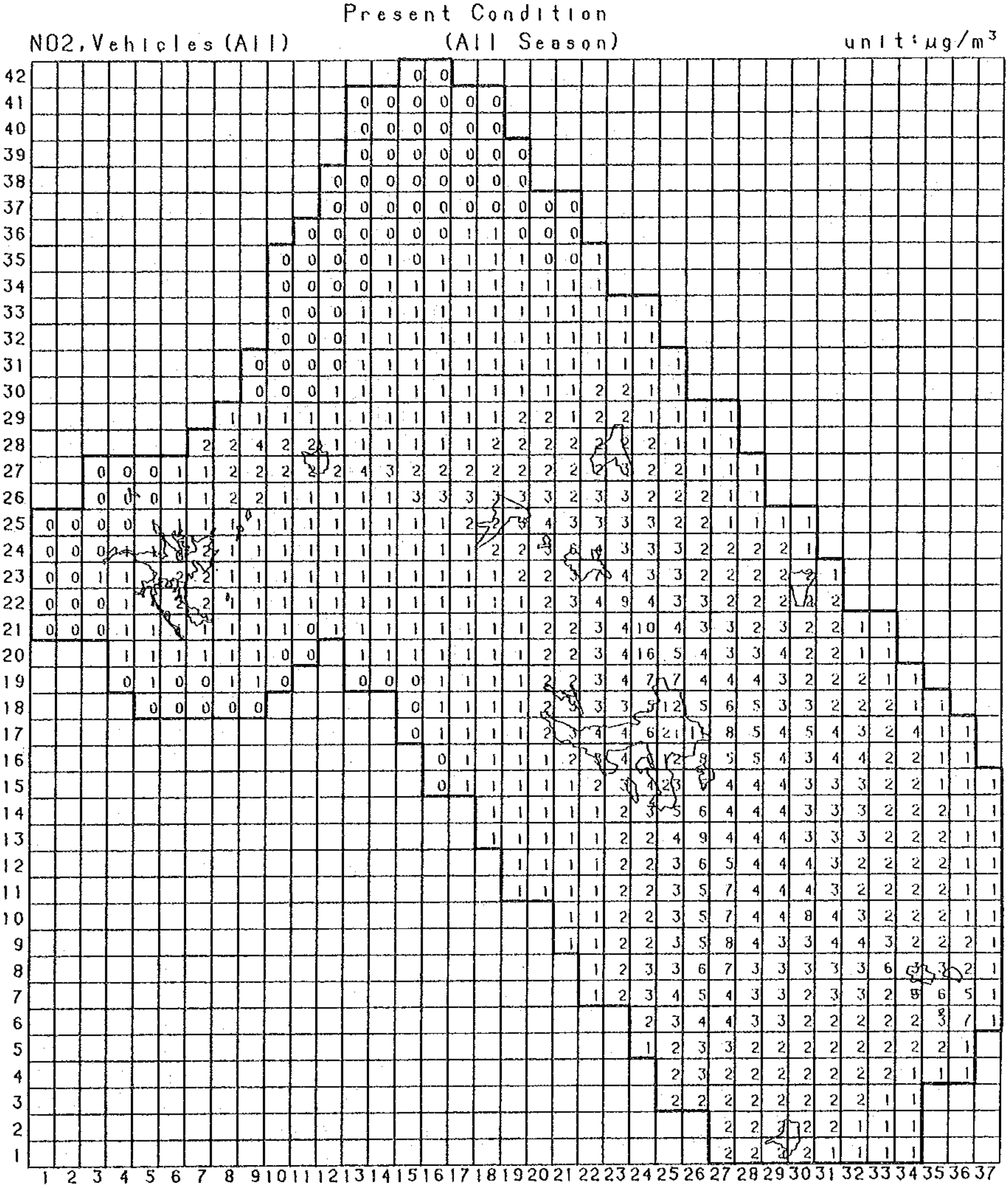


Figure D5.2.36 Annual Average Concentration for NO2 in 1993 (Motor Vehicles)

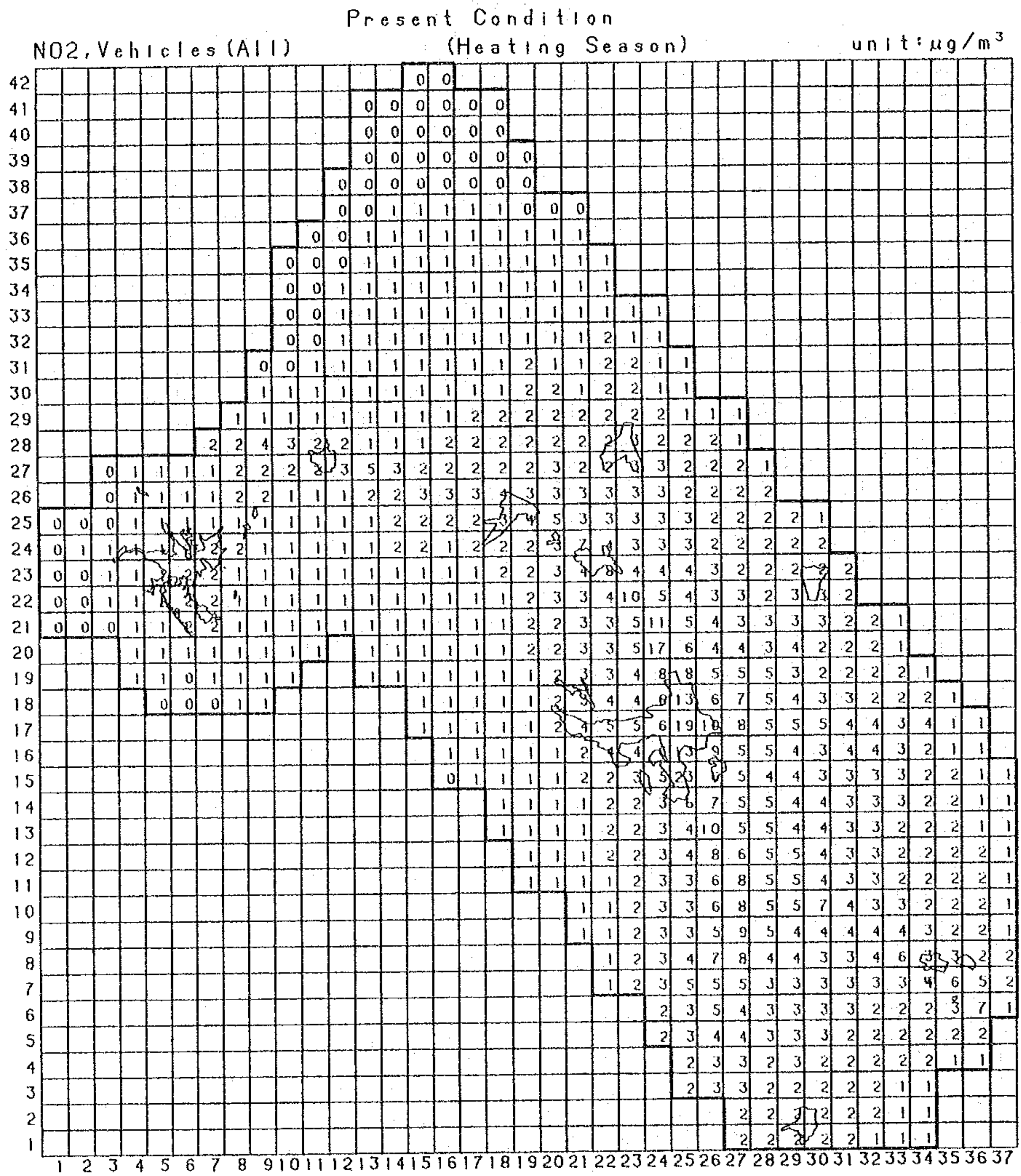


Figure D5.2.37 Average Concentration for NO2 in Heating Season (1993, Motor Vehicles)

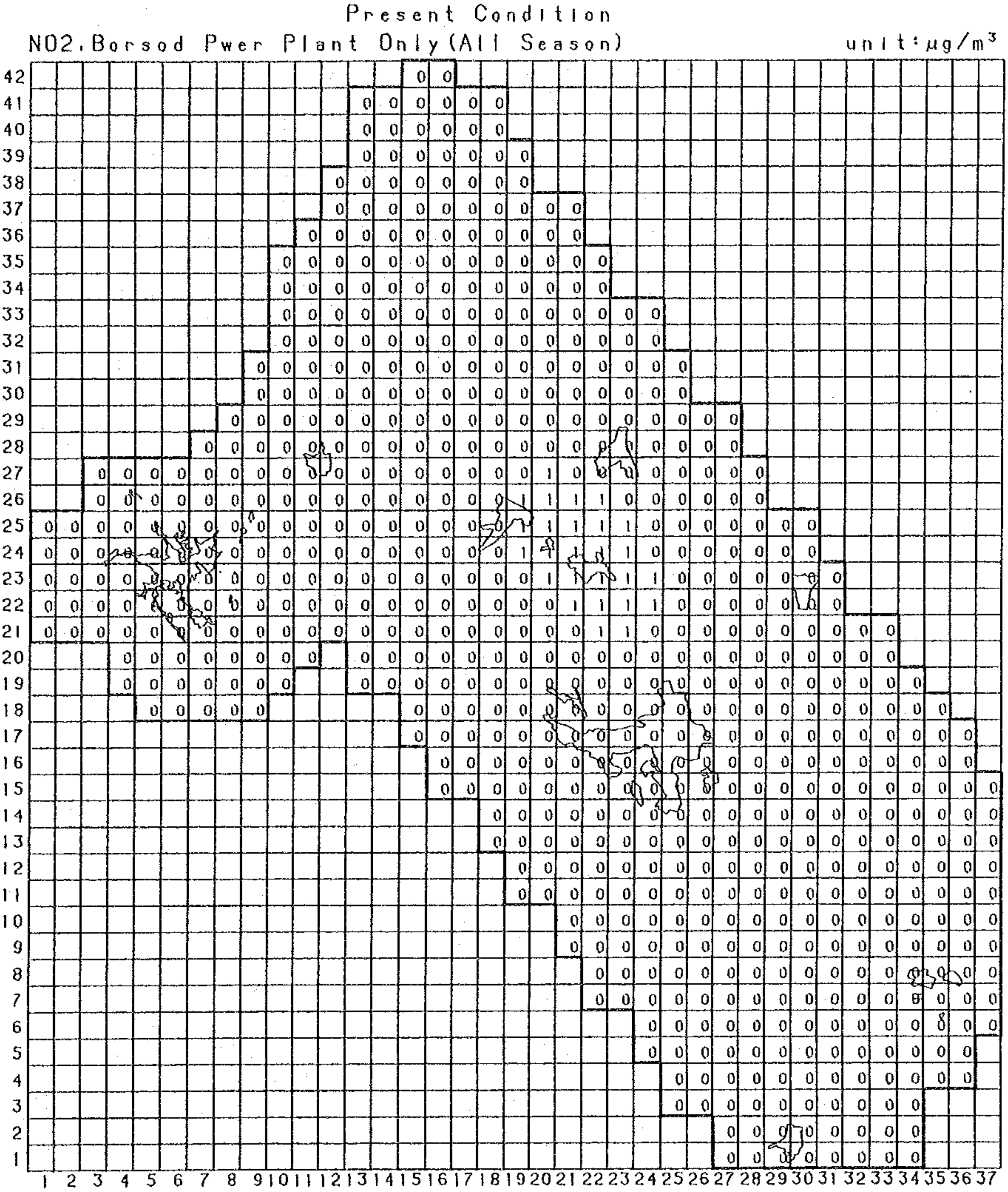


Figure D5.2.38 Annual Average Concentration for NO2 in 1993 (Borsod P.S.)

DATA FOR CHAPTER 6

Table D6.2.1 (1) The Result of Analysis of Ingredients in TSP

Sampling Point : Kazincbarciha (J2)

Component	1993 June Conc. (ug/m3)	June Cont. (%)	July(First) Conc. (ug/m3)	July(First) Cont. (%)	July(Latter) Conc. (ug/m3)	July(Latter) Cont. (%)	Aug. Conc. (ug/m3)	Aug. Cont. (%)	Sep. Conc. (ug/m3)	Sep. Cont. (%)	Oct. Conc. (ug/m3)	Oct. Cont. (%)	Nov. Conc. (ug/m3)	Nov. Cont. (%)	Des. Conc. (ug/m3)	Des. Cont. (%)
TSP	22.8	100.0	(48.0)	100.0	59.0	100.0	68.0	100.0	169.8	100.0	155.1	100.0	109.6	100.0	58.4	100.0
Pb	0.032	0.140	0.025	(0.052)	0.053	0.090	0.039	0.057	0.082	0.048	0.131	0.084	0.047	0.043	0.101	0.173
Cd	0.0006	0.003	0.0006	(0.001)	0.0003	0.001	0.0005	0.001	0.0013	0.001	0.0042	0.003	0.0013	0.001	0.0034	0.006
Cr	0.007	0.031	ND	ND	0.007	0.012	0.005	0.007	0.0072	0.004	0.0067	0.004	0.0077	0.007	0.0005	0.001
Ni	0.0028	0.012	0.0010	(0.002)	0.0044	0.007	0.0035	0.005	0.0047	0.003	0.0057	0.004	0.0046	0.004	0.0012	0.002
Fe	0.619	2.71	2.059	(4.29)	2.79	4.73	1.715	2.52	2.782	1.64	2.031	1.31	2.848	2.60	0.964	1.65
Cu	0.006	0.026	0.008	(0.017)	0.021	0.036	0.008	0.012	0.026	0.015	0.360	0.232	0.016	0.015	0.013	0.022
Zn	*	*	0.029	(0.060)	0.061	0.103	0.024	0.035	0.086	0.051	0.106	0.068	0.046	0.042	0.047	0.080
Mn	0.022	0.096	0.026	(0.054)	0.078	0.132	0.017	0.025	0.080	0.047	0.057	0.037	0.030	0.027	0.015	0.026
Hg	0.0012	0.005	0.0032	(0.007)	0.0008	0.001	0.0013	0.002	0.0064	0.004	0.0038	0.002	0.0005	0.000	0.0004	0.001
Na	*	*	0.487	(1.01)	0.32	0.542	0.228	0.335	0.278	0.164	0.301	0.194	0.191	0.174	0.463	0.793
K	*	*	0.354	(0.738)	0.647	1.10	0.282	0.415	0.570	0.336	1.057	0.681	0.522	0.476	0.477	0.817
Ca	*	*	1.470	(3.06)	6.767	11.47	1.205	1.77	3.008	1.77	2.070	1.33	0.772	0.704	1.409	2.41
Mg	*	*	0.209	(0.435)	0.567	0.961	0.158	0.232	0.652	0.384	0.390	0.251	0.079	0.072	0.212	0.363
V	0.001	0.004	0.0020	(0.004)	0.0062	0.011	0.0029	0.004	0.0046	0.003	0.0077	0.005	0.0057	0.005	0.0036	0.006
Ti	0.365	1.60	0.367	(0.765)	0.622	1.05	0.864	1.27	0.262	0.154	0.117	0.075	0.011	0.010	0.020	0.034
Al	*	*	0.463	(0.964)	2.394	4.06	0.487	0.716	2.523	1.49	1.192	0.769	0.253	0.231	0.268	0.459
SO4	---	---	12.4	(25.8)	4.97	8.42	0.24	0.35	16.2	9.54	31.3	20.2	28.3	25.8	20.0	34.2
NO3	1.35	5.92	0.51	(1.06)	0.85	1.44	0.61	0.90	3.88	2.29	10.9	7.03	15.3	14.0	3.71	6.35
Cl	0.16	0.70	0.55	(1.15)	0.57	0.97	0.58	0.85	2.43	1.43	1.86	1.20	ND	ND	ND	ND
NH4	0.00	0.00	0.65	(1.35)	0.66	1.12	0.84	1.24	4.00	2.36	7.70	4.96	9.72	8.87	4.83	8.27
Na	1.58	6.93	0.48	(1.00)	0.19	0.32	0.18	0.26	0.22	0.13	0.22	0.14	0.09	0.08	0.08	0.14
K	0.29	1.27	0.35	(0.73)	0.21	0.36	0.23	0.34	0.42	0.25	1.03	0.66	0.52	0.47	0.47	0.80
Ca	0.25	1.10	0.87	(1.81)	4.26	7.22	0.54	0.79	2.07	1.22	1.43	0.92	0.66	0.60	0.35	0.60
Mg	0.015	0.07	0.073	(0.15)	0.084	0.14	0.058	0.09	0.360	0.21	0.350	0.23	0.058	0.05	0.045	0.08
C-ele.	2.4	10.5	4.5	(9.4)	7.1	12.0	4.2	6.2	18.8	11.1	26.7	17.2	28.6	26.1	17.0	29.1
C-org.	2.7	11.8	2.5	(5.2)	4.1	6.9	4.0	5.9	4.8	2.8	17.2	11.1	10.6	9.7	5.4	9.2
C-total	5.1	22.3	7.0	(14.6)	11.2	18.9	8.2	12.1	23.7	14.0	43.9	28.3	38.6	35.2	22.4	38.4

Component	1994 Jan. Conc. (ug/m3)	Jan. Cont. (%)	Feb. Conc. (ug/m3)	Feb. Cont. (%)	Mar. Conc. (ug/m3)	Mar. Cont. (%)	Apr. Conc. (ug/m3)	Apr. Cont. (%)	May Conc. (ug/m3)	May Cont. (%)	Average Conc. (ug/m3)	Average Cont. (%)
TSP	97.7	100.0	178.5	100.0	100.7	100.0	108.9	100.0	130.8	100.0	104.9	100.0
Pb	0.080	0.082	0.108	0.061	0.029	0.029	0.075	0.069	0.097	0.074	0.069	0.079
Cd	0.0014	0.001	0.0023	0.001	ND	0.000	0.0008	0.001	0.0014	0.001	0.0014	0.002
Cr	0.0002	0.000	ND	0.000	0.0083	0.008	0.0083	0.008	0.0116	0.009	0.0053	0.008
Ni	0.0033	0.003	0.0018	0.001	0.0036	0.004	0.0033	0.003	0.0052	0.004	0.0035	0.004
Fe	0.983	1.01	2.443	1.37	1.954	1.94	2.896	2.66	4.719	3.61	2.216	1.482
Cu	0.021	0.021	0.019	0.011	0.020	0.020	0.032	0.029	0.037	0.028	0.045	0.039
Zn	0.057	0.058	0.078	0.044	0.051	0.051	0.101	0.093	0.075	0.057	0.063	0.062
Mn	0.018	0.018	0.045	0.025	0.040	0.040	0.044	0.040	0.057	0.044	0.041	0.046
Hg	0.0002	0.000	0.0007	0.000	0.0003	0.000	0.0003	0.000	0.0009	0.001	0.0015	0.001
Na	0.620	0.635	0.508	0.285	0.490	0.487	0.443	0.407	0.610	0.466	0.412	0.407
K	0.641	0.656	0.881	0.494	0.409	0.406	0.766	0.703	0.559	0.427	0.597	0.492
Ca	1.373	1.41	2.148	1.20	2.604	2.59	1.917	1.76	3.741	2.86	2.374	1.458
Mg	0.774	0.792	0.420	0.235	0.476	0.473	0.380	0.349	0.929	0.710	0.437	0.438
V	0.0078	0.008	0.0072	0.004	0.0073	0.007	0.0056	0.005	0.0081	0.006	0.0054	0.006
Ti	0.039	0.040	0.120	0.067	0.157	0.156	0.151	0.139	0.253	0.193	0.258	0.072
Al	0.364	0.373	0.907	0.508	2.313	2.30	2.219	2.04	3.444	2.63	1.402	1.046
SO4	23.4	24.0	29.3	16.4	8.96	8.90	12.7	11.7	5.78	4.42	16.13	14.90
NO3	6.17	6.32	11.90	6.67	4.04	4.01	3.40	3.12	2.70	2.06	5.02	5.01
Cl	7.45	7.63	24.80	13.89	0.42	0.42	0.00	0.00	0.68	0.52	3.04	2.30
NH4	7.37	7.54	7.93	4.44	1.65	1.64	3.28	3.01	0.36	0.28	3.77	3.64
Na	0.17	0.17	0.50	0.28	0.29	0.29	0.38	0.35	0.58	0.44	0.38	0.80
K	0.62	0.63	0.86	0.48	0.39	0.39	0.72	0.66	0.58	0.44	0.51	0.56
Ca	0.43	0.44	2.08	1.17	1.48	1.47	1.47	1.35	2.67	2.04	1.43	1.58
Mg	0.067	0.07	0.073	0.04	0.075	0.07	0.175	0.16	0.173	0.13	0.124	0.11
C-ele.	25.4	26.0	39.8	22.3	5.4	5.4	12.4	11.4	7.7	5.9	15.4	15.3
C-org.	10.0	10.2	17.6	9.9	5.0	5.0	5.0	4.6	4.0	3.1	6.8	7.5
C-total	35.4	36.2	57.4	32.2	20.4	20.3	17.3	15.9	11.7	8.9	23.3	23.6

Note
- Content (%) : Ratio of Component for TSP
- * : Data could not be evaluated due to high blank value of Hungarian filter.
- ND : Not Detected
- ( ) : Reference data (due to damage of filter)
- --- : Sample was Not Clear for Sulphate Analysis.
- Pretreatment Method
  - Metallic Elements : HNO3+H2O2 Digestion
  - Ion Components : Water Extraction

Table D6.2.1 (2)　The Result of Analysis of Ingredients in TSP

Sampling Point : Nyekladhaza (J7)

Component	1993																1994										Average	
	June		July (First)		July (Latter)		Aug.		Sep.		Oct.		Nov.		Des.		Jan.		Feb.		Mar.		Apr.		May			
	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)
TSP	40.6	100.0	(150.0)	100.0	59.0	100.0	52.7	100.0	195.3	100.0	147.4	100.0	109.3	100.0	122.0	100.0	49.4	100.0	124.1	100.0	110.1	100.0	129.7	100.0	59.1	100.0	92.2	100.0
Pb	0.025	0.062	0.072	(0.048)	0.053	0.090	0.033	0.063	0.220	0.113	0.093	0.063	0.072	0.066	0.103	0.084	0.024	0.049	0.067	0.054	0.051	0.046	0.050	0.039	0.025	0.042	0.068	0.059
Cd	*	*	0.0007	(0.000)	0.0003	0.001	0.0002	0.000	0.0011	0.001	0.0015	0.001	0.0015	0.001	0.0012	0.001	0.0004	0.001	0.0011	0.001	ND	0.000	0.0009	0.001	0.0005	0.001	0.0008	0.001
Cr	ND	ND	0.015	(0.01)	0.007	0.012	0.002	0.004	0.0345	0.018	0.0102	0.007	0.0038	0.003	0.0141	0.012	ND	0.000	0.0010	0.001	0.0068	0.006	0.0103	0.008	0.0060	0.010	0.0085	0.006
Ni	0.0004	0.001	0.0042	(0.003)	0.0044	0.007	0.0001	0.000	0.0062	0.003	0.0074	0.005	0.0030	0.003	0.0058	0.005	0.0004	0.001	0.0027	0.002	0.0037	0.003	0.0053	0.004	0.0047	0.008	0.0037	0.003
Fe	1.178	2.90	6.261	(4.17)	2.79	4.73	0.472	0.896	11.29	5.78	4.065	2.76	1.073	0.982	6.814	5.59	0.697	1.41	1.510	1.22	2.740	2.49	4.271	3.29	2.200	3.72	3.489	2.164
Cu	0.008	0.020	0.074	(0.049)	0.021	0.036	0.033	0.063	0.224	0.115	0.540	0.366	0.014	0.013	0.024	0.020	0.038	0.077	0.240	0.193	0.099	0.090	0.022	0.017	0.018	0.030	0.104	0.080
Zn	*	*	0.119	(0.079)	0.061	0.103	0.022	0.042	0.269	0.138	0.094	0.064	0.120	0.110	0.129	0.106	0.038	0.077	0.074	0.060	0.078	0.071	0.090	0.069	0.060	0.102	0.0962	0.078
Mn	0.032	0.079	0.12	(0.08)	0.078	0.132	0.013	0.025	0.276	0.141	0.063	0.043	0.020	0.018	0.062	0.051	0.014	0.028	0.026	0.021	0.037	0.034	0.069	0.053	0.036	0.061	0.065	0.053
Hg	0.0014	0.003	0.0033	(0.002)	0.0008	0.001	0.0005	0.001	0.0047	0.002	0.0017	0.001	0.0005	0.000	0.0023	0.002	ND	0.000	0.0002	0.000	0.0003	0.000	0.0002	0.000	0.0003	0.001	0.0012	0.001
Na	*	*	0.649	(0.433)	0.32	0.542	0.158	0.300	0.460	0.236	0.232	0.157	0.617	0.565	0.465	0.381	2.017	4.08	0.471	0.380	0.518	0.470	0.391	0.301	0.285	0.482	0.549	0.658
K	*	*	0.961	(0.641)	0.647	1.10	0.218	0.414	1.196	0.612	0.745	0.505	0.564	0.516	0.720	0.590	0.272	0.551	0.519	0.418	0.410	0.372	0.460	0.355	0.345	0.584	0.588	0.410
Ca	*	*	8.280	(5.52)	6.767	11.47	0.703	1.33	2.704	1.38	3.026	2.05	0.575	0.526	2.691	2.21	1.418	2.87	1.442	1.16	3.560	3.23	3.819	2.94	1.714	2.90	3.058	1.607
Mg	*	*	0.811	(0.541)	0.567	0.961	0.106	0.201	0.802	0.411	0.363	0.246	0.082	0.075	0.376	0.308	0.246	0.498	0.257	0.207	0.319	0.290	0.525	0.405	0.329	0.557	0.399	0.347
V	0.0018	0.004	0.0118	(0.008)	0.0062	0.011	0.0025	0.005	0.0059	0.003	0.0149	0.010	0.0076	0.007	0.0114	0.009	0.0020	0.004	0.0103	0.008	0.0088	0.008	0.0097	0.007	0.0030	0.005	0.0074	0.006
Ti	0.408	1.00	0.63	(0.420)	0.622	1.05	0.424	0.805	0.281	0.144	0.140	0.095	0.033	0.030	0.164	0.134	0.075	0.152	0.091	0.073	0.147	0.134	0.264	0.204	0.059	0.100	0.257	0.144
Al	*	*	3.46	(2.31)	2.394	4.06	0.307	0.583	3.016	1.54	1.417	0.961	0.185	0.169	1.313	1.08	0.418	0.846	0.648	0.522	2.060	1.87	2.801	2.16	1.219	2.06	1.480	0.907
SO4	---	---	13.8	(9.20)	4.97	8.42	0.67	1.27	10.7	5.48	20.3	13.8	23.0	21.0	21.2	17.4	9.00	18.2	6.69	5.39	9.49	8.62	9.72	7.49	4.38	7.41	11.16	9.54
NO3	1.52	3.74	1.41	(0.94)	0.85	1.44	0.18	0.34	1.91	0.98	11.8	8.01	8.64	7.90	5.58	4.57	2.44	4.94	3.30	2.66	2.83	2.57	3.08	2.37	1.35	2.28	3.45	3.22
Cl	1.53	3.77	0.66	(0.44)	0.57	0.97	0.62	1.18	2.59	1.33	1.40	0.95	1.77	1.62	5.91	4.84	27.9	56.5	0.20	0.16	0.43	0.39	0.46	0.35	0.57	0.96	3.43	5.62
NH4	0.02	0.05	0.75	(0.50)	0.66	1.12	1.31	2.49	0.32	0.16	4.42	3.00	5.94	5.43	5.11	4.19	1.24	2.51	1.53	1.23	1.97	1.79	2.11	1.63	0.93	1.57	2.02	1.94
Na	2.14	5.27	0.23	(0.15)	0.19	0.32	0.11	0.21	0.37	0.19	0.23	0.16	0.60	0.55	0.33	0.27	1.63	3.30	0.28	0.23	0.33	0.30	0.21	0.16	0.18	0.30	0.53	0.87
K	0.39	0.96	0.34	(0.23)	0.21	0.36	0.14	0.27	0.82	0.42	0.71	0.48	0.51	0.47	0.68	0.56	0.20	0.40	0.47	0.38	0.39	0.35	0.44	0.34	0.33	0.56	0.43	0.43
Ca	0.49	1.21	2.82	(1.88)	4.26	7.22	0.28	0.53	2.23	1.14	1.55	1.05	0.50	0.46	1.79	1.47	0.39	0.79	0.91	0.74	2.22	2.02	2.40	1.85	1.01	1.71	1.60	1.55
Mg	0.023	0.06	0.159	(0.11)	0.084	0.14	0.047	0.09	0.317	0.16	0.188	0.13	0.066	0.06	0.114	0.09	0.077	0.16	0.064	0.05	0.063	0.06	0.130	0.10	0.054	0.09	0.107	0.09
C-ele.	3.9	9.6	7.2	(4.8)	7.1	12.0	6.4	12.1	20.7	10.6	21.7	14.7	36.0	32.9	15.3	12.5	10.6	21.5	17.2	13.9	14.8	13.4	13.0	10.0	5.5	9.3	13.8	12.6
C-org.	3.4	8.4	4.1	(2.7)	4.1	6.9	2.9	5.5	5.2	3	12.7	8.6	16.3	14.9	9.3	7.6	4.2	8.5	9.4	7.6	5.5	5.0	4.6	3.5	1.4	2.4	6.4	6.3
C-total	7.3	18.0	11.3	(7.5)	11.2	18.9	9.3	17.6	25.8	13.2	34.5	23.4	52.3	47.8	24.6	20.2	14.8	30.0	26.6	21.4	20.3	18.4	17.6	13.6	6.9	11.7	20.2	19.6

Note
- Content (%) : Ratio of Component for TSP
- * : Data could not be evaluated due to high blank value of Hungarian filter.
- ND : Not Detected
- ( ) : Reference data (due to damage of filter)
- --- : Sample was Not Clear for Sulphate Analysis.
- Pretreatment Method
  - Metallic Elements : HNO3+H2O2 Digestion
  - Ion Components : Water Extraction

Table D6.2.1 (3) The Result of Analysis of Ingredients in TSP

Sampling Point : Miskolc-ANTSZ (H1)

Component	1993																1994										Average	
	June		July(First)		July(Latter)		Aug.		Sep.		Oct.		Nov.		Des.		Jan.		Feb.		Mar.		Apr.		May			
	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)	Conc. (ug/m3)	Cont. (%)
TSP	28.1	100.0	46.0	100.0	-	-	57.4	100.0	75.2	100.0	140.5	100.0	123.4	100.0	73.9	100.0	58.8	100.0	127.0	100.0	61.1	100.0	59.4	100.0	46.6	100.0	74.8	100.0
Pb	0.038	0.135	0.042	0.091	-	-	0.077	0.134	0.043	0.057	0.138	0.098	0.131	0.106	0.100	0.135	0.026	0.044	0.157	0.124	0.037	0.061	0.153	0.258	0.024	0.052	0.081	0.108
Cd	*	*	*	*	-	-	0.0011	0.002	0.0006	0.001	0.0014	0.001	0.0032	0.003	0.0026	0.004	0.0015	0.003	0.0028	0.002	0.0009	0.001	0.0023	0.004	0.0007	0.002	0.0017	0.002
Cr	0.004	0.014	ND	ND	-	-	0.014	0.024	0.0027	0.004	0.0318	0.023	0.0180	0.015	0.0027	0.004	ND	0.000	0.0031	0.002	0.0053	0.009	0.0056	0.009	0.0062	0.013	0.0078	0.010
Ni	0.0011	0.004	0.0010	0.002	-	-	0.0037	0.006	0.0003	0.000	0.0095	0.007	0.0096	0.008	0.0056	0.008	0.0003	0.001	0.0049	0.004	0.0033	0.005	0.0023	0.004	0.0020	0.004	0.0036	0.004
Fe	0.900	3.20	1.703	3.70	-	-	3.543	6.17	1.542	2.05	11.98	8.53	5.861	4.75	1.510	2.04	1.711	2.91	3.576	2.82	3.927	6.43	3.891	6.55	2.056	4.41	3.517	3.374
Cu	0.007	0.025	0.011	0.024	-	-	0.014	0.024	0.022	0.029	0.040	0.028	0.024	0.019	0.017	0.023	0.014	0.024	0.033	0.026	0.015	0.025	0.031	0.052	0.022	0.047	0.021	0.029
Zn	*	*	*	*	-	-	0.069	0.120	0.054	0.072	0.242	0.172	0.119	0.096	0.083	0.112	0.036	0.061	0.078	0.061	0.065	0.106	0.062	0.104	0.055	0.118	0.086	0.102
Mn	0.024	0.085	0.032	0.070	-	-	0.063	0.110	0.033	0.044	0.197	0.140	0.057	0.046	0.028	0.038	0.055	0.094	0.088	0.069	0.035	0.057	0.032	0.054	0.030	0.064	0.056	0.073
Hg	0.001	0.004	0.0072	0.016	-	-	0.0009	0.002	0.0006	0.001	0.0019	0.001	0.0012	0.001	0.0005	0.001	3E-05	0.000	0.0006	0.000	0.0002	0.000	0.0002	0.000	0.0006	0.001	0.0012	0.002
Na	*	*	*	*	-	-	0.410	0.714	0.216	0.287	0.388	0.276	0.281	0.228	0.405	0.548	0.182	0.310	0.545	0.429	0.379	0.620	0.475	0.800	0.325	0.697	0.361	0.491
K	*	*	*	*	-	-	0.499	0.869	0.646	0.859	1.281	0.912	0.683	0.553	0.500	0.677	0.343	0.583	1.934	1.52	0.342	0.560	1.229	2.07	0.250	0.536	0.771	0.914
Ca	*	*	*	*	-	-	2.398	4.18	1.551	2.06	4.489	3.20	2.261	1.83	1.881	2.55	1.630	2.77	2.412	1.90	1.761	2.88	1.454	2.45	1.540	3.30	2.138	2.294
Mg	*	*	*	*	-	-	0.295	0.514	0.278	0.370	0.618	0.440	0.202	0.164	0.215	0.291	0.288	0.490	0.272	0.214	0.221	0.362	0.128	0.215	0.299	0.642	0.282	0.370
V	0.0029	0.010	0.0030	0.007	-	-	0.0025	0.004	0.0020	0.003	0.0060	0.004	0.0272	0.022	0.0121	0.016	0.0071	0.012	0.0160	0.013	0.0075	0.012	0.0028	0.005	0.0024	0.005	0.0076	0.009
Ti	0.395	1.41	0.475	1.030	-	-	0.774	1.35	0.090	0.120	0.124	0.088	0.053	0.043	0.052	0.070	0.073	0.124	0.098	0.077	0.083	0.136	0.041	0.069	0.065	0.139	0.194	0.158
Al	*	*	*	*	-	-	0.587	1.02	1.081	1.44	1.540	1.10	0.660	0.535	0.588	0.796	0.334	0.568	0.488	0.384	0.863	1.41	0.748	1.26	0.960	2.06	0.785	0.955
SO4	---	---	14.1	30.7	-	-	7.74	13.5	7.00	9.31	16.1	11.5	22.3	18.1	17.0	23.0	16.1	27.4	8.20	6.46	6.51	10.7	8.60	14.5	1.63	3.50	11.39	15.31
NO3	1.23	4.38	2.20	4.78	-	-	0.69	1.20	2.30	3.06	2.31	1.64	10.6	8.59	4.45	6.02	6.13	10.4	2.77	2.18	3.03	4.96	2.99	5.03	1.01	2.17	3.31	4.54
Cl	0.05	0.18	1.29	2.80	-	-	0.60	1.05	0.50	0.66	1.98	1.41	1.34	1.09	0.63	0.85	0.21	0.36	0.59	0.46	0.35	0.57	0.20	0.34	0.36	0.77	0.68	0.88
NH4	0.04	0.14	0.43	0.93	-	-	1.37	2.39	0.15	0.20	0.87	0.62	5.62	4.55	4.7	6.36	5.13	8.72	1.65	1.30	1.31	2.14	1.48	2.49	0.22	0.47	1.91	2.53
Na	1.71	6.09	3.06	6.65	-	-	0.31	0.54	0.20	0.27	0.31	0.22	0.24	0.19	0.34	0.46	ND	ND	0.32	0.25	0.22	0.36	0.42	0.71	0.22	0.47	0.61	1.35
K	0.41	1.46	0.73	1.59	-	-	0.50	0.87	0.59	0.78	0.81	0.58	0.66	0.53	0.48	0.65	0.32	0.54	1.31	1.03	0.33	0.54	1.18	1.99	0.24	0.52	0.63	0.92
Ca	0.47	1.67	0.50	1.09	-	-	1.62	2.82	1.24	1.65	3.46	2.46	1.86	1.51	0.86	1.16	0.83	1.41	1.53	1.20	1.12	1.83	1.20	2.02	0.47	1.01	1.26	1.65
Mg	0.032	0.11	0.021	0.05	-	-	0.105	0.18	0.105	0.14	0.270	0.19	0.119	0.10	0.078	0.11	0.116	0.20	0.068	0.05	0.055	0.09	0.096	0.16	0.038	0.08	0.092	0.12
C-ele.	3.4	12.1	4.8	10.4	-	-	6.8	11.8	10.2	13.6	16.5	11.7	24.5	19.9	17.5	23.7	11.7	19.9	18.7	14.7	9.1	14.9	7.6	12.8	5.2	11.2	11.3	14.7
C-org.	2.7	9.6	4.9	10.7	-	-	3.2	5.5	3.2	4.3	8.9	6.3	13.1	10.6	6.8	9.2	4.5	7.7	7.8	6.1	3.8	6.2	3.5	5.9	2.5	5.4	5.4	7.3
C-total	6.1	21.7	9.7	21.1	-	-	9.9	17.3	13.3	17.7	25.4	18.1	37.6	30.5	24.2	32.7	16.3	27.7	26.4	20.8	12.8	20.9	11.1	18.7	7.7	16.5	16.7	22.0

Note
- Content (%) : Ratio of Component for TSP
- * : Data could not be evaluated due to high blank value of Hungarian filter.
- ND : Not Detected
- --- : Sample was Not Clear for Sulphate Analysis.
- Pretreatment Method
  - Metallic Elements : HNO3+H2O2 Digestion
  - Ion Components : Water Extraction

Table D6.2.2 The Result of Soil Ingredient Analysis

(Unit:mg/kg, dry soil)

Component	Kazincbarcika (J2)	Nyekladhaza (J7)	Miskolc (Buza ter) (EC1)	Mucsony (M1) (Ash Site)
Pb	14.8	21.0	21.8	6.2
Cd	12.0	20.1	14.7	23.6
Cr	12.0	20.1	14.7	23.6
Ni	15.0	13.1	16.5	14.9
Fe	12549	16902	19811	22738
Cu	12.0	13.8	19.1	17.6
Zn	47.0	50.8	126.2	43.0
Mn	436	400	608	320
Hg	0.153	0.363	0.162	0.045
Na	113	208	145	1511
K	1471	1523	2006	3628
Ca	11177	9380	3700	21048
Mg	4300	3506	3005	5293
V	19	14	20	42
Ti	2300	1845	2377	1940
Al	9447	13009	11264	40008
SO4--	-	-	-	10000
NO3-	-	-	-	26
Cl-	-	-	-	2080
NH4+	-	-	-	*
Na+	11	28	44	97
K+	70	23	112	38
Ca++	225	74	98	2183
Mg++	41	14	16	300
C-ele.	9700	5000	4100	14700
C-org.	4800	7400	5100	400
C-total	14500	12400	9200	15100

