SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Suomen Soodakattilayhdistys ry

Final Summary Report on Nitrogen Oxide Emissions from Finnish Pulp Mills

Nikolai DeMartini, Mikko Hupa

Raportti 9/2010

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Final Summary Report on Nitrogen Oxide Emissions from Finnish Pulp Mills

Nikolai DeMartini
Mikko Hupa
12 February 2010

This is a summary report of the nitrogen emissions from the Finnish pulp mills measured between 1998 and 2008. A summary of the state of knowledge of NOx formation in recovery boilers ("Nitrogen oxide emissions from pulp mills and the factors affecting them – a summary of the current knowledge") was written for the Finnish Recovery Boiler Committee by Mikko Hupa in October 10, 2005. The dates of the mill balances are given in Table I.

Table I. Campaigns and dates for nitrogen measurements at recovery boilers and lime kilns (SW – softwood; HW – hardwood).

Tehdas	Mill	Year
A – SW	MB, Kemi	1998
A – HW	MB, Kemi	1998
B – 1	Kaskinen	2001 (EU-Rempulp)
B – 2	Kaskinen	2004
C	Rauma	2004
D	Joutseno	2004
E	MB, Kemi	2005
F – SW	Äänekoski	2005
F – HW	Äänekoski	2005
G	Oulu	2007
H	Pietarsaari	2008

The NO + NO_2 emissions varied between 1.08 to 1.52 kg NO_2/ADt and 0.12 to 0.66 kg NO_2/ADt for the recovery boilers and lime kilns respectively for totals of between 1.3 and 2.1 kg NO_2/ADt, Figure 1. The nitrogen concentration in the black liquor as wt % dry solids is given in Figure 2. The percentage of fuel nitrogen which forms NO + NO_2 in the recovery boiler varied between 26 and 33% for all but two mills one of which was 20% and the other was 44%, Figure 3. The % of fuel-N exiting the recovery boiler as smelt was between 22 and 45% based on the smelt nitrogen and/or the nitrogen flows into and out of the dissolving tank. The individual mill balances are given in Appendix I and individual mill data is given in Appendix II. In Appendix I the nitrogen flows in the diagram boxes are presented as kilograms of elemental nitrogen per air-dry tonne of pulp, i.e. as kg N/ADt. Data for the nitrogen flow with the smelt for the Oulu recovery boiler is missing and so the recovery boiler balance is missing in Appendix I and

the nitrogen distribution is missing from Figure 3. Data for the recovery boiler and lime kiln $NO+NO_2$ for Oulu was available and are given in Figure 1 and Appendix II.

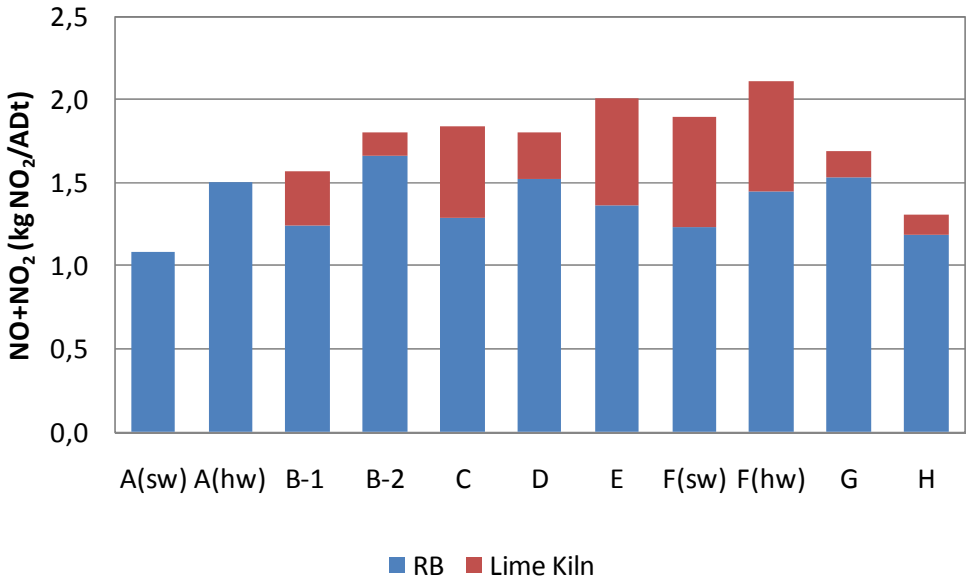


Figure 1. NO + NO_2 emissions as kg NO_2/ADT for the mills. Lime kiln emissions were not measured for mill A.

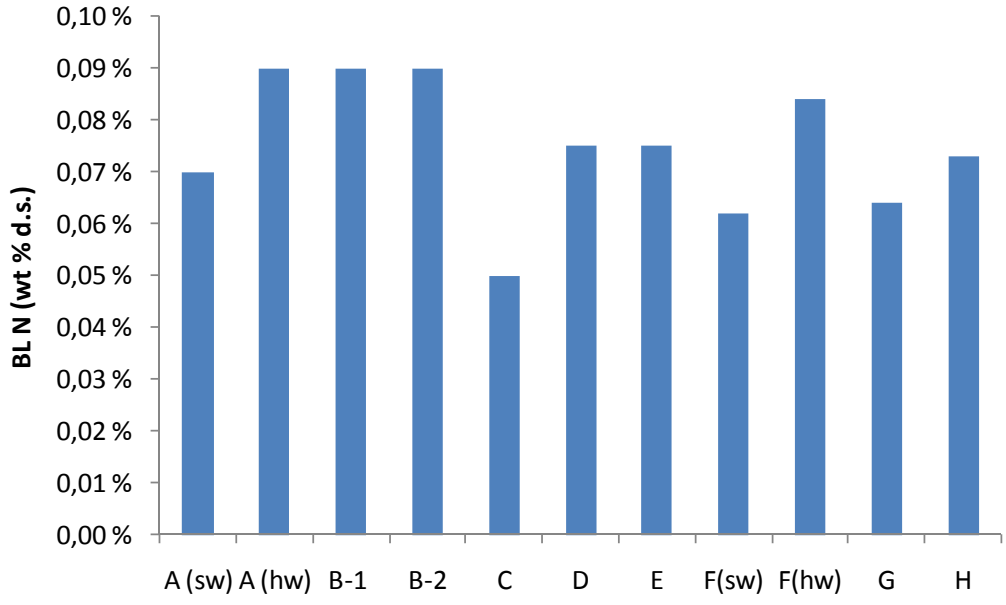


Figure 2. Concentration of nitrogen in the mill black liquors.

