	☒		
Liquid mass flow	0	-1.7e+308	1.7e+308	kg/s
Gas mass flow	218.5	-1.7e+308	1.7e+308	kg/s
Mole flow	0	-1.7e+308	1.7e+308	mol/s
Name of inlet connection point	BO_PO13			
Name of outlet connection point	BO_PO14			
Flow model	2			
Name of fluid	WS			

OK Cancel

Figure 15, Properties dialog for piping between spray attenuator DSH2 and superheater 3A (100 % load).

Field	Value	Min	Max	Unit
Module type	CONTROL_VALVE			
Module name	BO_COV03			
Label				
Flow length of valve	1	-1.7e+308	1.7e+308	m
Flow area	0.25	-1.7e+308	1.7e+308	m2
Mass flow	218.5	-1.7e+308	1.7e+308	kg/s
Position set point of valve	0.8	0	1	
Nominal position of valve	0.8	0	1	
Nominal mass flow	220.5	-1.7e+308	1.7e+308	kg/s
Nominal pressure loss	0.5	-1.7e+308	1.7e+308	MPa
Nominal density	79.8	-1.7e+308	1.7e+308	kg/m3
Shape of specific curve	1	☒		
Driving time of valve	30	-1.7e+308	1.7e+308	s
Discharge coefficient	0.75	-1.7e+308	1.7e+308	
Relaxation coefficient of mass flow	1	0.001	1	
Is momentum transferred over the valve	T			
Explicit connection	0	☒		
Connection between two experiments	0	☒		
Is flow limited to sonic velocity	0	☒		
Treatment of a closed valve	1	☒		
Leak position for flow through a closed valve	0	0	1	
Valve behaviour when external power is lost	1	☒		
Malfunction	0	☒		
Name of busbar to supply electricity	NULL			
Name of electric supply BIN SIGNAL	NULL			
Liquid mass flow	0	-1.7e+308	1.7e+308	kg/s
Gas mass flow	218.5	-1.7e+308	1.7e+308	kg/s
Position of valve	0.8	0	1	
Name of inlet connection point	BO_PO15			
Name of outlet connection point	BO_PO16			
Flow model	2			
Name of fluid	WS			

OK Cancel

Figure 16, Properties dialog for main steam stop valve (100 % load).

Field	Value	Min	Max	Unit
Module type	TURBINE_SECTION			
Module name	BO_TU01			
Label				
Mass flow	218.5	-1.7e+308	1.7e+308	kg/s
Nominal mass flow	218.5	-1.7e+308	1.7e+308	kg/s
Nominal inlet pressure	24.43	-1.7e+308	1.7e+308	MPa
Nominal inlet specific volume	0.0128	-1.7e+308	1.7e+308	m3/kg
Nominal outlet pressure	5.61	-1.7e+308	1.7e+308	MPa
Rotation speed	3000	-1.7e+308	1.7e+308	rpm
Efficiency of isentropic expansion	71.3	-1.7e+308	1.7e+308	%
Flow/efficiency curve: volume or mass flow	1 ☒			
Flow/efficiency curve[1]	150.0000 71.30000			
Flow/efficiency curve[2]	200.0000 71.30000			
Flow/efficiency curve[3]	250.0000 71.30000			
Flow/efficiency curve[4]	0.000000 0.000000			
Flow/efficiency curve[5]	0.000000 0.000000			
Flow/efficiency curve[6]	0.000000 0.000000			
Flow/efficiency curve[7]	0.000000 0.000000			
Flow/efficiency curve[8]	0.000000 0.000000			
Flow/efficiency curve[9]	0.000000 0.000000			
Flow/efficiency curve[10]	0.000000 0.000000			
Rotation speed/efficiency curve[1]	0.000000 0.000000			
Rotation speed/efficiency curve[2]	0.000000 0.000000			
Rotation speed/efficiency curve[3]	0.000000 0.000000			
Rotation speed/efficiency curve[4]	0.000000 0.000000			
Rotation speed/efficiency curve[5]	0.000000 0.000000			
Rotation speed/efficiency curve[6]	0.000000 0.000000			
Rotation speed/efficiency curve[7]	0.000000 0.000000			
Rotation speed/efficiency curve[8]	0.000000 0.000000			
Rotation speed/efficiency curve[9]	0.000000 0.000000			
Rotation speed/efficiency curve[10]	0.000000 0.000000			
Is Stodola coefficient calculated	1 ☒			
Stodola coefficient	0.0051387604	-1.7e+308	1.7e+308	m2
Thermal power drop over the turbine section	64.78751	-1.7e+308	1.7e+308	MW
Name of outlet connection point	BO_PO17			
Name of fluid	WS			

OK Cancel

Figure 17, Properties dialog for high-pressure turbine (100 % load).