Note
- Pretreatment Method
  - Metallic Elements : HNO3+H2O2 Digestion
  - Ion Components : Water Extraction
- * : M1 Sample had Own Color for NH4+ Analysis
- - : Colloide Sample

Table D6.2.3 The Stack Gas Emissions and Concentration of each Ingredient at Stationary Sources

No.	05/0		07/0		08/0		09/2		17/1				18/0		25/1		25/2		26/3		15/4					
Name of Enterprise	BORSODI ENERGETIKAI KFT. (BORSODI HOEROMU)		PANNONGLAS IPARI RT. SAJOSZENT-PETERI UVEGGYAR		BORSODI ERCELOKESZITO MUZSGORITO KFT.		SAGROCHEM KFT.		HEJOCSABAI CEMENT- ES MESZIPARI RT.				STRABAG HUNGARIA EPITO KFT.		TISZAI EROMU RT. I. HOEROMU		TISZAI II HOEROMU		KOROSI CS. S. U. KAZANHAZ		DNM DIOSGYORY NEMESACEL MUVEK FA.					
Sourse No.	P001-3		P019		P001-1		P055		P031		P010		P001		P001-1		P003		P001-2		E.P. Dust		Cyclon Dust		E.P. Dust	
Furnace Name	No.3 Water tube boiler 100 t/h		No.1 & No.2 Glass melting tank oven		No.1 Sintering furnace		Incinerator: Solvent 100kg/h Solid 60kg/h		Shaft kiln for limestone 19 t/h		SP Cement kiln 83 t/h		Dryer for aggregate 60 t/h		No.4 Water tube boiler 125 t/h		No. 3 Water tube boiler 670 t/h		Section boiler 0.232MW		No.3 Blast furnace		No.3 Blast furnace		No.3 Blast furnace	
Kind of fuel	Brown coal & natural gas		Natural gas		Coal & coke		Waste solvent paper, urethane		Natural gas		Natural gas		Natural gas		Brown coal & natural gas		Heavy oil & inert gas or N. gas		Brown & Black Coal		Coke		Coke		Coke	
Fuel Consumption	35.91 t/h 1500 m3/h		1860 m3/h (No.1, 2 total)				Waste solvent & solid		2670 m3/h		7970 m3/h		450 m3/h		48.69 t/h 700 m3/h		38.7 t/h (H. oil) 36700 m3/h(Inert)		0.19 t/h							
Stack Gas Flux (dry m3N/hr)	171000		43300 (No.1, 2 total)		374000		2380		34300		297000		26700		161000		906000		6436							
Unit / Components	Conc. (mg/m3)	Emission (g/hr)	Conc. (mg/m3)	Emission (g/hr)	Conc. (mg/m3)	Emission (g/hr)	Conc. (mg/m3)	Emission (g/hr)	Conc. (mg/m3)	Emission (g/hr)	Conc. (mg/m3)	Emission (g/hr)	Conc. (mg/m3)	Emission (g/hr)	Conc. (mg/m3)	Emission (g/hr)	Conc. (mg/m3)	Emission (g/hr)	Conc. (mg/m3)	Emission (g/hr)	Conc. (g/kg)	Emission (g/hr)	Conc. (g/kg)	Emission (g/hr)	Conc. (g/kg)	Emission (g/hr)
DUST	209	35739	28.2	1221	343	128282	38.0	90.4	4.8	165	33.0	9801	19.0	507	820	132020	231	209286	148	953	–	–	–	–	–	–
Pb	0.0102	1.740	0.0152	0.657	1.08	404	0.0110	0.0262	0.0014	0.049	ND	ND	0.0011	0.0292	0.0280	4.52	0.0183	16.5	ND	ND	1.47	–	0.411	–	7.63	–
Cd	ND	ND	0.0012	0.0498	0.0110	4.11	0.0106	0.0252	ND	ND	0.00047	0.140	ND	ND	ND	ND	ND	ND	0.0023	0.0153	0.014	–	0.006	–	0.056	–
Cr	ND	ND	0.0901	3.90	0.0108	4.04	0.0208	0.0496	0.0107	0.367	ND	ND	ND	ND	0.0521	8.38	0.0192	17.4	0.0269	0.177	0.296	–	0.376	–	0.318	–
Ni	0.0097	1.651	0.0005	0.0219	0.0163	6.08	0.0048	0.0114	0.0027	0.092	0.0071	2.105	ND	ND	0.0319	5.14	0.615	558	0.0167	0.110	0.079	–	0.087	–	0.101	–
Fe	5.71	977	0.0555	2.40	11.8	4419	0.0734	0.175	0.336	11.5	1.0828	321.592	0.197	5.27	15.9	2566	5.11	4625	3.08	20.3	164	–	232	–	238	–
Cu	0.0055	0.936	0.0037	0.158	0.112	41.9	0.0111	0.0264	0.0012	0.040	0.0041	1.216	0.0002	0.0048	0.0194	3.12	0.0048	4.38	0.0239	0.158	0.168	–	0.095	–	0.193	–
Zn	0.0258	4.41	0.0059	0.254	0.0411	15.4	0.148	0.351	0.0007	0.024	0.0090	2.666	0.0004	0.0110	0.0855	13.8	0.0142	12.8	1.80	11.9	3.32	–	1.24	–	15.0	–
Mn	0.0263	4.49	0.0011	0.0455	0.0892	33.4	0.0007	0.0016	0.0032	0.111	0.0035	1.053	0.0022	0.0576	0.165	26.6	0.0076	6.90	0.0417	0.275	2.38	–	4.38	–	3.87	–
Hg	0.0003	0.043	0.0000	0.0019	0.0017	0.64	0.0001	0.0002	0.0001	0.003	0.0001	0.023	0.0000	0.0001	0.0010	0.154	0.0001	0.0749	0.0002	0.0014	0.003	–	0.002	–	0.006	–
Na	0.461	78.9	5.65	245	3.49	1306	1.04	2.46	0.0460	1.58	ND	ND	0.0218	0.582	1.87	301	0.422	382	0.396	2.61	0.895	–	0.505	–	0.598	–
K	0.790	135	0.586	25.4	17.4	6510	0.328	0.779	0.0279	0.958	ND	ND	0.0287	0.765	2.76	444	0.0233	21.1	0.409	2.70	2.22	–	0.999	–	0.939	–
Ca	2.98	509	1.26	54.4	3.37	1261	0.158	0.377	0.204	7.00	2.6759	794.749	0.0801	2.14	32.1	5169	0.672	609	3.34	22.0	57.3	–	54.7	–	81.3	–
Mg	0.721	123	0.288	12.5	0.124	46.3	0.0672	0.160	0.0360	1.24	ND	ND	0.0292	0.780	5.21	838	0.0318	28.8	0.617	4.07	3.05	–	3.03	–	3.99	–
V	0.0038	0.643	ND	ND	0.0103	3.86	0.0008	0.0020	0.0040	0.136	ND	ND	0.0004	0.0106	0.0870	14.0	2.43	2204	0.0686	0.453	0.031	–	0.050	–	0.068	–
Ti	0.0976	16.7	ND	ND	0.0123	4.62	ND	ND	ND	ND	ND	ND	5.57	149	0.576	92.7	ND	ND	ND	ND	0.193	–	0.265	–	0.192	–
Al	6.44	1101	3.47	150	0.476	178	1.38	3.29	ND	ND	0.10316	30.640	0.667	17.8	26.7	4301	1.18	1070	ND	ND	4.19	–	5.63	–	6.98	–
SO4--	7.055	1206	–	–	5.229	1956	–	–	–	–	0.000	0	4.001	107	9.89	1592	109.9	99567	7.550	49.79	…	…	…	…	…	…
NO3-	0.289	49	–	–	0.447	167	–	–	–	–	0.095	28	0.065	1.7	0.196	32	0.083	75	0.309	2.04	…	…	…	…	…	…
Cl-	20.723	3544	–	–	*	*	–	–	–	–	1.904	565	22.007	588	30.7	4947	*	*	2.745	18.11	…	…	…	…	…	…
NH4+	0.295	51	–	–	0.760	284	–	–	–	–	0.203	60	0.900	24.0	0.141	23	0.091	82	0.844	5.57	…	…	…	…	…	…
Na+	0.309	53	–	–	8.729	3265	–	–	–	–	0.206	61	0.310	8.3	0.283	45	0.938	850	0.178	1.18	…	…	…	…	…	…
K+	0.161	28	–	–	42.558	15917	–	–	–	–	0.116	34	0.173	4.6	0.144	23	1.182	1071	0.093	0.61	…	…	…	…	…	…
Ca++	1.402	240	–	–	6.870	2570	–	–	–	–	1.596	474	0.360	9.6	0.470	76	0.259	235	0.628	4.14	…	…	…	…	…	…
Mg++	0.183	31	–	–	0.146	55	–	–	–	–	0.020	6	0.067	1.8	0.077	12	0.081	73	0.100	0.66	…	…	…	…	…	…
C-ele.	0.147	25.1	ND	ND	11.3	4226	2.94	7.00	ND	ND	10.8	3197	0.260	6.94	2.62	421.82	12.3	11135	43.0	283	169.000	–	240	–	160.5	–
C-org.	0.058	9.9	ND	ND	4.4	1631	0.06	0.14	ND	ND	ND	ND	0.063	1.68	0.44	70.84	4.7	4267	12.7	83	15.100	–	2.7	–	30.0	–
C-total	0.205	35.1	ND	ND	15.7	5872	3.00	7.14	ND	ND	10.8	3197	0.323	8.62	3.06	492.66	17.0	15402	55.6	367	184.100	–	242.7	–	190.5	–

Note :
- No. : Reference Number
- dry m3N/hr : Stack Gas Quantity at Dry Base.
- Hg (Dust in Stack) : Analysis Method is Vaporization by Heating and Atomic Absorption Photometry
- Pretreatment Method   Metallic Elements : HNO3 + H2O2 Digestion
  Ion Components : Water Extraction
- Emission : Emission Factor
- ND : Not Detected
- … : Oily Sample ,   * : The Samples Had Own Color for Cl- Analysis.

Table D6.2.4 Percentage of Carbon in Dust and the Concentration of Carbon in Exhaust Gas from Stationary Sources

No.	Name of enterprise	Source No.	Furnace Name	Kind of fuel	Particle	Carbon					
						C-ele		C-org		C-total	
					Conc. (mg/m3)	Conc. (mg/m3)	Content (%)	Conc. (mg/m3)	Content (%)	Conc. (mg/m3)	Content (%)
05/0	BORSODI ENERGETIKAI KFT. (BORSODI HOEROMU)	P001-3	No.3 Water tube boiler 100 t/h	Brown coal & natural gas	209	0.147	0.07	0.058	0.03	0.205	0.10
		P002-1	No.4 Water tube boiler 100 t/h	Brown coal & natural gas	140	0.653	0.47	0.653	0.47	1.31	0.93
07/0	PANNONGLAS IPARI RT. SAJOSZENTPETERI UVEGGYAR	P019	No.2 glass melting tank oven	Natural gas	10	ND	ND	ND	ND	ND	ND
08/0	BORSODI ERCELOKESZITO MUZSGORITO KFT.	P001-1	No.1 Sintering furnace	Coal & coke	343	11.3	3.29	4.36	1.27	15.7	4.57
09/2	SAGROCHEM KFT.	P055	Incinerator: Solvent 100kg/h, solid 60kg/h	Waste solvent paper, urethane	30	2.94	9.75	0.059	0.20	3.00	9.95
17/1	HEJOCSABAI CEMENT- ES MESZIPARI RT.	P031	Shaft kiln for limestone 19 t/h	Natural gas	5	ND	ND	ND	ND	ND	ND
		P010	SP Cement kiln 83 t/h	Natural gas	33	10.8	32.73	ND	ND	10.8	32.73
18/0	STRABAG HUNGARIA EPITO KFT.	P001	Dryer for aggregate 60 t/h	Natural gas	190	0.260	0.14	0.063	0.03	0.323	0.17
25/1	TISZAI EROMU RT. I. HOEROMU	P001-1	No. 1 Water tube boiler 125 t/h	Brown coal & natural gas	178	1.80	1.01	0.487	0.27	2.29	1.28
		P002-2	No. 4 Water tube boiler 125 t/h	Brown coal & natural gas	820	2.62	0.32	0.442	0.05	3.06	0.37
25/2	TISZAI EROMU RT. II. HOEROMU	P003	No. 3 Water tube boiler 670 t/h	Inert gas & heavy oil	231	12.3	5.32	4.71	2.04	17.0	7.36
26/3	KOROSI CS. S. U. KAZANHAZ	P001-2	Section boiler 0.232 Mw	Brown coal & Black coal	148	43.0	29.05	12.700	8.58	55.700	37.64
15/4	DNM DIOSGYORY NEMESACEL MUVEK FA.	E.P. dust	No.3 Blast furnace E.P. dust	Coke	-	-	16.90	-	1.51	-	18.41
		Cyclon dust	No.3 Blast furnace Ciklon dust		-	-	24.00	-	0.27	-	24.27
		E.P. dross	No.3 Blast furnace E.P. dross		-	-	16.05	-	3.00	-	19.05

Note ・ND : Not Detected

Table D6.2.5 (1) Exhaust Emissions and Concentration of Mobile Sources

(Passenger car and Light truck)

Component	Passenger Car (Trabant 601…2storke) Miskolc M. 2 + ECE 15.04			Light truck (Mazda E2200 Diesel) Miskolc Mode 1 + 90 EUDC			Passenger Car (Skoda 105) Miskolc Mode 1+ ECE 15.04			Passenger Car (Ford Escort 1.6 Diesel) Miskolc Mode 1			Passenger Car (Ford Escort 1.6 Diesel) 120 EUDC			Passenger Car (Dacia 1310) Miskolc Mode 1			Mean Value		
	Conc. (ug/m3)	Emission (ug/km)	Content (%)	Conc. (ug/m3)	Emission (ug/km)	Content (%)	Conc. (ug/m3)	Emission (ug/km)	Content (%)	Conc. (ug/m3)	Emission (ug/km)	Content (%)	Conc. (ug/m3)	Emission (ug/km)	Content (%)	Conc. (ug/m3)	Emission (ug/km)	Content (%)	Conc. (ug/m3)	Emission (ug/km)	Content (%)
DUST	11000	89100	100	12300	106000	100	13800	101000	100	3940	37800	100	19800	118000	100	4130	224000	100	10828	112650	100
Pb	80.2	634	0.729	0.560	4.44	0.0046	208	1447	1.51	6.75	64.6	0.171	12.9	77.3	0.0651	79.5	432	1.92	(123)6.73	(837)48.4	(1.39)0.08
Cd	0.016	0.18	0.0001	0.030	0.25	0.0002	ND	ND	ND	0.104	1.00	0.0027	0.298	1.79	0.0015	0.016	0.09	0.0004	0.077	0.54	0.0008
Cr	1.65	18.3	0.0150	0.390	3.07	0.0032	0.017	0.25	0.0001	ND	ND	ND	ND	ND	ND	0.076	0.41	0.0018	0.355	3.67	0.0034
Ni	1.36	15.1	0.0124	0.931	7.61	0.0076	0.054	0.47	0.0004	0.100	0.963	0.0026	0.746	4.47	0.0038	0.076	0.41	0.0018	0.545	4.83	0.0048
Fe	8.32	80.9	0.0757	33.6	274	0.273	1.350	11.1	0.0098	0.294	2.81	0.0075	3.68	22.0	0.0186	26.3	143	0.638	12.3	89	0.170
Cu	1.17	12.8	0.0107	0.889	7.89	0.0072	0.205	1.58	0.0015	1.40	13.4	0.0354	2.58	15.5	0.0130	0.363	1.97	0.0088	1.101	8.84	0.0128
Zn	+	+	+	256	1906	2.08	15.5	130	0.1122	+	+	+	+	+	+	91	494	2.20	30	237	0.56
Mn	0.028	0.28	0.0003	1.89	16.4	0.0154	0.153	1.08	0.0011	ND	ND	ND	1.95	11.7	0.0098	0.247	1.34	0.0060	0.694	4.95	0.0050
Hg	0.006	0.03	0.0001	ND	ND	ND	0.007	0.04	0.0000	0.002	0.02	0.0000	0.032	0.194	0.0002	0.019	0.10	0.0005	0.006	0.03	0.0001
Na	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
K	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ca	18.5	121	0.169	255	2077	2.07	41.9	359	0.304	+	+	+	+	+	+	50.8	276	1.23	22.5	225	0.34
Mg	2.49	19.6	0.0227	39.7	321	0.323	10.0	86.5	0.0725	+	+	+	+	+	+	10.9	59.3	0.264	3.7	37.2	0.062
V	0.010	0.11	0.0001	0.199	1.67	0.0016	0.014	0.10	0.0001	0.007	0.06	0.0002	ND	ND	ND	0.151	0.82	0.0037	0.059	0.44	0.0009
Ti	0.042	0.31	0.0004	0.931	8.09	0.0076	0.031	0.35	0.0002	0.091	0.88	0.0023	0.249	1.49	0.0013	0.252	1.37	0.0061	0.266	2.08	0.0030
Al	ND	ND	ND	345	2878	2.80	23.8	192	0.173	1.31	12.5	0.0331	+	+	+	58.0	315	1.40	69.9	557	0.73
SO4--	0.285	1.33	0.001	9.01	74.1	0.0733	ND	ND	ND	ND	ND	ND	-	-	-	ND	ND	ND	1.86	15.1	0.015
NO3-	0.052	0.24	0.000	1.73	14.2	0.0140	0.016	0.176	0.0001	0.433	2.59	0.0110	-	-	-	0.078	0.426	0.002	0.46	3.53	0.005
Cl-	3.64	17.1	0.016	41.3	340	0.336	4.62	52.3	0.0334	24.4	146	0.618	-	-	-	7.16	39	0.173	16.2	119	0.235
NH4+	0.007	0.03	0.0000	0.050	0.414	0.0004	0.006	0.067	0.0000	0.028	0.167	0.0007	-	-	-	0.034	0.186	0.001	0.03	0.17	0.000
Na+	17.1	80.1	0.077	ND	ND	ND	ND	ND	ND	49.7	298	1.26	-	-	-	45.5	247	1.10	22.5	125	0.488
K+	4.95	23.2	0.022	21.8	179	0.177	7.77	88.0	0.0563	51.2	307	1.30	-	-	-	21.6	117	0.523	21.5	143	0.416
Ca++	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	ND	ND	ND	ND	ND	ND
Mg++	3.07	14.4	0.014	30.8	253	0.250	5.85	66.2	0.0424	9.446	56.6	0.240	-	-	-	6.14	33	0.149	11.1	84.7	0.139
C-ele.	160	1600	1.5	8665	73786	70.4	325	3399	2.4	2490	23800	63.2	13180	79000	66.6	410	2200	9.9	4205	30631	35.7
C-org.	7650	170132	69.5	1140	9558	9.3	9215	70800	66.8	390	3800	9.9	1680	10000	8.5	650	3600	15.7	3454	44648	30.0
C-total	7810	171733	71.0	9805	83344	79.7	9540	74199	69.1	2880	27600	73.1	14860	89000	75.1	1060	5800	25.7	7659	75279	65.6
Sample for Ion Analysis	Miskolc Mode 1 Dust 22.17 mg/m3 0.104 g/km			90 EUDC Dust 13.57 mg/m3 0.101 g/km			90 EUDC Dust 27.27 mg/m3 0.098 g/km			ECE 15.04 Dust 3.87 mg/m3 0.067 g/km						120 EUDC Dust 9.59 mg/m3 0.057 g/km					

Note
- Pretreatment Method
  - Metallic Elements : HNO3 + H2O2 Digestion
  - Ion Components : Water Extraction
- Emission : Emission Factor (ug/km/Veh.)
- Content(%) : Ratio of Component for Dust
- * : Bl Value of Filter Paoer is too Large to Analyze and Fix a Quantity.
- ND : Data Under the Limit of Detection, Adding Fluctuation of Bl Value of Filter Paper.
- + : Peculiar Data Affected by Bl Value of Filter Paper in Itself.
- The Mean Value was Calculated Including the Peculiar Data and the Data Under the Limit of Detection.
- Pb : ( ) : Trabant, Skoda, Dacia

Table D6.2.5 (2) Exhaust Emissions and Concentration of Mobile Sources

(Heavy vehicle)

Component	Test-1 (2100 rev/min) 637 Newton 132.8 kw			Test-2 (2000 rev/min) 656 Newton 130.1 kw			Test-3 (1800 rev/min) 684 Newton 123 kw		
	Conc. (ug/m3)	Emission (mg/hr)	Emission (mg/kwh)	Conc. (ug/m3)	Emission (mg/hr)	Emission (mg/kwh)	Conc. (ug/m3)	Emission (mg/hr)	Emission (mg/kwh)
DUST	87900	22713	171	94100	23638	182	98400	22435	182
Pb	2.50	0.62	0.0047	26.2	6.59	0.0506	1.25	0.29	0.0023
Cd	0.31	0.08	0.0006	-1.11	-0.28	-0.0021	0.44	0.10	0.0008
Cr	11.3	2.79	0.0210	31.1	7.81	0.0600	21.3	4.85	0.0394
Ni	25.0	6.21	0.0468	115	28.8	0.221	71.9	16.4	0.133
Fe	166	41.3	0.311	607	152	1.17	233	53.2	0.432
Cu	90.3	22.4	0.169	409	103	0.789	252	57.4	0.466
Zn	3625	900	6.78	5732	1440	11.1	-4000	-912	-7.41
Mn	18.8	4.66	0.0351	67.1	16.8	0.130	37.5	8.55	0.1
Hg	1.69	0.42	0.0032	0.85	0.21	0.0016	0.44	0.10	0.0008
Na	*	*	*	*	*	*	*	*	*
K	*	*	*	*	*	*	*	*	*
Ca	+	+	+	+	+	+	2625	599	4.87
Mg	533	132	1.00	873	219	1.69	103	23	0.19
V	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ti	8.95	2.22	0.0167	19.7	4.95	0.0381	0.20	0.05	0.0
Al	3813	947	7.13	+	+	+	188	42.8	0.35
C-ele.	27400	7080	53.3	31000	7787	59.9	26900	6133	49.9
C-org.	9900	2558	19.3	9700	2437	18.7	8100	1847	15.0
C-total	37300	9638	72.6	40700	10224	78.6	35000	7980	64.9

Component	Test-4 (1600 rev/min) 705 Newton 112.8 kw			Test-6 (1200 rev/min) 706 Newton 85.63 kw			Test-15 (2100 rev/min) 637 Newton 132.8 kw			Mean Value			
	Conc. (ug/m3)	Emission (mg/hr)	Emission (mg/kwh)	Conc. (ug/m3)	Emission (mg/hr)	Emission (mg/kwh)	Conc. (ug/m3)	Emission (mg/hr)	Emission (mg/kwh)	Conc. (ug/m3)	Emission (mg/hr)	Emission (mg/kwh)	Content (%)
DUST	85900	18623	165	155500	28270	330	109100	28191	212	105150	23978	207	100
Pb	3.75	0.81	0.0072	25.7	4.67	0.0546	27.2	7.03	0.0529	14.4	3.34	0.0287	0.0137
Cd	0.44	0.09	0.0008	2.07	0.377	0.0044	0.29	0.08	0.0006	0.41	0.07	0.0008	0.0004
Cr	18.8	4.07	0.0360	18.6	3.38	0.0394	13.2	3.42	0.0258	19.0	4.39	0.0369	0.0181
Ni	75.6	16.4	0.145	57.1	10.4	0.121	47.1	12.2	0.0916	65.2	15.1	0.1266	0.0620
Fe	172	37.3	0.331	401	72.9	0.851	248	64.1	0.4824	305	70.2	0.5965	0.2896
Cu	212	46.0	0.408	149	27.1	0.316	165	42.7	0.3212	213	49.7	0.4116	0.2024
Zn	-6075	-1317	-11.7	-1286	-234	-2.73	18294	4727	35.60	2715	767	5.27	2.58
Mn	37.5	8.13	0.0721	21.4	3.90	0.0455	14.7	3.80	0.0286	32.8	7.65	0.0634	0.0312
Hg	0.38	0.08	0.0007	4	0.727	0.0085	0.515	0.13	0.0010	1.311	0.28	0.0026	0.0012
Na	*	*	*	*	*	*	*	*	*	*	*	*	13.17
K	*	*	*	*	*	*	*	*	*	*	*	*	2.35
Ca	4575	992	8.79	4000	727	8.49	4206	1087	8.18	1699	351	3.42	1.62
Mg	ND	ND	ND	ND	ND	ND	326	84	0.64	242	64	0.46	0.23
V	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ti	ND	ND	ND	3.09	0.561	0.01	11.265	2.91	0.0219	6.714	1.68	0.0130	0.0064
Al	+	+	+	+	+	+	809	209	1.57	1530	407	2.86	1.46
C-ele.	26900	5832	51.7	76900	13980	163.3	22000	5685	42.8	35183	7750	70.1	33.5
C-org.	8100	1756	15.6	14200	2582	30.1	9300	2403	18.1	9883	2264	19.5	9.4
C-total	35000	7588	67.3	91100	16562	193.4	31300	8088	60.9	45067	10013	89.6	42.9

(Heavy vehicle)

Component	Test-5 (1400 rev/mni) 713 Newton 100.5 kw			Test-7 (1000 rev/min) 691 Newton 71.11 kw			Test-13 (1400 rev/min) 713 Newton 100.5 kw			Mean Value			
	Conc. (ug/m3)	Emission (mg/hr)	Emission (mg/kwh)	Conc. (ug/m3)	Emission (mg/hr)	Content (mg/kwh)	Conc. (ug/m3)	Emission (mg/hr)	Content (mg/kwh)	Conc. (ug/m3)	Emission (mg/hr)	Emission (mg/kwh)	Content (%)
DUST	152400	30602	304	82200	13777	194	127900	25682	256	120833	23354	251	100
SO4--	50.0	10.0	0.0999	39.5	6.62	0.0930	12.5	2.51	0.0250	34.0	6.39	0.0726	0.0281
NO3-	4.85	0.974	0.0097	2.95	0.494	0.0069	ND	ND	ND	2.6001	0.4895	0.0055	0.0022
Cl-	162	32.5	0.323	168	28.2	0.3970	150	30.1	0.2997	160	30.3	0.3400	0.1325
NH4+	×	×	×	×	×	×	×	×	×	×	×	×	×
Na+	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
K+	871	175	1.74	313	52	0.738	278	55.7	0.554	487	94.3	1.011	0.403
Ca++	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mg++	94.1	18.9	0.188	34.2	5.73	0.0806	ND	ND	ND	42.7761	8.2108	0.0896	0.0354
C-ele.	61900	12430	124	37900	6352	82.4	41600	8353	83.1	47133	9045	96.4	39.0
C-org.	23600	4739	47.2	9700	1626	21.1	7100	1426	14.2	13467	2597	27.5	11.1
C-total	85500	17168	171	47600	7978	103	48700	9779	97.3	60600	11642	123.9	50.2

Note
- Pretreatment Method Metallic Elements : HNO_3 + H_2O_2 Digestion
  Ion Components : Water Extraction
- Emission : Emission Factor (mg/hr/Veh.), (mg/kwh/Veh.)
- Content(%) : Ratio of Component for Dust
- * : Bl Value of Filter Paoer is too Large to Analyze and Fix a Quantity.
- ND : Data Under the Limit of Detection, Adding Fluctuation of Bl Value of Filter Paper.
- + : Peculiar Data Affected by Bl Value of Filter Paper in Itself.
- The Mean Value was Calculated Including the Peculiar Data and the Data Under the Limit of Detection.
- × : This Samples Had Own Color for NH4+ Analysis.

Table D6.2.6 Result of Emission Factor and Carbon Analysis in the Automobile Exhaust Gas

(Passenger car and Light truck)

Vehicle type / Model	Test mode	Particle		Carbon					
				C-ele		C-org		C-total	
		Conc. (mg/m3)	Emission (g/km)	Conc. (mg/m3)	Emission (g/km)	Conc. (mg/m3)	Emission (g/km)	Conc. (mg/m3)	Emission (g/km)
Trabant 601 (2-storke engine)	Miskolc mode 1	22.17	0.104	0.30	0.0014	14.32	0.0672	14.62	0.0686
	Miskolc mode 2	12.47	0.068	0.09	0.0005	8.71	0.0476	8.80	0.0481
	90 EUDC	74.95	0.318	1.14	0.0048	62.46	0.2648	63.60	0.2696
	ECE 15.04	9.60	0.110	0.23	0.0027	6.59	0.0755	6.82	0.0782
Mazda E2200 Diesel (Light truck)	Miskolc mode 1	5.86	0.047	3.08	0.0247	0.21	0.0017	3.29	0.0264
	Miskolc mode 1	5.85	0.047	2.90	0.0234	0.23	0.0018	2.86	0.0230
	Miskolc mode 1	7.82	0.075	3.98	0.0379	0.33	0.0031	4.30	0.0410
	90 EUDC	13.57	0.101	8.88	0.0658	1.31	0.0097	10.18	0.0755
	90 EUDC	14.27	0.106	10.50	0.0781	1.22	0.0091	11.72	0.0872
	90 EUDC	16.76	0.138	13.35	0.1097	1.95	0.0160	15.29	0.1257
Skoda 105	Miskolc mode 1	16.36	0.076	0.09	0.0004	10.02	0.0464	10.12	0.0468
	Miskolc mode 2	11.38	0.062	0.25	0.0014	6.35	0.0345	6.60	0.0359
	90 EUDC	27.27	0.098	0.51	0.0019	16.59	0.0599	17.11	0.0617
	ECE 15.04	11.23	0.127	0.56	0.0064	8.41	0.0952	8.97	0.1016
	60 km/h	14.43	0.051	0.05	0.0002	6.28	0.0224	6.33	0.0226
	80 km/h	31.38	0.084	0.50	0.0013	16.04	0.0431	16.54	0.0444
	100 km/h	100.84	0.254	2.51	0.0063	66.32	0.1672	68.833	0.1735
Ford Escort 1.6 Diesel	Miskolc mode 1	3.94	0.038	2.49	0.0238	0.39	0.0038	2.88	0.0276
	Miskolc mode 1	3.97	0.038	2.28	0.0218	0.32	0.0031	2.60	0.0248
	Miskolc mode 1	3.30	0.032	2.79	0.0267	0.36	0.0034	5.50	0.0527
	Miskolc mode 2	4.14	0.034	2.55	0.0210	1.03	0.0085	3.74	0.0308
	120 EUDC	44.96	0.269	28.71	0.1716	6.45	0.0385	35.16	0.2102
	120 EUDC	19.78	0.119	13.18	0.0790	1.68	0.0100	14.86	0.0890
	120 EUDC	20.92	0.125	12.17	0.0727	1.82	0.0108	11.97	0.0715
	ECE 15.04	3.87	0.067	1.92	0.0332	0.30	0.0052	4.83	0.0835
Dacia 1310	Miskolc mode 1	4.13	0.022	0.41	0.0022	0.65	0.0036	0.91	0.0049
	Miskolc mode 2	2.64	0.017	0.19	0.0012	0.84	0.0053	0.83	0.0053
	120 EUDC	9.59	0.057	0.76	0.0046	5.02	0.0300	5.48	0.0328

Table D6.2.7 The Analysis Results of Carbon Contained in Exhaust Gas

(Heavy vehicle)

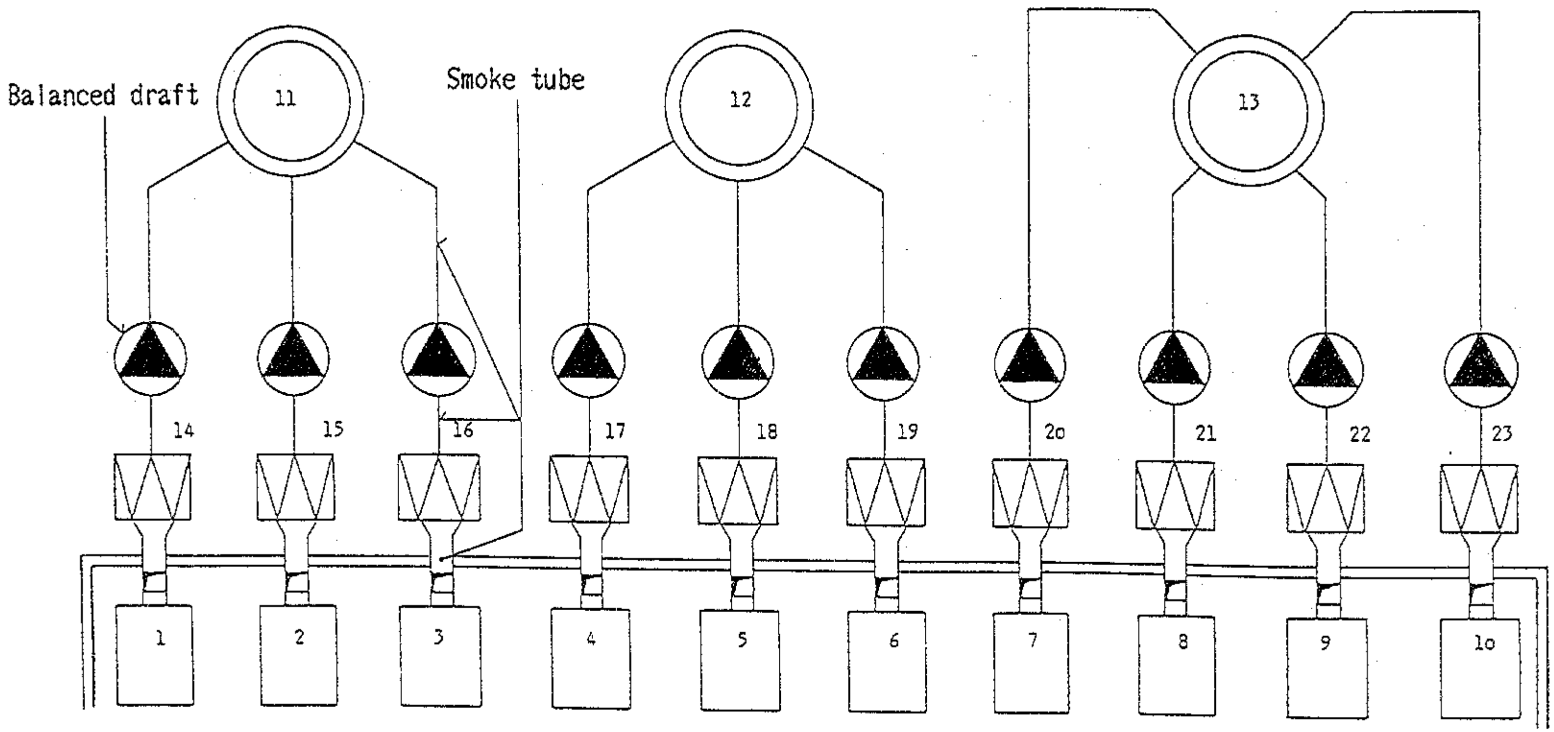
Rev./min of Engine	Load on the Dynamometer (Newton)	Particle conc. (mg/m3)	Carbon					
			C-ele		C-org		C-total	
			conc. (mg/m3)	Content (%)	conc. (mg/m3)	Content (%)	conc. (mg/m3)	Content (%)
2100 rev/min	660	87.9	27.4	31.2	9.9	11.3	37.4	42.5
2000 rev/min	676	94.1	31.0	33.0	9.7	10.3	40.7	43.3
1800 rev/min	700	98.4	26.9	27.4	8.1	8.2	35.0	35.6
1600 rev/min	722	85.9	26.9	31.3	8.1	9.4	35.0	40.7
1400 rev/min	732	152.4	61.9	40.7	23.6	15.5	85.5	56.1
1200 rev/min	726	155.5	76.9	49.4	14.2	9.1	91.1	58.6
1000 rev/min	701	82.2	37.9	46.1	9.7	11.9	47.6	58.0
1400 rev/min	72	16.9	6.9	40.9	4.9	28.9	11.8	69.7
1400 rev/min	187	18.3	7.8	42.6	5.7	31.2	13.5	73.7
1400 rev/min	368	22.6	2.6	11.5	3.6	16.0	6.2	27.5
1400 rev/min	551	23.1	6.7	29.1	7.9	34.4	14.7	63.5
1400 rev/min	731	127.9	41.6	32.5	7.1	5.5	48.6	38.0
2100 rev/min	646	109.1	22.0	20.1	9.3	8.5	31.3	28.6
2100 rev/min	495	22.3	3.5	15.5	3.3	14.7	6.7	30.2
2100 rev/min	329	22.8	(<2.7)	(<11.9)	(<3.4)	(<14.8)	(<6.1)	(<26.7)
2100 rev/min	162	19.7	(<2.7)	(<13.7)	(<3.4)	(<17.1)	(<6.1)	(<30.7)
2100 rev/min	65	16.2	(<2.7)	(<16.7)	(<3.4)	(<20.8)	(<6.1)	(<37.5)

Note
- Content (%) : Ratio of carbon in the particles.
- ( ) : Reference data

DATA FOR CHAPTER 7

BORSOD POWER PLANT

11,12,13 are required with measurment of
SO2,NOx,CO,CO2,O2,Dust,Tg,Vg at all time

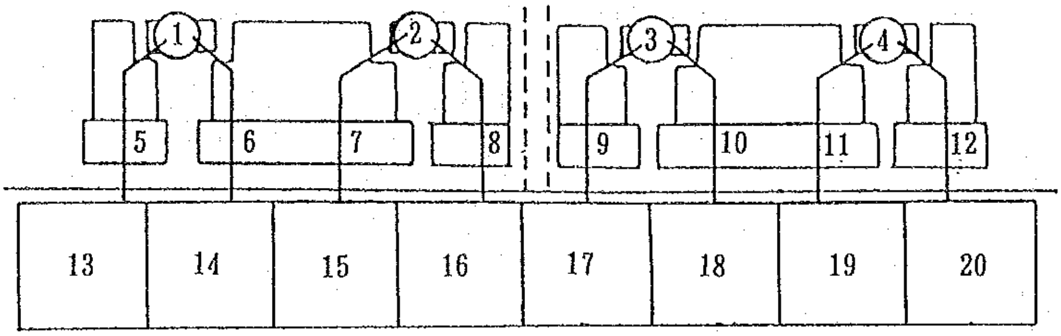


1-10:Boilers(100t/h)
11-13:Smoke stack (HO=100m)
14-23:Electrofilter(E.P.)