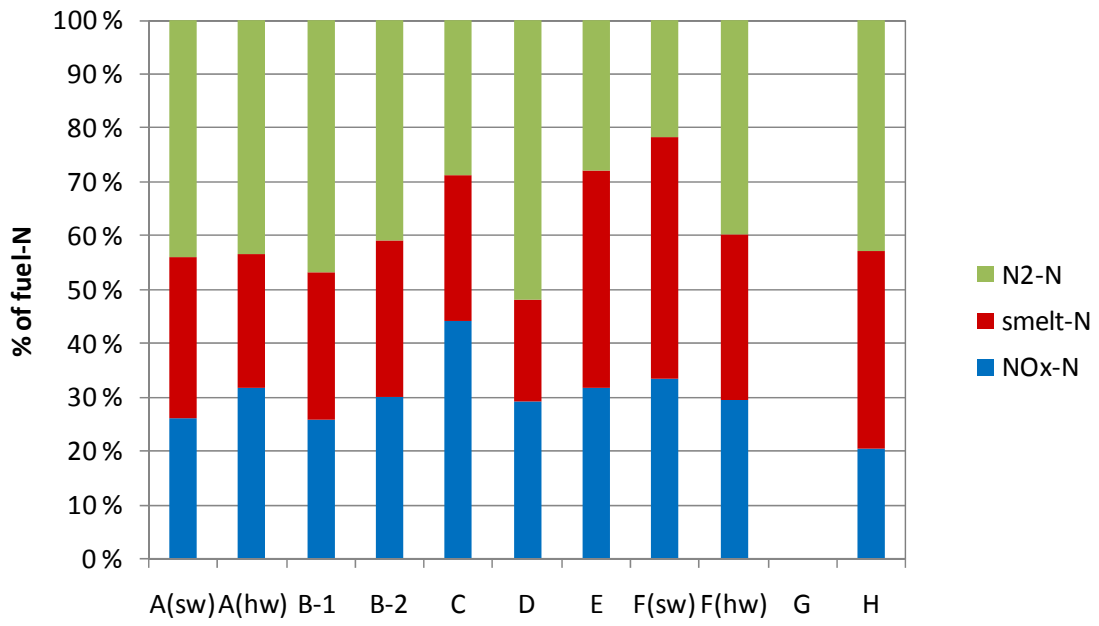
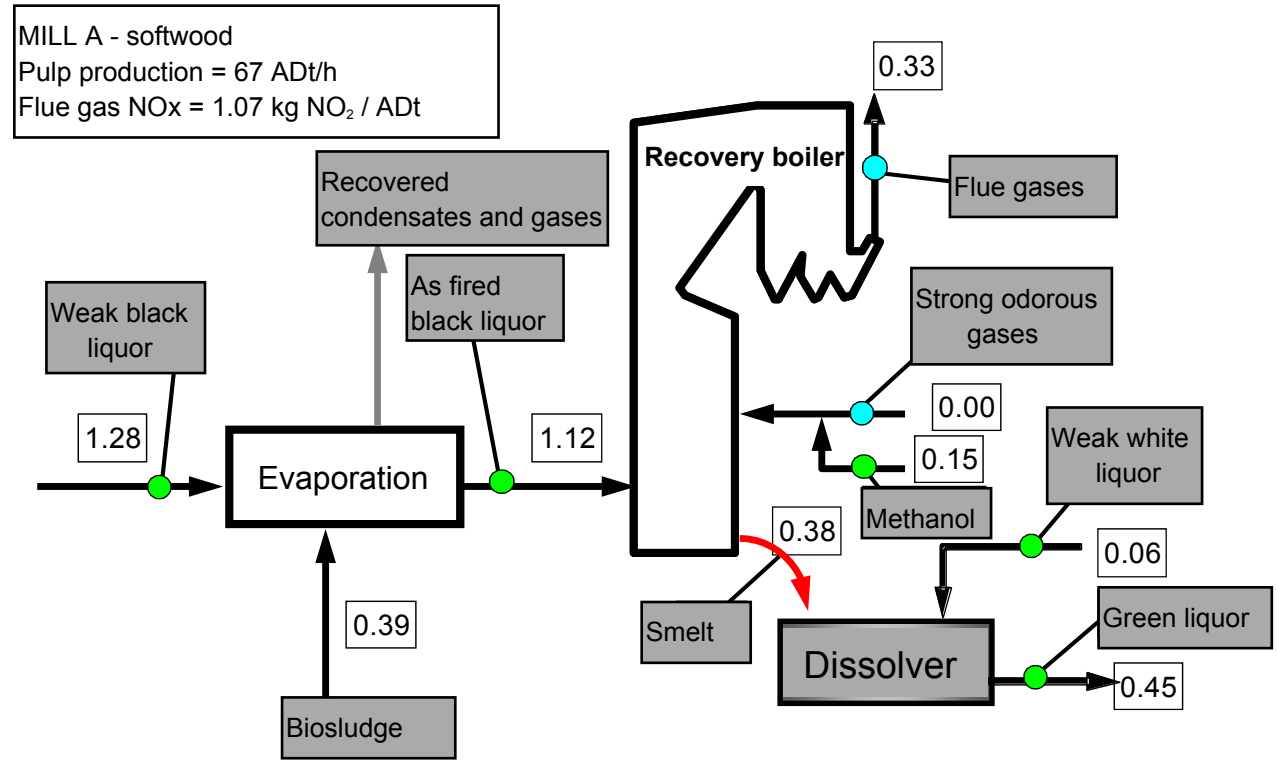
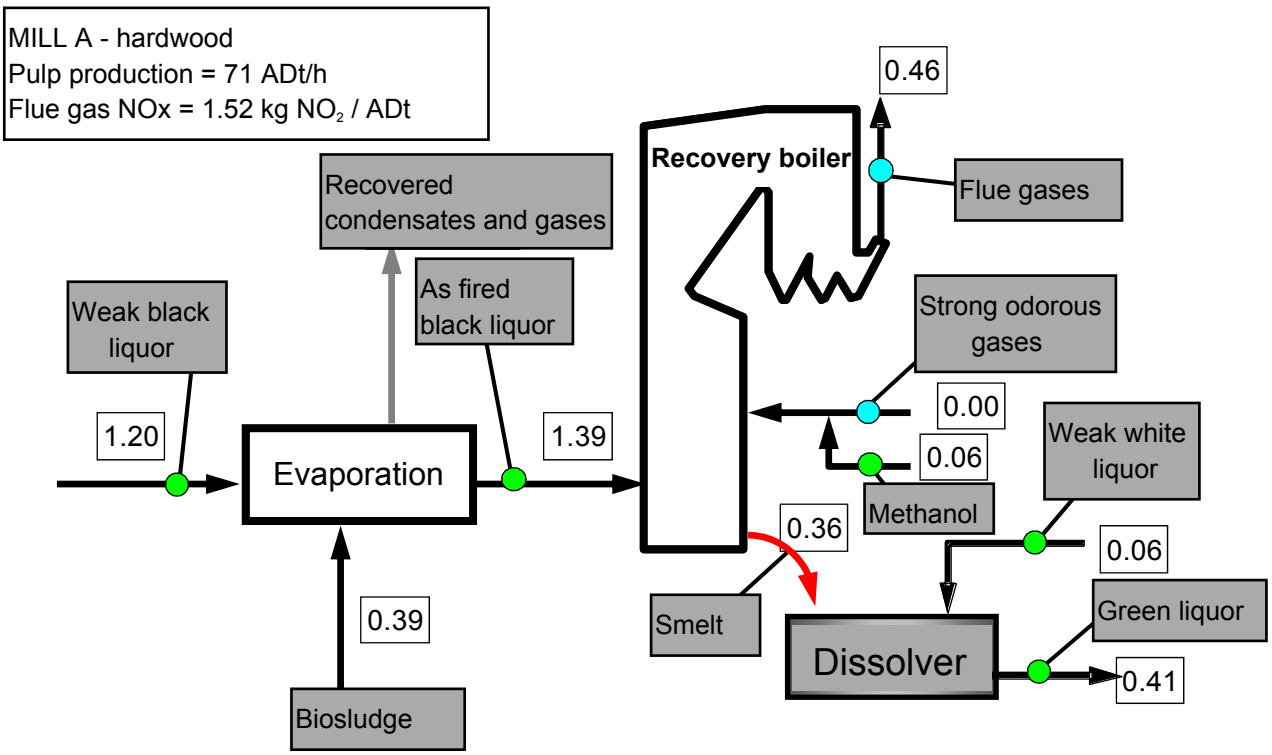
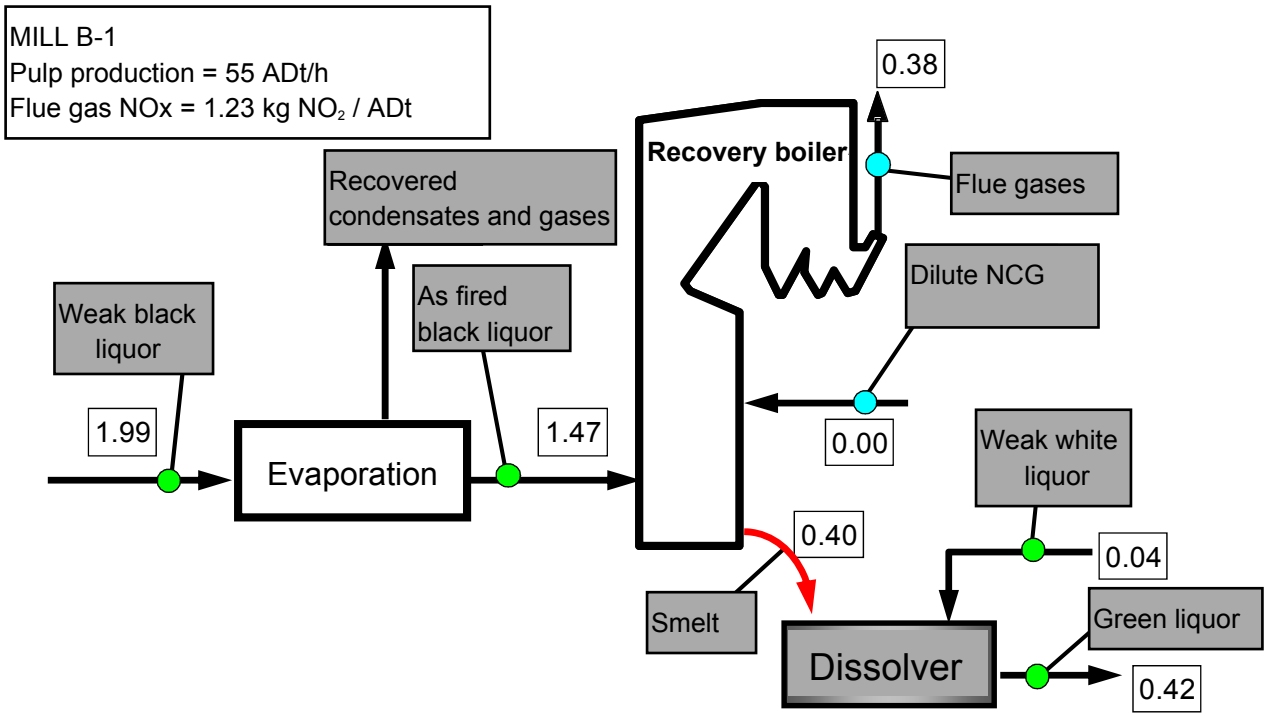