Figure D7.2.1 BORSOD Power Plant

TISZAPALKONYA POWER PLANT

1,2,3,4 are required with measurment of
SO2,NOx,CO,CO2,O2,Dust,Tg,Vg at all time



1- 4:Smoke stack (HO=120m)
5-12:Electrofilter(E.P.)
13-20:Boilers(125t/h)

Figure D7.2.2 TISZA I Power Plant - Flow Sheet for Boiler and EP

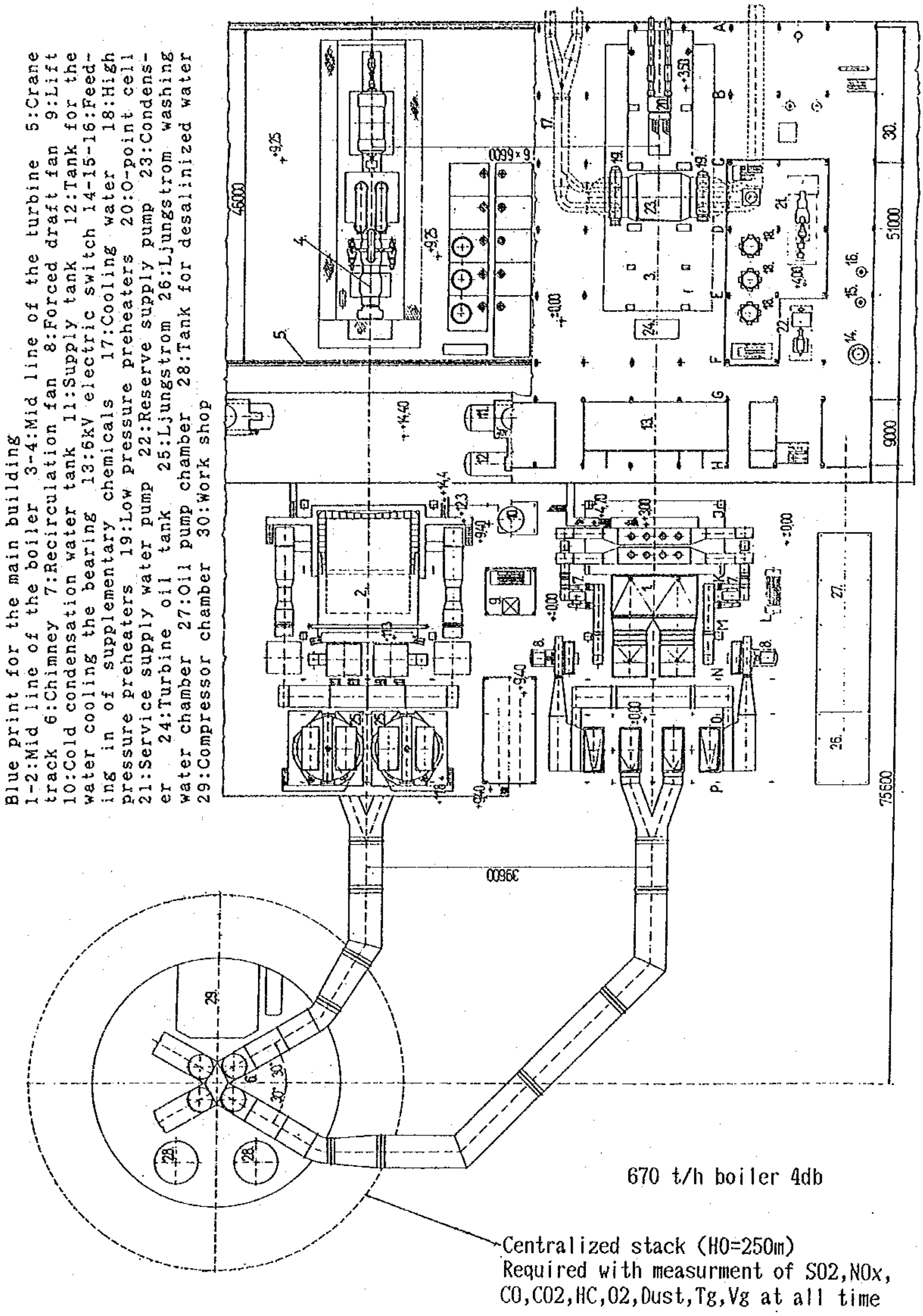


Figure D7.2.3 TISZA II Power Plant

T I S Z A II. P O W E R P L A N T

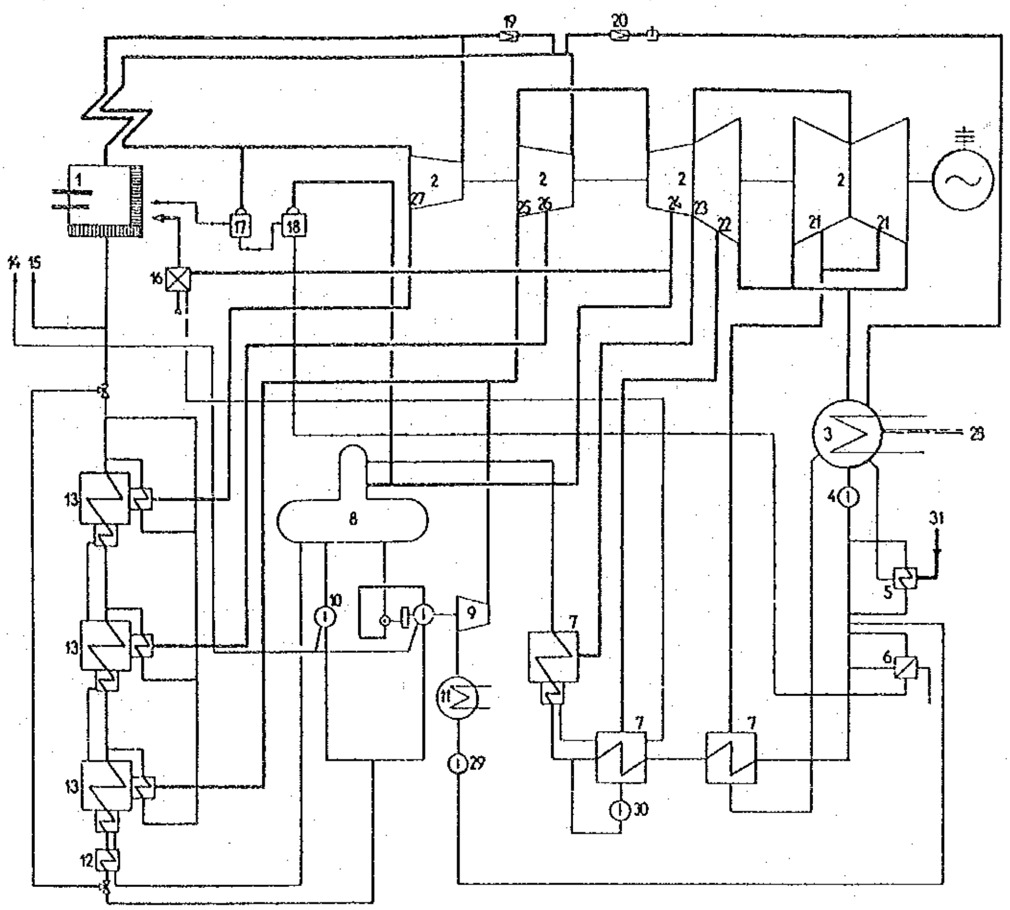


Figure D7.2.4 TISZA II Power Plant - Flow Sheet for Power Generation and Heat Supply

Simplified piping chart
1:Steam boiler 2:Steam turbine 3:Condenser of main turbine 4:Precipitation pump of the main turbine 5:Cooler of the stuffing box steam 6:Alkali cooler 7:Low pressure preheaters 8:Supply tank with degassing device 9:Turbine driven supply pump 10:Electric supply pump 11:Condenser of supply turbine 12:Expose precipitation cooler to the 5th high pressure preheater 13:High pressure preheaters 14:Injection into the reheater 15:Injection into the overheater 16:Boiler air stove 17:High pressure alkali evaporator 18:Low pressure alkali evaporator 19:Redactor of high pressure bypass 20:Redactor of low pressure bypass
21-27:Side draws on the main turbine 28:Reserve water inlet
29:Precipitation pump of the supply turbine 30:Precipitation pump of the 2nd preheater 31:Steam from the stuffing box system of the main turbine

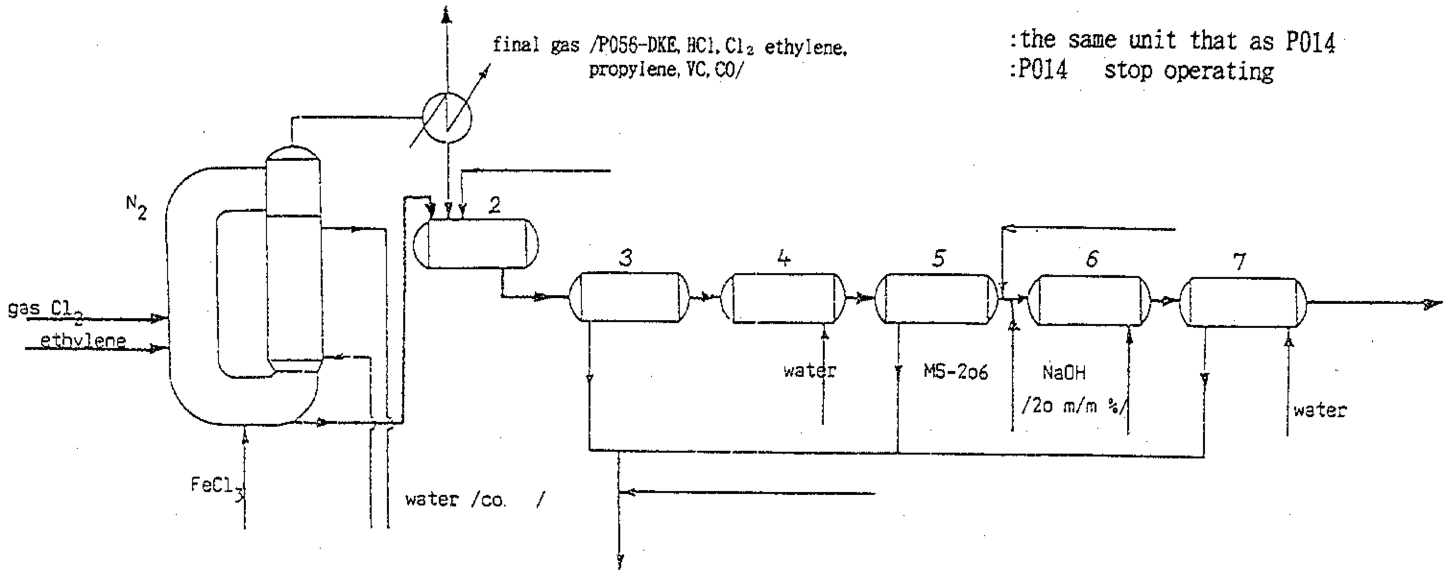
BORSODCHEM RT. KAZINCBARCIKA

Synthesis of vinyl chloride

1. Synthetize of di-clorine - ethane

● Emission source

:the same unit that as P014
:P014 stop operating



Signs:

1 - reactor /direct chlorinating/
2 - tank /raw DKE/
3 - 1. acid washing
4 - 2. - " -
5 - 1. lye washing
6 - 2. - " -
7 - wet vashing

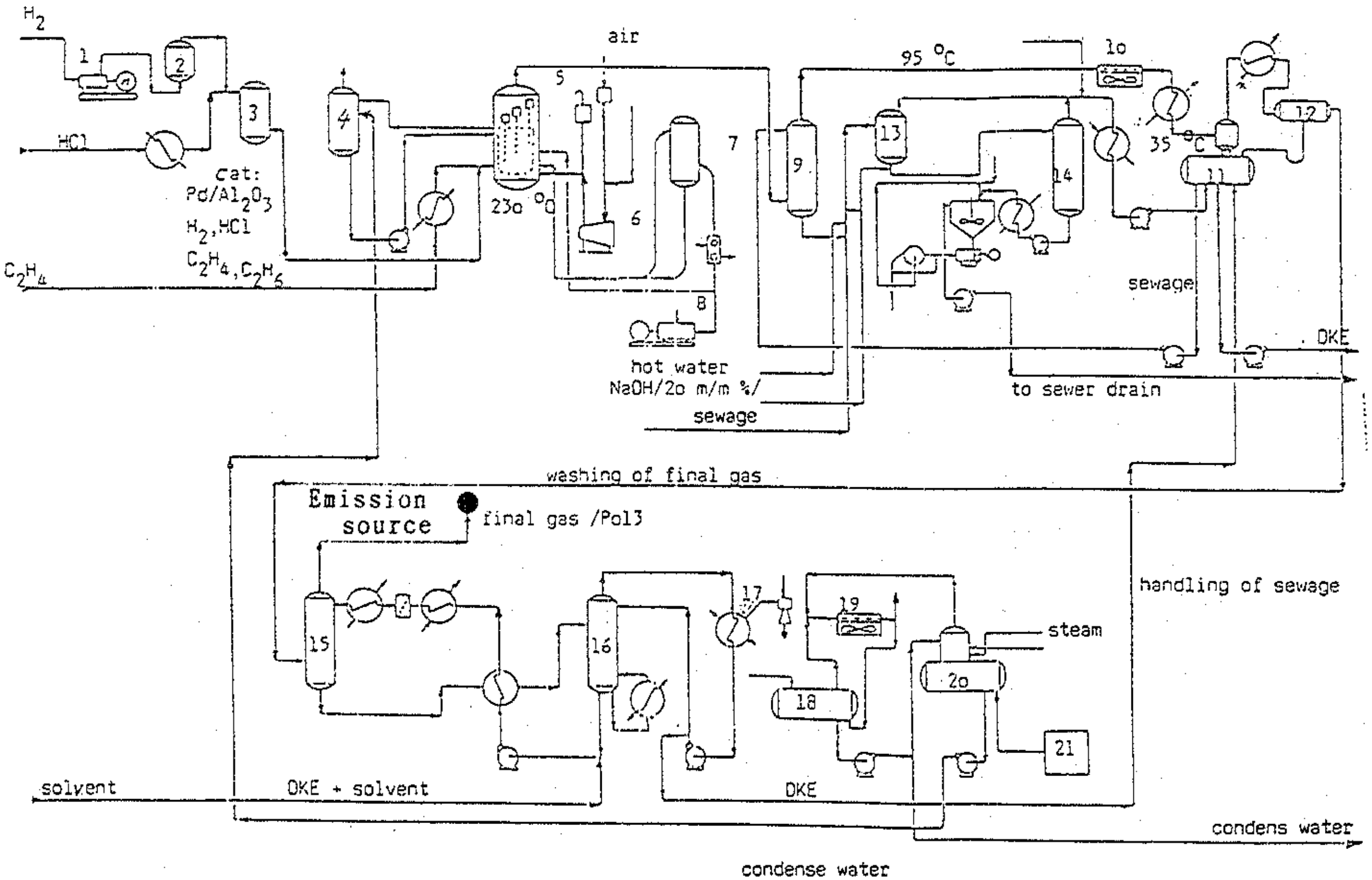
Product /t/h/	
raw di-chlorine-ethane	17,8

Figure D7.2.5 BORSODCHEM RT. - Synthesis of Vinyl Chloride (1 of 5)

BORSODCHEM RT. KAZINCBARCIKA

Synthesis of vinyl chloride

Oxi-hydro -'chlorinating



Signs:

1 - compressor
2 - H_2 dryer /Al_2O_3/
3 - hydrogenation reactor
4 - steam tank
5 - ractor
6 - compressor
9 - column
/cooler washing/
1o - condensator /air cooler/
11 - decanting
12 - separator
13 - neutralize tank
14 - stripper of sewage
15 - absorber
16 - column
17 - condensator
18 - condens tank
19 - condensator
2o - de-aerator
21 - feed-water tank

Product /t/h/

raw di-chlorine-ethane 19,o

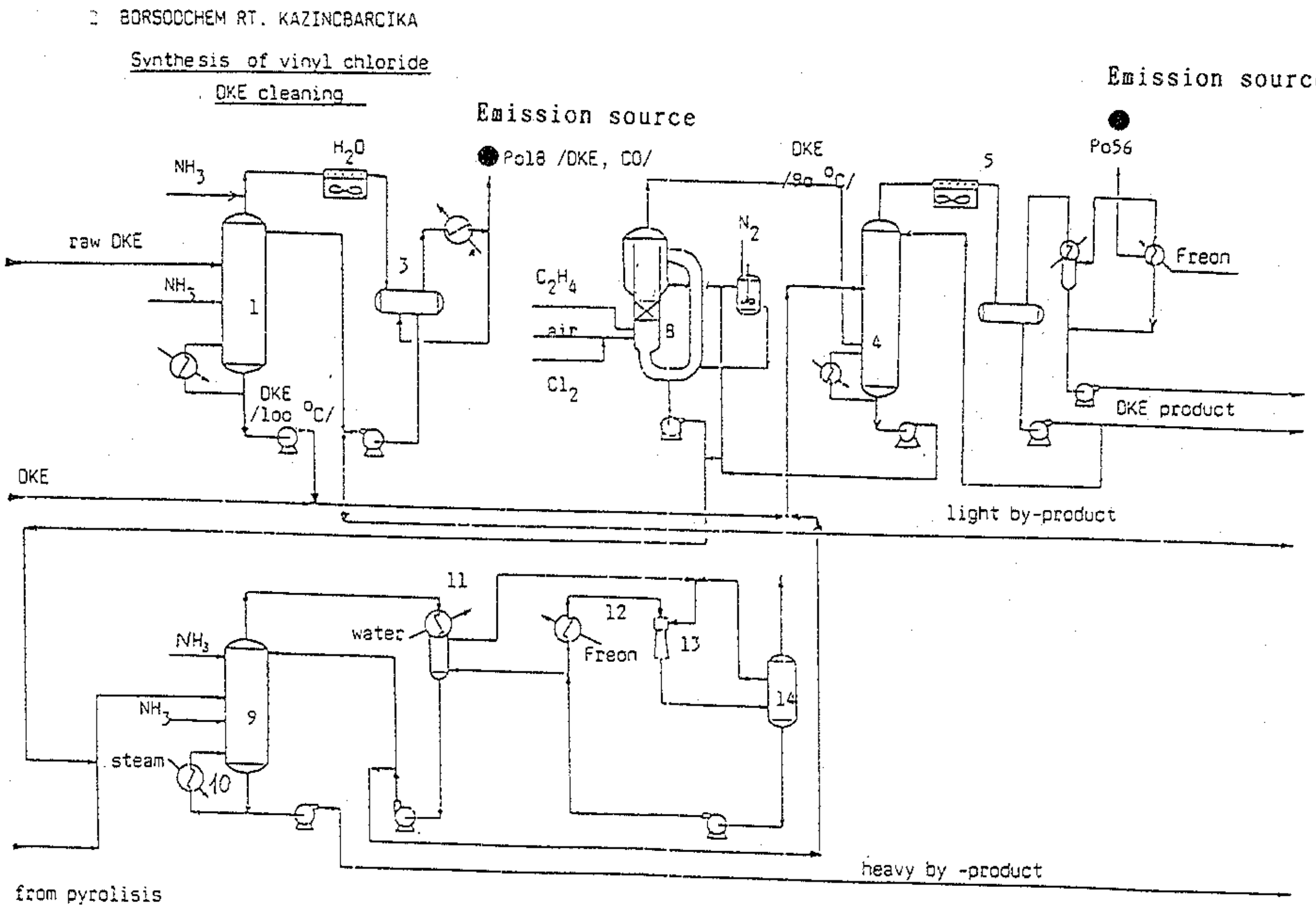
Emissions /kg/h/

V = 11.ooo Nm^3/ h

T = 15 °C

Pol3	
$C_2Cl_2H_4$	35
C_2ClH_3	1,24
C_2H_6	3,28
C_2H_4	95,2
CO	93,7

Figure D7.2.6 BORSODCHEM RT. - Synthesis of Vinyl Chloride (2 of 5)



Signs:

1 - azeotropic distillator
2 - condensator
3 - reflux tank
4 - column of trays
5 - condensator
6 - reflux tank
7 - vacuum distillator
8 - HTDC - reactor
9 - vacuum distillator
1o - boiling tank
11 - condensator
12 - condensator
13 - vacuum ejector
14 - tank of pump

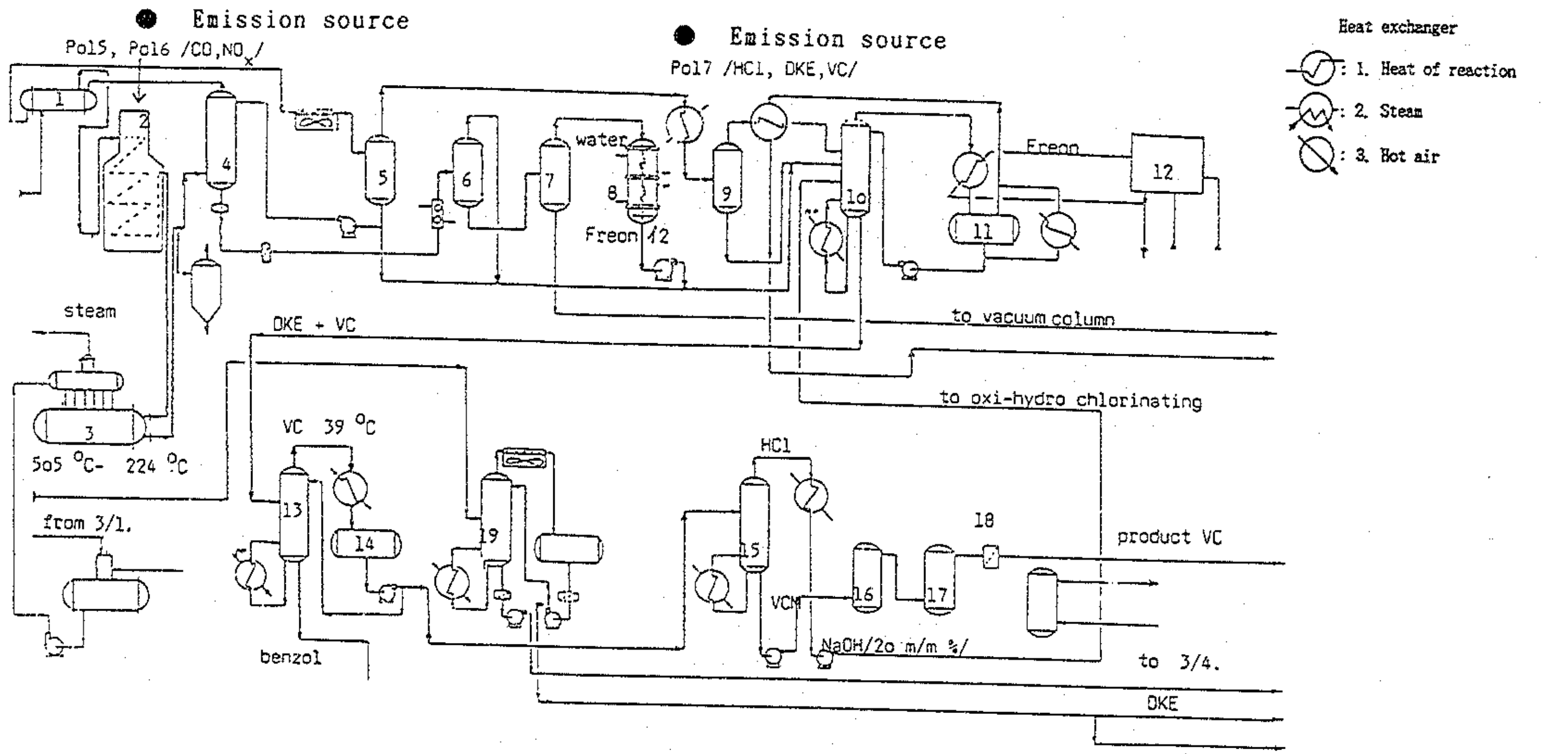
Products /t/h/	
cleared di-chlorine-ethane	71,3
raw - " - /HTDC-reactor/	21,1

Figure D7.2.7 BORSODCHEM RT. - Synthesis of Vinyl Chloride (3 of 5)

BORSODCHEM rt. KAZINCBARCIKA

Synthe sis of vinyl chloride

DKE pyrolisis



Signs:

1 - cooler
2 - pyrolysis boyler
3 - generator
4 - cooling
5 - quench column
6 - tank
7 - "
8 - condensator of steam
9 - steam separator
10 - column of trays
11 - reflux tank
12 - cooler
13 - column of trays
14 - reflux tank
15 - stripper /VCM HCl/
16 - drier /agen : solid NaOH/
17 - "
18 - filter
19 - column
20 - reflux tank

Product /t/h/	
vinyl chloride	24,3

vinyl chloride /t/1992./: 146.940

Utilized materials /t/1992./

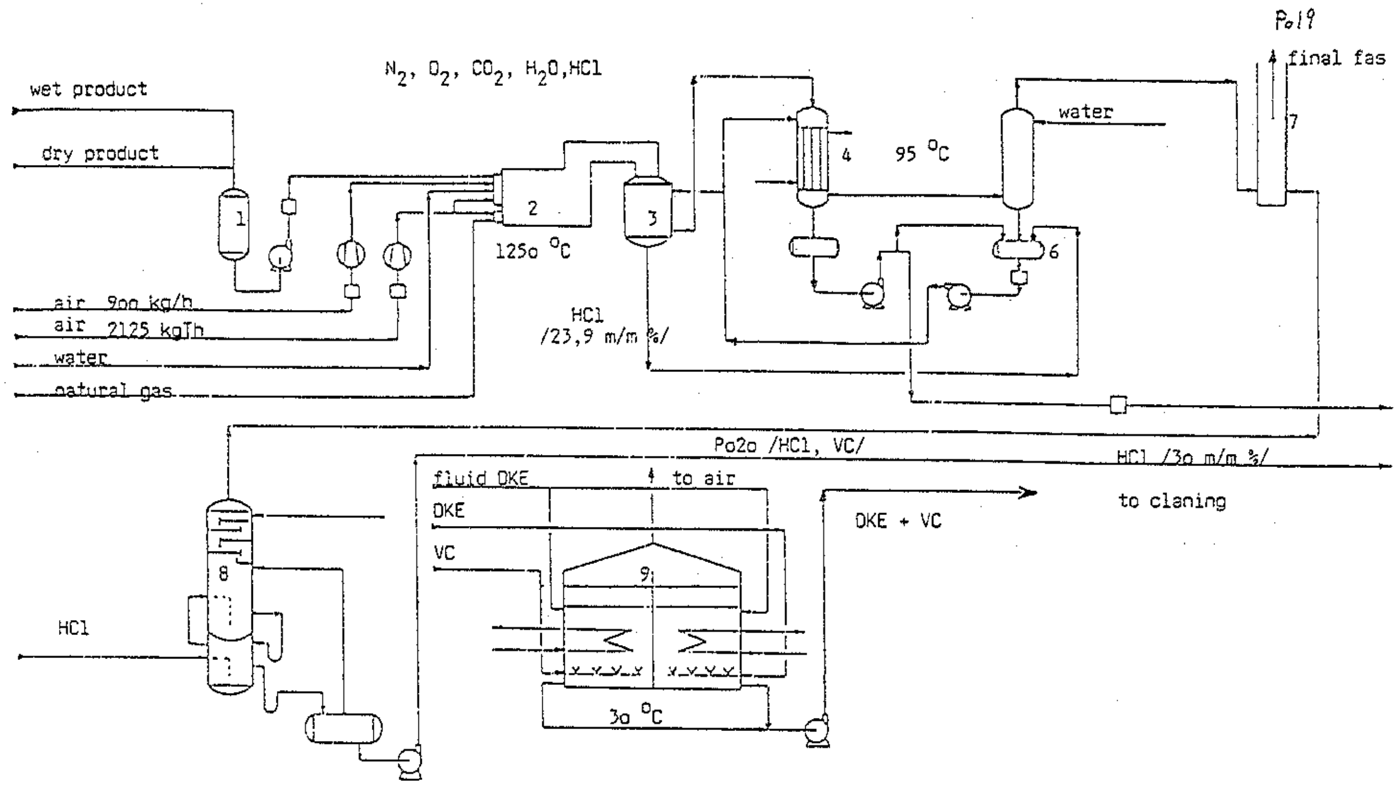
ethylene	67.219
Cl_2	78.898

Figure D7.2.8 BORSODCHEM RT. - Synthesis of Vinyl Chloride (4 of 5)

BORSODCHEM RT. KAZINCBARCIKA

Synthesis of vinyl cholide

Burn of by-product



Signs:

1 - tank
2 - burning
3 - quickly cooler
4 - HCl absorber
5 - absorber
6 - HCl tank
7 - smoke stack /Po19-HCl, Cl_2, organic/
8 - HCl absorber /catastrophe/
9 - absorber /catasrophe/ /solvent - fluid DKE/

Figure D7.2.9 BORSODCHEM RT. - Synthesis of Vinyl Chloride (5 of 5)

BORSODCHEM RT. KAZINCBARCIKA

Synthesis of vinyl chloride

1. Direct chlorinating

$$C_2H_4 + Cl_2 \xrightarrow[\text{catalyst}]{FeCl_3} C_2H_4Cl_2 \qquad /1/1/$$

2. Oxi-hydro chlorinating

$$C_2H_4 + 2HCl + 1/2O_2 \xrightarrow[\text{/fluid/}]{FeCl_3\ \text{catalyst}} C_2H_4Cl_2 + H_2O \qquad /2/5/$$

3. DKE pyrolisis

$$\underset{\text{DKE}}{Cl-CH_2-CH_2-Cl} \longrightarrow \underset{\text{VC}}{CH_2=CH-Cl} + HCl \qquad /4/2/$$

Specific consumptions

	per VC ton
steam	0.265 GJ
electric energy	228 KWh
C_2H_4	0.49 t
Cl_2	0.62 t

Emissions

P013

$V=11,000\ Nm^3/h \quad H_0=47$

$T=15\ ^\circ C$

$C_2Cl_2H_4$

C_2ClH_3

C_2H_6

C_2H_4

CO

P015 — $V=12,000\ Nm^3/h$ — $H_0=37$

- CO — $T=140$ ℃
- NO_x

P016 — $V=33,000\ Nm^3/h$ — $H_0=37$

- CO — $T=140$ ℃
- NO_x

P017 — $V=50\ Nm^3/h$ — $H_0=20$

- HCl — $T=5$ ℃
- DKE

P018 — $V=40\ Nm^3/h$ — $H_0=47$

- CO — $T=10$ ℃
- DHE

P019 — $V=2,800\ Nm^3/h$ — $H_0=38$

- HCl — $T=15$ ℃
- Cl_2
- organic

P020 — $V=2\ Nm^3/h$ — $H_0=25$

- HCl — $T=20$ ℃
- VC

P056 — $V=1,000\ Nm^3/h$

- VC (C_2ClH_3) — $T=20$ ℃
- C_2H_4
- $C_2H_4Cl_2$
- CO
- HCl
- Cl_2

BORSODCHEM RT,KAZINCBARCIKA

CPE synthesis

1 - storage, homogenisator
2 - scales
3 - suspendation
4 - autoclave / chlorination/
5 - evaporator
6 - storage /fluid Cl_2/
7 - NaoH - absorber
8 - storage /CPE-suspensio/
9 - centrifuging
    wash with water,neutralize with Na_2CO_3
    stabilizing with Ca-stearate
    mixing with air

1o - dryer I.

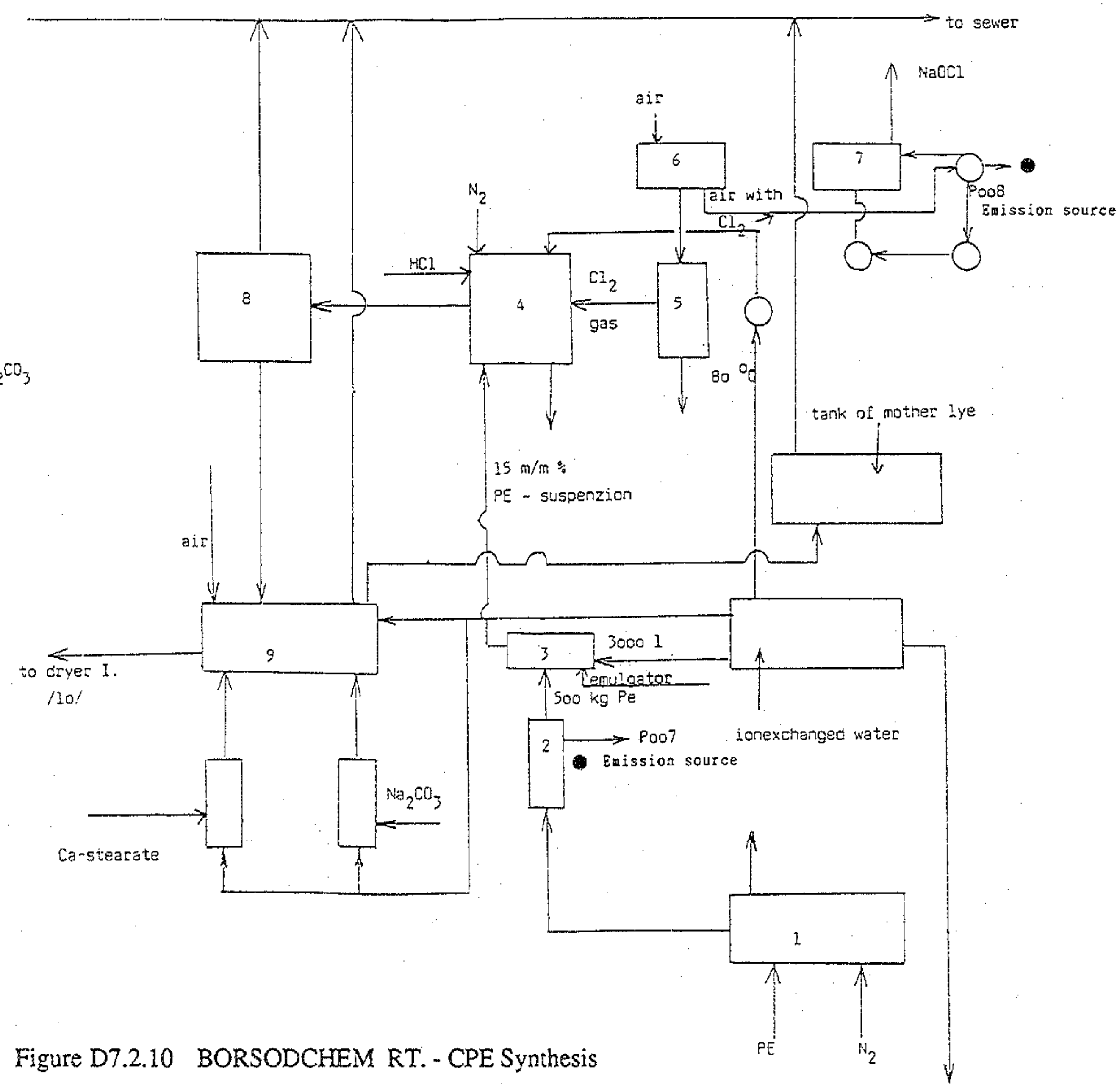


Figure D7.2.10 BORSODCHEM RT. - CPE Synthesis

BORSODCHEM RT. KAZINCBARCIKA

Synthesis of Chlorinated polyethylene /CPE/

Technology:

The polyethylene is chlorinated in two steps.
The CPE is dried in fluid-dryer after filtering and washing.
The product is a mixture of PVC and CPE in 50-50 % rates.

Specific consumptions:

	per CPE ton
electric energy	3177 KWh
steam	25 GJ
PE	0.7 t
Cl_2	0.8 t

Modernity of the technology: middling

Plans for the near future: no.

Emissions /kg/h/

P010		V=12,000 Nm^3 /h	H_o = 7m
	flue dust	T=45℃	S=0.24m^2
P011		V=20,000 Nm^3 /h	H_o =14m
	flue dust	T=40℃	S=0.6 m^2
P012		V=1,500 Nm^3 /h	H_o =20m
	flue dust	T=25℃	S=0.6 m^2
P007		V=4,000 Nm^3 /h	H_o =10m
	flue dust	T=40℃	S=0.25m^2
P008		V=10 Nm^3 /h	H_o =9 m
	flue dust	T=40℃	S=0.03m^2

Chlorinating /4/

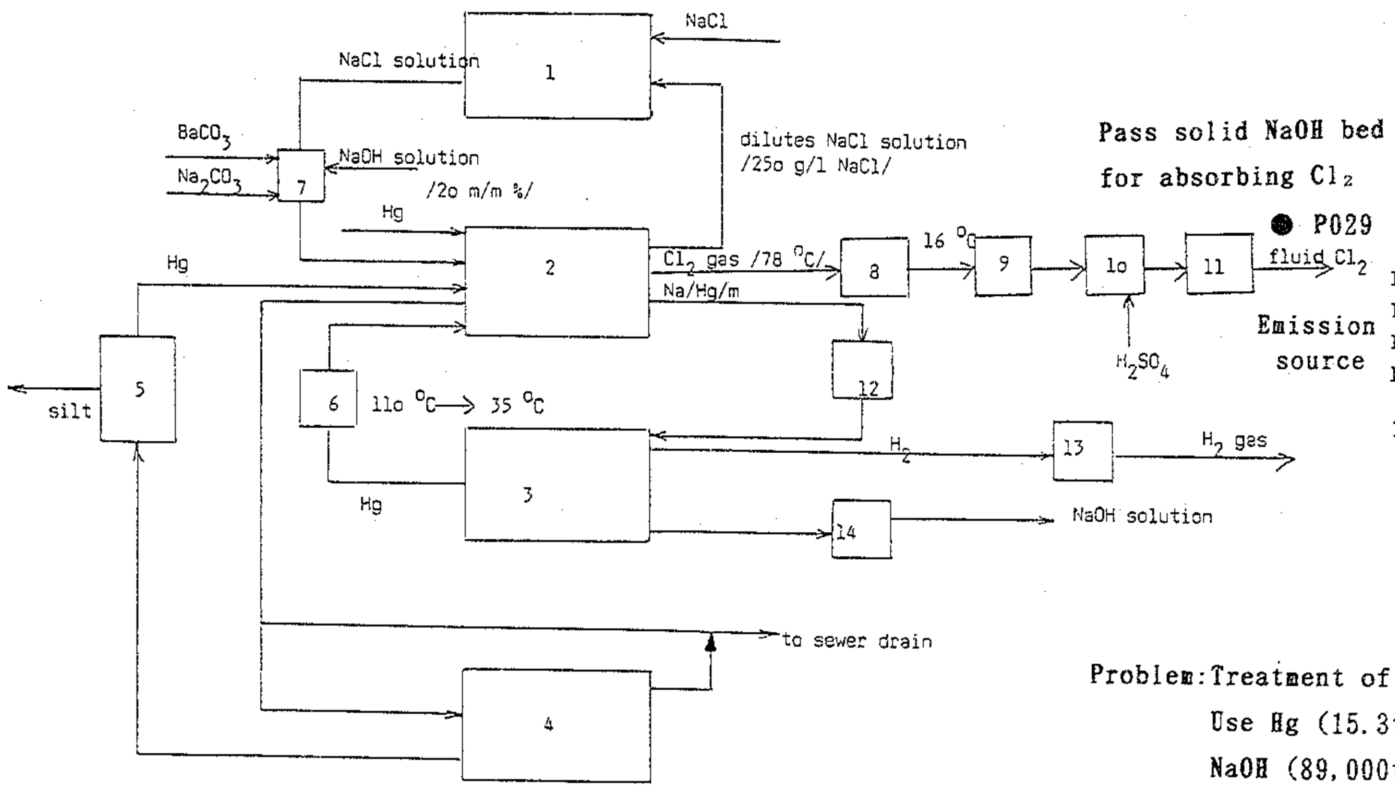
Utilized materials /charge

PE-suspension 3500 kg
/15m/m %/

ionexhanged water 2000 l
Cl_2 gas 580 kg
product/charge 750-800 kg CPE
production time/charge 15 hours
/10 chlorinating autoclaves are working in the factory/.

BORSODCHEM RT, KAZINBARCIKA

NaCl electrolysis



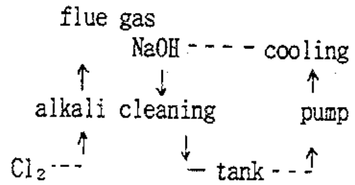
Signs:

1 - solver
2 - primer cell
3 - second cell
4 - exempt of sewage from Hg
5 - distillation
6 - cooler
7 - cooler and filter
8 - cooler
9 - filter with glass fibre
10 - dryer
11 - compressor
12 water clousure
13 - H_2 cleaning /active coal absorber/
14 - NaOH cleaning /active coal absorber/

Problem: Treatment of Hg

Use Hg (15.3t/year) for production of NaOH (89,000t/year) and Cl_2 (77,000t/year)

note: In case of emergency, Neutralization of Cl_2 is capable at 10~15 minutes.
Continuous processing can process up to 3t/h by liquid 20% NaOH
One Unit is operating in usually, but It's two units are to be operated in case of emergency.

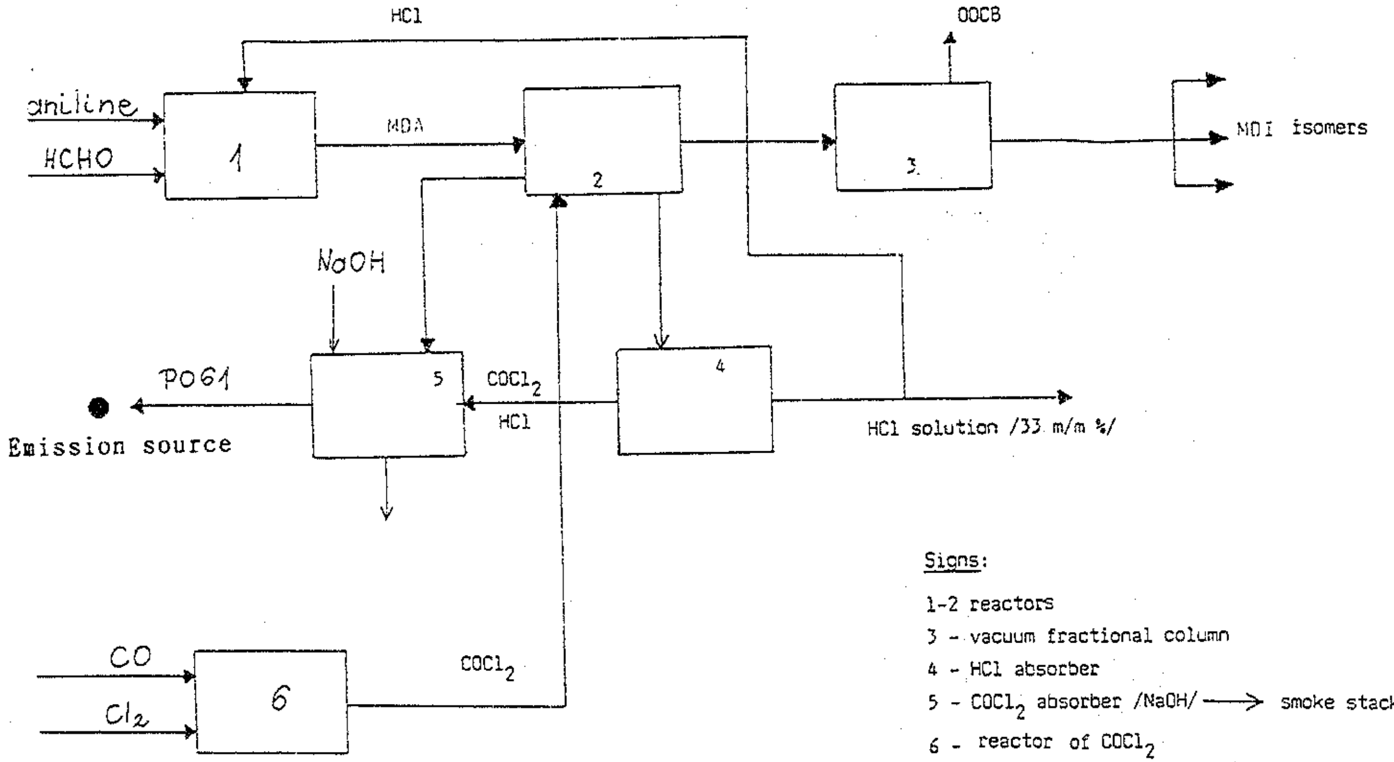


flue gas: 4000m³ /h, 25°C
Operating time is 8152 hours in 1992
(operating rate: 92.8%)
Operating rate is 99.9% in 1978

Figure D7.2.11 BORSODCHEM RT. - NaCl Electrolysis

BORSODCHEM RT. KAZINCBARCIKA

MDI synthesis



Signs:

1-2 reactors

3 - vacuum fractional column

4 - HCl absorber

5 - $COCl_2$ absorber /NaOH/ ⟶ smoke stack /Po61-$COCl_2$,CO/

6 - reactor of $COCl_2$

Utilized materials/hour	
aniline	1,27 t
HCHO	o,76 t
Cl_2	o,93 t
CO	322 Nm^3

Product /MDI/: 1,66 t/h

Emissions

Po61

$COCl_2$

CO

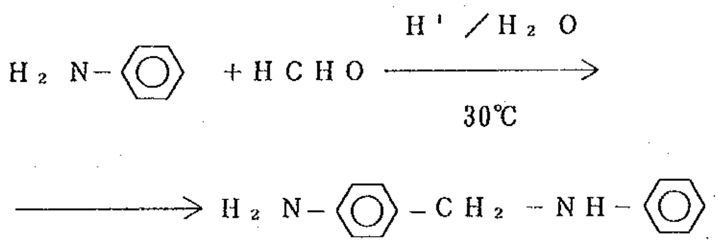
Figure D7.2.12 BORSODCHEM RT. - MDI Synthesis

BORSODCHEM RT. KAZINCBARCIKA

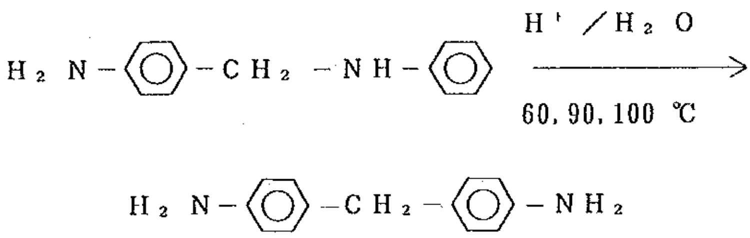
MDI synthesis

MDI=methylene methylene-diphenyl-di-isocyanate

1. Condensation /1/

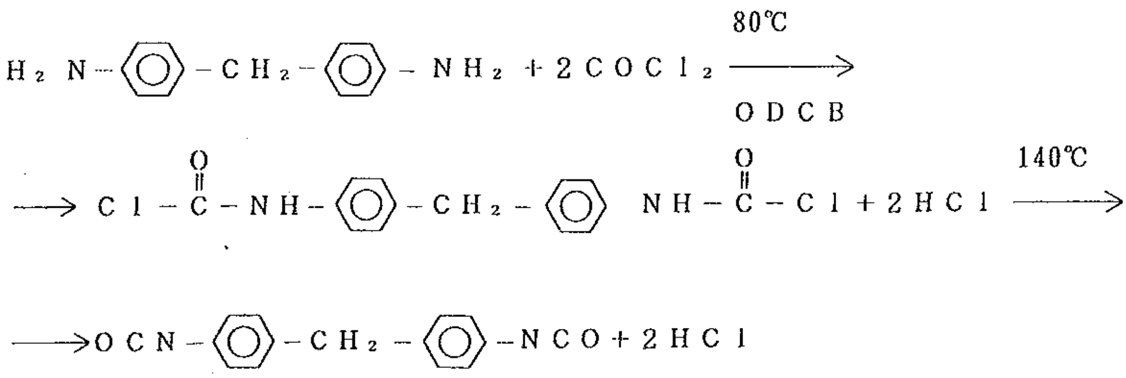


2. Regroup: in three steps /1/



MDA

3. MDI synthetize /2/



MDI

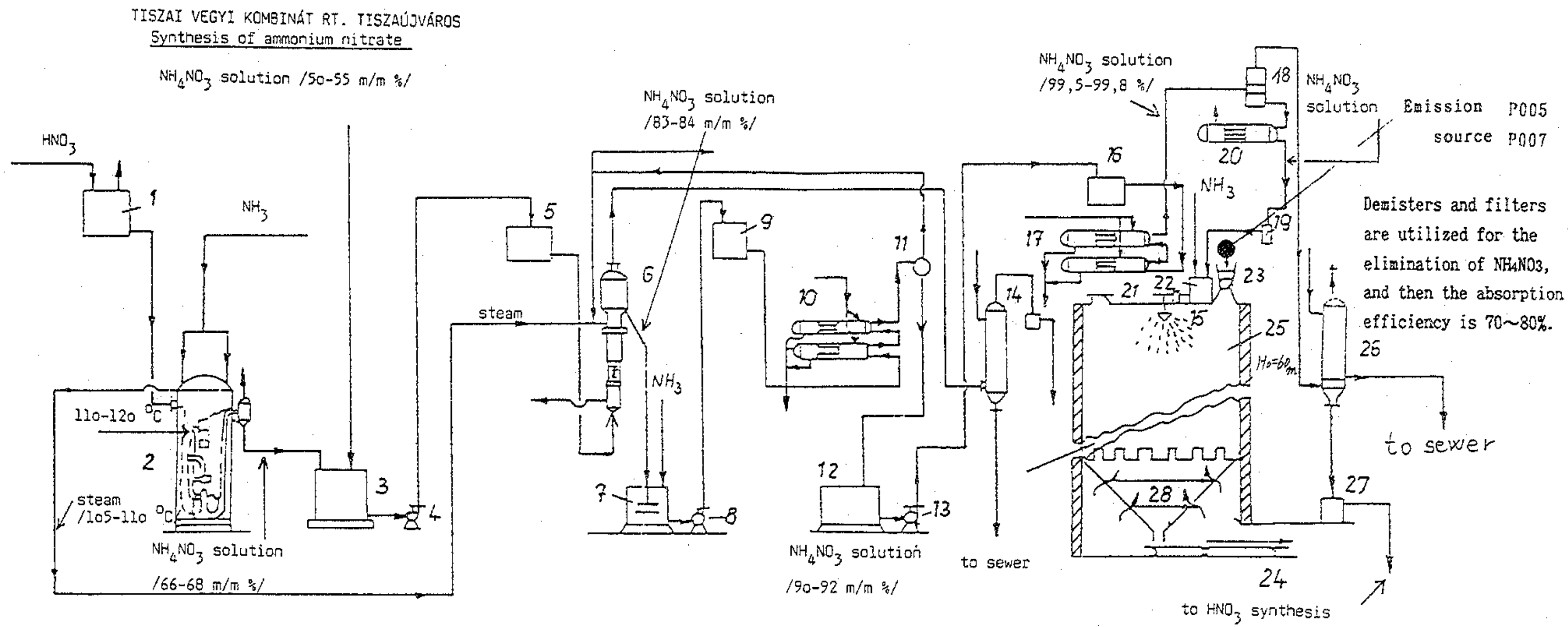
Product:

CR-MDI
M-MDI
P-MDI

Specific consumptions:

	per MDI ton
steam	28.9 GJ
electric energy	1502 KWh
aniline	0.79 t
HCHO	0.41 t
Cl_2	0.59 t
CO	0.20 t

Modernity of the technology: modern
Plans for the near future: no.



Signs:

1 - tank
2 - neutralizer
3 - tank
4 - pump
5 - tank
6 - steamer
7 - post-neutralizer
8 - pump
9 - tank
1o - steamer /155-16o °C/
11 - separator
12 - tank
13 - pump
14 - barometric condenser
15 - rotary granulator /centrifuge/
16 - tank
17 - steamer /168-17o °C/
18 - tank
19 - hydraulic closure
2o - film- steamer
21 - filter
22 - tank
23 - ventillator /Poo5, Poo7/
24 - conveyor
25 - spreading tower
26 - surface condenser
27 - tank of condensate
28 - fluidizing cooler

Emission /kg/h/
Poo5 or Poo7
flue dust 19,o (NH_4NO_3)
/at 35,8 t/h NH_3/

The probrem is exhaust of NH_4NO_3 from 23

Figure D7.2.13 TISZA I VEGYI KOMBINÁT RT. - Synthesis of Ammonium Nitrate

TISZAI VEGYI KOMBINAT RT., TISZAUJVAROS

Production of Ammonium nitrate /NH_4NO_3/

Technology:

$$HNO_3 + NH_3 \longrightarrow NH_4NO_3 \qquad /2/$$

Specific consumptions:

	per product ton
steam	0.37 t
electric energy	15 KWh
NH_3	0.42 t
HNO_3	0.79 t

Modernity of the technology: out-of date

Plans for the near future: no.

Utilized materials /t/h/

NH_3	25.0
HNO_3 /100m/m %/	49.4

Product /t/h/

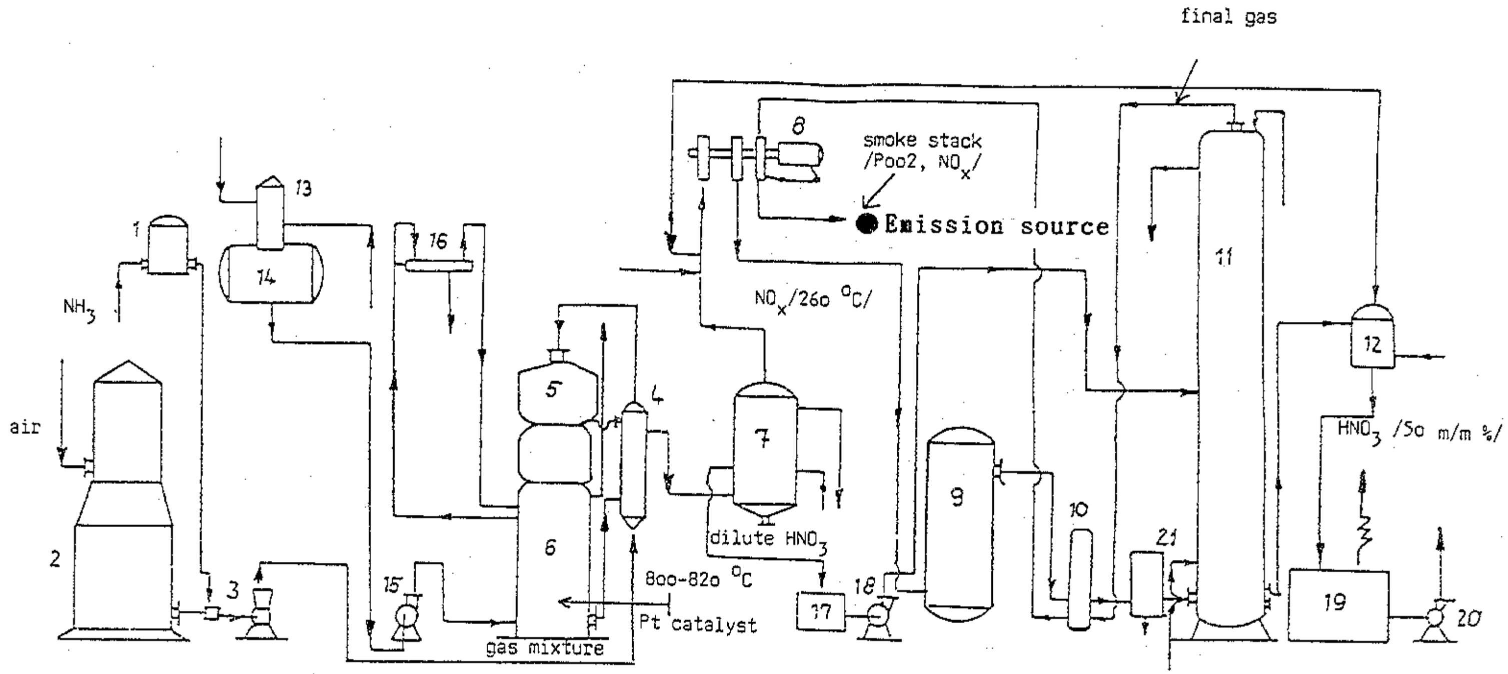
NH_4NO_3	62.5

Product /t/1992./

NH_4NO_3	72,164

TISZAI VEGYI KOMBINÁT RT, TISZAÚJVÁROS

Synthesis of Nitric Acid



Signs

1 - filter
2 - filter
3 - ventillator
4 - pre-heater
5 - filter
6 - reactor
7 - cooler-washing
8 - compressor
9 - oxidizer
1o - pre-heater of finalgas
11 - absorber
12 - decolouration tower
13 - degassing
14 - tank
15 - pump
16 - separator
17 - tank
18 - pump
19 - tank
2o - pump
21 - cooler

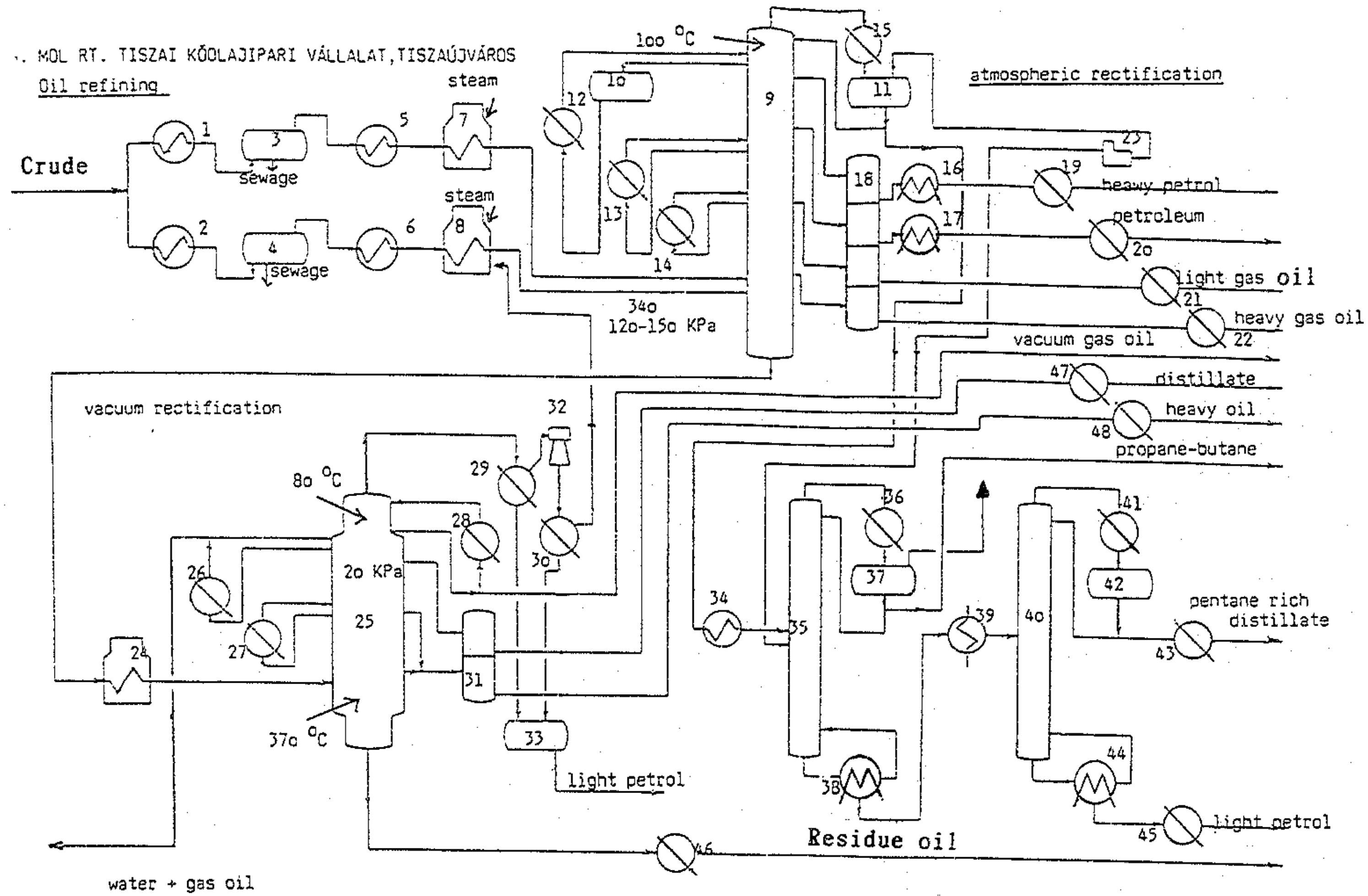
Emission /kg/h, Poo2/

NO_x 588

/No : NO_2 = 6o : 4o/=1100ppm:500ppm

/at 17.3oo Nm^3 NH_3 /hour/

Figure D7.2.14 TISZA I VEGYI KOMBINÁT RT. - Synthesis of Nitric Acid



Signs:

1 - heat exchanger
2 - " -
3 - separator
4 - " -
5 - heat exchanger
6 - " -
7 - pipe-still
8 - " -
9 - column

10 - reflux tank
11 - " -
12-17. - heat exchanger
18 - column
19-22. - heat exchanger
23 - compressor
24 - pipe-still
25 - vacuum column
26-30. - heat exchanger

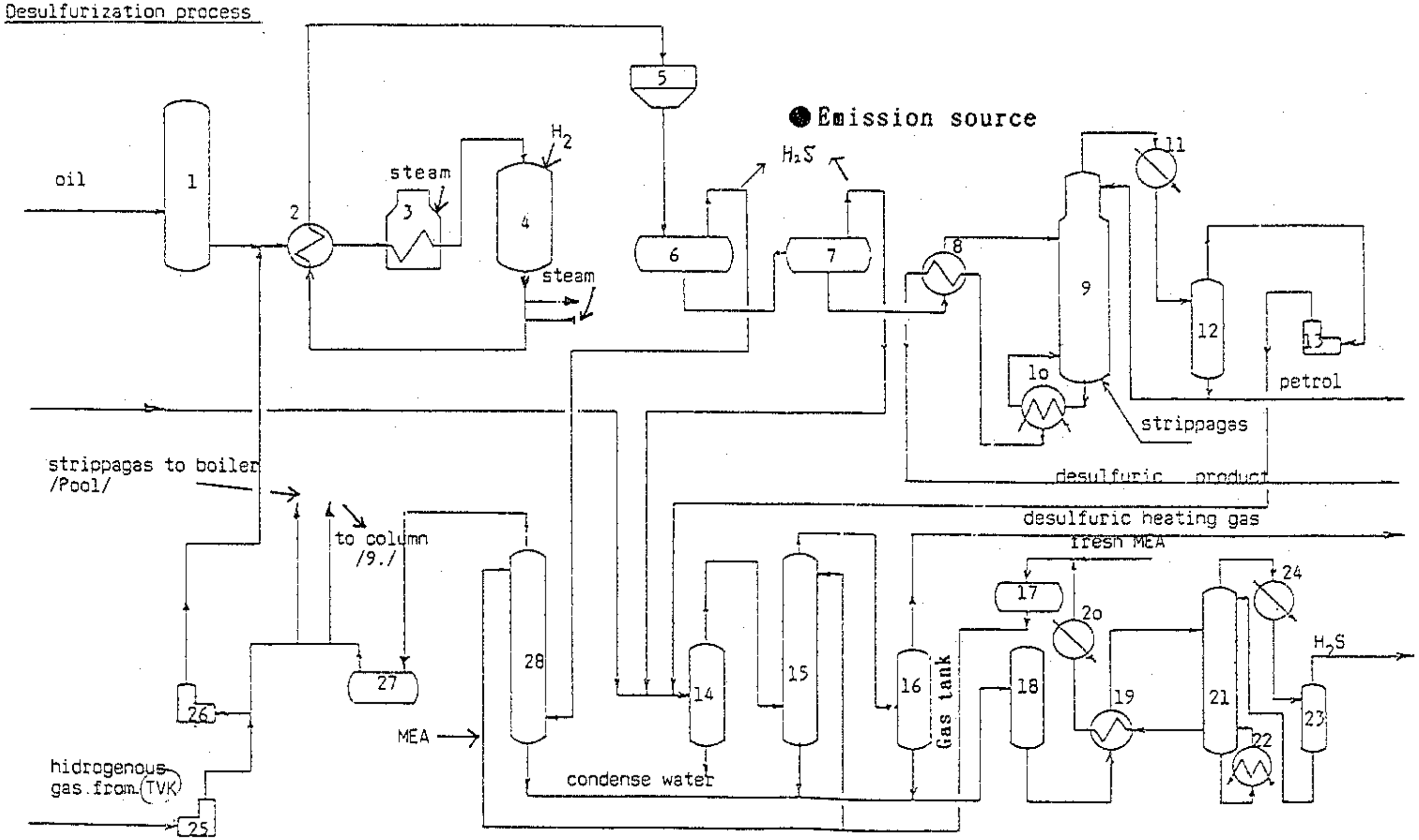
31 - stripper
32 - vacuum ejector
33 - reflux tank
34 - heat exhanger
35 - column
36 - heat exchanger
37 - reflux tank
38-39. heat exchanger
40 - column / re-running/

42 - reflux tank
43-48. - heat exchanger

Figure D7.2.15 MOL RT. - Oil Refining

MOL RT.TISZAI KÖOLAJIPARI VÁLLALAT TISZAÚJVÁROS

Desulfurization process



Signs:

1 - tank
2 - heat exchanger
3 - pipe-still
4 - reactor
5 - heat exchanger
6 - separator
7 - " -
8 - heat exchanger
9 - column
1o - heat exchanger
11 - " -
12 - separator
13 - compressor
14 - tank
15 - column
16 - tank
17 - tank
18 - tank
19 - heat exchanger
2o - " -
21 - column
22 - heat exchanger
23 - tank
24 - heat exchange equipment
25 - compressor
26 - -
27 - tank
28 - column

MEA = m - ethanol-amine /agent/

Pass amine system for absorbing sulfur.

Sulfur recovery (Ciaus method)

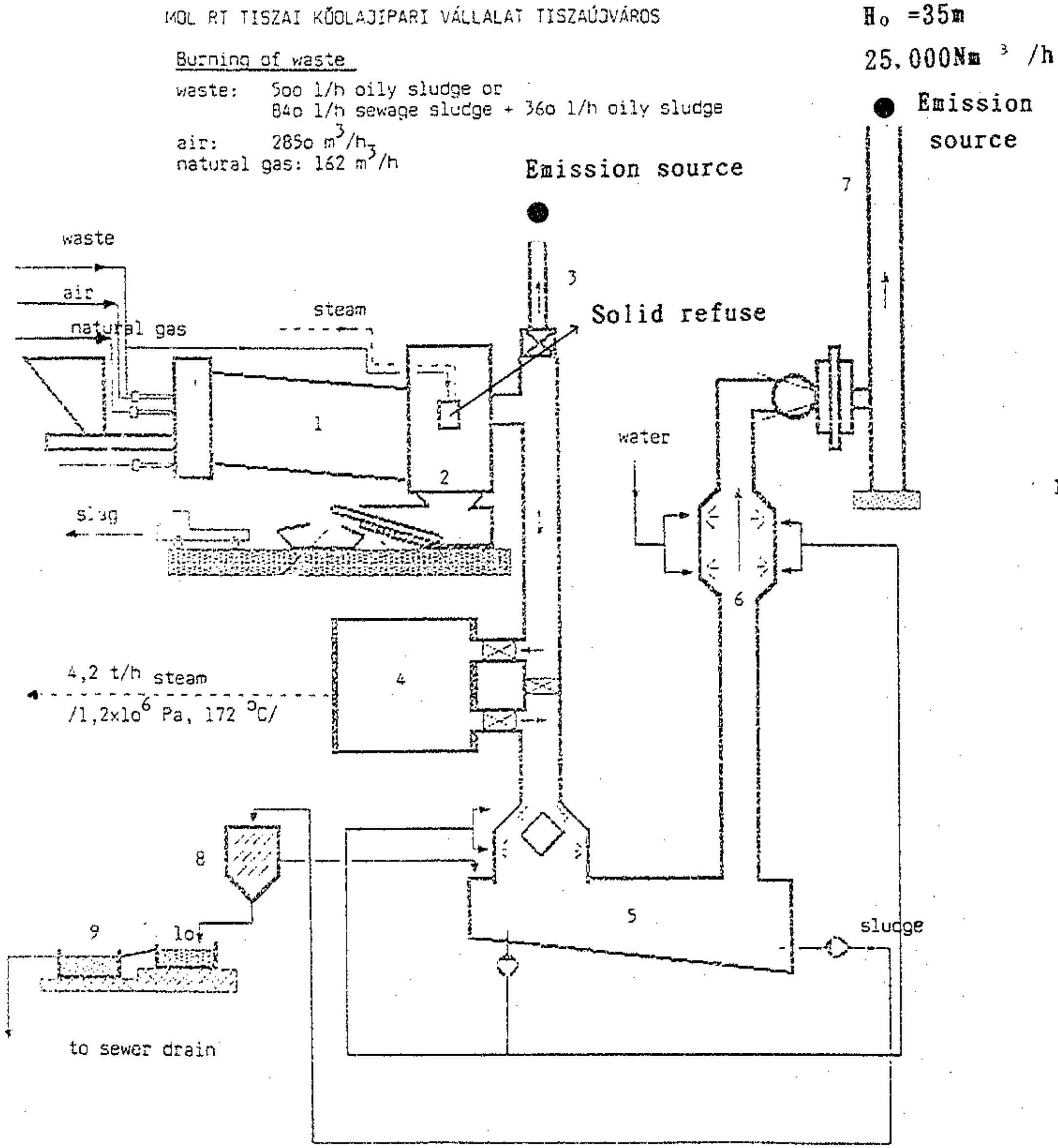
90%

3.400t/1992

SO2 exhaust value from sulfur recovery system

90-100kg

Figure D7.2.16 MOL RT. - Desulfurization Process

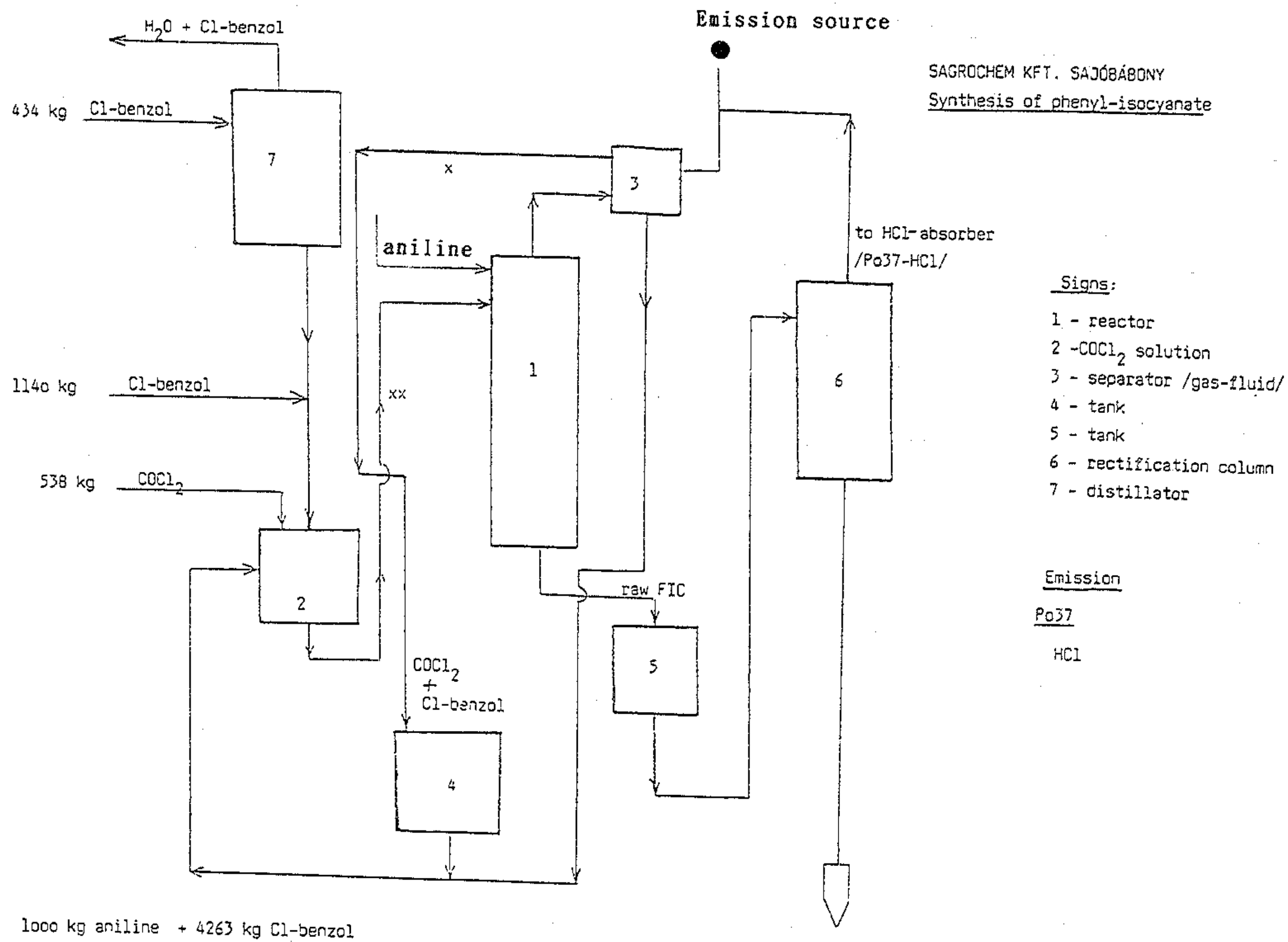


Signs:

1 - burning /revolving tube stile/
2 - post - burning /9oo-95o °C/
3 - emergency smoke stack
4 - exploit of thermal energy
5 - gas washing
6 - - " -
7 - smoke stack
/ Poo5 - CO, NO_x, SO_2, flue dust, CH/
8 - precipitator
9 - - " -
1o - - " -

Control Plan:modernize dust separaters

Figure D7.2.17 MOL RT. - Burning of Waste



x 1000 kg aniline + 4263 kg Cl-benzol

xx 583 kg $COCl_2$ + 1430 kg Cl-benzol

Production time /h/charge/: 11 hours

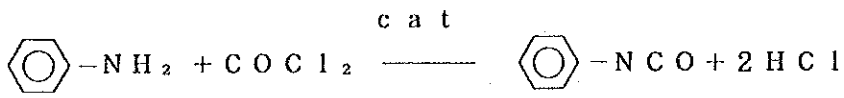
Production /t/1992/: 328,4

Product: FIC-solution
20 v/v %, 1325 kg FIC in 5535 kg Cl-benzol/

Figure D7.2.18 SAGROCHEM KFT. - Synthesis of Phenyl-Isocyanate

SAGROCHEM KET. SAJOBABONY

Synthesis of phenyl-isocyanate



aniline phosgene phenyl-isocyanate

Specific consumptions

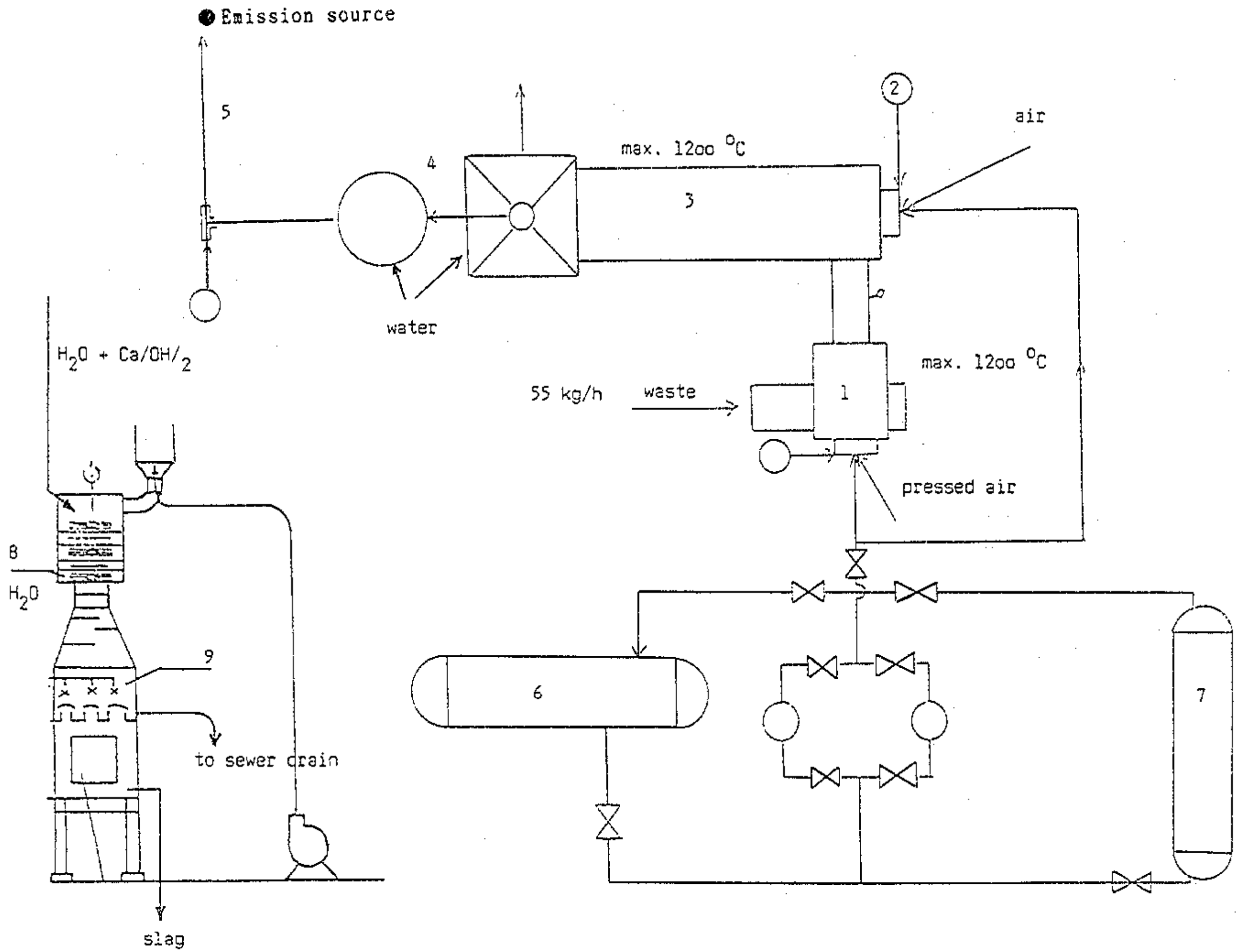
	per product ton
electric energy	160 KWh
steam	16 GJ
aniline	0.75 t
$COCl_2$	0.44 t

Modernity of technology: middling

Plans for the near future: no.