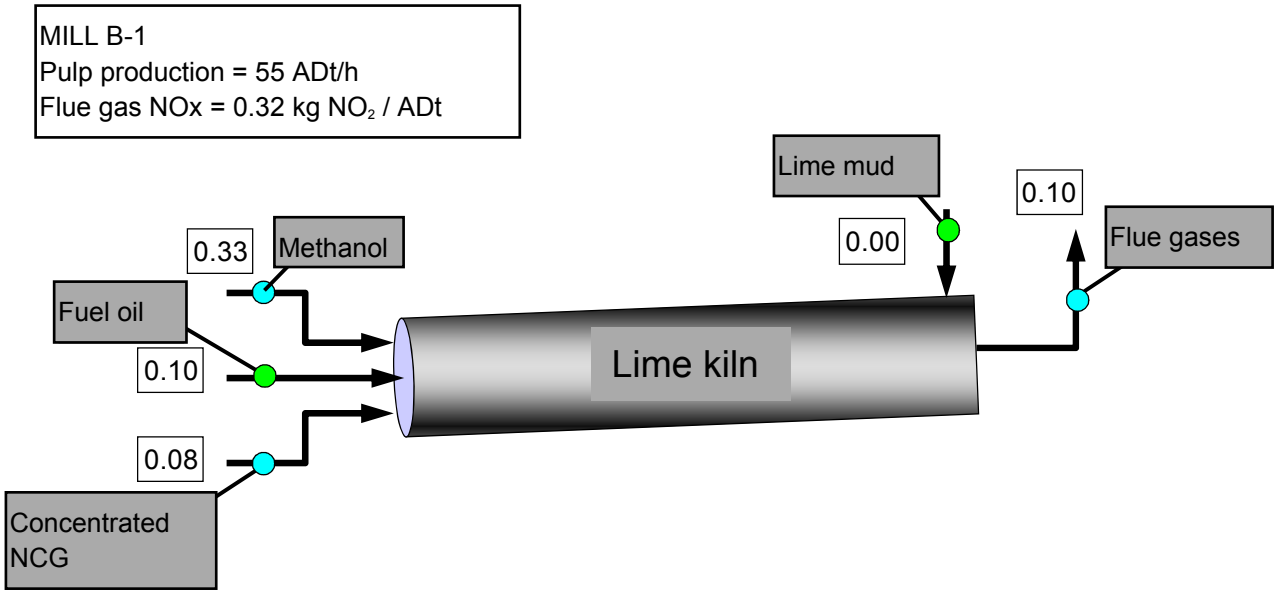
Figure 3. NO + NO_2, smelt-N as % of fuel-N and the N_2 by balance. Smelt data wasn't available for mill G.

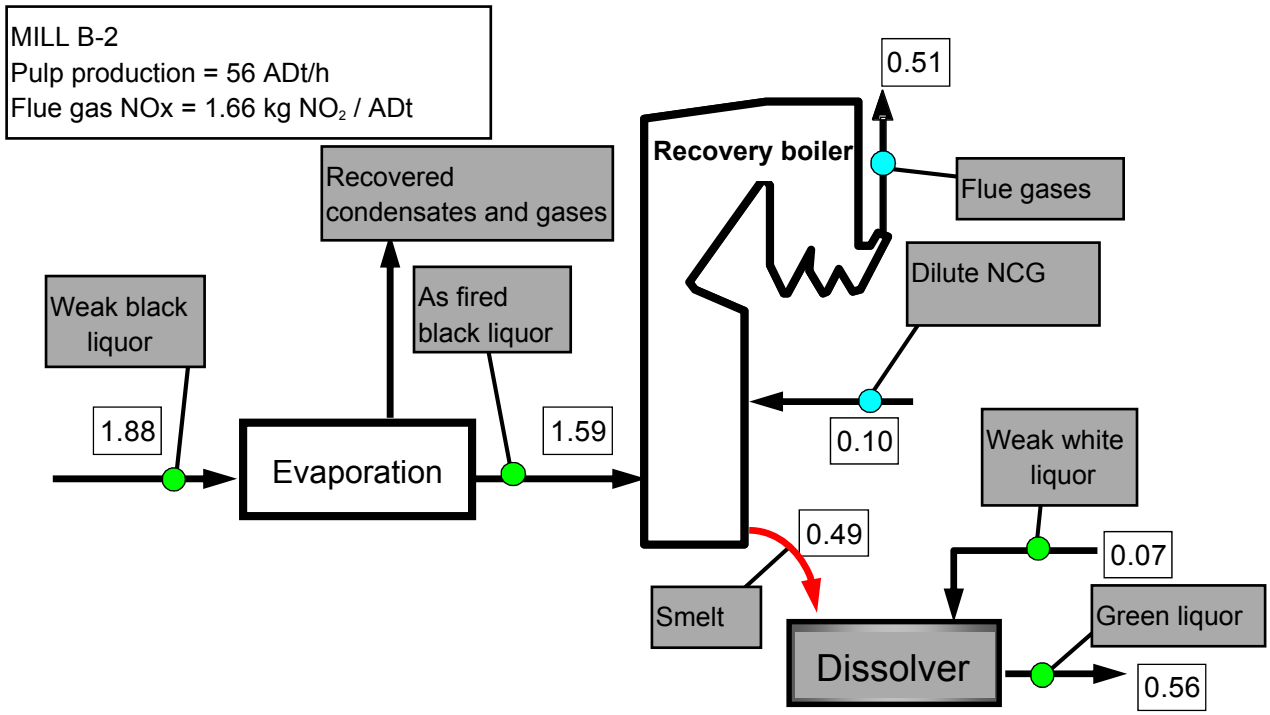
Appendix I. Nitrogen Balances given as kg N/ADt pulp.