SAGROCHEM KFT , SAJÓBÁBONY

Burning of Waste



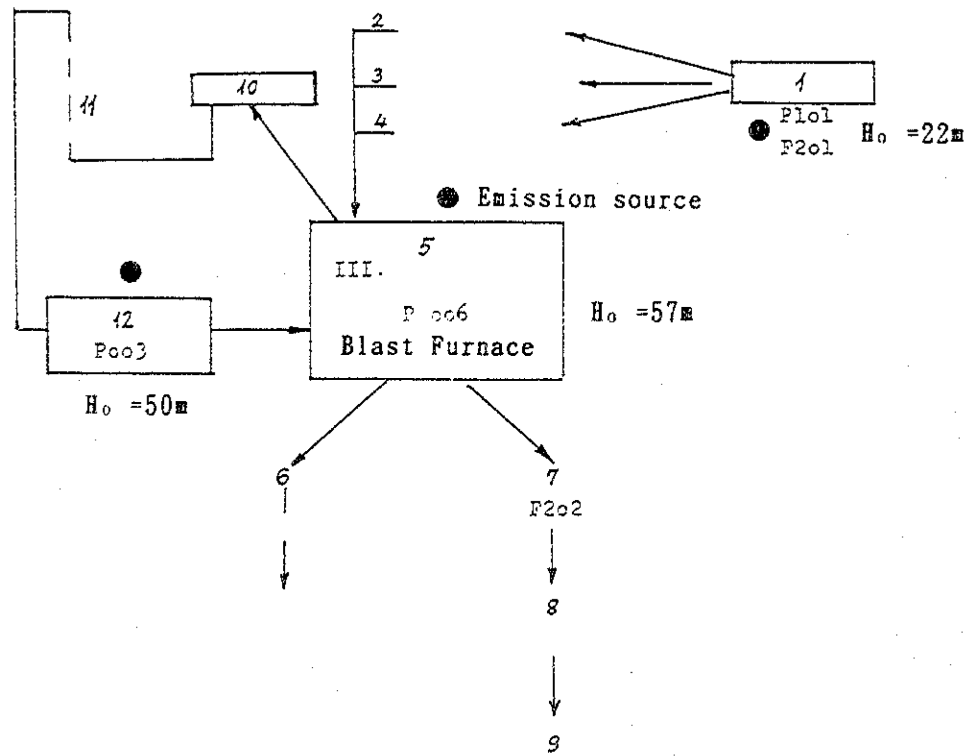
Signs:

1 - burning
2 - ventillator
3 - post - burning
4 - gas washing
5 - smoke stack
6 - tank of waste
7 - tank of oil
8,9 - gas washing

Modernity ot the technoloy: modern
Plans for the near future: no

Emissions /mg/Nm^3/	
CO	8,o
NO_x	25o,o
CH /C/	3,o
HCl	2o,o
flue dust	9,o

Figure D7.2.19 SAGROCHEM KFT. - Burning of Waste



DIÓSGYŐRI NEMESACÉL MŰVEK KFT. F.A. MISKOLC

Pig-iron production

Signs:

1 - shelter
2 - iron-bearing
3 - coke
4 - limestone
5 - smelting-furnace
6 - slag /slag storing/
7 - pig-iron discharge
8 - pig-iron
9 - steel-works
1o - pipe gas
11 - cyclone
dust bag
electrofilter
12 - air-heating (200℃ 49.629 m³ /h)

Emission:

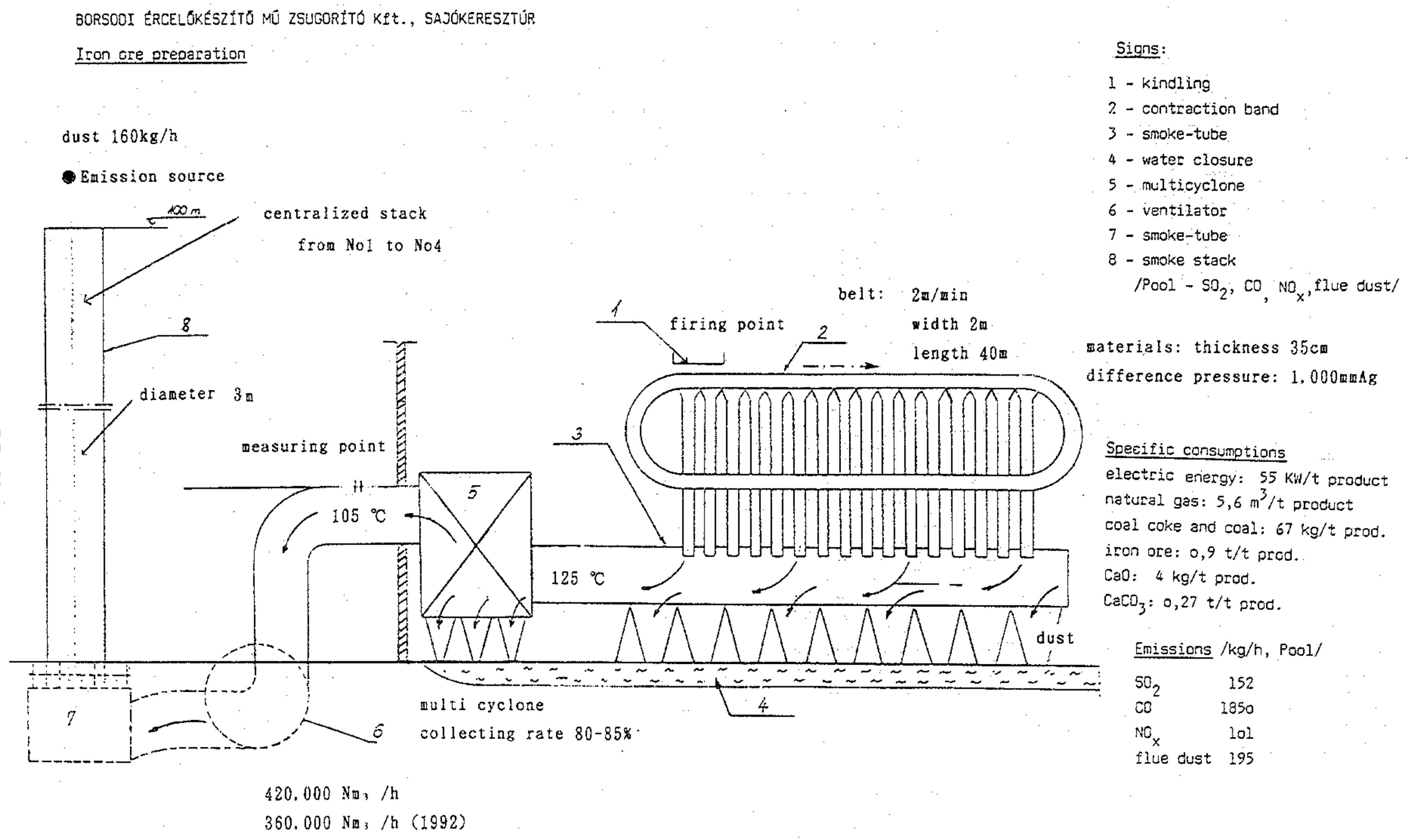
Poo3	CO: o,35 kg/h
	NO_x: o,15 kg/h
	solid: 1,48 kg/h
Poo6	CO: 1296 kg/h
Blast furnace	NO_x: 1,7 kg/h
	solid : 98,5 kg/h
	BFgas 19.619.700m³ exhaust
P1o1	solid: o,18 kg/h

Modernity ot the technology:
out-of-date

Plans for the near future: nl

* To be phased out in future

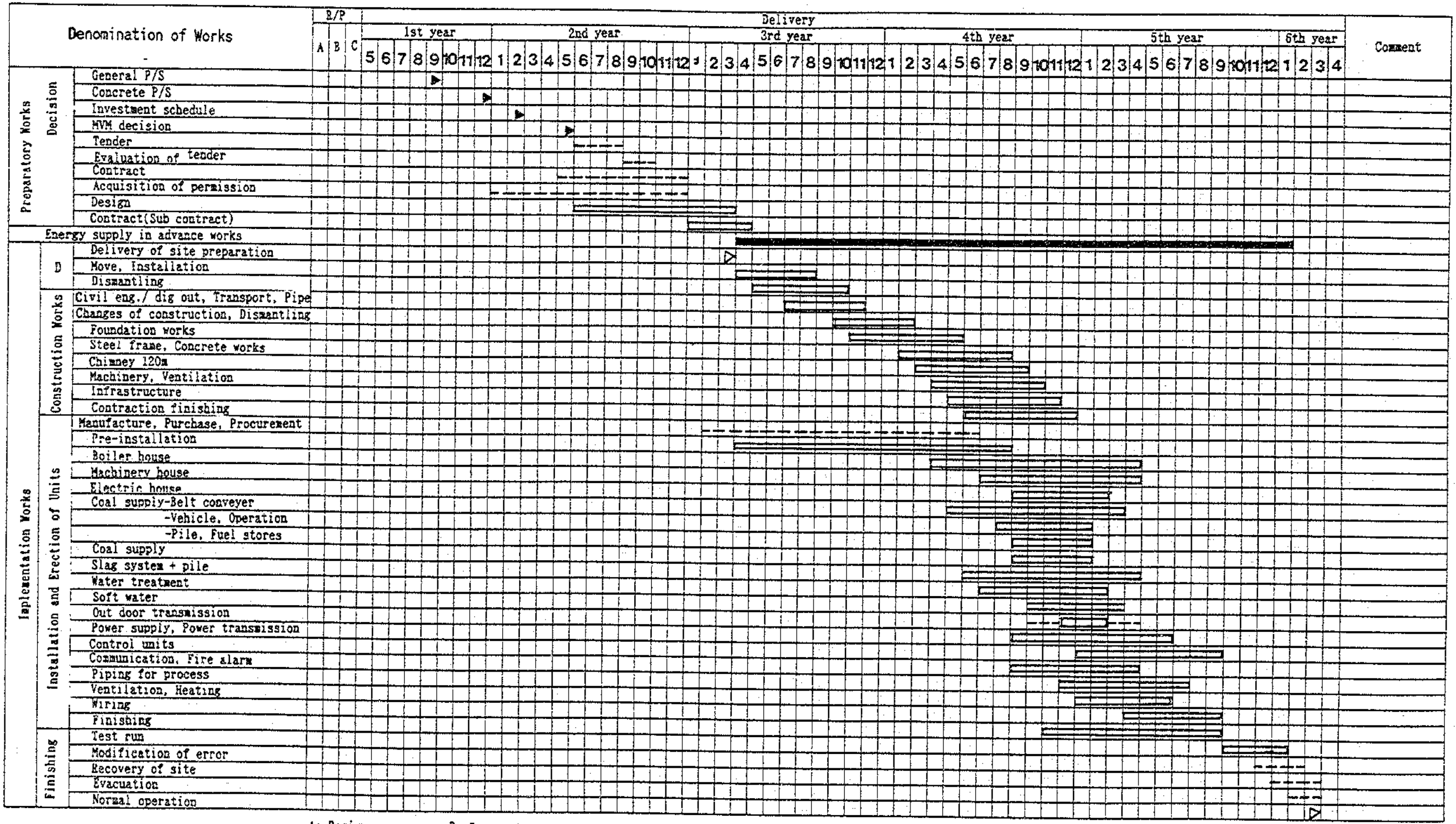
Figure D7.2.20 DIÓSGYÖRI NEMESACÉL MÜVEK KFT. - Pig-Iron Production



* To be phased out in future

Figure D7.2.21 BORSODI ÉRCLÖKÉSZÍTö Mü ZSUGORÍTÓ KFT - Iron Ore Preparation

BORSOD POWER PLANT
Implementation Schedule



A: Designer
B: Orderer
C: Sub contract
B/P: Responsible persons
D: Preparatory

Figure D7.2.22 Implementation Schedule for 150MW Unit in Borsod Power Station

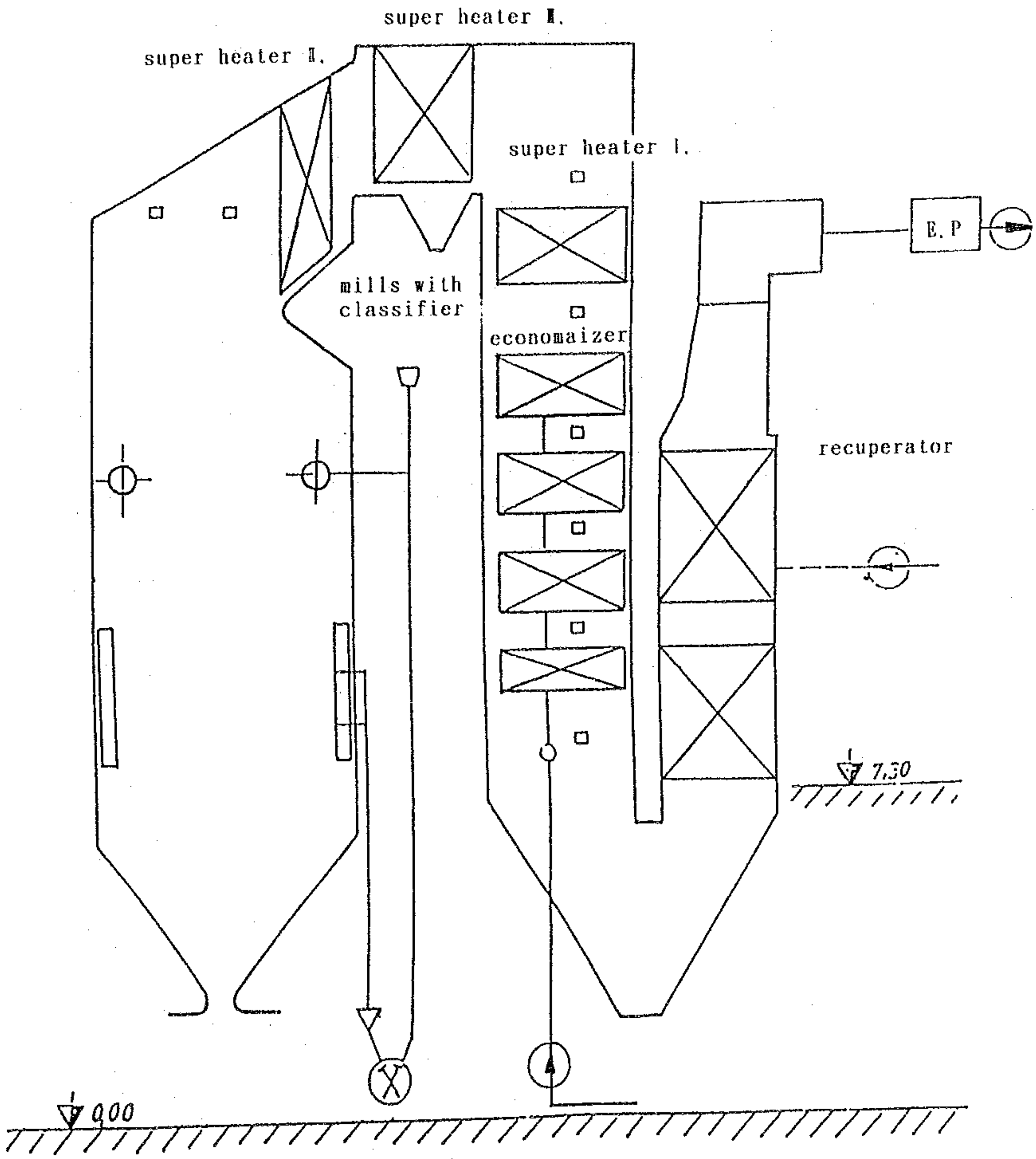


Figure D7.2.23 Boiler Surface of the Planned 100 t/h HFBC Boiler for Borsod Power Plant

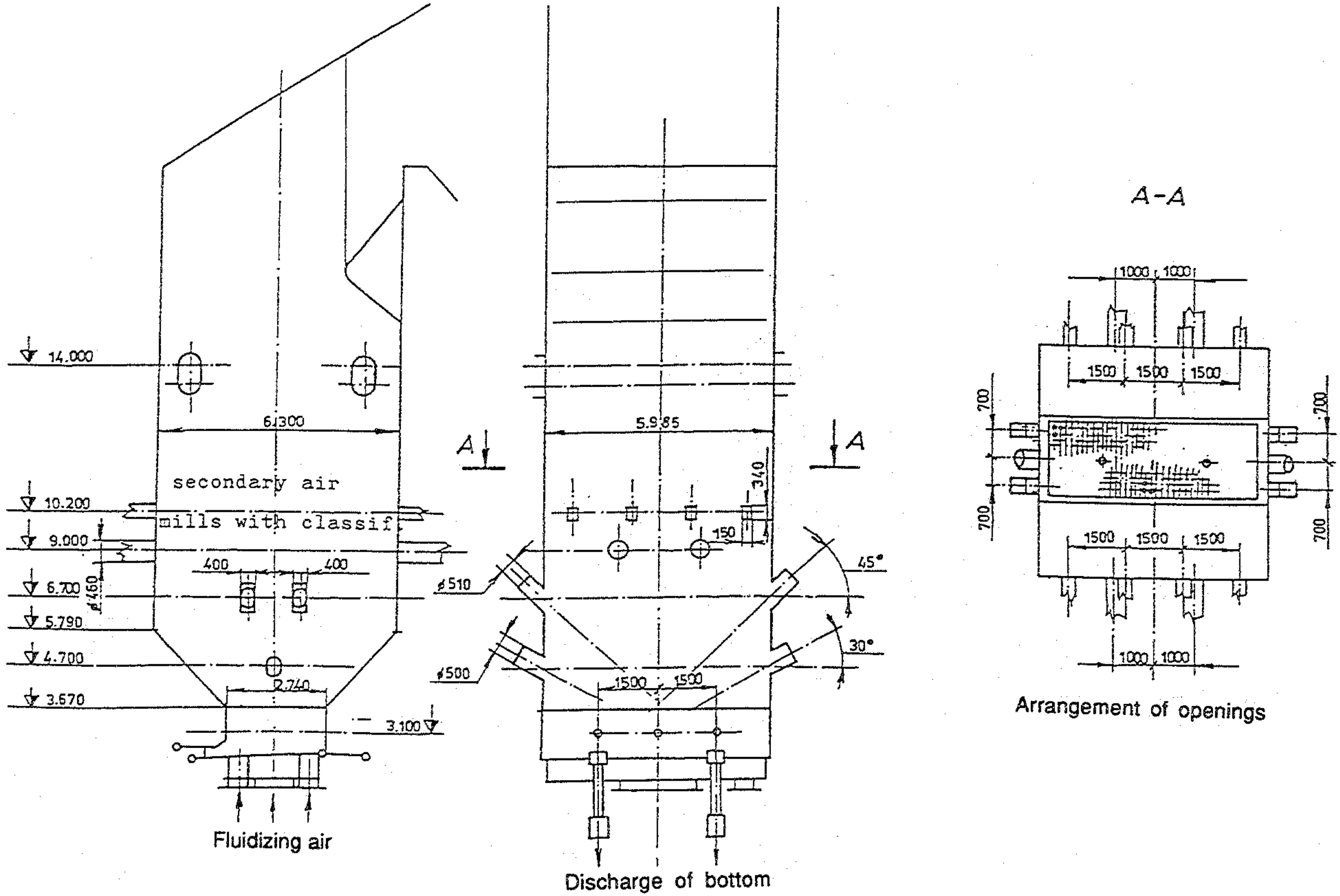


Figure D7.2.24 Arrangement of Air Distributor, Air Blow, Burners and Coal-dust Discharge for Planned HFBC Boiler in Borsod Power Station

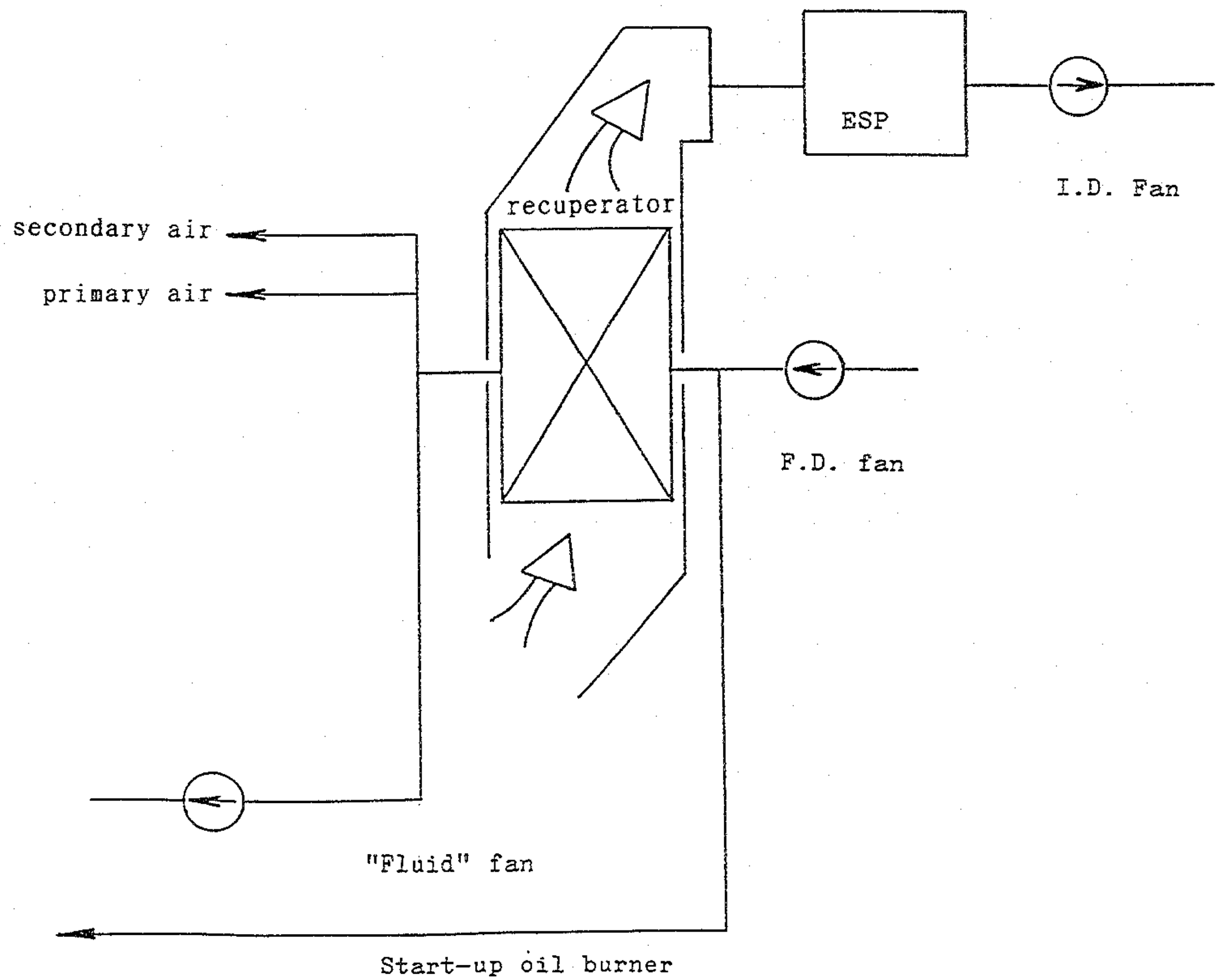


Figure D7.2.25 Scheme of Combustion Air for Planned HFBC Boiler in Borsod Power Station

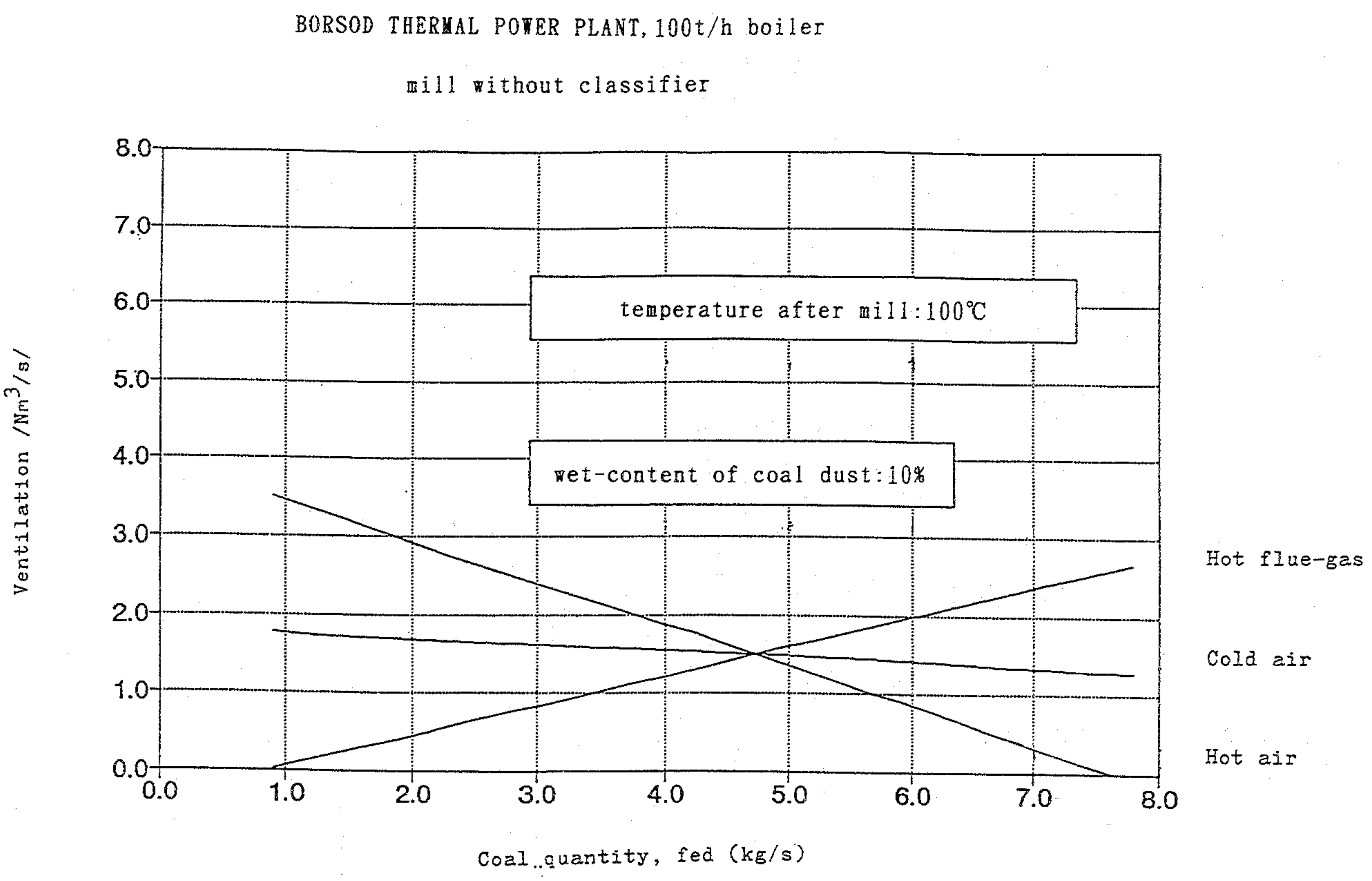


Figure D7.2.26 Result of Heat Balance Calculation (1) (HFBC Boiler for Borsod Power Station)

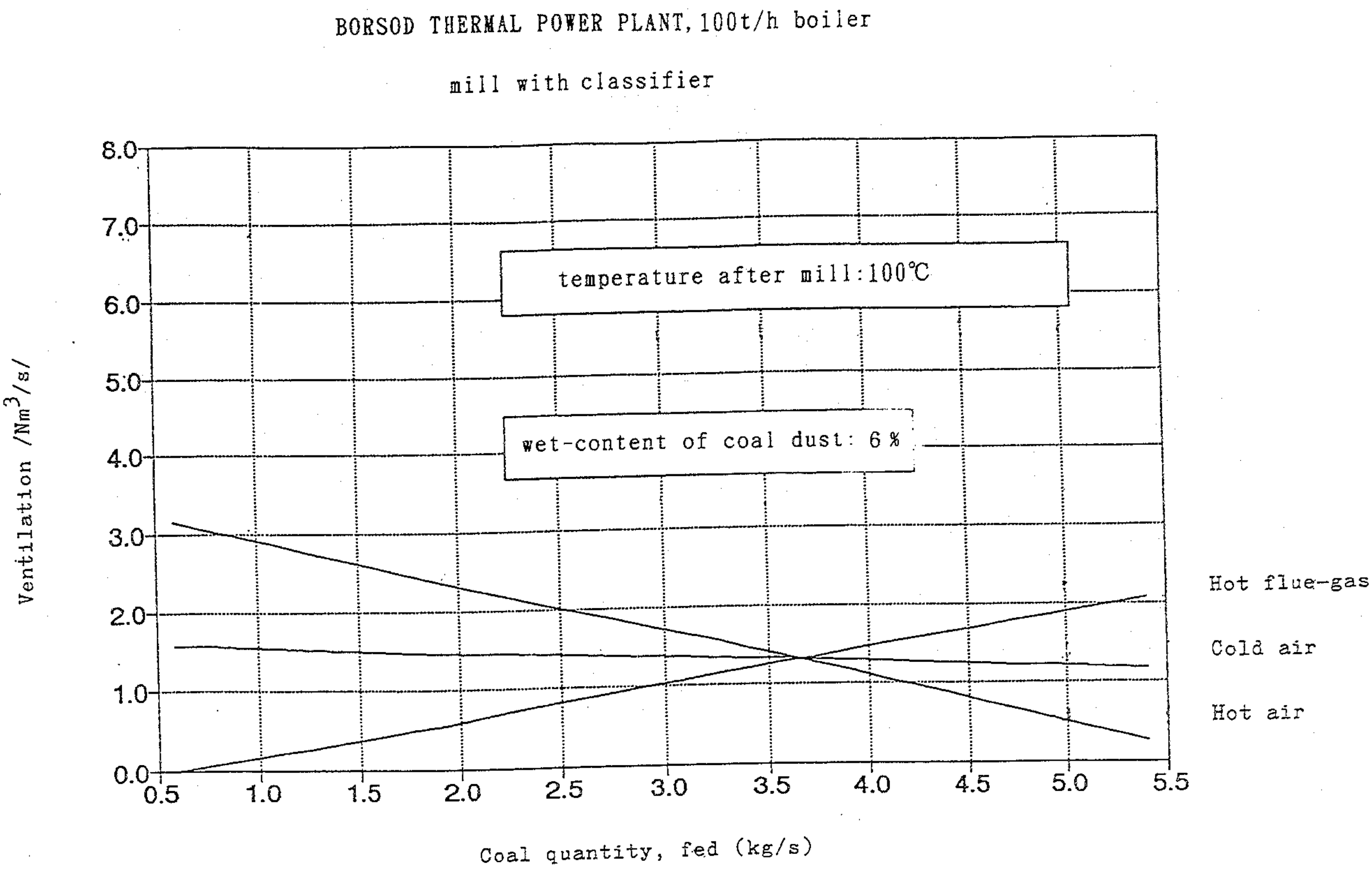


Figure D7.2.27 Result of Heat Balance Calculation (2) (HFBC Boiler for Borsod Power Station)

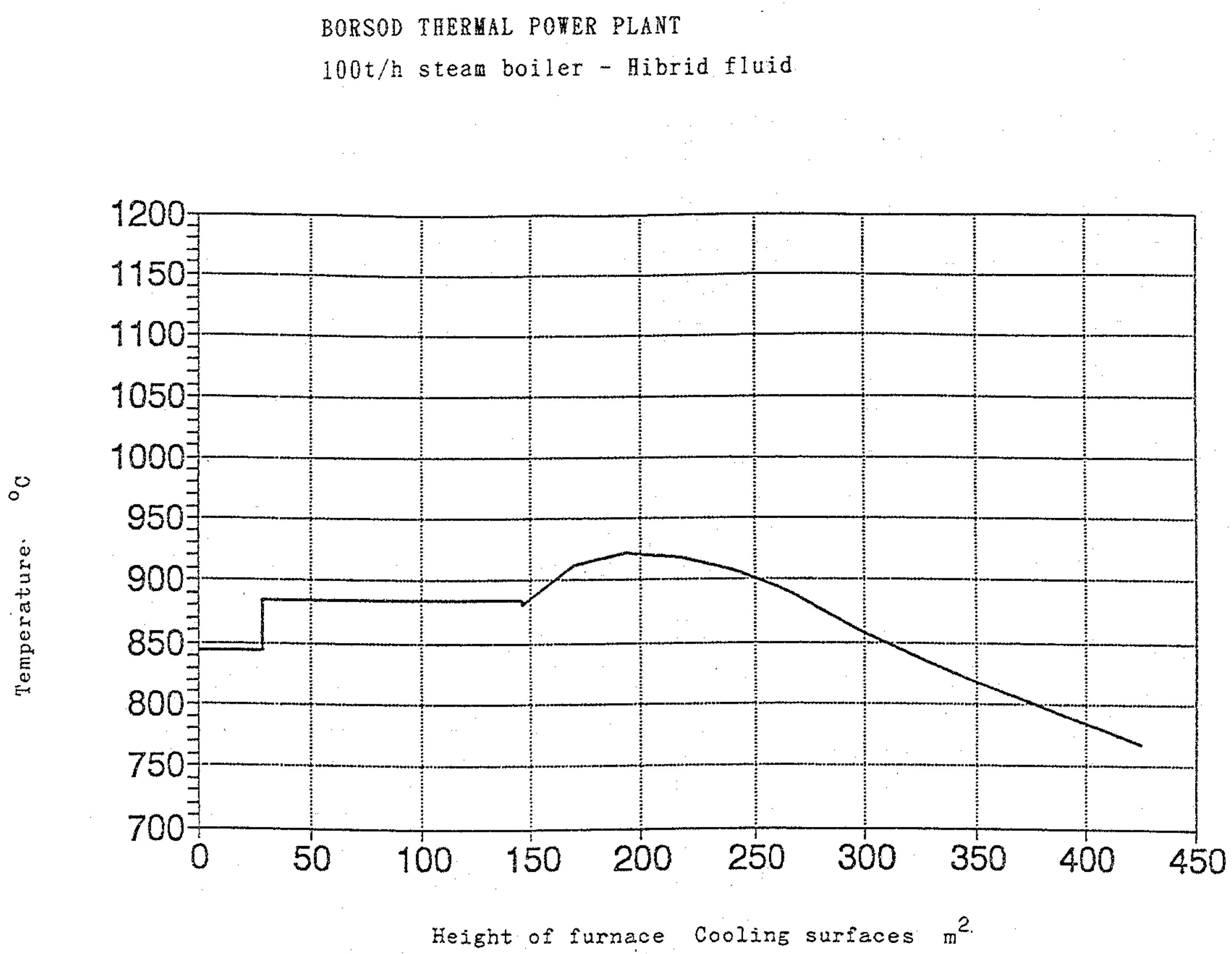
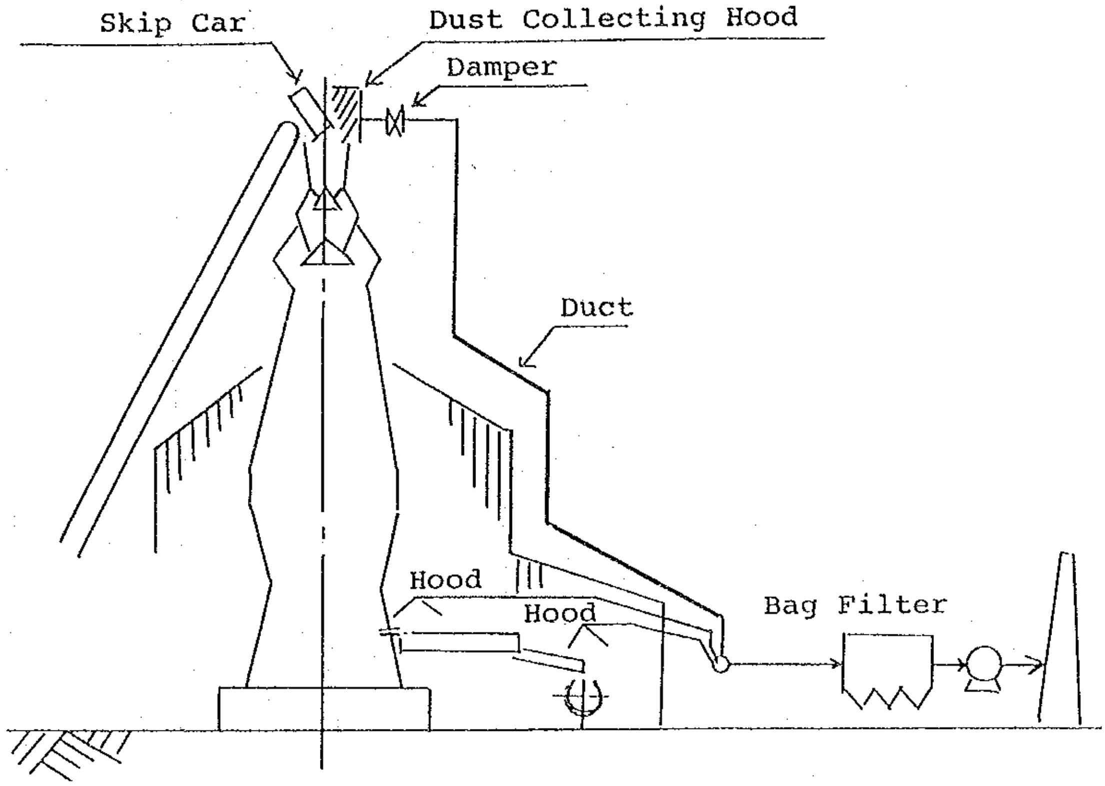


Figure D7.2.28 Furnace Heat Distribution (HFBC Boiler for Borsod Power Station)



* To be phased out in future

Figure D7.2.29 Dust collecting System for the Emission from the Casting Floor and Furnace Top in DNM Recommended by UNIDO

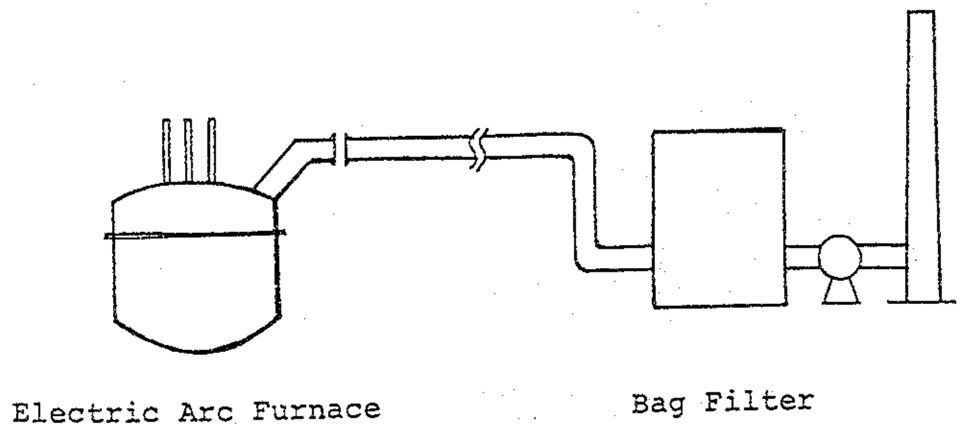


Figure D7.2.30 Dust collecting System for Electric Arc Furnace Recommended for DNM by UNIDO

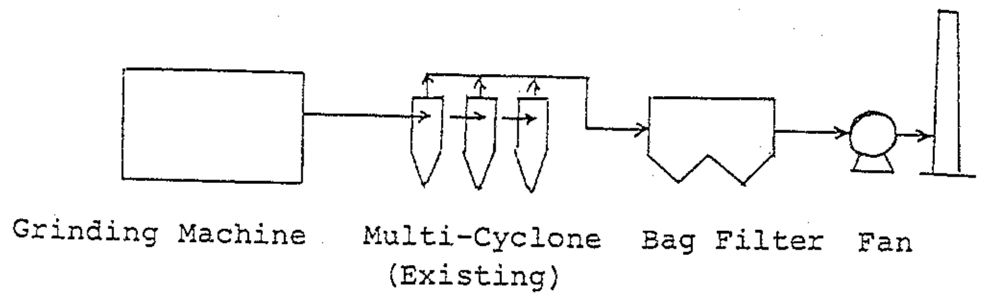


Figure D7.2.31 Dust collecting System for Grinding Machine Recommended for DNM by UNIDO