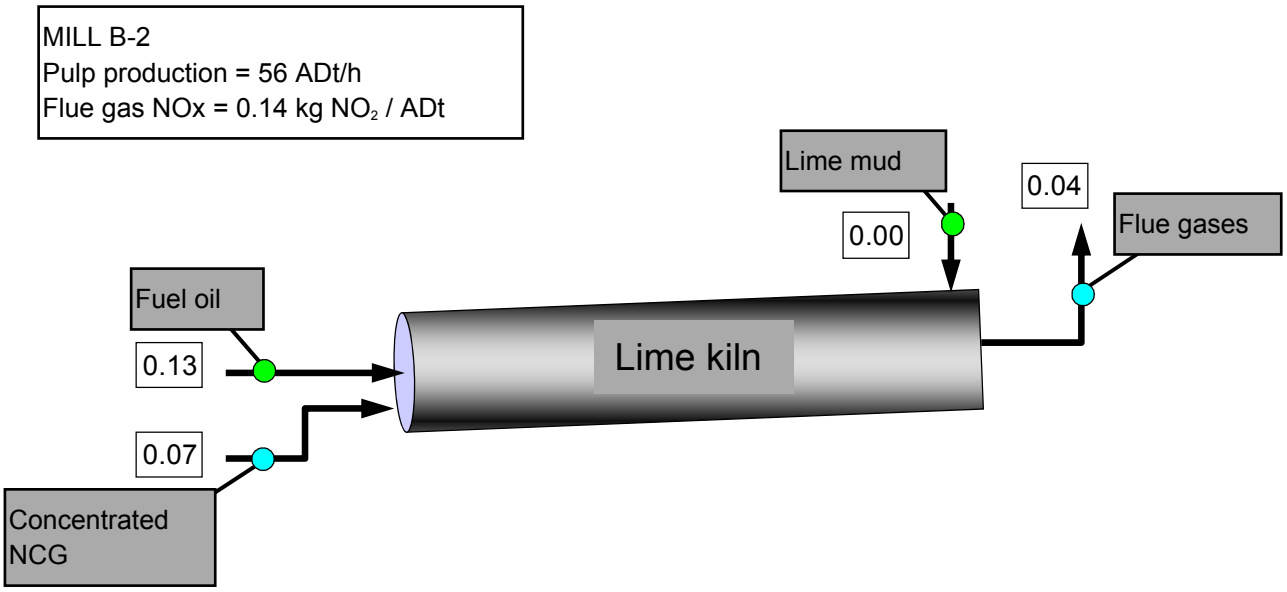


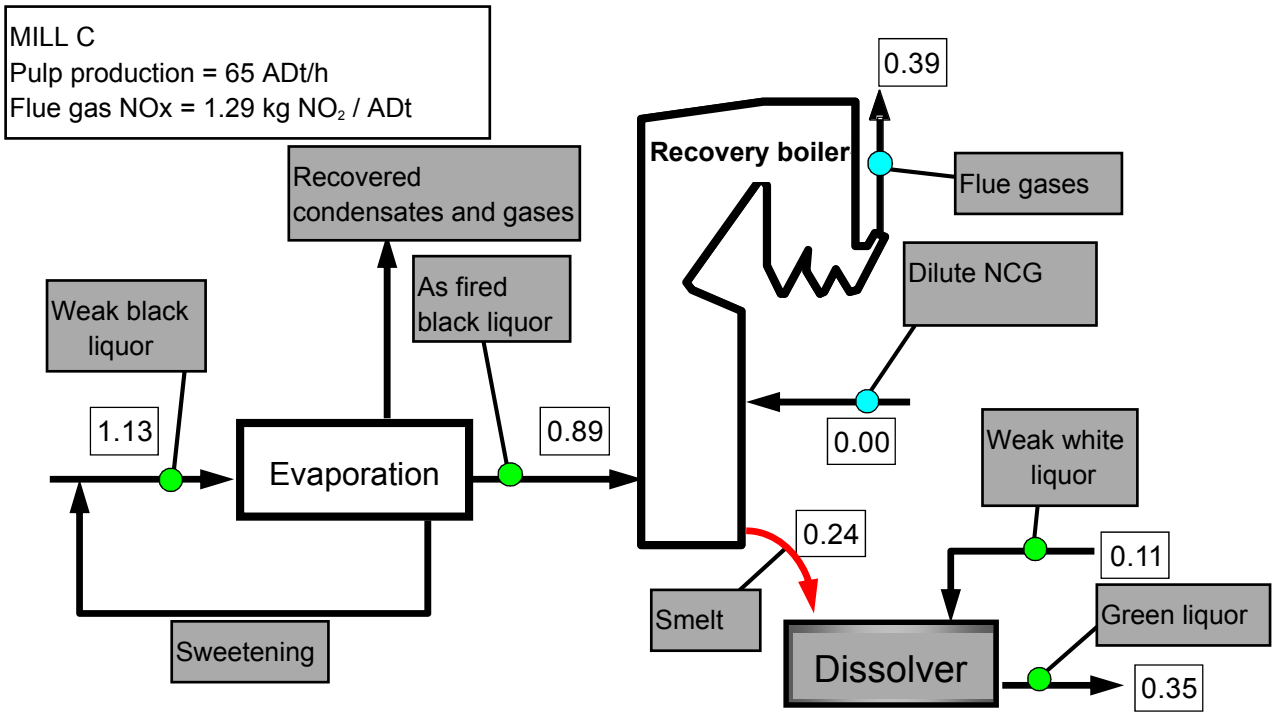


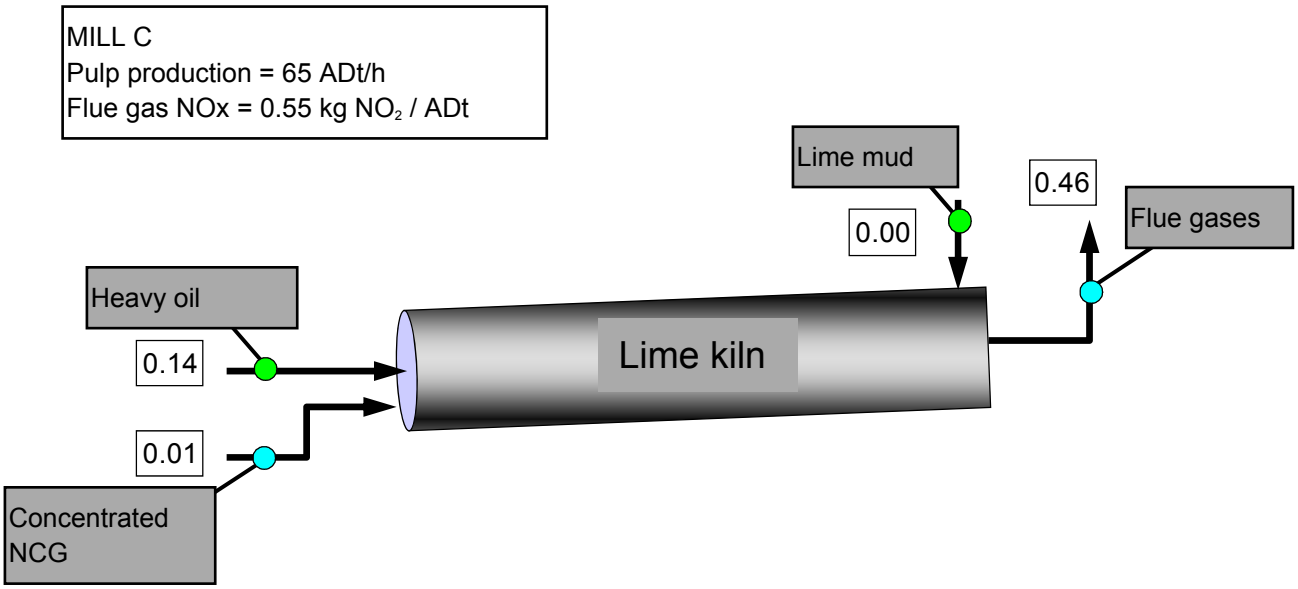

MILL B-1
Pulp production = 55 ADt/h
Flue gas NOx = 1.23 kg NO_2 / ADt
0.38
Recovery boiler
Flue gases
Recovered condensates and gases
Dilute NCG
Weak black liquor
As fired black liquor
1.99
Evaporation
1.47
0.00
Weak white liquor
0.40
0.04
Smelt
Green liquor
Dissolver
0.42

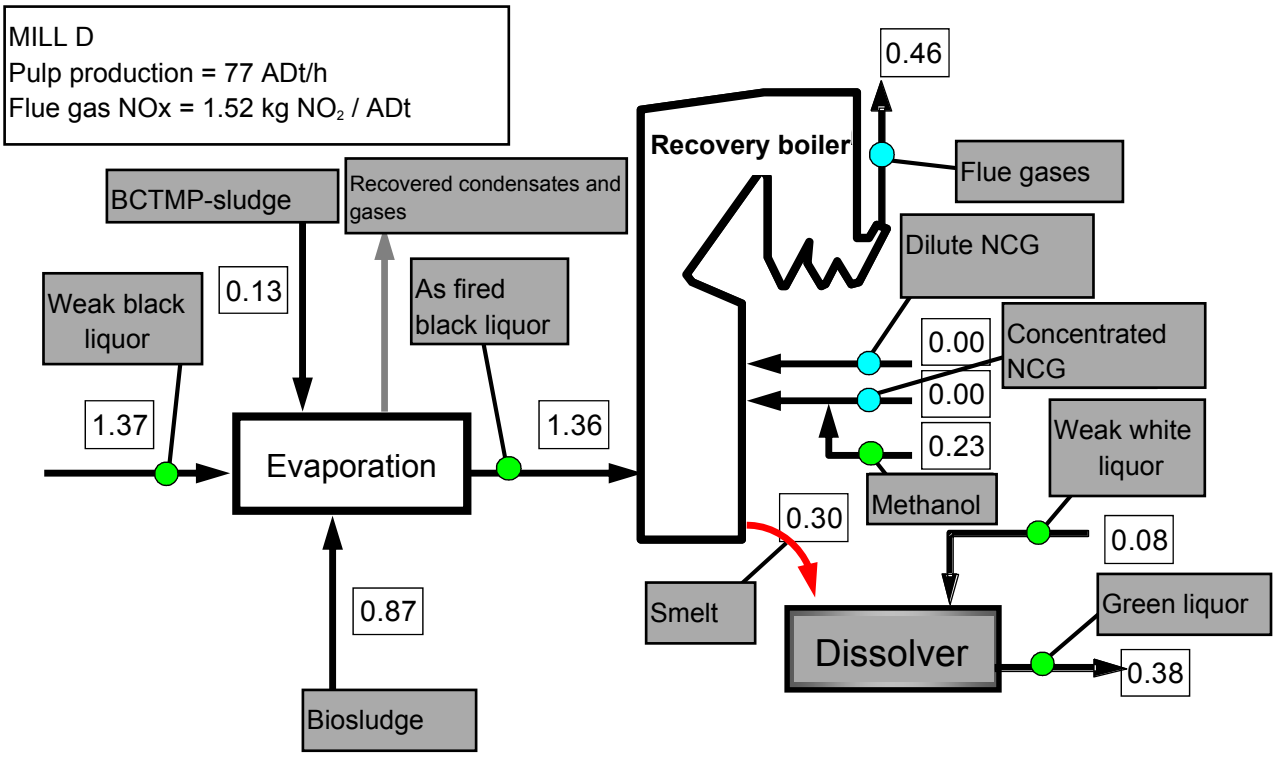

MILL B-1
Pulp production = 55 ADt/h
Flue gas NOx = 0.32 kg NO_2 / ADt
Lime mud
0.10
0.00
Flue gases
0.33
Methanol
Fuel oil
0.10
Lime kiln
0.08
Concentrated NCG

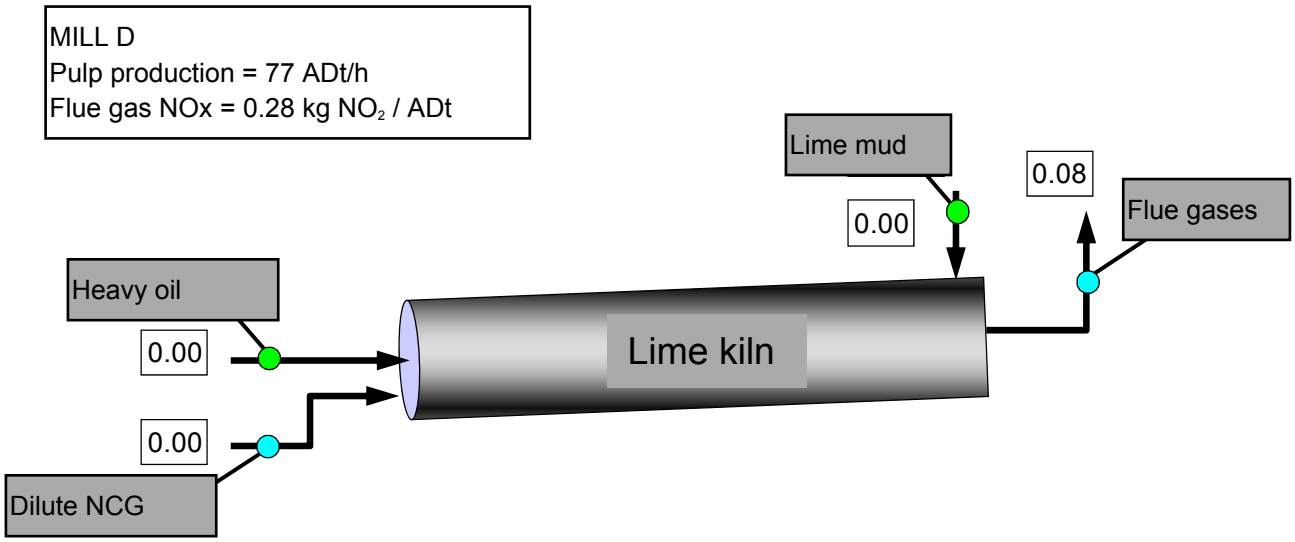

MILL B-2
Pulp production = 56 ADt/h
Flue gas NOx = 1.66 kg NO_2 / ADt
0.51
Recovery boiler
Flue gases
Recovered condensates and gases
Dilute NCG
Weak black liquor
As fired black liquor
1.88
Evaporation
1.59
0.10
Weak white liquor
0.49
0.07
Smelt
Green liquor
Dissolver
0.56

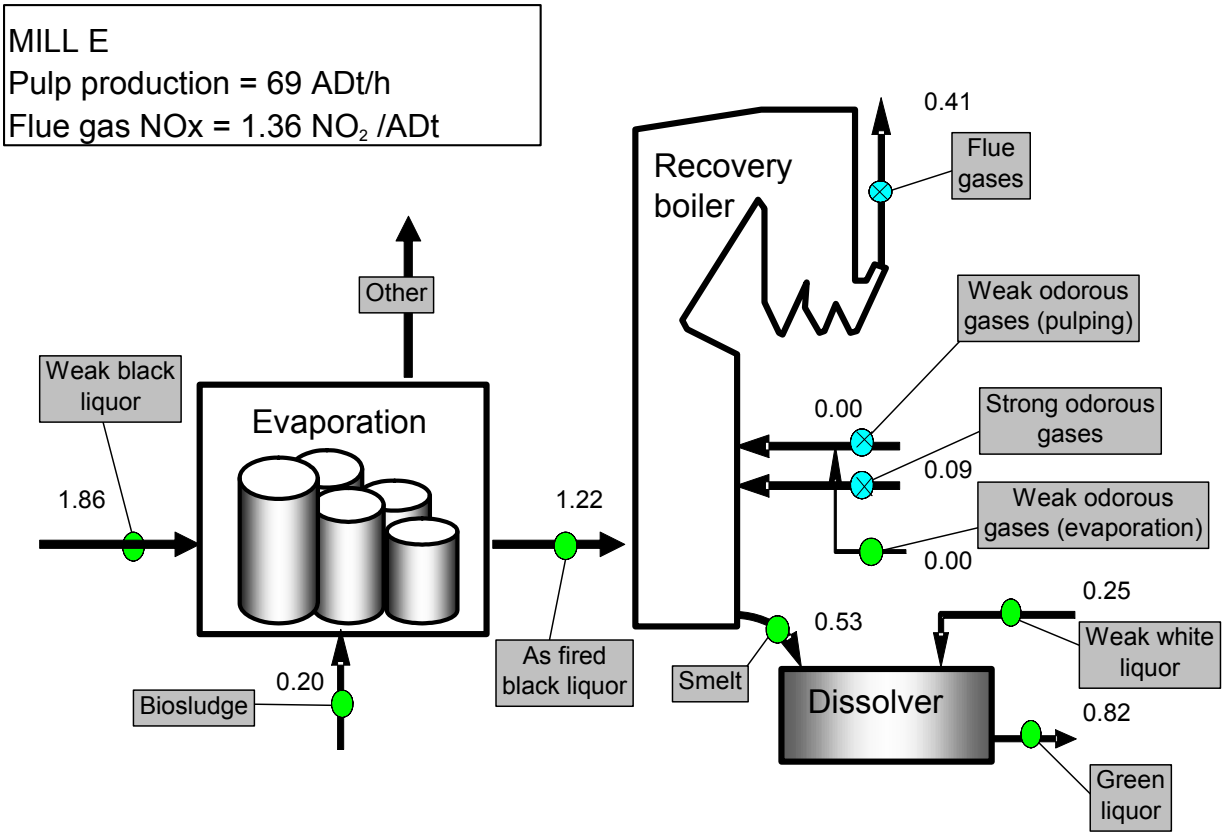

MILL B-2
Pulp production = 56 ADt/h
Flue gas NOx = 0.14 kg NO_2 / ADt
Lime mud
0.04
0.00
Flue gases
Fuel oil
0.13
Lime kiln
0.07
Concentrated NCG

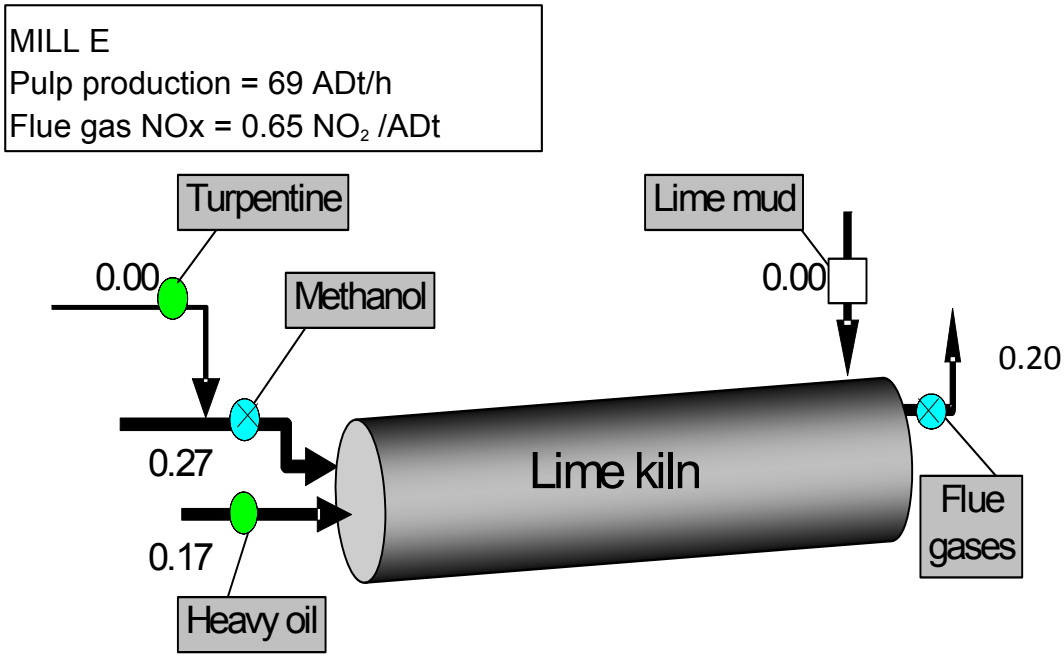

MILL C
Pulp production = 65 ADt/h
Flue gas NOx = 1.29 kg NO_2 / ADt
Recovered condensates and gases
Weak black liquor
As fired black liquor
1.13
Evaporation
0.89
Sweetening
Recovery boiler
0.39
Flue gases
Dilute NCG
0.00
Weak white liquor
0.24
0.11
Smelt
Green liquor
Dissolver
0.35


MILL C
Pulp production = 65 ADt/h
Flue gas NOx = 0.55 kg NO_2 / ADt
Lime mud
0.00
0.46
Flue gases
Heavy oil
0.14
Lime kiln
0.01
Concentrated NCG

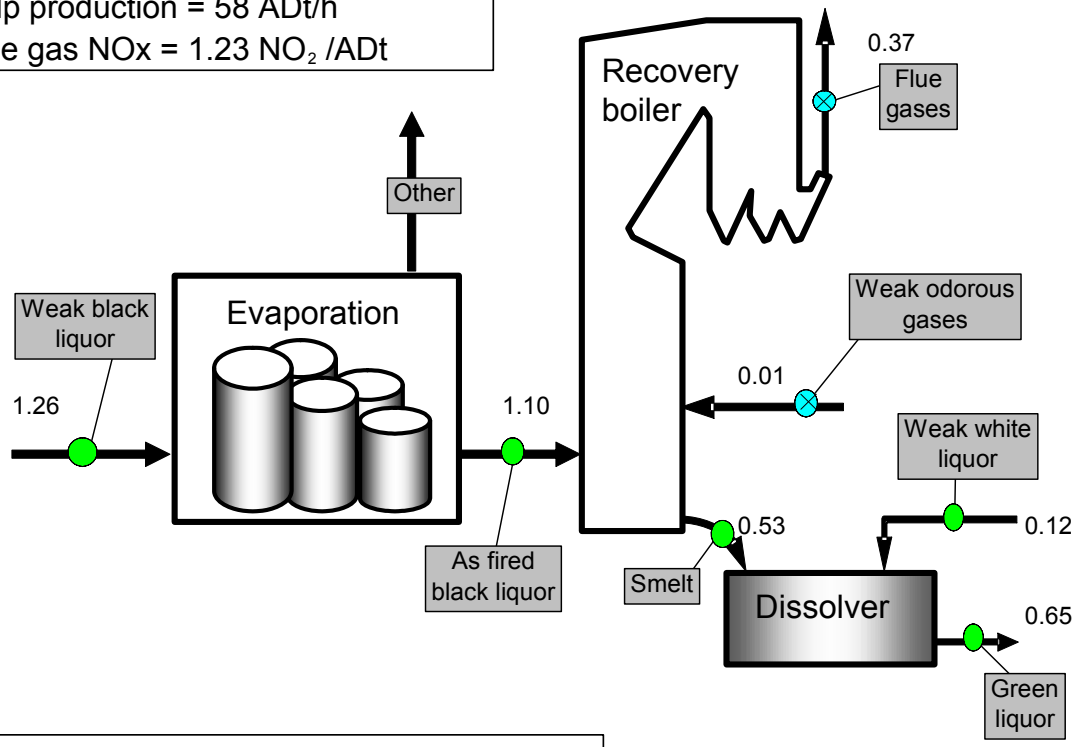

MILL D
Pulp production = 77 ADt/h
Flue gas NOx = 1.52 kg NO_2 / ADt
0.46
Recovery boiler
Flue gases
BCTMP-sludge
Recovered condensates and gases
Dilute NCG
Weak black liquor
0.13
As fired black liquor
0.00
Concentrated NCG
0.00
1.37
Evaporation
1.36
0.23
Weak white liquor
Methanol
0.30
0.08
0.87
Smelt
Dissolver
Green liquor
0.38
Biosludge


MILL D
Pulp production = 77 ADt/h
Flue gas NOx = 0.28 kg NO_2 / ADt
Lime mud
0.08
0.00
Flue gases
Heavy oil
0.00
Lime kiln
0.00
Dilute NCG

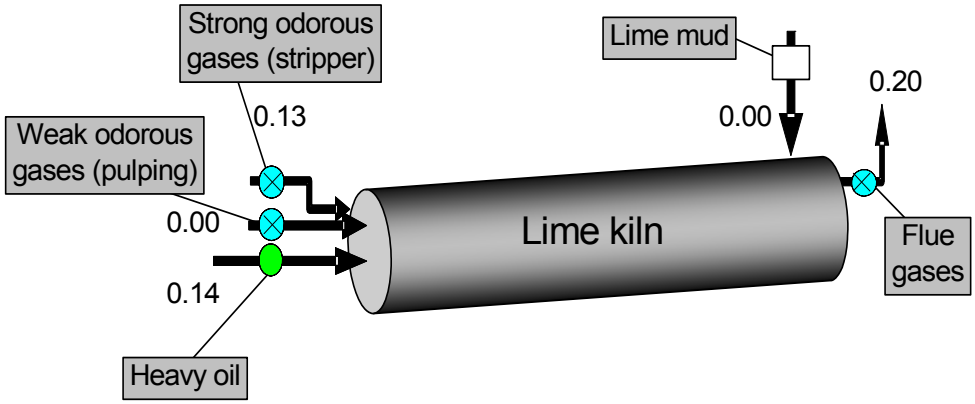

MILL E
Pulp production = 69 ADt/h
Flue gas NOx = 1.36 NO_2 /ADt
Recovery boiler
0.41
Flue gases
Other
Weak odorous gases (pulping)
Weak black liquor
Evaporation
0.00
Strong odorous gases
0.09
1.86
1.22
Weak odorous gases (evaporation)
0.00
0.25
0.53
Weak white liquor
As fired black liquor
Smelt
Dissolver
0.20
Biosludge
0.82
Green liquor

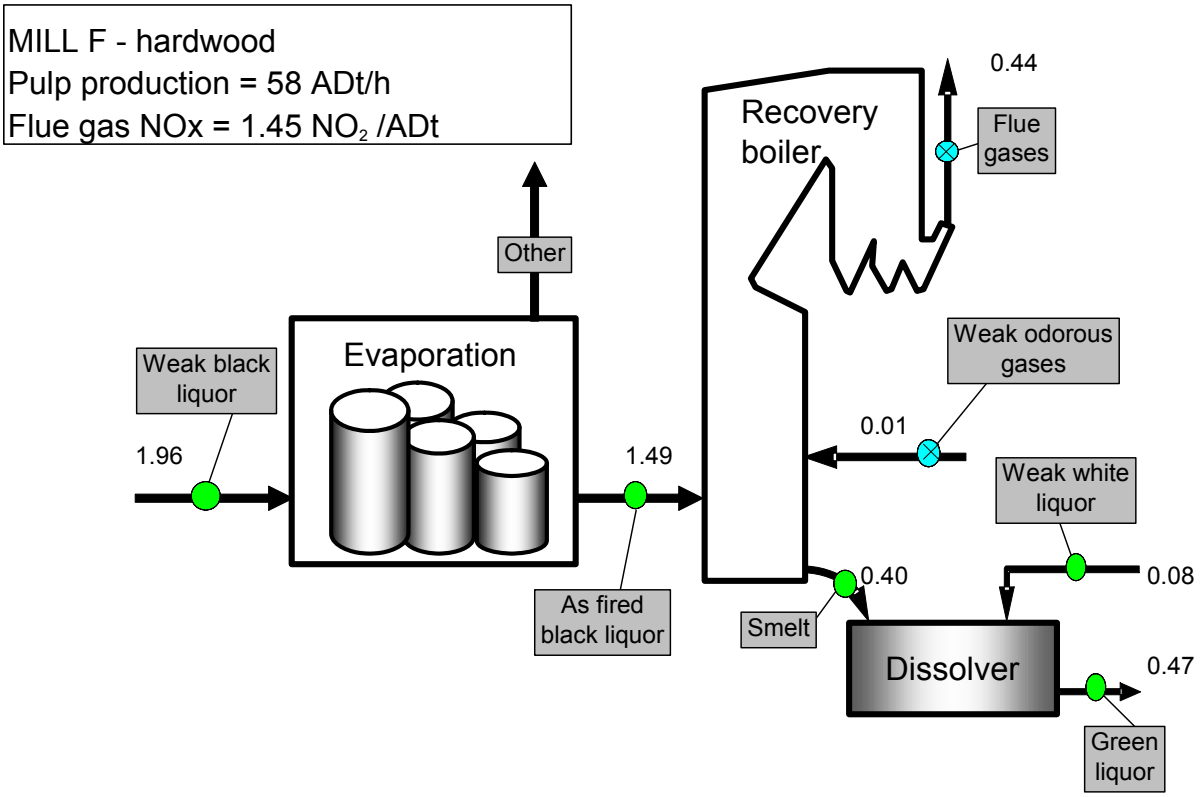

MILL E
Pulp production = 69 ADt/h
Flue gas NOx = 0.65 NO_2 /ADt
Turpentine
Lime mud
0.00
Methanol
0.00
0.20
0.27
Lime kiln
Flue gases
0.17
Heavy oil

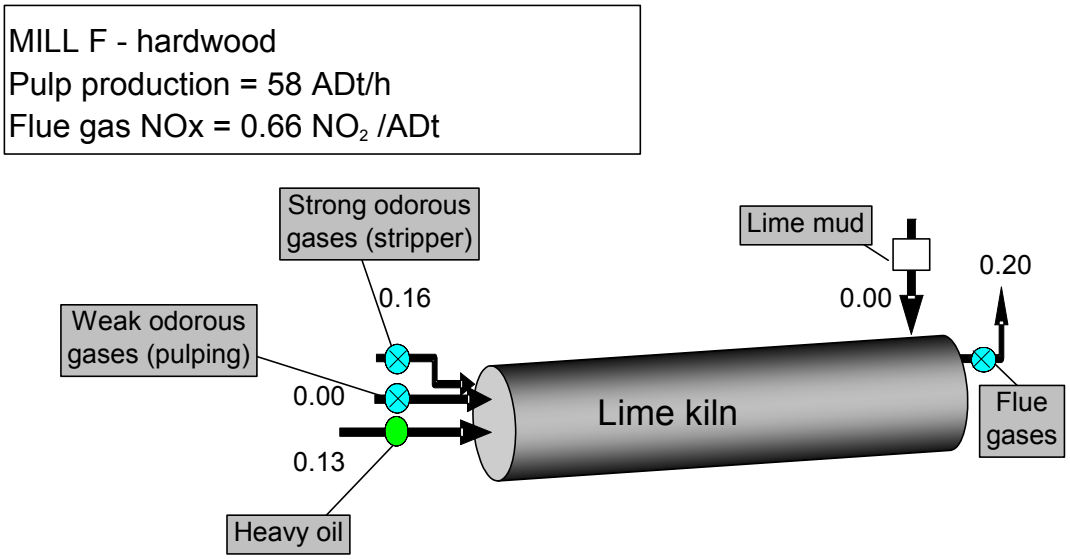
MILL F - softwood
Pulp production = 58 ADt/h
Flue gas NOx = 1.23 NO_2 /ADt

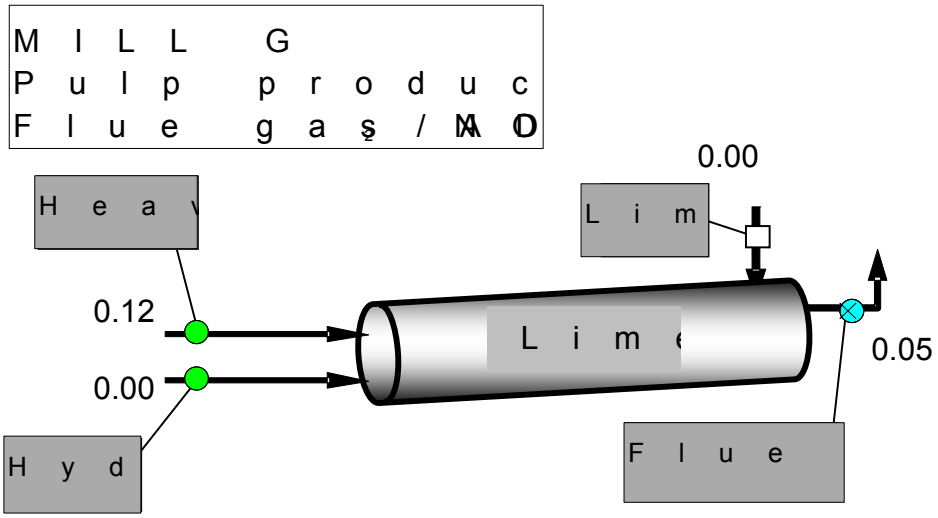


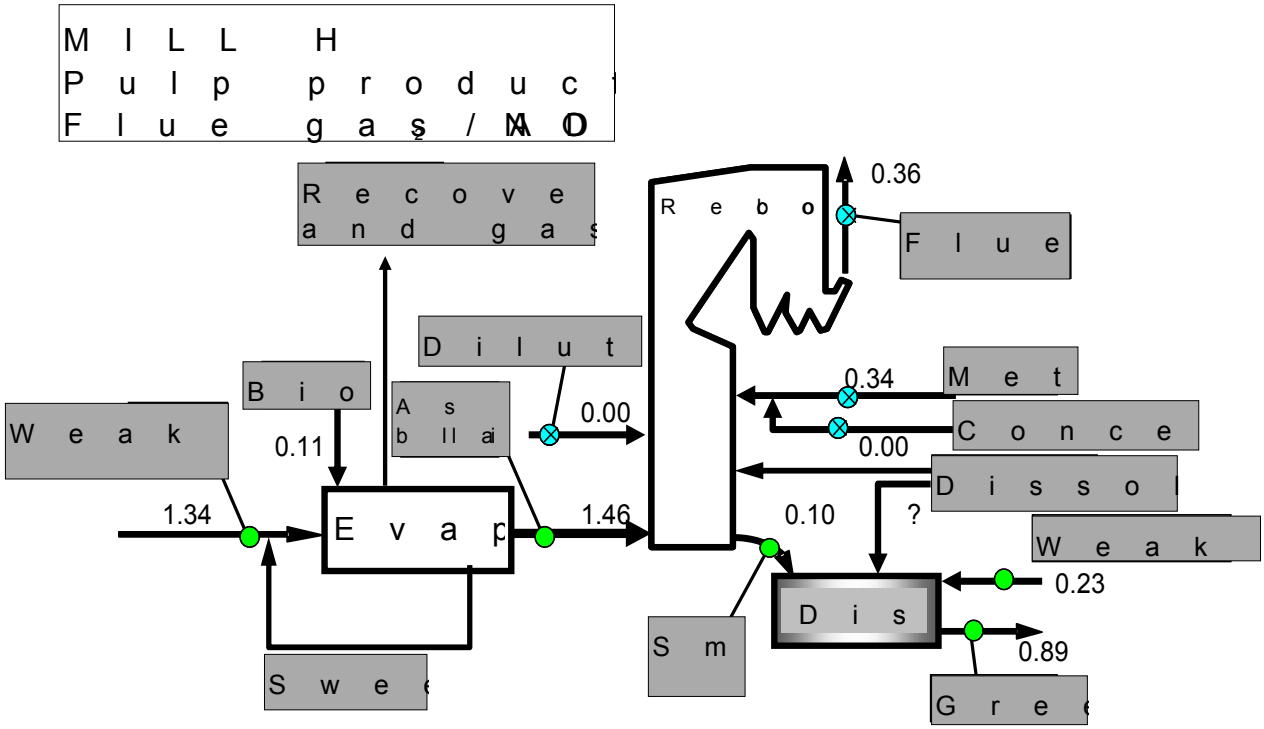
MILL F - softwood
Pulp production = 58 ADt/h
Flue gas NOx = 0.66 NO_2 /ADt

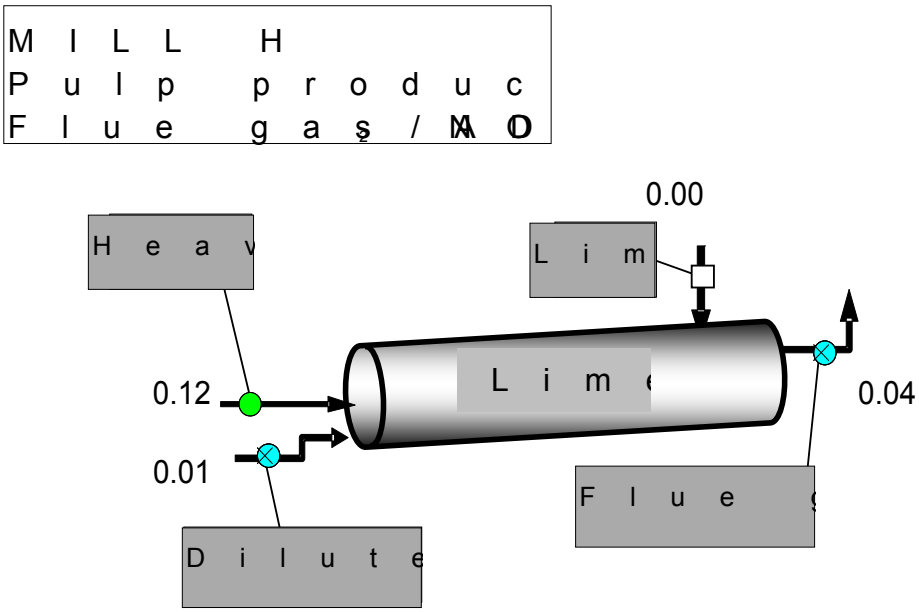



MILL F - hardwood
Pulp production = 58 ADt/h
Flue gas NOx = 1.45 NO_2 /ADt
Recovery boiler
0.44
Flue gases
Other
Evaporation
Weak black liquor
1.96
1.49
Weak odorous gases
0.01
Weak white liquor
0.08
0.40
As fired black liquor
Smelt
Dissolver
0.47
Green liquor


MILL F - hardwood
Pulp production = 58 ADt/h
Flue gas NOx = 0.66 NO_2 /ADt
Strong odorous gases (stripper)
0.16
Lime mud
0.00
0.20
Weak odorous gases (pulping)
0.00
0.13
Heavy oil
Lime kiln
Flue gases


MILL G
Pulp produc
Flue gas / M
0.00
Lim
Heav
0.12
0.00
Lime
0.05
Hyd
Flue


M I L L H
P u l p p r o d u c
F l u e g a s / M O
R e c o v e
a n d g a
R e b o
0.36
F l u e
D i l u t
B i o
A s
b l l a
0.00
0.34
M e t
C o n c e
0.00
W e a k
0.11
D i s s o l
1.34
E v a p
1.46
0.10
?
W e a k
0.23
D i s
S m
0.89
S w e
G r e


M I L L H
P u l p p r o d u c
F l u e g a s / M O
0.00
H e a v
L i m
L i m
0.12
0.04
0.01
F l u e
D i l u t e

Appendix II. Tabulated data.

Mill	A-SW	A-HW	B-1	B-2	C	D	E	F-SW	F-HW	G	H
Production at Measurement ADt /d	1600	1708	1310	1343	1570	1836	1665	1398	1398	918	2036
Wood Species	softwood	birch	birch, aspen, sawdust	birch, aspen, sawdust	softwood	softwood	softwood / birch	softwood	birch	softwood	softwood, birch, eucalyptus
BL -N % d.s.	0.07 %	0.09 %	0.09 %	0.09 %	0.05 %	0.08 %	0.08 %	0.06 %	0.08 %	0.06 %	0.07 %
Fired in the Recovery Boiler (Y = yes, - = no)											
Black Liquor	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Strong NCG	Y	Y	-	-	Y	Y	Y	-	-	-	Y
Weak NCG	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Methanol	Y	Y	-	-	Y	Y	-	-	-	Y (~30%)	Y (+turp.)
Biosludge	Y	Y	-	-	-	Y	-	-	-	-	Y
BCTMP sludge	-	-	-	-	-	Y	-	-	-	-	-
Fired in the Lime Kiln (Y = yes, - = no)											
Natural Gas			-	-	-	Y	-	-	-	-	-
Firing Oil			Y	Y	-	-	-	-	-	-	-
Heavy Oil			-	-	Y	-	Y	Y	Y	Y	Y
Strong NCG			Y	Y	Y	-	-	Y	Y	-	-
Weak NCG			-	-	-	Y	-	Y	Y	-	-
Methanol			Y	-	-	-	Y	-	-	-	-
Hydrogen			-	-	-	-	-	-	-	Y	-
NO_X, Recovery Boiler											
ppm (3% O_2)	95	125	89	148	105	113	105	90	106		
kg N/ AD/t	0.33	0.46	0.38	0.51	0.39	0.46	0.41	0.37	0.44	0.47	0.36
kg NO_2 / ADt	**1.07**	**1.52**	**1.23**	**1.66**	**1.29**	**1.52**	**1.36**	**1.23**	**1.45**	**1.53**	**1.19**
NO_X, Lime Kiln											
ppm (3% O_2)	3)	3)	272	148	256	140	439	140	140	-	-
kg N/ AD/t	3)	3)	0.10	0.04	0.17	0.08	0.20	0.20	0.20	0.05	0.04
kg NO_2 / ADt	3)	3)	**0.32**	**0.14**	**0.55**	**0.28**	**0.65**	**0.66**	**0.66**	**0.15**	**0.12**
kg NO_2 / ADt	**-**	**-**	**1.55**	**1.80**	**1.84**	**1.80**	**2.01**	**1.89**	**2.11**	**1.69**	**1.31**

SUOMEN SOODAKATTILAYHDISTYS RY
RAPORTTISARJA

1/2009 Suomen Soodakattilayhdistys ry
Konemestaripäivä 22.1.2009, esitelmät
Sokos Hotel Vaakuna, Kouvola/UPM Kymmene Oyj, Kymin tehdas, Kuusankoski
(16A0913-E0099) 22.1.2009

2/2009 Suomen Soodakattilayhdistys ry
Soodakattila-alan yhteistoiminta
Vuosikertomus 2008
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3/2009 Suomen Soodakattilayhdistys ry
Pöytäkirja. Vuosikokous 2.4.2009, Pöyry Industry Oy, Vantaa
(16A0913-E0101) 16.4.2009

4/2009 Suomen Soodakattilayhdistys ry
Soodakattilan keon lämmönsiirto-ominaisuudet – Kirjallisuuskatsaus
Lappeenrannan Teknillinen Yliopisto, Professori Esa Vakkilainen
(16A0913-E0102) 30.12.2008

5a/2009 Suomen Soodakattilayhdistys ry
Utveckling och användning av en korttidssond vid mätningar av överbäring
i sodapannor
Åbo Akademi, Niklas Vähä-Savo
(16A0913-E0103) 25.9.2009

5b/2009 Suomen Soodakattilayhdistys ry
Minuuttisondi-projekti
Åbo Akademi, Niklas Vähä-Savo
(16A0913-E0104) 25.9.2009

6/2009 Suomen Soodakattilayhdistys ry
Sähkösuodintuhkan puhdistus. Osa IV
Prosessin koeajo tehdaskaltaisella laitteistolla
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7/2009 Suomen Soodakattilayhdistys ry
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Sokos Hotel Flamingo, Vantaa
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8/2009 Suomen Soodakattilayhdistys ry
Muutosilmiöt soodakattilakeossa
Lappeenrannan Teknillinen Yliopisto, Tanja Pentisaari
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Konemestaripäivä 11.2.2010, esitelmät
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2/2010 Suomen Soodakattilayhdistys ry
Once-through and reheater recovery boiler – concept studies
Lappeenranta University of Technology
Faculty of Technology. Departement of Energy Technology
Esa Vakkilainen, Juha Kaikko, Marcelo Hamaguchi
(16A0913-E0110) 17.3.2010

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Kurt Sirén, Sirra T:mi
(16A0913-E0111) 15.3.2010

4/2010 Suomen Soodakattilayhdistys ry
Seisokin vaativat määräaikaistestaukset soodakattiloilla
Mauri Heikkinen, Pöyry Finland Oy
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5/2010 Suomen Soodakattilayhdistys ry
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(16A0913-E0114) 5.5.2010

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Markku Pekkanen, Raimo Nieminen, Tuomas Lehtinen; Pöyry Industry Oy
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Puu-127.4030 Ympäristötekniikan erikoistyö
Andreas Lindberg, TKK, Puunjalostustekniikan osasto
(16A0913-E0116) 15.6.2010

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(16A0913-E0117) 12.2.2010