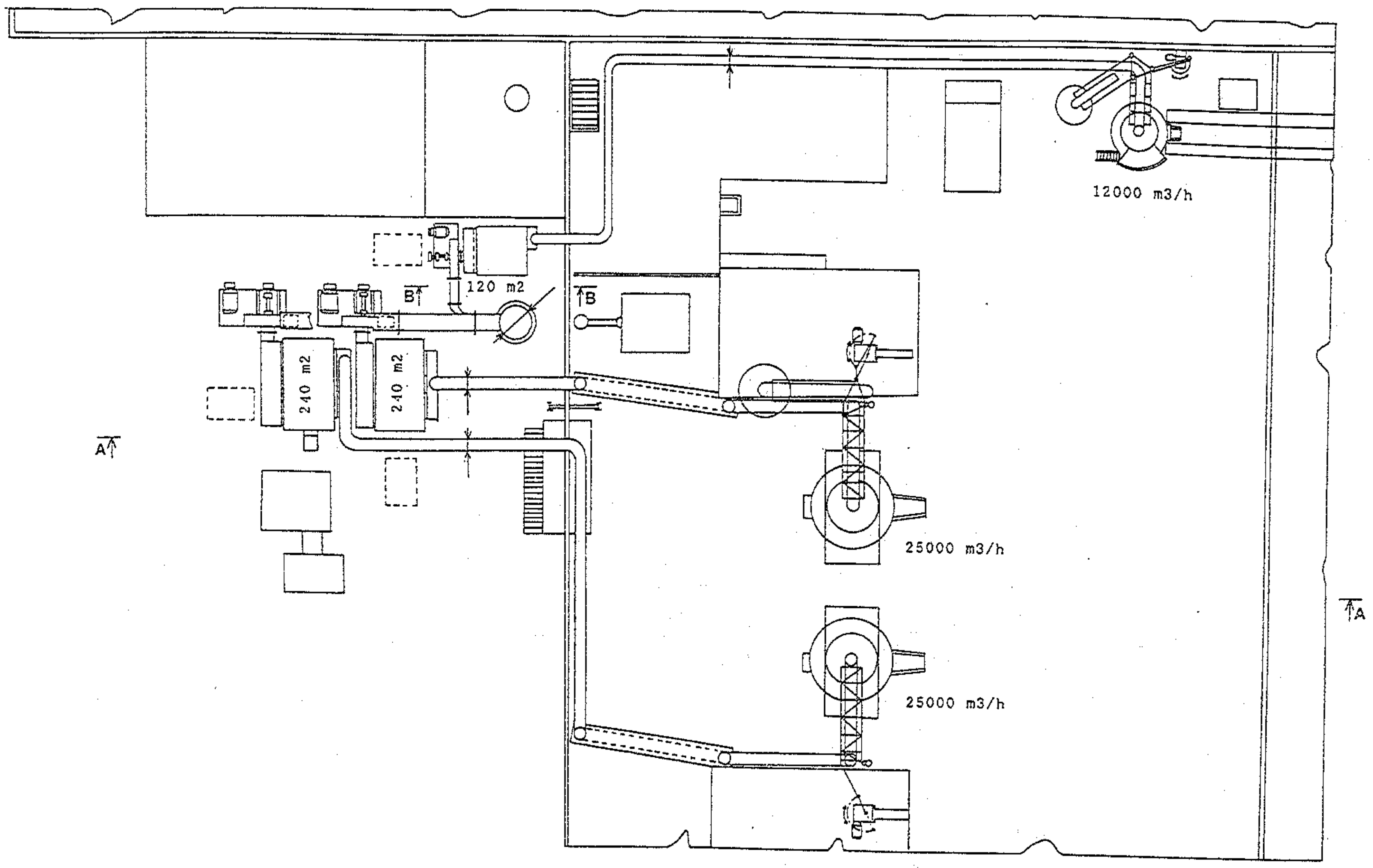


Figure D7.2.32 General Configuration of Suction Device and Dust Collector (planned in DAV)

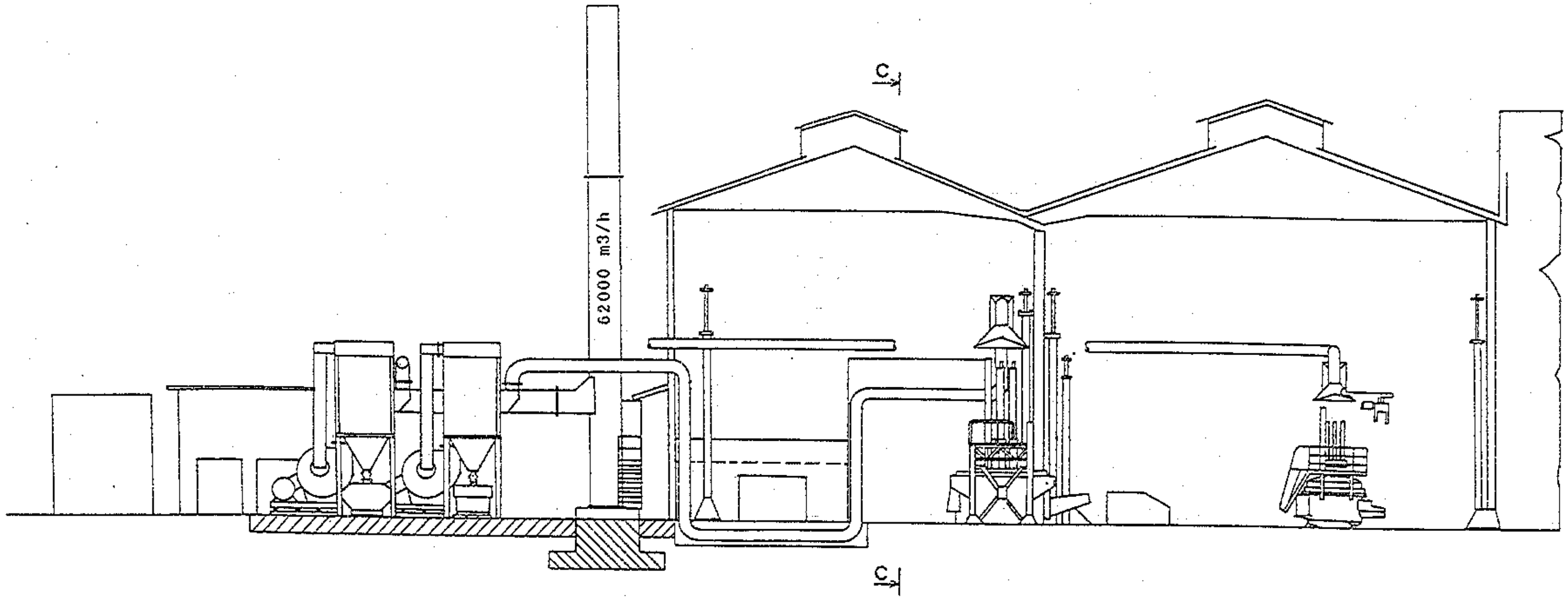


Figure D7.2.33 A - A Cross Section of Figure D7.2.32 (planned in DAV)

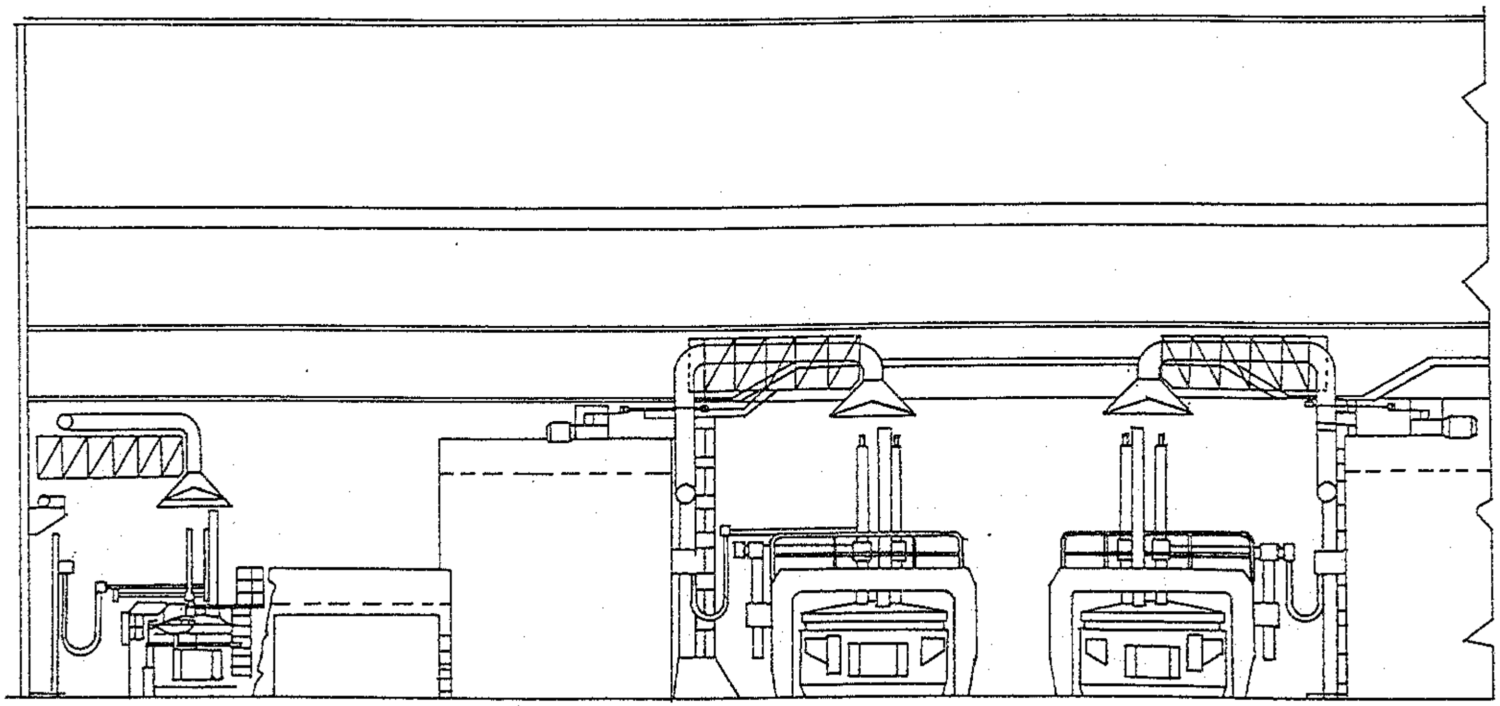


Figure D7.2.34 C - C Cross Section of Figure D7.2.33 (planned in DAV)

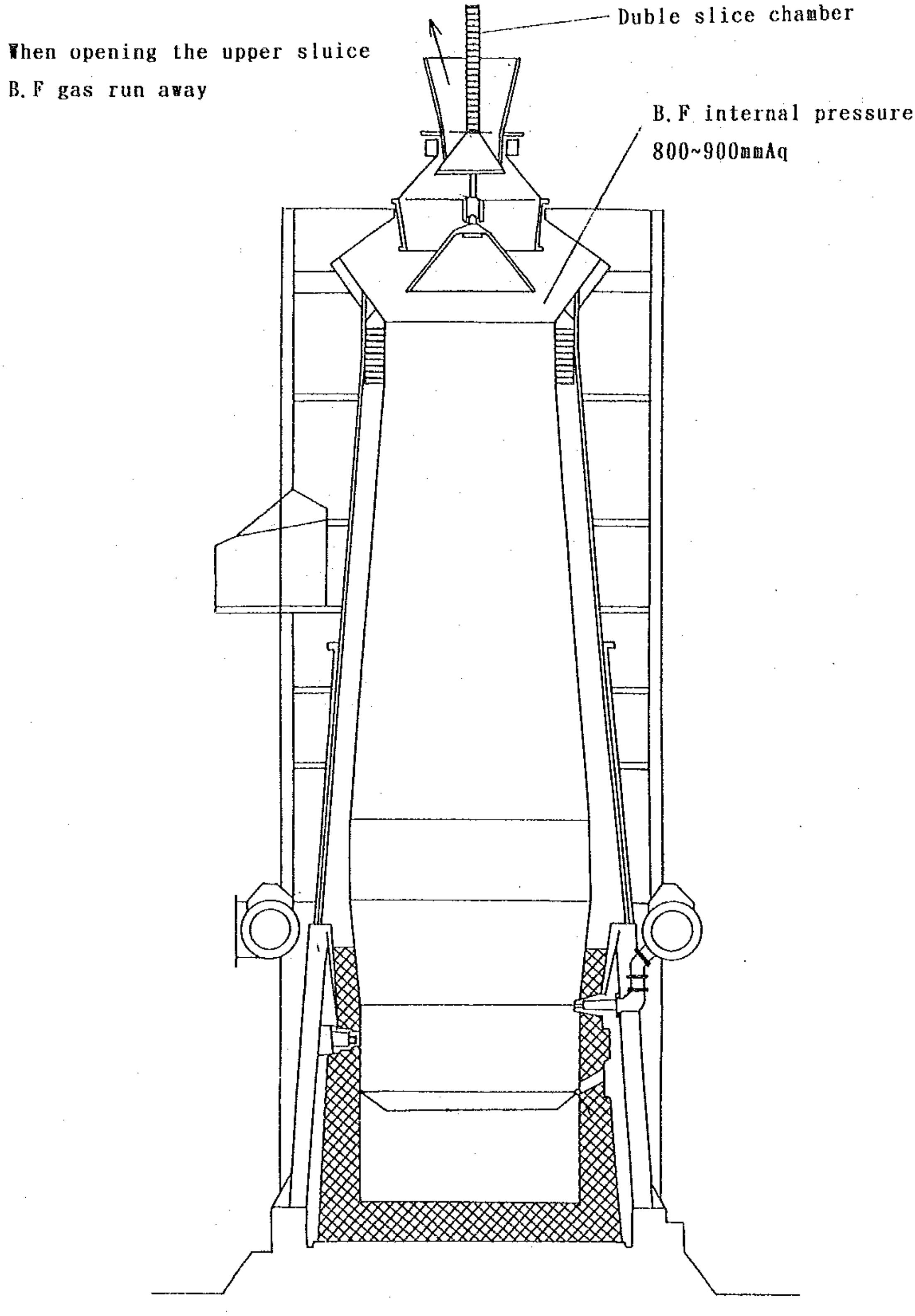


Figure D7.2.35 Blast Furnace of DNM

Combustion equipment that low calorie gas are burning

The combustion equipment use low calorie gas fuel example for blast furnace gas exhausting from iron mill. Thermal NOx is low and NOx concentration is 20ppm (02=12%) to give an case example.

The combustion equipment have two features. One is the fuel nozzle which mix large amount of fuel gas and air in optimum condition. Another cooling structure at surface of the combustion equipment effectively.

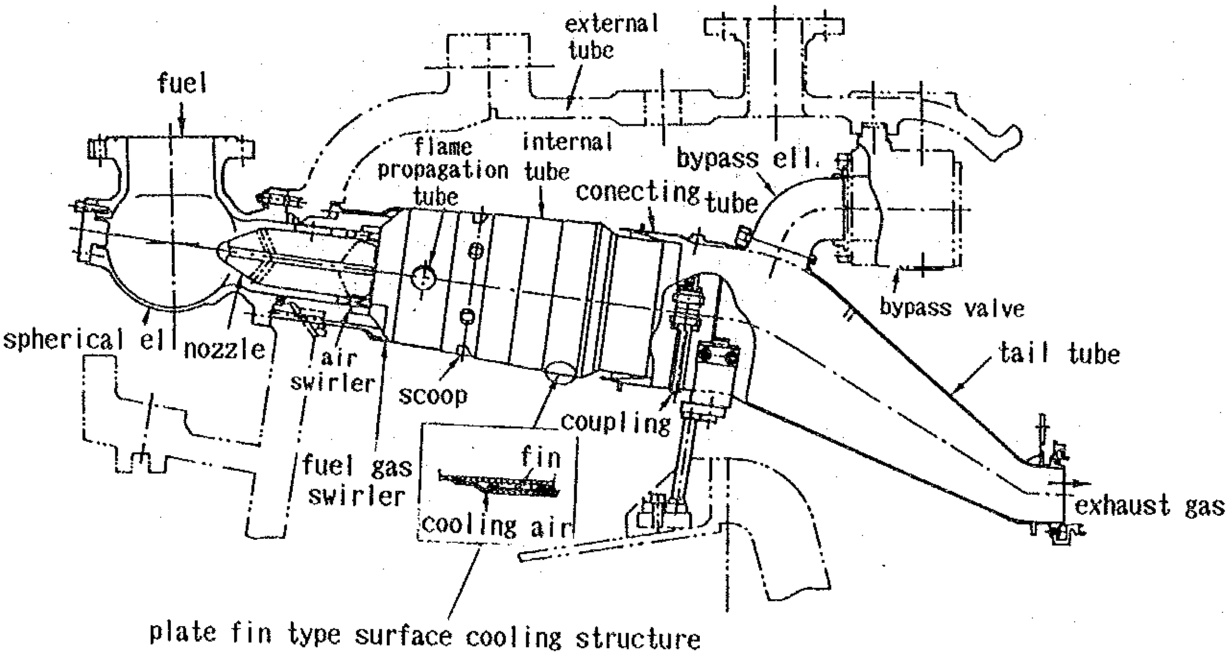


Figure D7.2.36 Combustion Equipment for Low Calorie Gas

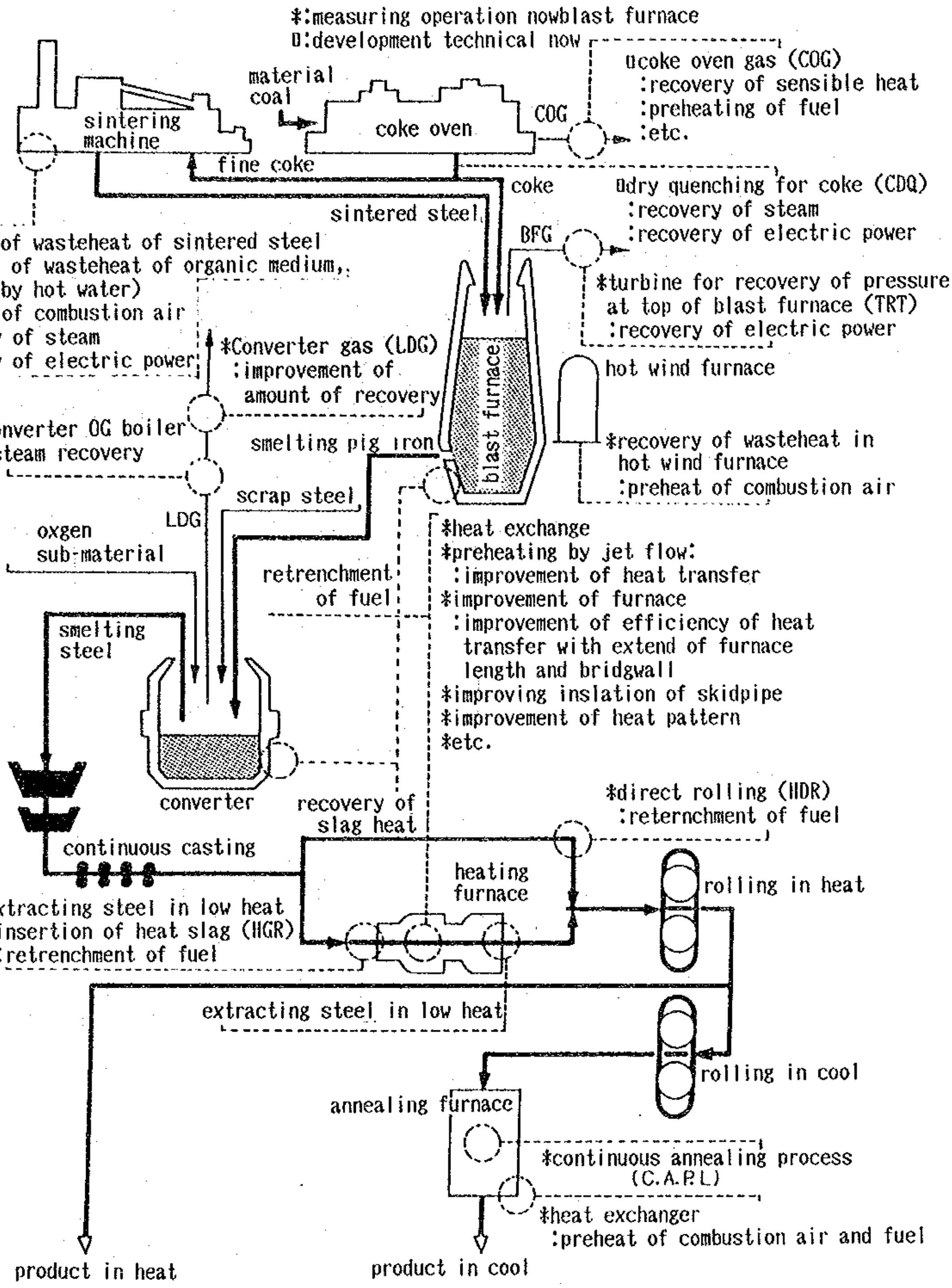


Figure D7.2.37 Principal Measures for Energy Saving in Iron Factories

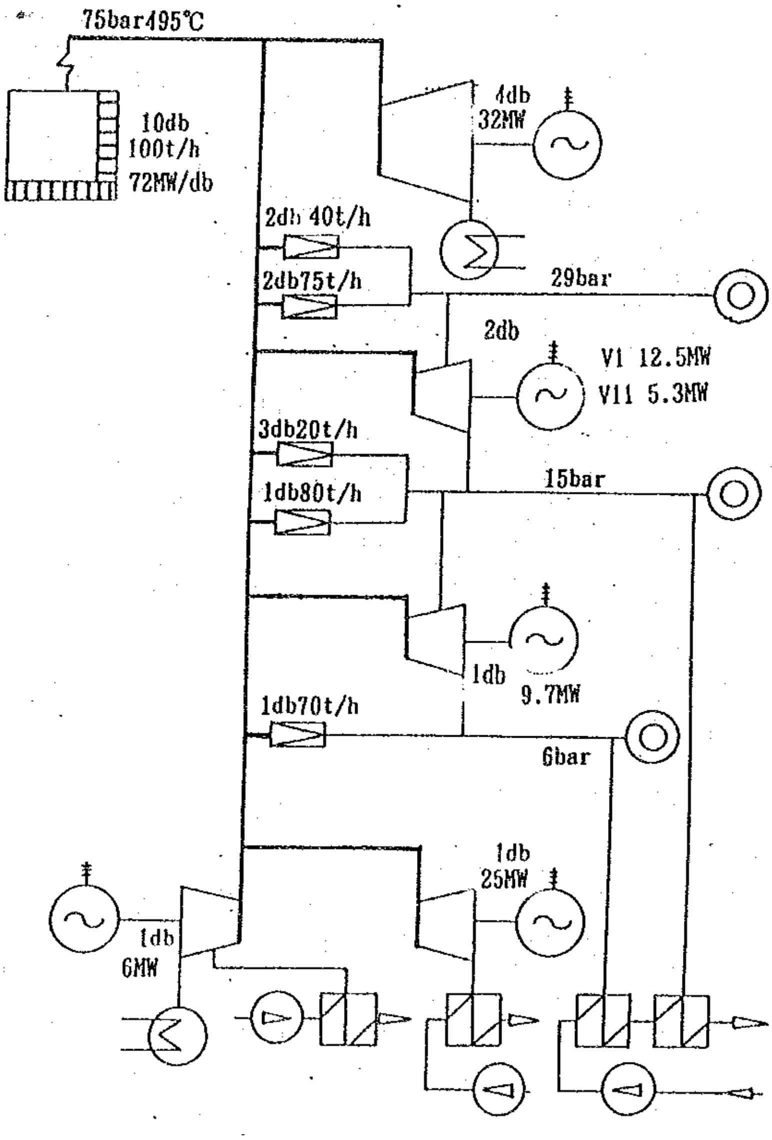


Figure D7.2.38 Flow Sheet for Power Generation and Heat Supply in BORSOD Power Plant

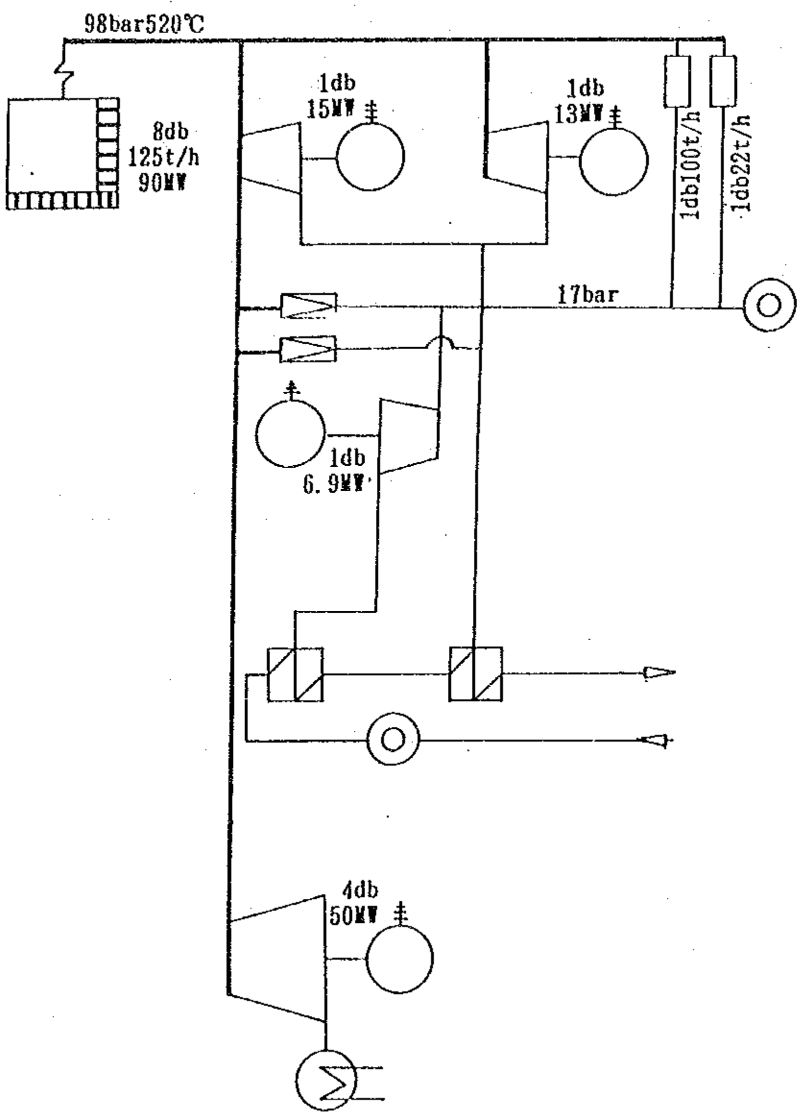


Figure D7.2.39 Flow Sheet for Power Generation and Heat Supply in TISZA I Power Plant

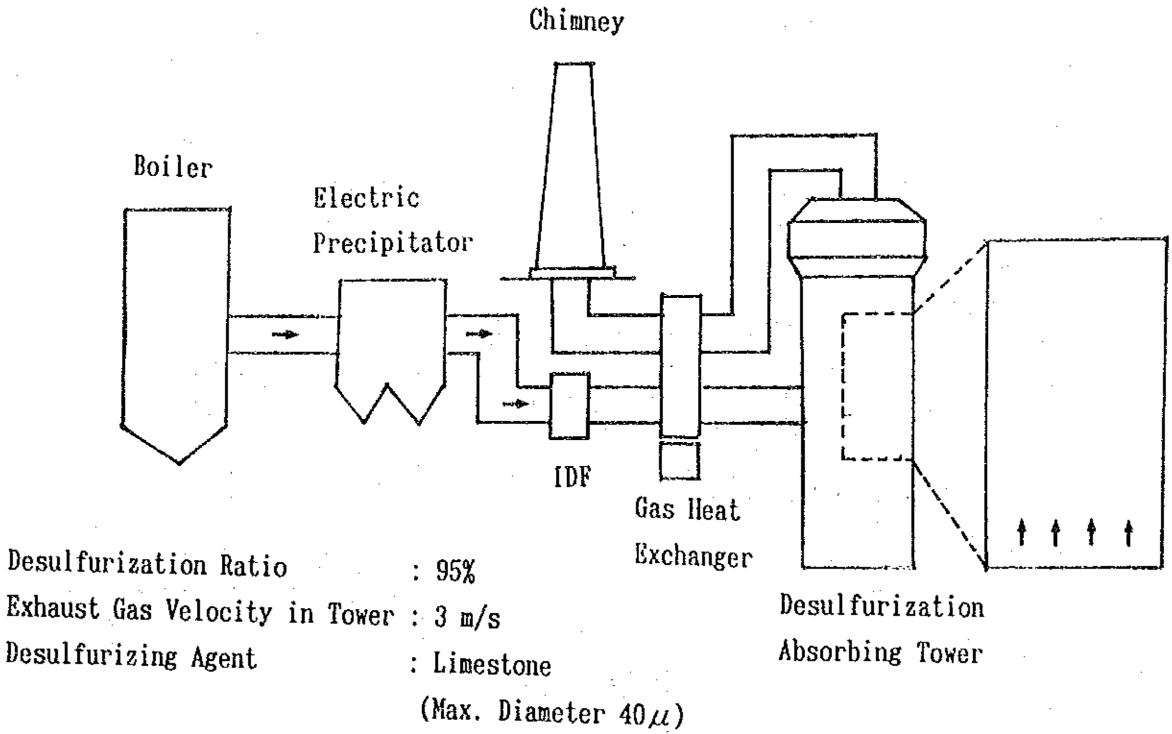


Figure D7.3.1 Wet Type Limestone-Gypsum Process

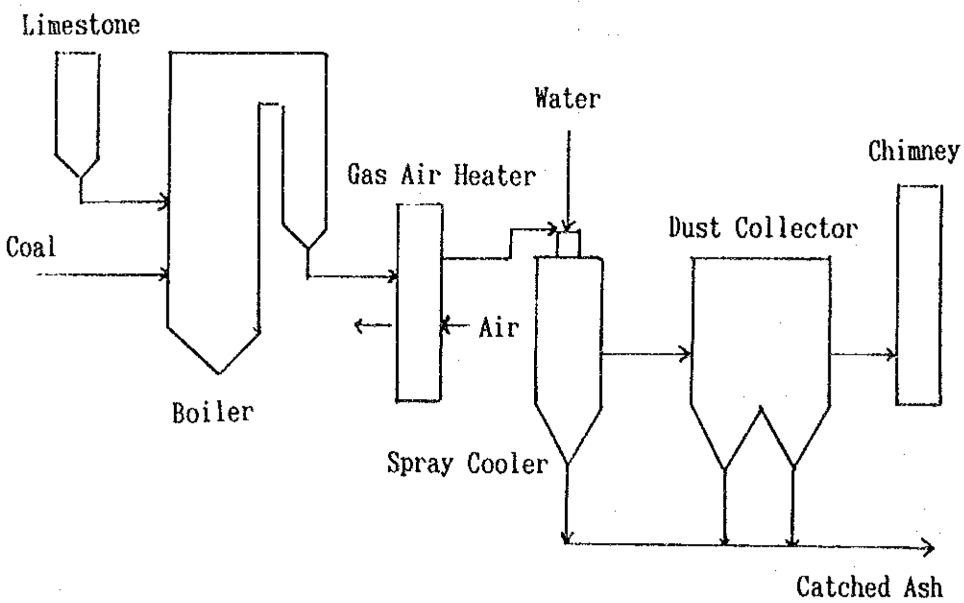


Figure D7.3.2 Secondary Desulfurization System in Semi-Dry Type Two-Stage Process

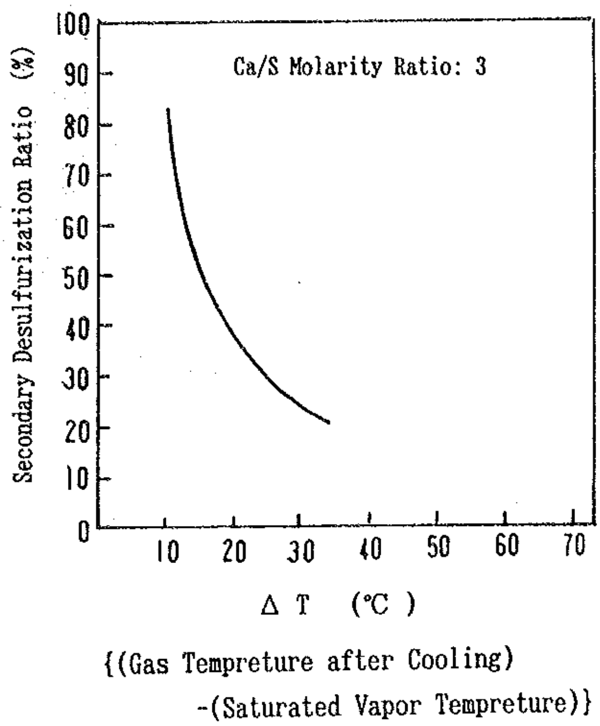


Figure D7.3.3 Secondary Desulfurization Ratio in Semi-Dry Type Two-Stage Process

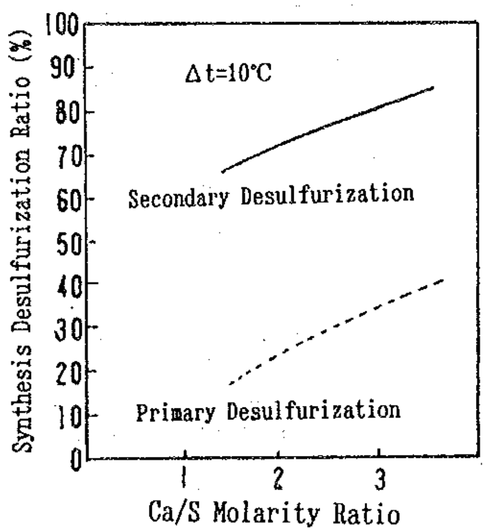


Figure D7.3.4 Overall Desulfurization Ratio in Semi-Dry Type Two-Stage Process

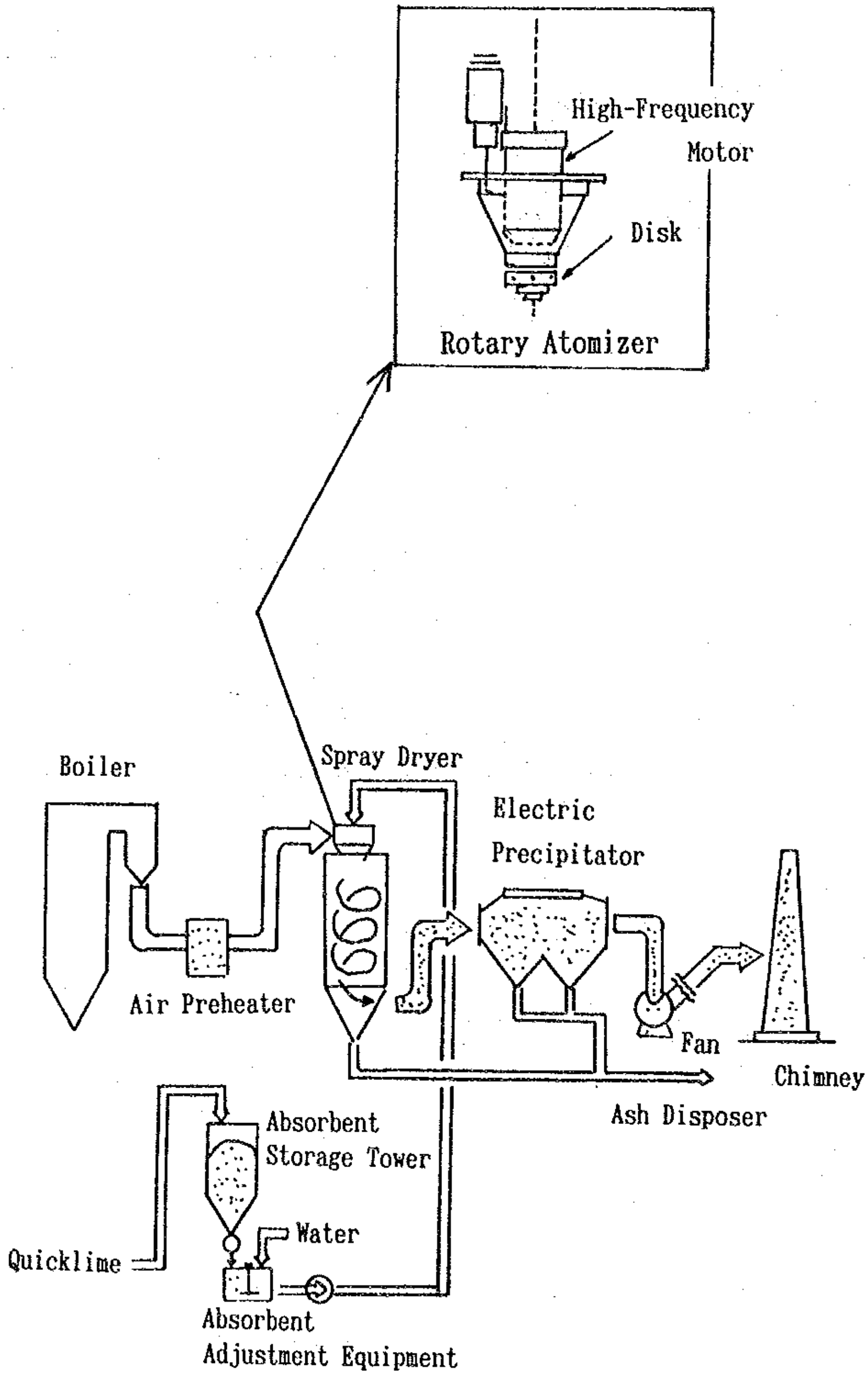


Figure D7.3.5 Semi-Dry Type Spray Dryer Process

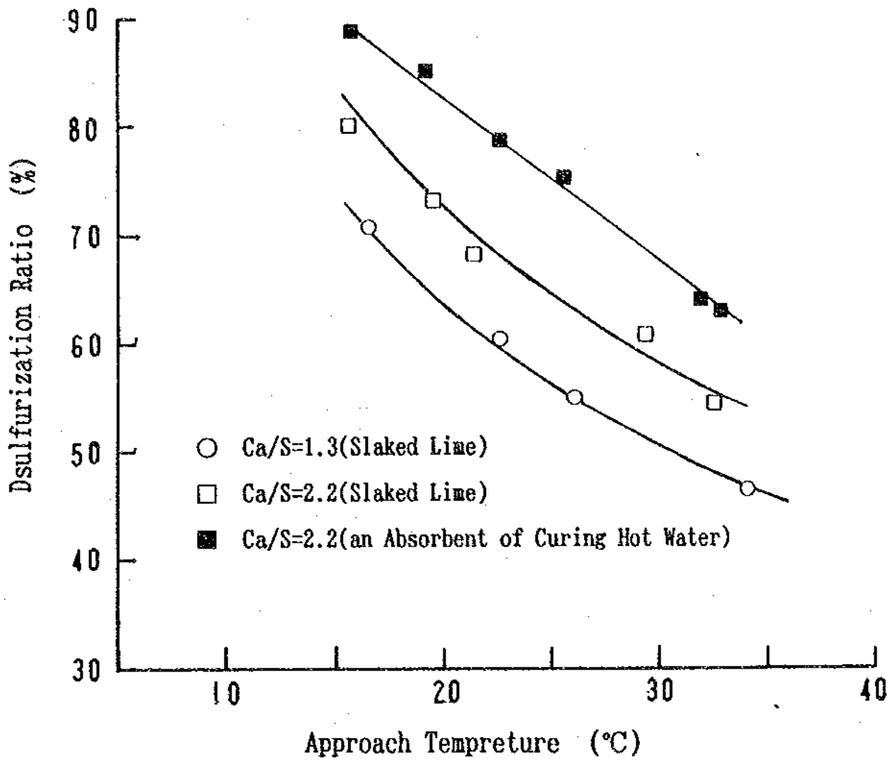
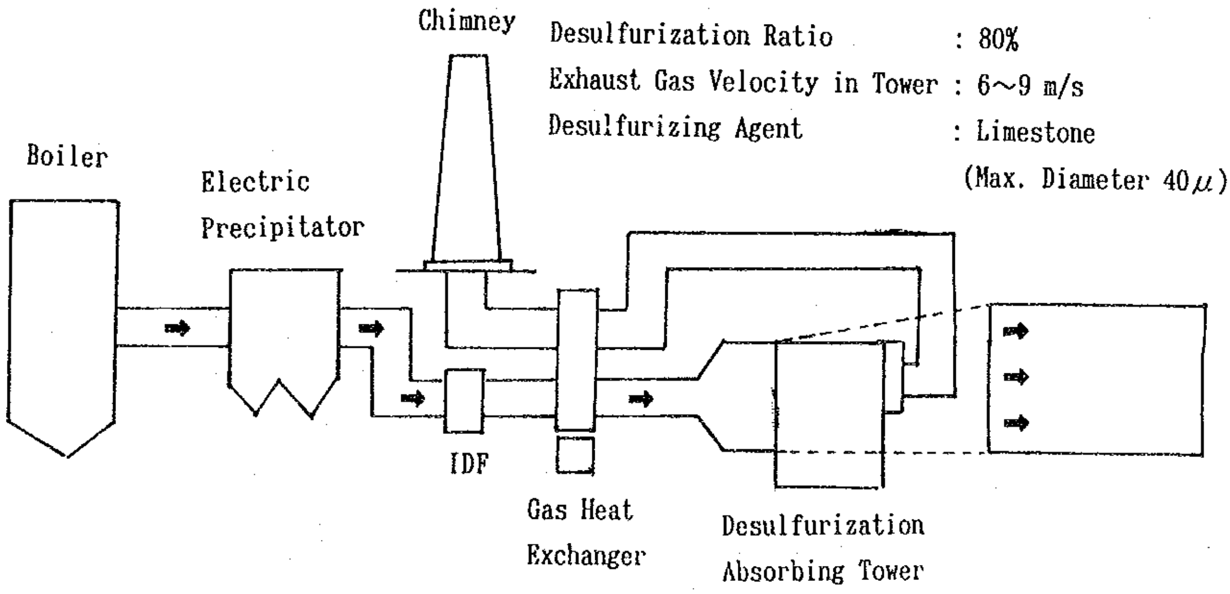


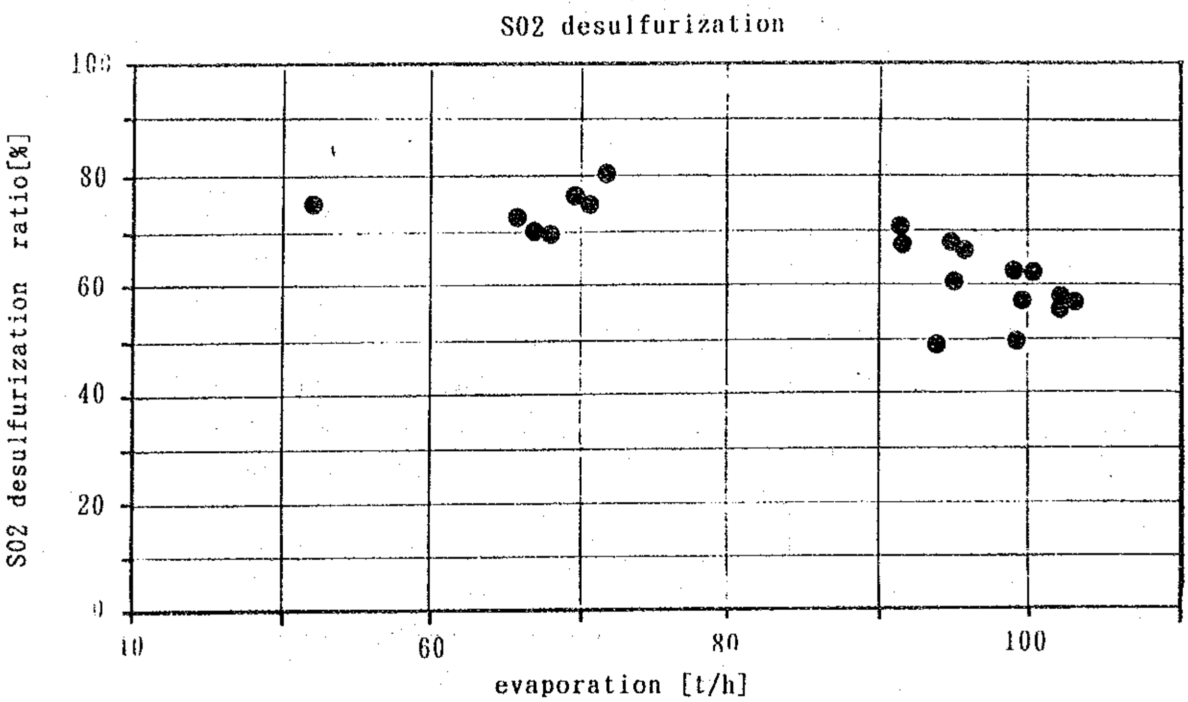
Figure D7.3.6 The Relationship between the Desulfurization Ratio and Ca/S mole Fraction and the Approach Temperature (Semi-Dry Type Spray Dryer Process)

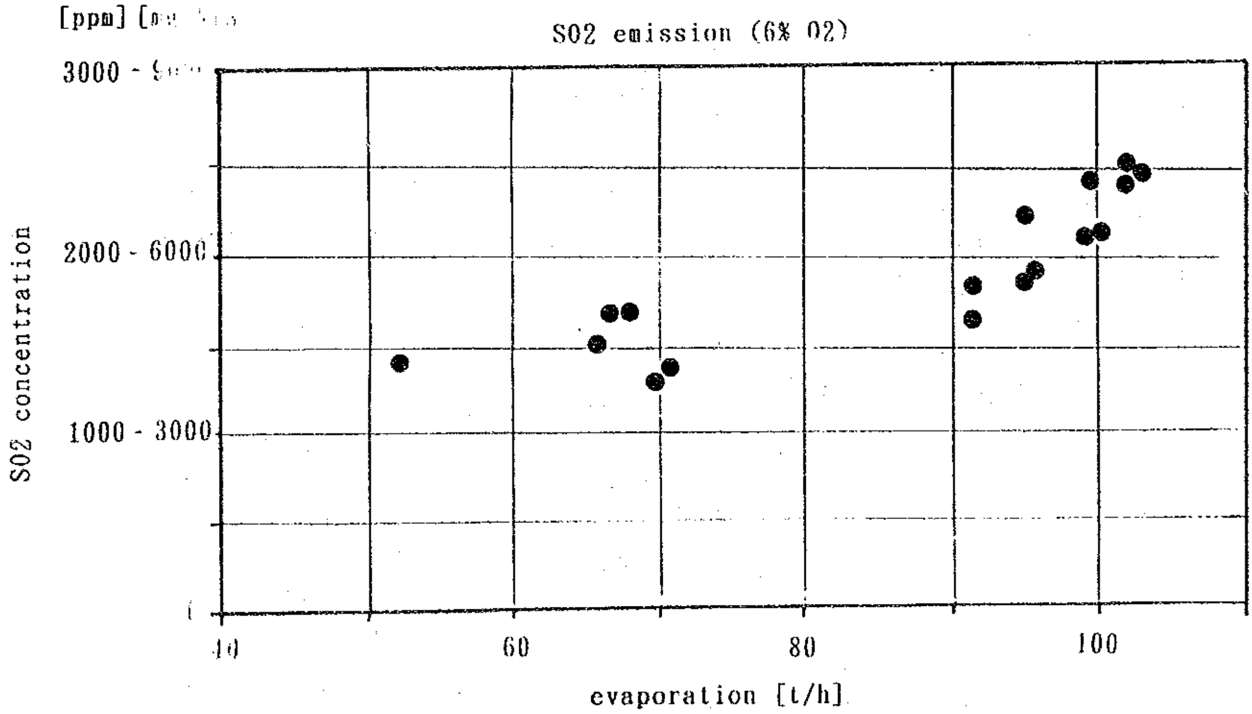


Note : This simple type has helped achieve decrease in the construction cost and simplification of the maintenance by increasing the space velocity of flue gas to make the desulfurization absorption tower compact.

Figure D7.3.7 Wet Type Limestone Gypsum (Simple Type)

Ajka Power Plant boiler No.11





Fuel consumption 29～30 t/h-Coal
Heating value 8500～9500 kJ/kg

Figure D7.3.8 Result of Combustion Test of HFBC by VEIKI (1)

Ajka Power Plant boiler No.11

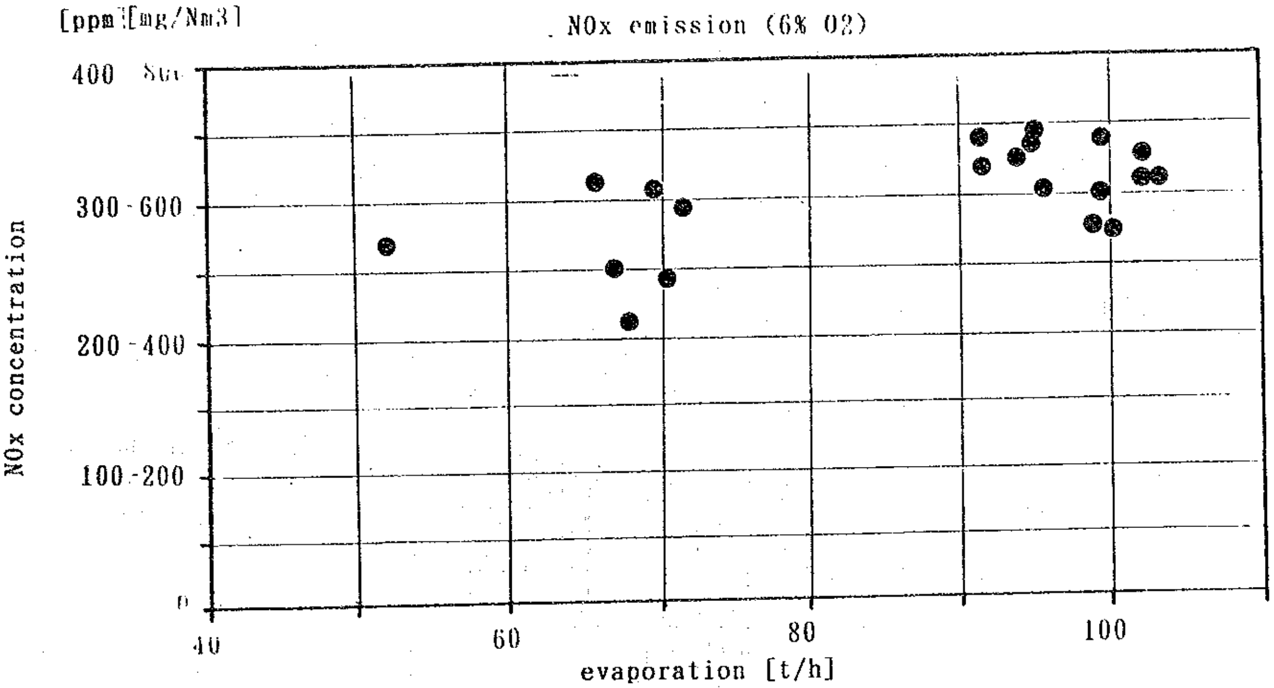


Figure D7.3.9 Result of Combustion Test of HFBC by VEIKI (2)

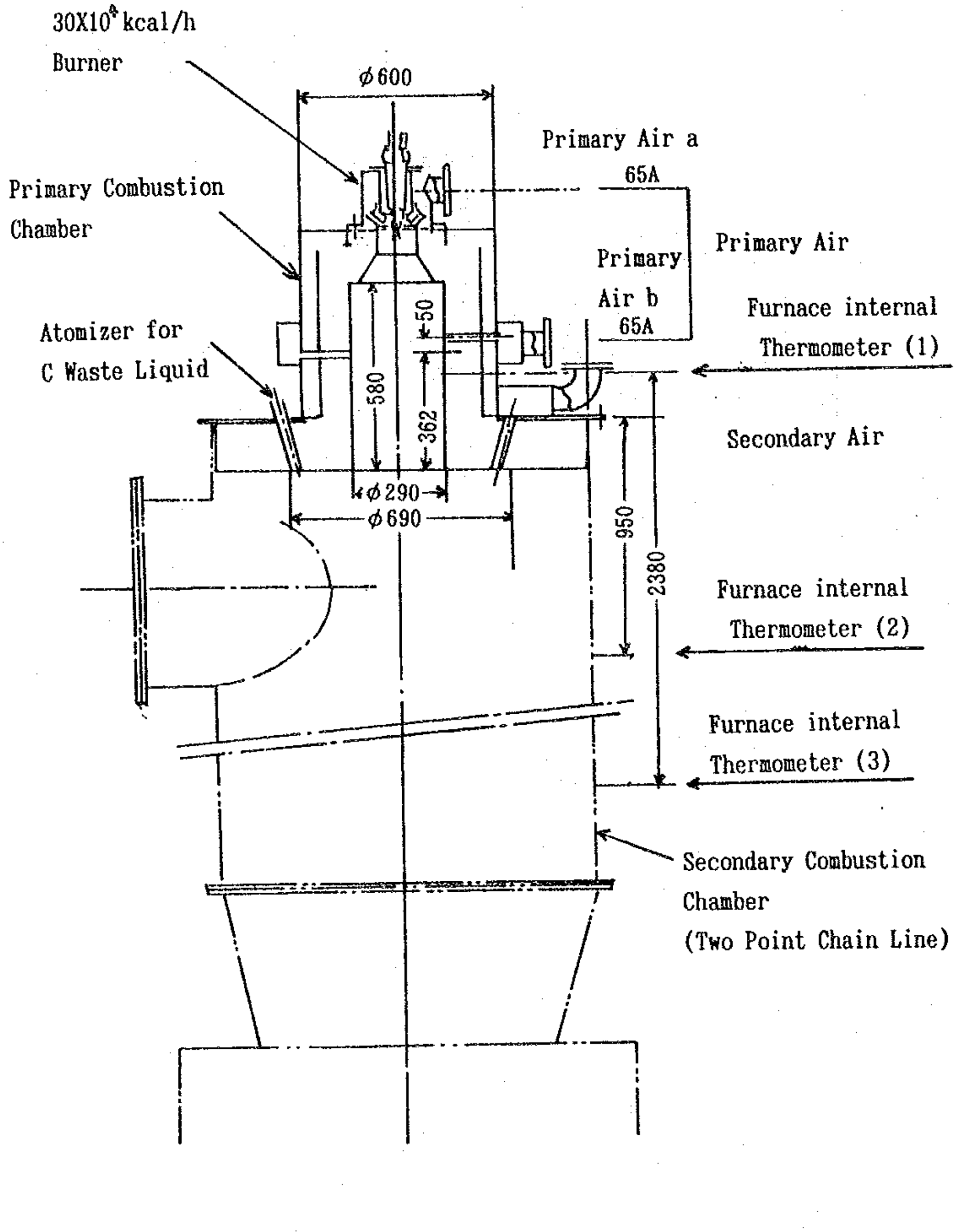


Figure D7.3.10 An Example of Two-Stage Combustion for Waste Liquid Incineration

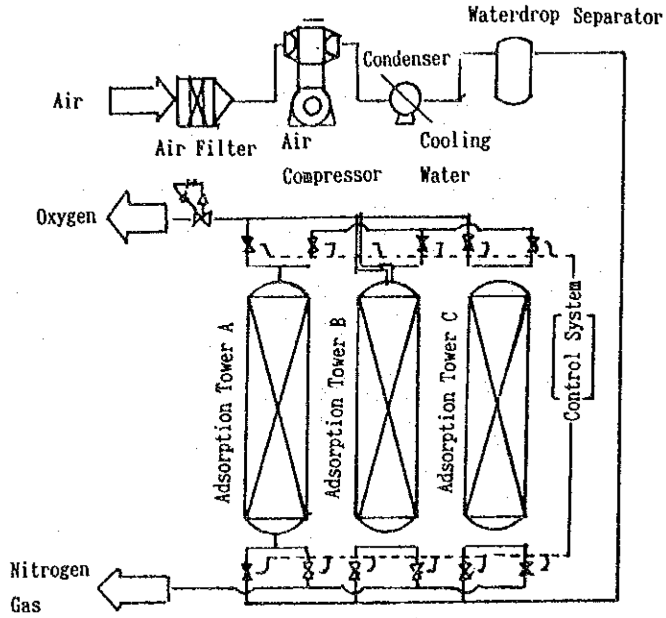


Figure D7.3.11 Lindox Process for Oxygen Production

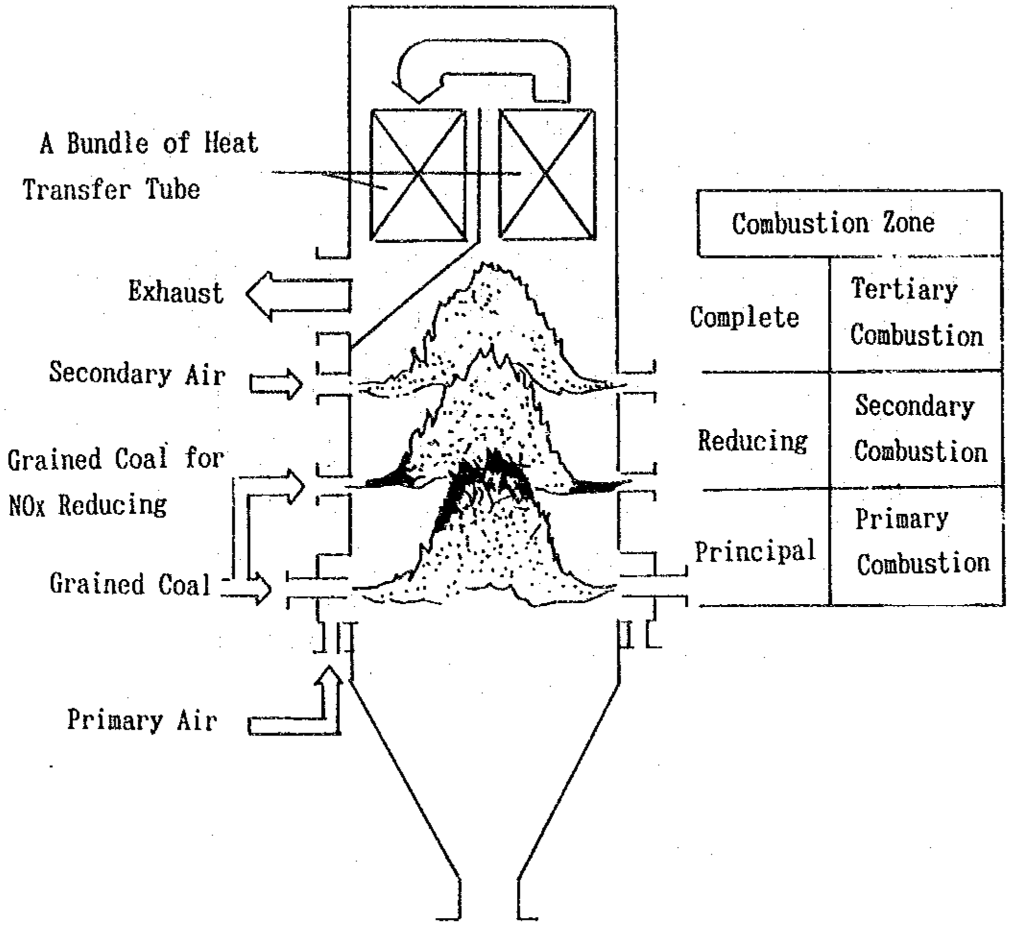


Figure D7.3.12 Combustion Type Internal Denitration Process

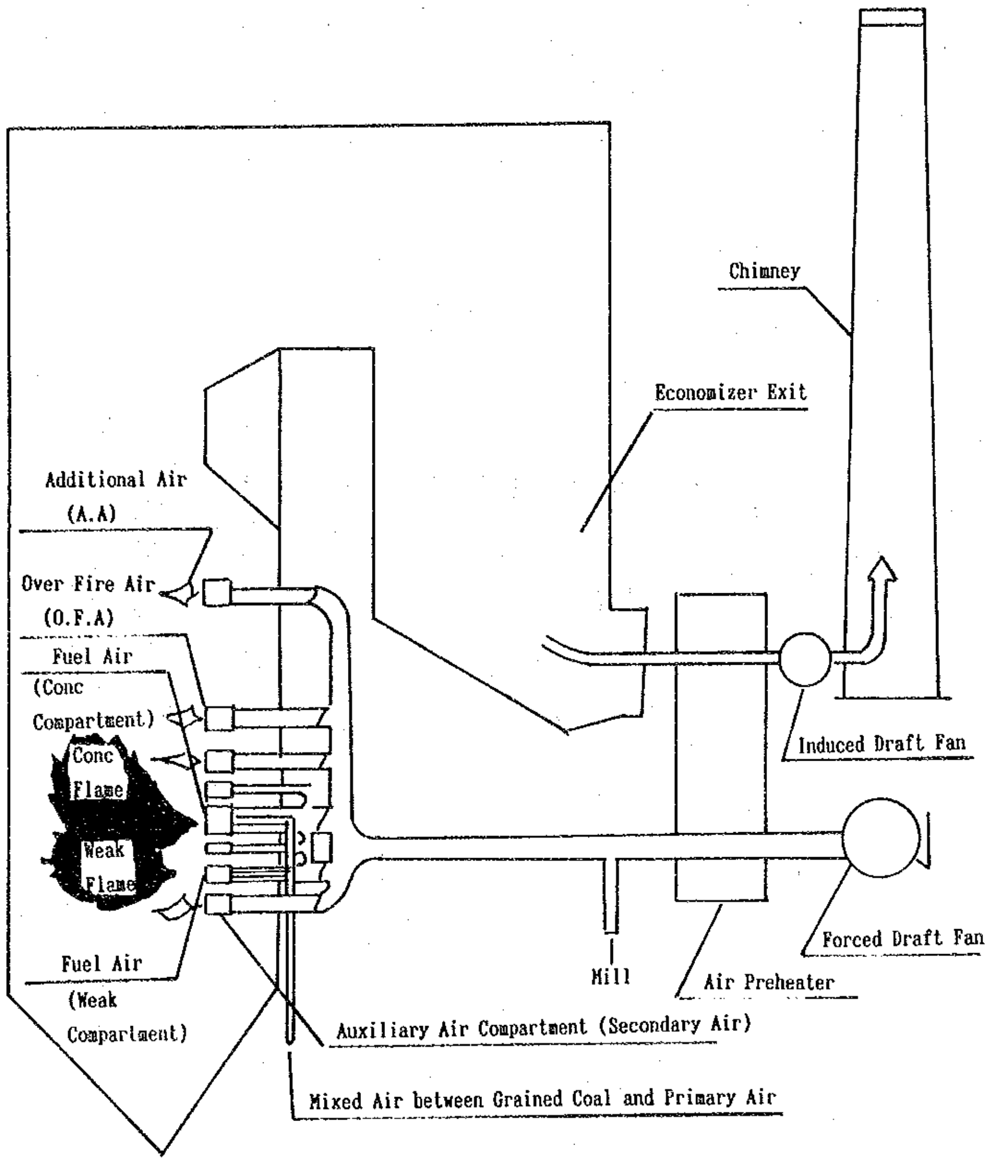


Figure D7.3.13 Conceptual View of Improved Furnace Internal Denitration Process

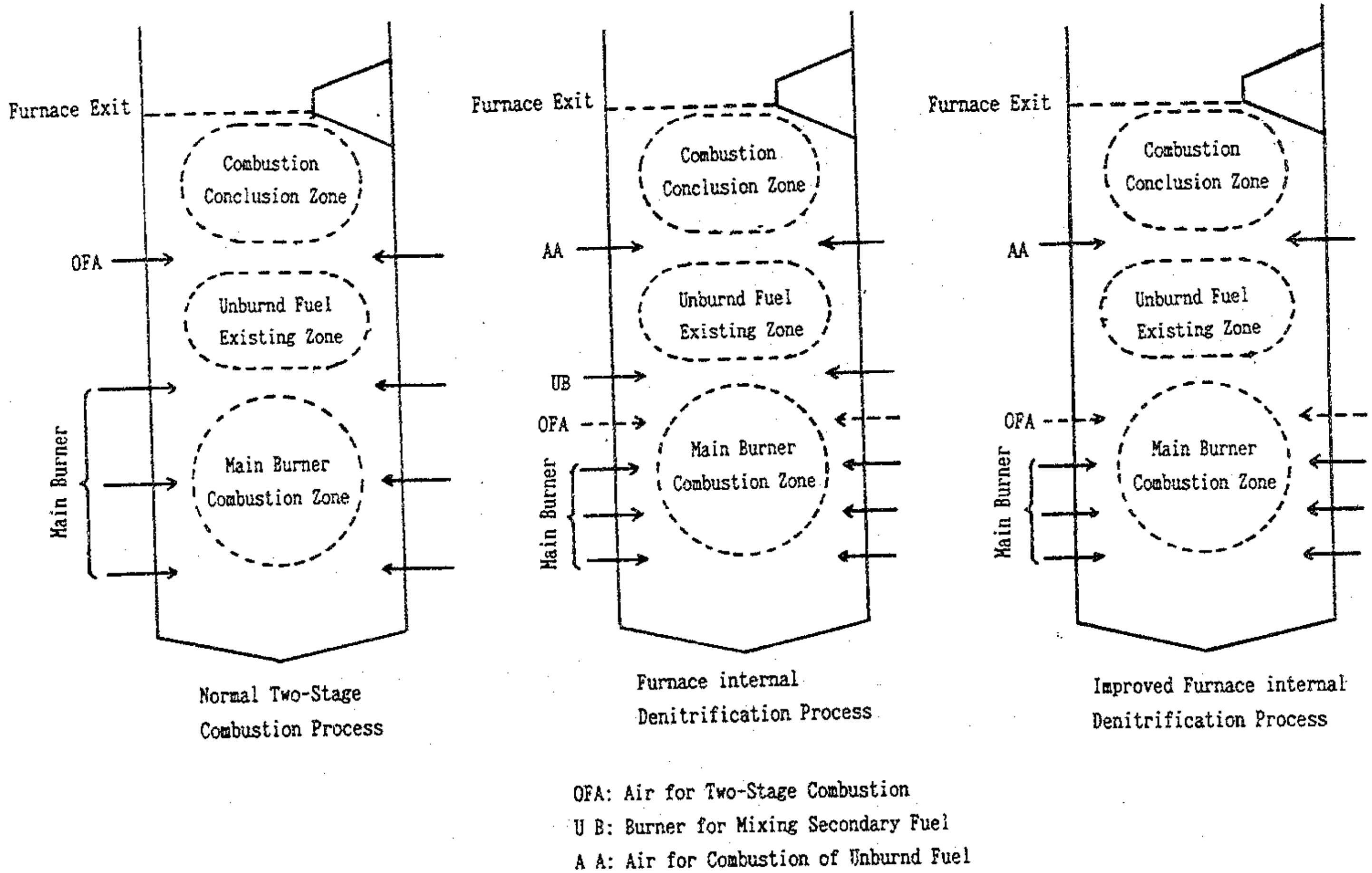


Figure D7.3.14 Difference Between Two-Stage Combustion Process, Furnace Internal Denitration Process and Improved Furnace Internal Denitration Process

Verification Test of Brown Coal Combustion

by

The Hybrid Fluidized Bed Combustion Boiler

1. Background of Verification Test

Regarding measures against air pollution due to large stationary sources in the Sajo Valley area, the JICA Study Team repeated discussion with the Hungarian counterpart. Conclusions were reached on the following points:

(1) For flue gas desulfurizers proposed by the JICA Study Team, regardless of systems including the wet desulfurization system, such as the lime and gypsum method prevailing in Japan, and semi-dry desulfurization technique which has been developed recently, the amount of the initial investment and running costs for them are high. Therefore, it is difficult to employ them due to the economic conditions of Hungary.

(2) From the viewpoint of measures against coal miner unemployment in the country, the government of Hungary in principle forbids domestic steam power plants to use imported charcoal, and also forbids or restricts the use of natural gas and good quality fuel oil in order to save foreign money. Especially, the government has taken relief measures for coal mine companies continuously operating in the red by merging generating companies and coal mine companies as a coal mine policy since the autumn of 1993. Tisza Power Generating Company, in the study area, united with Bukkabrany Coal Mine Company, and Borsod Power Plant, which had separated from Tisza Power Generating Company on 1 December, 1993, also united with Lyuko Coal Mine Company to establish Borsod Energy Company to promote the protection of coal miners.

(3) As the brown coal produced from domestic mines has a low heat value, high ash content and high sulfur content, employment of in-furnace sulfur removal by means of a circulating fluidized-bed boiler or a hybrid fluidized-bed combustion boiler developed by the National Electric Power Laboratory has been requested (hereinafter referred to as VEIKI).

In this background, under instructions from the Hungarian Electric Power Committee, Borsod Energy Company carried out the F/S (mainly on calculation of heat balance) in 1991 in order to remodel the existing pulverized-coal combustion boiler with a rated evaporation quantity of 100t/h into a hybrid fluidized-bed combustion boiler. It also proposed a plan to the JICA Study Team for remodeling boilers into the hybrid boiler burning fluidized-bed type as a part of measures against air pollution. This hybrid fluidized bed combustion boiler is a burning installation which VEIKI has been researching and developing since 1980. The hearth part of the existing pulverized-coal combustion boiler has been cut and removed and the fluidized-bed combustion device has been newly installed. It has already been operated for practical use since 1990. In the case of the Ajka Power Plant which has been remodeled in this way, a desulfurization efficiency of 60 - 80% has been achieved. However, the JICA Study Team pointed out that, if this system is adopted in the study area, it is required to change combustion conditions must be changed and the efficiency of desulfurization must be re-examined because of mechanical problems such as wear of heat transmission pipes and because of the difference in properties.

Based on this background, it was decided to carry out a combustion verification test in the hybrid fluidized-bed combustion boiler at Ajka Power Plant by using the same type of brown coal used in Borsod Power Plant and Tisza Power Plant as well as desulfurization agents produced in the concerned area.

2. Technical Background of Hybrid Fluidized-Bed Combustion

2-1. Coal Combustion System

Coal combustion systems which are in practical use now are roughly classified into stoker firing (fixed-bed combustion, lump coal), pulverized-coal combustion (powdered coal) and fluidized-layer (bed) combustion (coarse coal). Among them, stoker firing facilities are now manufactured exclusively as small-capacity industrial boilers because, although installation costs are low, there are problems in such as the generation of clinker (fusion of ash). For large boilers which have large supplementary facilities such as pulverized-coal mills, dust collectors and maintenance which costs much, pulverized-coal combustion is the mainstream of boilers for electricity generation because its combustion efficiency is high and it can easily cope with changes in load. These boilers require flue-gas desulfurizers, a combustion system for lowering NOx or denitration devices.

On the other hand, research and development of fluidized-bed combustion progresses worldwide because it has merits because, for example, in-furnace sulfur removal is possible by using desulfurization agents such as limestone and dolomite, and stable combustion is possible without the influence of coal properties.

Therefore, this combustion system has been started to be generalized. This fluidized-bed combustion is classified roughly into bubbling fluidized-bed combustion and circulating fluidized-bed combustion. Bubbling fluidized-bed combustion utilizes air bubbles generated by pressurized air fed from the lower part to raise fluid materials and make them in fluid. As mentioned above, in-furnace sulfur removal can be achieved by using limestone etc. as fluid materials. In addition, this combustion has an advantage in that generation of NOx is small because the combustion temperature is as low as 800 to 900 ℃. The characteristic mark is that heat capacity is large and the heat transmission rate is high while combustion temperature is low. On the other hand, it is pointed out that the combustion efficiency is lowered by scattering from the layer of air bubbles as well as unburned carbon. Circulating fluidized-bed combustion has been developed to solve this problem. There are two types; outside circulation and inside circulation. This circulating fluidized-bed combustion employs a system where unburnt carbon and desulfurization agents, as well as emissions, are collected and sent back to the layer. As it has the merits, for example, that combustion efficiency of coal which has a high fuel ratio (the amount of fixed carbon) is made higher by circulation and that the desulfurization efficiency becomes higher because particle diameters of desulfurization agents can be made small, its development has progressed rapidly and is now put into practical use.

2-2. Characteristics and Structure of Hybrid Fluidized-Bed Combustion

The hybrid fluidized-bed combustion boiler developed by VEIKI and used for this test belongs to the bubbling fluidized-bed combustion type. The lower part of the existing powdered-coal combustion boiler has been reconstructed into 420 wind boxes, nozzles have been equipped which are divided into three parts to form the fluid layer in the bottom part of the furnace and a strong push fan has been added. Blow-off velocities of air from nozzles are made to be 6-7m/s in the middle part and 3-4m/s in the front and rear parts, which enables fluid materials to circulate and form a 4.5m long layer. Fuel coal fed into the layer is carried on the circulating stream of fluid materials, circulates in the layer eight to ten times, and scatters from the surface of the layer with exhaust gas. VEIKI explains that furnace temperature is made uniform because fluid materials in the layer circulate furiously. However, this fluid layer also causes wear to heat transmission pipes in the layer. Figures 2-2-1 and 2-2-2 respectively show the structure of the hybrid fluidized-bed combustion boiler and that of a pulverized-coal combustion boiler before being remodeled.

The rated vapor generation amount of the hybrid fluidized-bed combustion boiler at Ajka Power Plant is 100t/h, while, within the range of bubbling fluidized-bed combustion, a load of approximately 60t/h is a limit. In order to raise the load, pulverized coal is required to be burnt in the upper part of the boiler to make up for an insufficient quantity of heat. For this purpose, the boiler is equipped with two pulverized-coal mills (without an air separator) for bubbling fluidized-bed combustion and two pulverized-coal mills (with an air separator) for burning powder coal. The structure of the mills with an air separator has been designed to separate large-diameter particles in order to raise burner combustion efficiency and to return them to the mills. Figure 2-2-3 shows the structure of the mills. Since different combustion systems are combined like this, it has been named a hybrid fluidized-bed combustion boiler. One of characteristics of general fluidized-bed combustion is that heat transmission pipes are installed within the fluid layer. However, the hybrid fluidized-bed combustion boiler has only the membrane type of heat transmission pipes.

In addition, the hybrid fluidized-bed combustion boiler is equipped with a super heater, an economizer (a device for feeding and heating water) and an air preheater as energy-saving devices, and with an electric dust collector as a device for measures against soot particles. Fuel is carried on a belt conveyer from the coal storage yard to be temporarily stored in a hopper installed in the top, and is then fed into a drying cylinder by a stoker (a scraper conveyer). This coal-drying device takes in high-temperature emissions and preheated air by means of a long cylinder which is oriented upward and downward, and dries coal in the process where coal falls down the cylinder. The amount of gas is adjusted according to the amount of the water content in the coal, and dried coal is fed into the pulverized-coal mill to reduce it to powder. Powdered coal is transported to the fluid layer or the burner by air. Excess fluid materials due to the ash content in raw coal are discharged from an ash-discharging groove installed in the bottom of the furnace.

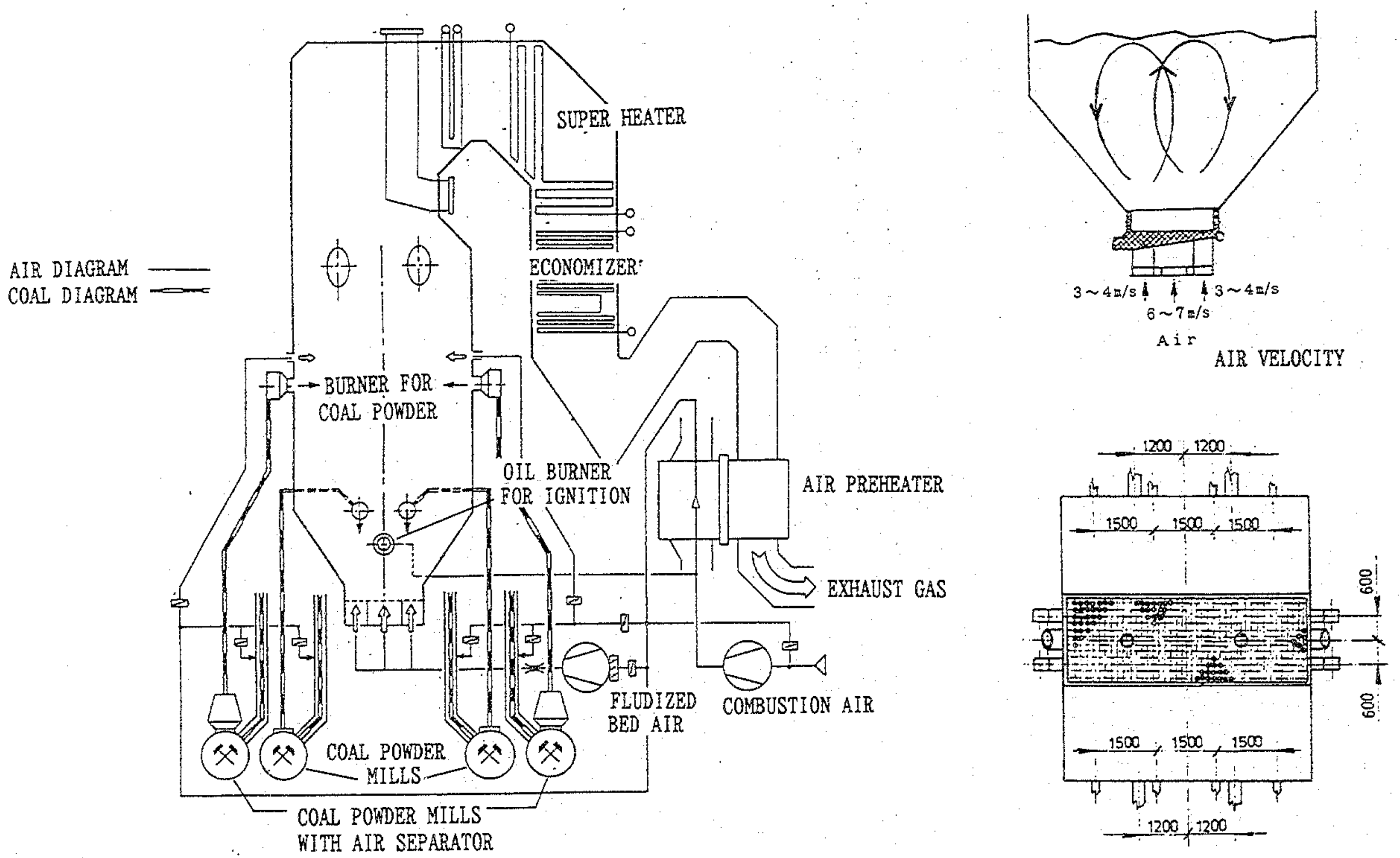


Figure 2-2-1. The Structure of the Hybrid Fluidized Bed Combustion Boiler

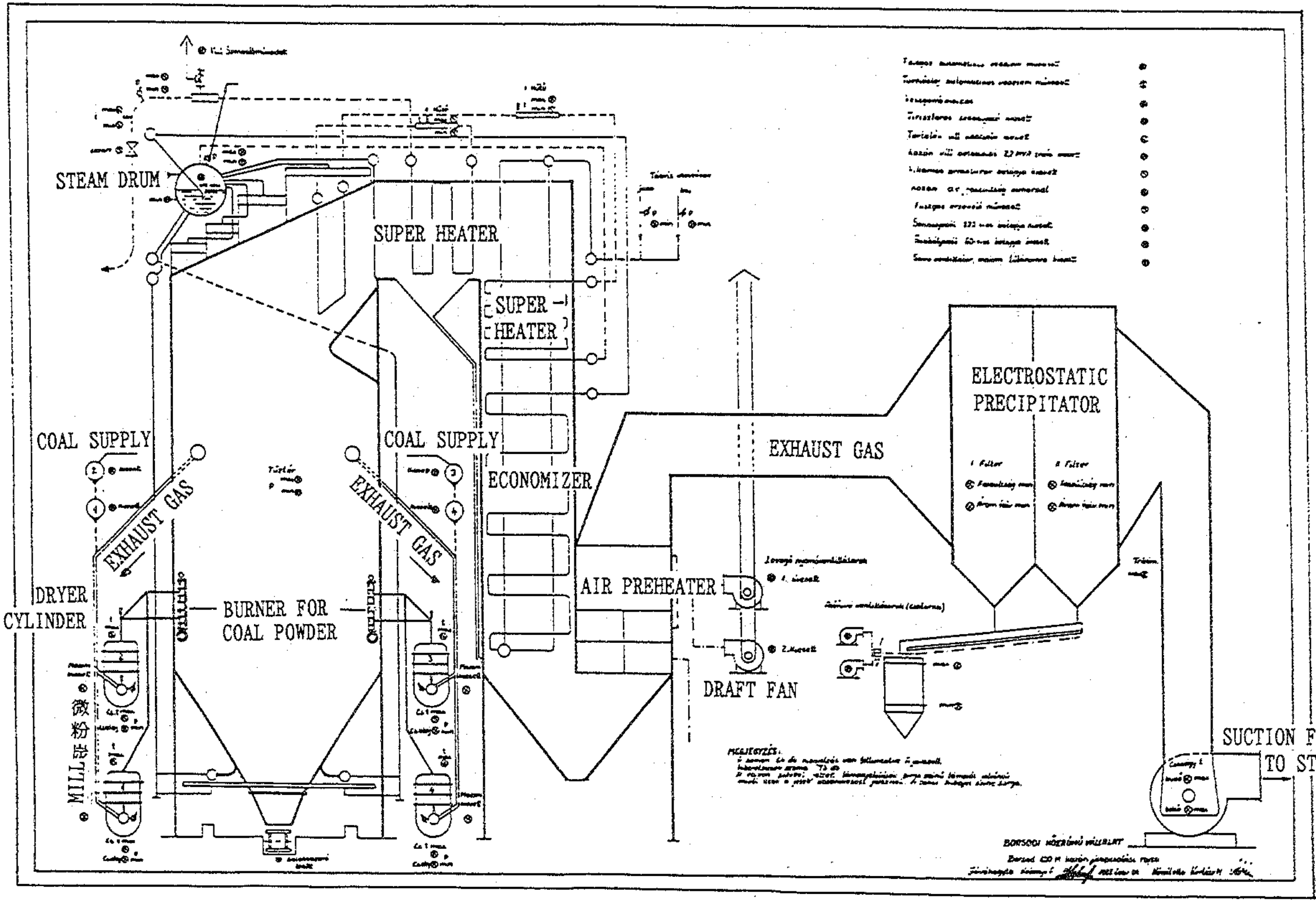


Figure 2-2-2. The Structure of the Powder Coal Combustion Boiler

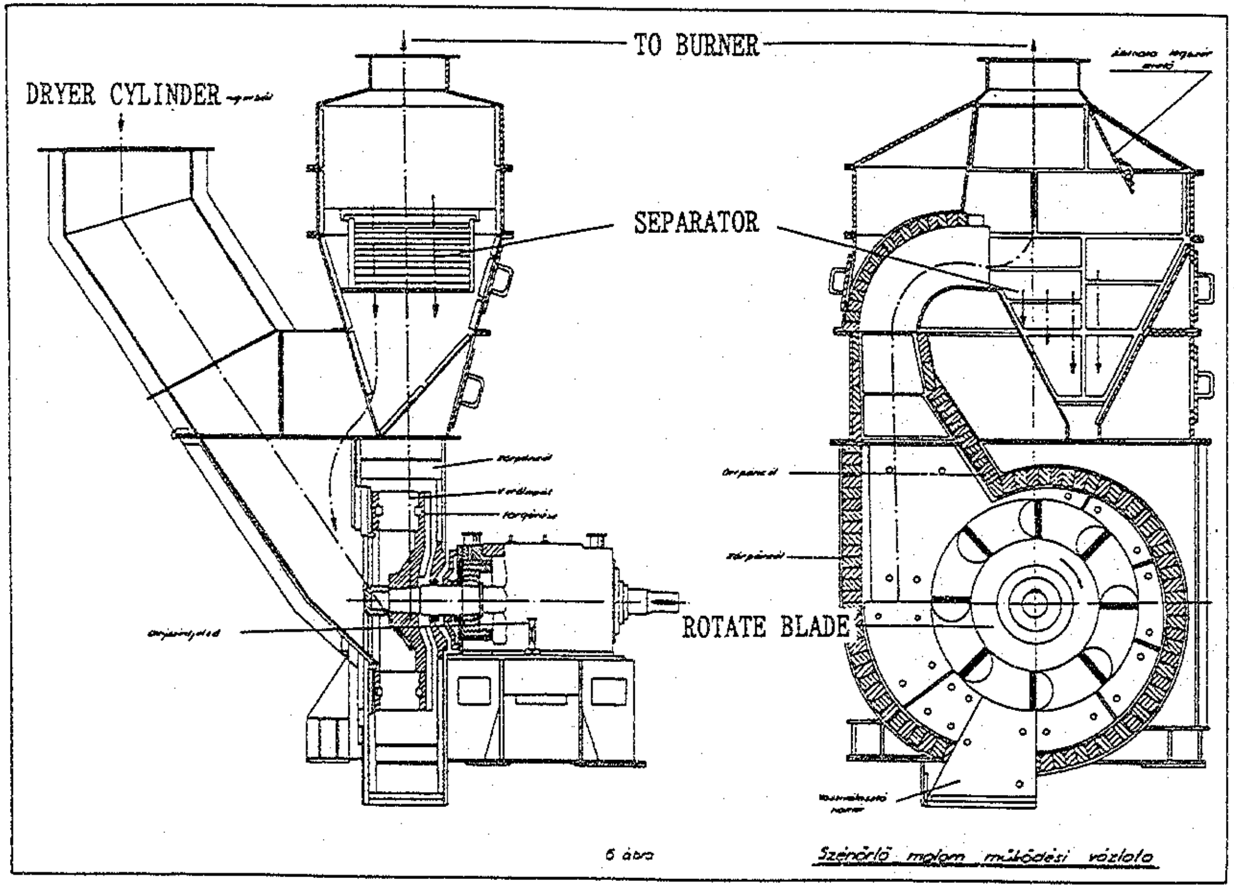


Figure 2-2-3. The Structure of the Mills

2-3 Characteristics and Existing Results of the Combustion Tests

2-3-1 Characteristics of Brown Coal Produced in Ajka

Brown coal used at Ajka Power Plant has low quality but a large amount of CaO in ash content. Therefore, it is possible to fix SO2 generated in the process of combustion in the furnace without newly added desulfurization agents if conditions are satisfied. The constituent parts are shown as follows. (For reference, those of Lyuko coal are also shown.)

		Ajka coal	Lyuko coal
Heat value	MJ/kg	9.0	8.5
	kcal/kg	2150	2030
Water content	%	20.0	25.7
Total carbon	%	35.0	24.5
Total sulfur	%	3.5	1.9
Ash amount	%	35.0	37.9
CaO in ash	%	40.0	11.4

(Analyzed by Hungarian National Mine Development Laboratory)

2-3-2. Existing Results of Combustion Tests Using Ajka Coal

Table 2-3-1 shows results of combustion tests carried out at Ajka Power Plant by Central Donau Environment Control and Supervision Department and according to the PHARE plan of EC.

(Through the PHARE plan of EC, a fan was provided for the fluid layer.)

Table 2-3-1. Existing Results of Combustion Tests Using Ajka Coal

Boiler load		60t/h(BFBC)			100t/h(HFBC)		
Boiler number		No.9	No.10	No.12	No.9	No.10	No.12
Desulfurization efficiency	%	75.0	78.0	62.7	27.1	37.3	51.6
Denitration	%	54.9	55.9	85.8	50.5	56.5	29.6

According to these results, if Ajka coal containing the large amount of CaO in ash is used, a good result will be obtained where the efficiency of desulfurization and the denitration rate of 60 - 80% is realized in the range of the bubbling fluidized-bed combustion. VEIKI insists on this point, and appeals the introduction of a hybrid fluidized-bed combustion boilers to coal power stations in countries in former Eastern Europe. However, desulfurization efficiency in the range of hybrid fluidized bed combustion vary and sufficient results have not been obtained.

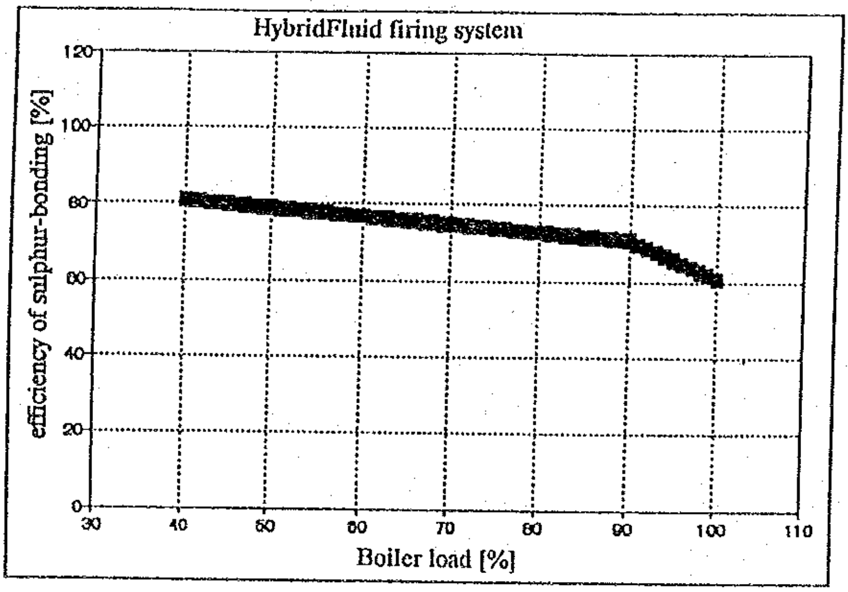


Figure 2-3-1. Relation between Boiler Load and Desulfurization Efficiency

3. Purposes, Location and Period of the Test

3.1 Purposes of the Test

The test was decided to aim at an investigation regarding the following points by using brown coal produced in the Lyuko mine and limestone produced in Felnemet, both of which are used now at Borsod Power Plant.

(1) Investigation of desulfurization efficiency and NOx of the hybrid fluidized-bed combustion boiler, classified by load

(2) Investigation of an insufficient quantity of heat

(3) Investigation of potentialities of combustion system improvements (under control of O2 concentration in emission)

3-2. Location of the Test

Boiler No. 12 for generation of electricity at the Second Ajka Power Plant in Ajka, Hungary

3-3. Period

From February 14 to 18, 1994

4. Method of Combustion Test

4-1. Sample Fuel

Sample fuel for this test was brown coal produced in the Lyuko Mine (750 tons for blank combustion and 1,300 tons for limestone mixture) and limestone produced in Felnemet (250 tons). Although raw coal and limestone have to be mixed before combustion, since there are no devices for adding desulfurization agents in the Ajka Power Plant, mixed coal was prepared using facilities at an iron-ore sintering factory in the suburbs of Miskolc City and transported to Ajka Power Plant by a goods wagon.
Table 4-1-1 shows the analysis results of tested fuel and limestone.
For sample coal ores, a fixed amount was gathered from a coaling station every fifteen minutes during the combustion test, prepared in the given method, and analyzed.

Table 4-1-1. Results of Sample Fuel Analysis

Item		Lyuko coal	Mixed coal
Heat value	MJ/kg	8.50	7.61
Water content	%	25.7	24.0
Ash content	%	37.9	39.8
Total carbon	%	24.5	23.7
Total sulfur	%	1.9	1.7
Total hydrocarbon	%	1.3	1.5
Nitrogen	%	0.4	0.4

Oxygen	%	8.3	8.9
Size	mm	20 or less	20 or less

Values of limestone analysis

$CaCO_3$%	95% or more
CaO%	45% or more
Size	-1.0mm

4-2. Specifications of the Boiler Tested

Specifications of the hybrid fluidized-bed combustion boiler used for the combustion test are as follows:

Model : Ajka-II 100-M
Year of manufacture: 1981
Year of remodeling: 1990
Rated quantity of evaporation: 100 t/h
Quantity of evaporation at maximum load: 120 t/h
Evaporation temperature: 500 °C
Feed water temperature: 190 °C
Area of heat transmission: 2071 m^2

4-3. Measurement Items

Items measured during the combustion test are classified as to pollutants and combustion parameters, operation parameters of the boiler, and the composition of burned ash. The items are shown below.

- Pollutants and combustion parameters: SO_2, NO_x, CO, CO_2, O_2 and the amount of soot particles.
- Operational parameters of the Boiler: Generation amount of evaporation, temperature of evaporation, temperature of feed water, temperature of the fluid layer, temperature of exhausted gas (from the super heater, the economizer, the air preheater and the electric dust collector, the number of stoker conveyer rotations, and each pressure in the furnace.
- Burnt ash: the amount of the water content, ignition loss, the total

amount of carbon, CO_2, SO_3 and CaO

Among these items, SO_2, NOx, CO, CO_2 and O_2 was collected from the existing port for collecting sample ores which was installed at the electric stoker outlet.
This position was selected since, although a little air enters this collecting position because it is situated in the rear part of the stream from the air preheater and the stoker, exhausted gas from the pulverized-coal combustion boiler contains a large amount of soot particles which may cause clogging of tested collecting pipes. The amount of soot particles and exhausted gas flux were measured immediately behind the economizer. The composition of this gas was measured in parallel by means of a measuring instrument mounted in the measuring car provided by EKF (North Hungarian Environment Control and Supervision Department) and a measuring instrument which VEIKI affixed to this boiler.
Operational parameters of the boiler were recorded in a data recorder through a telemeter installed by VEIKI.
Burnt ash was collected from the four parts, i.e. the ash-discharging groove in the lower part of the boiler, the economizer, the air preheater and the electric dust collector, and analyzed in the National Mine Development Laboratory in the same way as the fuel.
The methods used in exhausted gas analysis are as follows:

SO_2: The ultraviolet absorption method
NOx: The chemiluminescene method
CO: The non-dispersed infrared ray absorption method
CO_2: The non-dispersed infrared ray absorption method
O_2: The magnetic pressure method
Soot particles: The cyclone sonde method

Temperature of the fluid layer was measured by thermometers situated in nine places in the layer, and changes in the amount fed were detected through the number of motor stoker rotations.

4-4 Modes for the Combustion Test

Modes for the combustion test were set up as follows:

Mode No.	1	2	3	4
Type of fuel	Lyuko coal		Mixed coal	
Method of combustion	HFBC	BFBC	HFBC	BFBC
Number of Mills	Three	Two	Three	Two

Note) HFBC: Hybrid Fluidized-bed Combustion
BFBC: Bubbling Fludized-bed Combustion

Boiler load in the test aimed at 50 - 100 t/h. As it was anticipated that the target load couldn't be achieved because heat value etc. of tested fuel were different from those of Ajka coal and because desulfurization agents were added to fuel, the test was put forward after load of mixed coal was presumed from combustion situations of Lyuko coal burnt.

4-5 Preparation for the Combustion Test

For fuel transported by the goods wagon, Lyuko coal and mixed coal was stored outdoors separately in the coal yard at Ajka Power Plant. Boiler No.12 was taken out of electricity generation in order to be tested, and its operation was stopped. After cooling the inside of the furnace, it was cleaned so that coal bunker, Ajka coal and ash would not remain in it.
Gravel of 3-5mm containing no desulfurization agents was scattered on the bottom of the furnace as fluid materials for the cold start. These fluid materials were gradually replaced with ash from raw coal during operation of the boiler.
In parallel with boiler maintenance, pulverized-coal mill blades were replaced with new ones.

4-6. Boiler Operating Conditions in Each Mode

By the cold start of the boiler, the fluid materials was heated by the heavy oil burner, coal was fed after temperature of the layer reached fire-catching temperature and stable flames were formed. About sixteen hours after start of the operation, the layer stabilized and entered the condition where measurement was possible.

Measurement was carried out with the following conditions:

- Boiler load would continue to be stable for four hours or so.
- The stoker and the powder mill would be stable and have no changes during operation.
- Temperature of exhausted gas would be stable after super heater No.2.
- Temperature of evaporation wouldn't fall to 500 ℃ or lower after super heater No.2.

In mode (1) of Lyuko coal, the maximum load was 90t/h due to insufficient capacity of the mill with a separator (because of insufficient capacity of the drying cylinder). It was estimated that, as a result, at the time of burning the next fuel, i.e., mixed coal, the maximum load of the boiler would drop more due to desulfurization agents. Therefore, mode (1) data was taken at 85/h. Then, after the mill with a separator was stopped and the load became stable at 80t/h, mode (2) data was taken. After measurement, the load was raised again and the remaining Lyuko coal was burnt in order to prepare for the test with mixed coal. In the process where Lyuko coal was replaced with mixed coal, distinct changes in SO_2 concentration were recorded. (Figure 4-6-1)

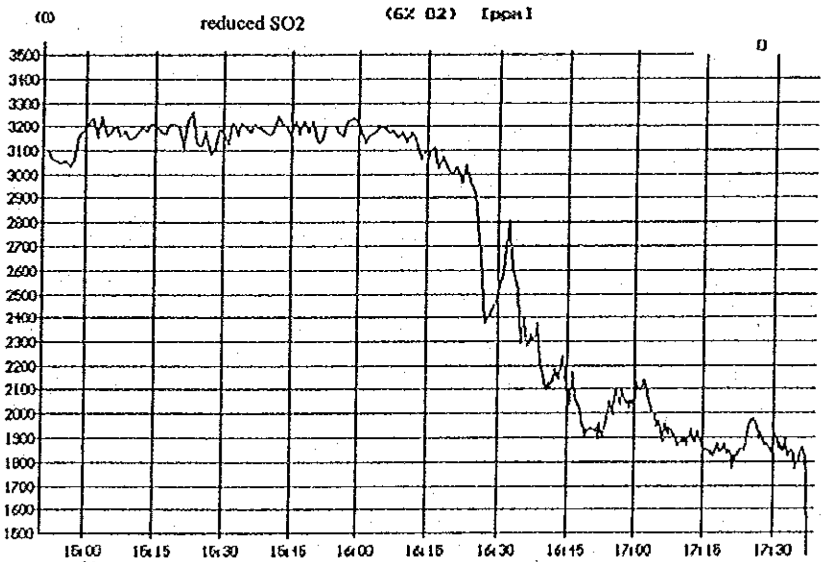


Figure 4-6-1. Changes in SO_2 Concentration Measured upon Replacement of Fuel

After replacement of fuel and after the combustion stabilized, measurement of modes (3) and (4) was made. For combustion of mixed coal, since temperature in the layer varied widely (with 900 ℃ in some parts), boiler load was set up at 80/t in mode (3) and at 43t/h in mode (4) and data was taken. The load in mode (4) was the minimum load which could maintain 500 ℃, which is the lower-limit value of the evaporation temperature.

4-7. Results of Measurement

Table 4-7-1 shows results, classified by modes, of pollutant measurement and combustion parameters. The data book contains the analysis results of boiler operation parameters and burnt ash.

Table 4-7-1. Results of Measurement of Pollutants and Combustion Parameters

Measurement mode	Mode No.	-	1	2	3	4
	Type of fuel	-	Lyuko coal		Mixed coal	
	Quantity of evaporation	t/h	85	60	80	43
Measured value	O2	%	12.6	14.9	12.9	15.9
	SO2	ppm	1,787	1,160	1,133	747
	NO	ppm	122	98	113	57
	CO	ppm	30	78	24	44
	CO2	%	7.4	5.3	7.4	4.4
	Soot particles	g/Nm3 @	---	---	51	31.5
	Amount of exhausted gas	Nm3/h	* 175,000	* 164,000	168,000	148,000
Conversed value of O2 to 6%	SO2	ppm	3,191	2,852	2,098	2,197
	SO2	mg/m3	9,117	8,149	5,994	6,277
	NO	ppm	218	241	209	168
	NOx	mg/m3 #	448	495	429	345
	CO	ppm	54	192	44	129
	CO	mg/m3	68	240	55	161
	CO2	%	13.2	13.0	13.7	12.9
Amount of exhaust	SO2	kg/h	1,595	1,426	1,007	929
	NOx	kg/h #	79	87	72	51
	CO	kg/h	9	34	7	19

Note:
@: Measured value at the outlet boiler
*: Estimated value
#: Value indicated as NOx and converted to No2

The table shows converted values of oxygen to 6% and the amount of pollutant emission per unit time as well as measured values.
Although the boiler was operated with adjustment of the air ratio so that the concentration of oxygen at the boiler outlet would be 6%, it was found from measured values of the oxygen concentration that the concentration was as high as 13-16%. This was caused by air entering from the air preheater and the dust collector because the point of sample collection was placed at the outlet of the electric dust collector. As it was difficult to evaluate different measured values of the remaining oxygen concentration , the oxygen concentration was converted to 6% to see data unitarily.
S02 concentration, although any difference due to different combustion systems was not notable, was 250ppm in the case of Lyuko coal and 100ppm in the case of mixed coal, and values as low as 655ppm and 1093ppm were obtained due to desulfurization agents. There was little difference in NOx concentration except for that in the mode (4). CO values in the range of fluidized bed combustion were three to four times those in the range of hybrid fluidized-bed combustion.

5. Air Pollutant Reduction Effect of the Hybrid Fluidized-Bed Combustion Boiler

5-1. Method and Results of Evaluation

Regarding valuation of the efficiency of desulfurization, the following two methods were examined:

a. Comparison of Theoretical S02 Concentration (the Maximum Concentration of S02) with Measured Values

As temperature of combustion reaches 1,100 - 1,400 ℃ in the case of powdered-coal combustion, nearly all of the sulfur content in raw coal is emitted into exhausted gas. In this method, the theoretical concentration of S02 is based on all the sulfur content and the theoretical amount of exhaust gas (the 6% converted value of 02) during combustion, and compared with measured values. This method has an advantage in that the concentration of the emission from the powdered-coal combustion boiler can be simulated.

b. Comparison According to Existence of Desulfurization Agents

In this method, the concentration of Lyuko coal and mixed coal under the same boiler load is compared, and the desulfurization efficiency due to natural CaO in raw coal can be neglected. In this test, as the target load could not be achieved in the combustion range of mixed of coal, it has a small problem.

Besides them, there is the method where measurement of the amount of combustion of raw coal per unit time is used for evaluation.

However, because there are no weighing facilities in the Ajka Power Plant, this method could not be employed.

The following table shows the desulfurization efficiency obtained.

Mode No.	1	2	3	4
Type of fuel	Lyuko	coal	Mixed	coal
Measured value ppm	3,191	2,852	2,098	2,197
Theoretical value ppm	4,130	4,241	3,799	3,799
Desulfurization rate a%	22.7	32.8	44.8	42.1
Desulfurization rate b%	-	-	34.3	23.0
Average temperature in the layer ℃	819	774	811	797

According to the results, in both high and low load ranges, the desulfurization efficiency obtained in the case of Ajka coal combustion could not be achieved, desulfurization efficiency in the hybrid fluidized-bed combustion with high load range was 44.8%, and that in the fluidized-bed combustion with low load range was 42.1%. When desulfurization agents were added, they were 23.0 - 34.3%.

5-2. Behavior of Desulfurization Agents (In-Furnace Sulfur Removal) and Boiler Combustion Conditions

In order to evaluate the low efficiency of desulfurizations measured in this test, behavior of desulfurization agents and operational conditions of the boiler are put in order below. Limestone, which is a desulfurization agent, is resolved at high temperature in the combustion chamber as follows:

$$CaCO_3 = CaO + CO_2 \quad \text{-----} \ (1)$$

The amount of CO_2 generation as a result of this reaction is small if there is the large amount of C02 in the combustion emission. Namely, unless the temperature is further raised, resolution does not occur. The relation between the equilibrium temperature and the resolution temperature of C02 is shown in Figure 5-2-1. In this test, as there is 13% or so in a 6% converted concentration of C02, it is found that resolution will not occur at 770 ℃ or more. CaO in coal reacts as follows:

CaO + SO2 + 1/2 O2 = CaSO4 ------ (2)

This reaction largely depends on temperature, and, as understood from Figure 5-2-2, the optimum temperature ranges from 800 to 900 ℃. If it exceeds 900 ℃, reduction reaction gradually occurs due to CO, H, etc. generated as a result of coal combustion and the desulfurization efficiency falls. As understood from formula (2), the oxygen concentration also contributes to the desulfurization efficiency.

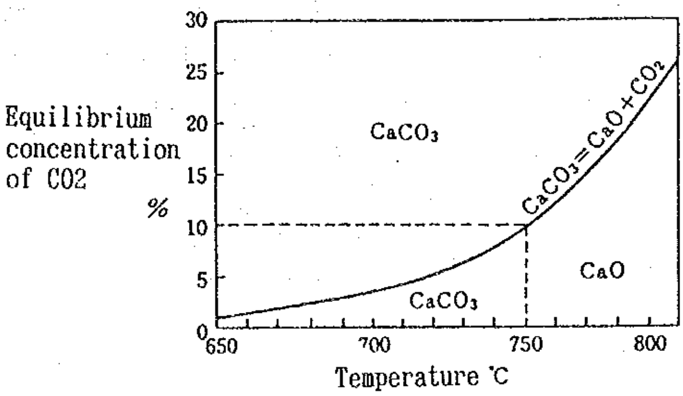


Figure 5-2-1. Relation between resolution temperature and C02 concentration of limestone

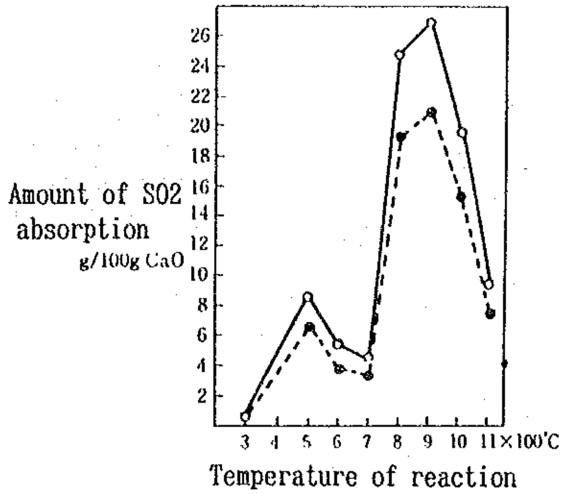


Figure 5-2-2. Optimum Temperature for Desulfurization

Source: "Flue Gas Desulfurization" SANGYOU KOGAI BOUSHI KYOUKAI

In this manner, it is found that the optimum temperature range for in-furnace sulfur removal is relatively narrow.

On the other hand, the ratio between Ca in the desulfurization agent and S during combustion is also an element to decide the desulfurization efficiency. Clearly, the higher the mol ratio represented by Ca/S is, the higher the efficiency of desulfurization is large. Figure 5-2-3 shows desulfurization efficiency in the hybrid fluidized-bed combustion boiler and Ca/S mol ratios, and Figure 5-2-4 shows relation between S02 concentration and Ca/S mol ratio of the bubbling fluidized-bed combustion boiler.

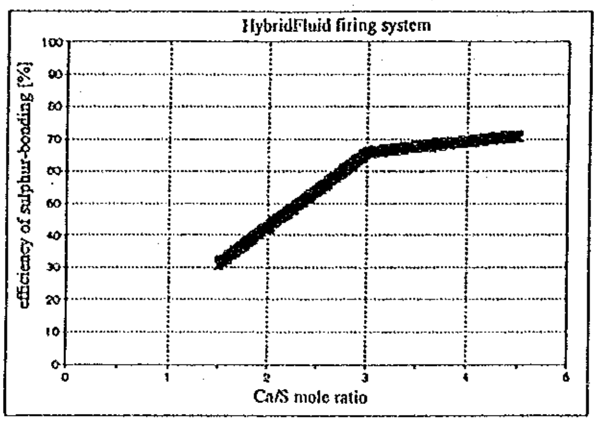


Figure 5-2-3. Relation Between Desulfurization Rates and Ca/S mol ratios on the Hybrid Fluidized-Bed Combustion Boiler

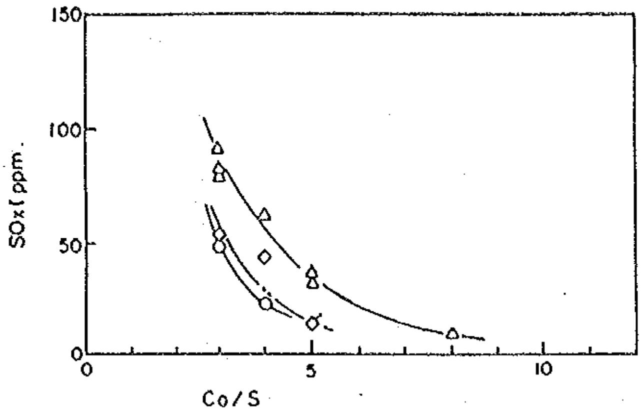


Figure 5-2-4. Relation Between S02 Concentration and Ca/S mol Ratio of the Bubbling Fluidized-Bed Combustion Boiler

As a desulfurization reaction is an endothermic reaction and requires the costs of desulfurization agents, employment of a system where the optimum mol ratio is selected and desulfurization agents are added is generally selected. In the case of fluidized-bed combustion, Ca/S=2 and, therefore, "3" is appropriate. In this investigation, "Ca/S=3" was decided as a target and limestone was added. According to results of the analysis by the laboratory, the mol ratio in the case of mixed coal was about 2.6, which is slightly lower than the planned value, but "3" was a desirable value for the addition amount of desulfurization agents. Adding to the Ca/S mol ratio, desulfurization efficiency is influenced by the diameters particle of desulfurization agents. This is attributable to the facts that the smaller a particle diameter is, the higher the desulfurization efficiency is and the more particles without reaction scatter, and that when a particle diameter is larger, the area where a reaction is valid (the specific area) is reduced. It can be understood from this that the time desulfurization agents stay in the layer is a matter of concern.

In addition, the method of mixing raw coal and desulfurization agents can be considered as a big factor. This point was clarified by investigation of the plan for measures against air pollution in Ankara carried out in 1984. A comparative combustion test was conducted to compare fuel formed as bricket by mixing powdered raw coal and desulfurization agents with fuel mixed with lump coal (20-40mm) and desulfurization agents. As a result, the desulfurization efficiency of 71 - 80% were obtained in the case of the former and of 32% in the case of the latter.

In this way, in order to obtain good desulfurization efficiency, it is necessary (1) to burn fuel at an appropriate temperature, (2) to select an appropriate Ca/S mol ratio, and (3) to mix desulfurization agents and raw coal in a better way and to take a sufficient reaction time.

5-3. Temperature of the Fluid Layer

As mentioned in the previous clause, it is clear that combustion temperature is deeply concerned with desulfurization efficiency. Though one of the major characters of fluidized-bed combustion is that temperature of the layer is controlled in the range from 800 to 900 ℃ so that desulfurization will occur in the furnace, desirable results were not obtained from this test. It can be considered that one of the causes of this is that temperature in the fluid layer was not even. Nine temperature detectors are installed within the layer. Temperature distribution is shown in Figures 5-3-1 to 5-3-4. The middle part in each figure represents the part with fast air-tower speed, which is 6-7m/s. Theoretically, the air-tower speed is made to be 3-4m/s in the front and rear parts so as to circulate fluid materials by a difference in speed between the front and rear parts and the middle part and also to uniformalize temperature in the layer. However, as seen from figures, although the temperature is within the optimum temperature range of 800-900 ℃ in the middle part, there are many parts with temperature under 800 ℃ and there are even some parts under 700 ℃. The cause of this difference in temperature is considered to be due to a difference in air-tower speed. However, if the amount of air is increased to raise speed (provided that the fluid-layer fan has excessive power), temperature in some parts in the layer exceeds 900 ℃, which causes sintering of the fluid media.

It is conjectured that the desulfurization efficiency could not be obtained, mainly because temperature of the layer could not be controlled in this way.

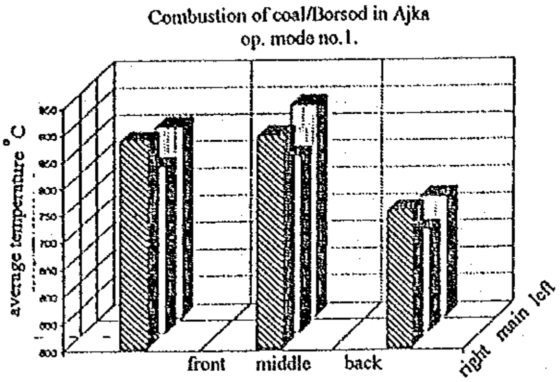


Figure 5-3-1. Distribution of Temperature in the fluidized-bed layer in Mode -1

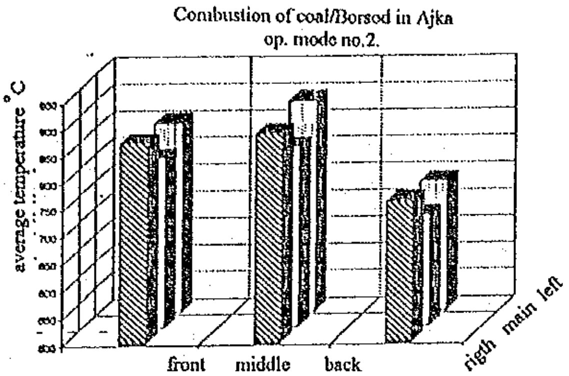


Figure 5-3-2. Distribution of Temperature in the fluidized-bed layer in Mode -2

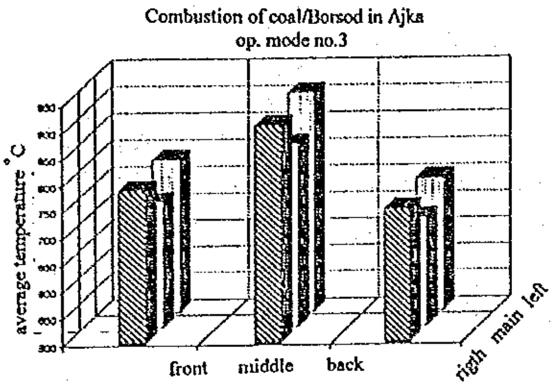


Figure 5-3-3. Distribution of Temperature in the fluidized-bed layer in Mode -3

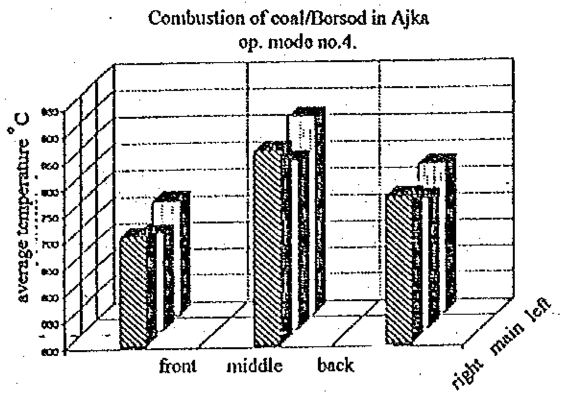


Figure 5-3-4. Distribution of Temperature in the fluidized-bed layer in Mode -4

5-4. Efficiency of Desulfurization and Points at Issue

As shown in the test results, the desulfurization efficiency was estimated to be 42-45% at most, and the rate when desulfurization agents were added was only 23-34%. These results can be put in order as follows:

- Temperature in the fluid layer could not be made uniform in the range from 800 ℃ to 900 ℃. Reaction with desulfurization agents was insufficient in some parts.
- Though the Ca/S mol ratio was appropriate, physical characteristics of limestone and characteristics of the mixture with raw coal were not appropriate. It is considered that a part of desulfurization agents without reaction scattered to the outside of the furnace together with exhausted gas.

- It is considered that, in the range of hybrid fluidized-bed combustion, parts with high temperature occurred inside the furnace due to use of the burner for pulverized-coal combustion, particles of desulfurization agents which had reacted in the fluid layer left the layer together with exhausted gas, and a part of them were reduced due to temperature and coexisting gas when the particles passed the area with high temperature.

5-5. NOx Concentration

According to causes of generation, NOx can be classified to thermal NOx generated by oxidation of nitrogen in the air upon combustion at high temperature and fuel NOx generated by oxidation of the nitrogen content contained in fuel. As fluidized-bed combustion has a lower combustion temperature than a float combustion system such as powdered-coal combustion, it is considered that almost all of generated NOx is fuel NOx. All of the nitrogen content in fuel is not converted to fuel NOx, but the degree of conversion depends on various kinds of factors. It was reported that 6-8% was converted in the past experiments.
In this test, the following results have been obtained.

Mode No.	1	2	3	4
Type of fuel	Lyuko coal		Mixed coal	
Quantity of evaporation t/h	85	60	80	43
NOx Concentration in ppm of 02 to 6%	218	241	209	168
Average temperature in the layer ℃	819	774	811	797

Definite difference in concentration due to different combustion systems could not be found in the results.
The results of measurement at the Borsod Power Plant in the study area were 250-290ppm (with the 6% converted value of 02 and load of about 75t/h). In this test, values are 218-209ppm and difference was 40-80ppm or so.

5-6. Insufficiency of Heat Value at High Load

The hybrid fluidized-bed combustion boiler makes up for insufficient heat value with pulverized-coal combustion under high-load operation. As mentioned above, in the case of pulverized-coal combustion, as the sulfur content in fuel is discharged without measures, the desulfurization efficiency lowers.

As a measure against this, the use natural gas or low-sulfur fuel oil instead of pulverized coal can be considered. Though additional facilities such as a burner, a controller and pipes for air and fuel are technically required, since the existing pulverized-coal combustion boiler uses natural gas and fuel oil as fuel at any time, remodeling for it is a small thing. Clearly, if fuel conversion is made for pulverized-coal combustion, SO2 emission can be reduced. However regarding desulfurization agents with a certain diameter used in the range of fluidized-bed combustion, since their particles scatter from the layer, there is a risk that the desulfurization efficiency of is lowered by a reduction of them in the range of high-temperature combustion.

It is necessary to study more about diameters of desulfurization agents to be added and methods of addition.

5-7. Potentialities of Combustion System Improvement

5-7-1. Concentration of Oxygen in Exhausted Gas

It is a basis of energy-saving combustion and an elementary measure to keep the concentration of oxygen remaining in exhausted gas from combustion as low as possible (the low air ratio). In addition, it is known that combustion with the low air ratio also has the effect of reducing the amount of NOx generation.

From the results of analysis, the theoretical amount of exhausted gas from dry combustion is as follows:

G=0.0887*C+0.0333*S+0.209*H+0.008*N-0.0263*(O+V*A)Nm3/kg = 2.236 Nm3/kg,

provided that W is the water content (%), A is the ash content (%), V is ignition loss, C is total carbon (%), S is total sulfur(%), H is total hydrogen (%), N is nitrogen (%) and O is oxygen (%).

As the air ratios are 1.4 in the case of O2 6% and 1.17 in the case of 3%, the amount is 3.130 Nm3/kg for 6% and 2.612 Nm3/kg for 3%, and difference between them is 0.518 Nm3/kg.

If the temperature of exhausted gas is 160 ℃, which is its acid dew point, reference temperature is 235 ℃, and average specific heat of dry exhausted gas is 1.38 KJ/Nm3K, possession heat which excess air takes out is as follows: