CHAPTER 6 DECOMMISSIONED SURVEY ON SITE

CHAPTER 6 DECOMMISSIONED SURVEY ON SITE

6.1 Use of Native Consultant

6.1.1 Purpose of commission

The purpose of this commission is to improve F/S accuracy and reduce F/S period by recommissioning ENERGOPROEKT PLC, a native consultant knowing details of law system and technological level of Bulgaria with a part of this survey, in order to contribute to this survey.

To achieve sufficient analysis and evaluation of the survey result and content of measured data as this survey mission, the mission intends to consult ENERGOPROEKT PLC sufficiently and cooperate with it in evaluation work, etc.

6.1.2 Commission period

The attached reference 6-1 shows a contract with ENERGOPROEKT PLC.

(1) The commission period is about 8 months from July 6, 1995 to February 28, 1996.

(2) The due date for offer related to collected reference materials is August 31, 1995 and the due date for offer related to measured data is December 31, 1995 and February 28, 1996 to coincide with each measurement date.

(3) After each offer date, received survey result was checked and confirmed about its content.

6.1.3 Commissioned content

The major content of commissioned work is shown as follows. The detail of the commissioned work is confirmed via the minute (dated July 3, 1995) shown in the attached reference 6-2 before commissioned.

(1) Survey of existing power pant facilities

- (a) Specification of each facility
- (b) Operational records
- (c) Others

(2) Survey of items re-usable in new plant

(a) Specifications and drawings of re-usable equipment/facilities
(b) Structure foundations
(c) Site survey of re-usable equipment/facilities
(d) Interface with new plant
(e) Specifications and drawings of regional heating steam piping
(f) History of facility

(3) Survey of existing transmission line and substation facilities

(a) Facility specifications and drawings
(b) Structure foundations
(c) Parameters/constants for power system analysis

(4) Environmental survey

(a) Geographical map of area
(b) Initial environmental evaluation
(c) Environmental impact assessment

(5) Geographical survey for facility construction

(a) Production of topographical map
(b) Production of facility layout

(6) Geological survey

(7) Hydrology observation

(8) Study of equipment/material procurement

(a) Machine repair shops, their technology level, and past performance
(b) Specification and prices of locally procurable items
(c) Cost of construction equipment, materials, and labor in each occupation
(d) Taxes on construction materials
(e) Current market prices and future prospect of limestone and gypsum

(9) Study of construction cost

(10) Constraints on power plant design

(a) Regulation by national and local governments

(b) NEK's internal regulations and standards

(c) Operational rules other than legal provisions

(d) Constraints on unloading, transportation route and transport of heavy articles

(11) Other assistance and advice required for the site survey

6.2 Geology and Hydrology Observation

6.2.1 Geological Survey

(1) General

The field geological survey for this feasibility study was carried out by subletting the actual work to ENERGO PROJECT in Sofia. The items of the geological survey carried out under this feasibility study are as follows:

- Boring : 8 boreholes ; 30 m/hole ; 240 m in total
- Test items : Standard penetration test
  Moisture test; Specific gravity test; Mechanical analysis of soil; Unconfined compressive test; Consolidation test; Chloride content test; Sulfate content test; Permeability test; PS logging; and Electrical logging.

(2) Outline of Geological Structure in the Surrounding Area

(a) General

The Maritsa East No.1 Thermal Power Plant is located around the eastern part of the Gornotrakeeska depression. The part of the Maritsa East No.1 Thermal Power Plant within the industrial zone is located in the Gornotrakeesky graben constituting one of the internal geological structure of the Gornotrakeeska depression.

The Gornotrakeesky graben is filled with Pliocene and Quaternary deposits. These deposits, which have been products in the upper diagonal bedrock due to Precambrian metamorphic belt, have been found on the northern slope of Mt.Sakar. These metamorphic facies constituting a part of such facies produced due to movement of North Roadopes～Sacar Slip have been subjected to intensive diastrophism. The deposits represented by Precambrian gneiss, quartz, plagioclase and two mica gneisses have been intruded and transited even to granite gneiss at some places. The depth where these materials exist is about 300 m.

(b) Geological conditions (Regional Geology)

① General

There are four separated lithologic and stratigraphic characters inside the Pliocene sedimentary facies of coal formation group located on the metamorphic belt.

② Geological stratigraphy

The stratigraphy to upward from the bottom section is as described below.

a) Basal horizon

In the basal horizon, the stratigraphy starts from a block consisting of weathered and broken gneiss containing sandy and clayey fills. These materials have been converted to breccia and psephite (conglomeratic rock) of clay. The upper basal horizon consists of the alternations gravel and sandy clay.

The thickness of this horizon is about 75 m.

b) Sub-coal horizon.

This horizon is represented by light brown sandy clay and silty clay. Existing in this upper part of this horizon are the layers of gray/green clay and brown/white clay containing thin and irregular sandy layer, as well as the layers of coarse polygenetic gravels with a thickness of 5～8 m The thickness of this sub-coal horizon is about 160 m.

c) Coal horizon.

This horizon is represented by the layers of thick gray/black～black silty clay containing coal fragments, as well as the poorly coal bearing and intensively clayey lignite coal layers The thickness of this horizon is about 35 m.

d) Upper coal horizon

This horizon is represented by silty, sandy and silty/sandy dense clays. The color ranges from gray to gray/green. This clay which has undergone swelling contains quartz and chalky fragments as well as small gravels. Spreading in this horizon are the clayey sand layers with irregular thickness ranging from 1～2 m to 4～5 m.
The thickness of this horizon is 30～40 m.
The Quaternary deposits cover all of the Pliocene sediments (deposits).

e) Diluvial deposits

These deposits are represented by clay containing sandy clay and gravel. The thickness is 1～2 m, rarely to 3～4 m. These deposits cover the slopes and some of the negative forms of the relief.

f) Alluvial deposits

These deposits forming the existing terraces of the Socolitza and Sazleeka Rivers are represented by sandy clay with a thickness of 3～4 m. Under the sandy clay layer, these are fine-grained sand and sand containing gravel.
The total thickness of the terrace deposits is 9～10 m.

(3) Geological Survey

Described below are the methods, quantity, positions, etc. of the geological survey carried out under this study.

(a) Boring survey

To clarify the geological conditions within the power plant site, eight (8) boring sites were selected mainly from the positions where important major power plant structures such as the powerhouse building, boiler equipment, chimney, oil storage tanks, coal storage yard, cooling water intake/discharge waterways are to be located. The selected boring sites are presented Figure 6-2-1.

In other words, eight (8) boreholes were drilled with the extension per hole and the the extension of all boreholes being 30 m and 240 m, respectively.

(b) Laboratory tests

The laboratory tests were carried out by using the undisturbed specimens and the test specimens selected from among the standard penetration test specimens sampled for clarifying the properties of the layers distributed in this site area, the laboratory tests.
The test items and quantity are as listed below.

Test items	No.of specimens
· Moisture test	21
· Specific gravity test	21
· Mechanical analysis of soil	21
· Unconfined compressive test	9
· Consolidation test	9
· Chloride content test	21
· Sulfate content test	21

(c) Permeability tests

The permeability test was carried out at the boreholes BH2 and BH5.
Meanwhile, the coefficient of permeability was obtained based on the LEFRANC's method.

(d) Electrical logging

This logging was carried out at the boreholes BH3 and BH5.

(e) PS logging

This logging was carried out at the boreholes BH1 and BH2.

(4) Results of Geological Survey

(a) General

The (geological) section/profile within the proposed power plant site consists of Alluvial deposits of Sokolitza River formed over the eroded Pliocene bedrock.

Based on the results of surveying the geological and lithological sections, the following items have been confirmed:

- Artificial fill(fill and banking) (Var.1) : Clay, sand and coal. This fill covers almost all of the thermal power plant site. The artificial fill with a maximum thickness (4.5~5.0 m) is located at the chimney and steam generating equipment sites (Boreholes BH3 and BH1). The thickness of the fill from the bottom of the outdoor coal storage yard is 2.8m (Borehole B6).
  The alluvial deposits and layers(alQ) of (under) Sokolitza River are represented by the following materials downward from the top:

- Sandy clay : Dark brown(Var.2) : This clay layer with a thickness ranging from 2.3 m (BH7) to 3.5 m(BH6) and 2.7 m on an average covers the entire site.
  During construction of the existing power plant, clay was removed and replaced by artificial fill at some places.

- Fine sand : Yellow/brown and intensively clayey (Var.3). At some places, fine sand was replaced by intensively sandy clay. With a thickness ranging from 1.5 m (BH8) to 3.9 m (BH6) and 3.7 m on an average, the average depth of this fine sand layer from the ground level is 6.2 m on an average.

- Coarse sand : Pure, quartzic, yellow or gray, in some place with small grand (Ver.4). They reach till a depth of 7.6M (BH7) to 10.5 m (BH5) from the surface.
  The thickness of them changes of 2.0m (BH7) to 7.0 m (BH5) average 3.6m.

- Coarse sand : Quartzous with high purity and very fine-grained gravels are contained (Ver.5). With a thickness ranging from 0.5 m (BH5) to 2.3 m (BH2), this coarse sand layer is located at the bottom of the Alluvial deposits, and its depth from the ground level ranges from 9.0 m (BH3) to 11.3 m (BH2).

The grading and composition of clay of the materials in the high terrace profile of Sokolitza River vary frequently in the horizontal and vertical directions. Lithologically dominant are the sandy materials ranging from intensively clayey fine sand to pure and highly quartzous coarse sand. The materials of these lithological varieties form alternations (interlaces). Apparently, these is the following remarkable trend. Namely, the deeper the geological section (profile), the larger the grain size, and the smaller the clay content.

Although the thickness of the Alluvial sandy and gravely material deposits is 9.0 m on average within the majority of the power plant site, the thickness is 6.0 m around the northern and western part of steam shop sections.

The Alluvial deposits have been formed on the irregular bedrock from the Pliocene clay deposits.

Silty and sandy clay (N_2) (Var.6) : These materials are high in density and consist of gray/brown and light gray materials with chalky spots containing rusty materials. These deposits are located under the Alluvial deposits at a depth of 6.0 m (BH4) through to 11.3 m (BH2) from the ground level. Such clay deposits form an upper Pliocene coal horizon with a thickness ranging approximately from 30 to 40 m.

(b) Result of Boring

Results of Standard Penetration test, PS logging and Electrical logging are shown in the Figure 6-2-2～6-2-9.

(c) Result of Laboratory Tests

① Phisical characteristics

Laboratory testing results by undisturbed samples and disturbed samples are shown in the Table 6-2-1. and Table 6-2-2.

Table 6-2-1 PHISICAL CHARACTERISTICS OF THE UNPISTURBED SAMPLES

Borehole No.	1	1	1	3	3	3	6	6	6
Sample No.	2 (Var.6)	3 (Var.6)	4 (Var.6)	3 (Var.6)	4 (Var.6)	5 (Var.6)	2 (Var.6)	3 (Var.6)	4 (Var.6)
Depth from the surface from-to, m	15^{50}- 16^{00}	15^{50}- 16^{00}	25^{50}- 26^{00}	12^{50}- 13^{00}	17^{50}- 18^{00}	21^{50}- 22^{00}	14^{50}- 15^{00}	18^{50}- 19^{00}	24^{50}- 25^{00}
Specific, density g/cm³	2.71	2.70	2.72	2.71	2.71	2.70	2.20	2.70	2.71
Bulk density, g/cm³	1.79	1.78	1.83	1.84	1.78	1.78	1.87	1.85	1.89
Dry mass, g/cm³	1.25	1.24	1.32	1.38	1.29	1.26	1.40	1.38	1.43
Pore volume, %	54	54	52	49	53	53	48	49	47
Pore coefficient	1.17	1.18	1.08	0.96	1.10	1.14	0.92	0.96	0.89
Water content, %	43.0	43.0	38.2	33.4	38.0	41.0	33.4	33.5	32.5
Atterberg Limit - W_L	80.0	85.5	71.0	66.5	78.5	84.5	69.0	77.0	75.0
Atterberg Limit - W_p	46.5	42.0	39.5	33.0	38.5	35.5	31.0	33.0	33.5
Plasticity, %	33.5	43.5	31.5	33.5	40.0	49.0	38.0	44.0	41.5
Index of consistency	1.10	0.98	1.05	0.99	1.00	0.88	0.92	1.00	1.05
Initial saturation - Sr	0.73	0.75	0.99	0.93	0.93	1.02	0.98	0.96	0.98

Table 6-2-2 PHISICAL CHARACTERISTICS OF THE DISTURBED SAMPLES

Borehole No.	1	2	2	3	3	4	5	5	6	7	8	8
Sample No.	1 (Var. 5)	1 (Var. 4)	2 (Var. 5)	1 (Var. 4)	2 (Var. 5)	1 (Var. 3)	1 (Var. 4)	2 (Var. 4)	1 (Var. 3)	1 (Var. 4)	1 (Var. 2)	2 (Var. 5)
Depth from the surface from - to, m	8^{00}- 8^{50}	7^{00}- 7^{50}	10^{00}- 10^{50}	6^{00}- 6^{50}	8^{00}- 8^{50}	5^{00}- 5^{50}	4^{00}- 4^{50}	7^{00}- 7^{50}	4^{00}- 4^{50}	6^{00}- 6^{50}	3^{00}- 3^{50}	5^{00}- 5^{50}
Specific gravity g/cm³	2.67	2.66	2.66	2.68	2.65	2.68	2.67	2.67	2.71	2.68	2.70	2.67
Water content, %	21.5	12.4	9.0	20.6	14.8	12.6	13.7	11.5	16.2	11.7	17.8	15.6

② Result of Unconfined Compression

With test for unconfined compressive strength was tested by 9 undisturbed samples of clays.
The result are shown in the Table 6-2-3.

Table 6-2-3 RESULTS OF UNCONFINED COMPRESSIVE STRENGTH TEST

Borehole No.	1	1	1	3	3	3	6	6	6
Sample No.	2	3	4	3	4	5	2	3	4
Normal stress, 10^5Pa	6.0	3.8	3.6	2.6	1.8	2.3	1.1	2.2	4.7
Strain at falure, %	2.5	3.6	1.3	5.8	2.4	1.5	3.3	2.4	2.6

③ Result of Consolidation

One-dimensional consolidation were made to 9 undisturbed samples of clays.
The result are shown in the Table 6-2-4.

Table 6-2-4 RESULTS OF ONE - DIMENSIONAL CONSOLIDATION

Borehole No.	1	1	1	3	3	3	6	6	6
Sample No.	2	3	4	3	4	5	2	3	4
Final moisture, %	45.2	51.7	38.8	42.7	39.4	41.7	33.9	38.1	36.6
Final wet weight g/cm^3	1.84	1.88	1.84	1.88	1.84	1.80	1.91	1,79	1.93
Coefficient of consolidation c_v	σ =3.43 c_v=1.49	σ =3.43 c_v=8.17	σ =3.43 c_v=1.03	σ =3.43 c_v=8.66	σ =3.43 c_v=3.81	σ =4.13 c_v=1.23	σ =3.43 c_v=2.74	σ =3.43 c_v=0.54	σ =3.43 c_v=1.57
σ ,.10^5 Pa c_v, mm^2/min	σ =5.43 c_v=0.32	σ =6.73 c_v=2.10	σ =5.43 c_v=0.42	σ =5.43 c_v=8.56	σ =6.73 c_v=2.12	σ =6.73 c_v=0.69	σ =6.73 c_v=1.49	σ =5.43 c_v=0.54	c_v=6.73 c_v=1.09

④ Chemical Analysis

The chemical analysis were made 9 undisturbed samples and 12 disturbed samples. The result are shown in the Table 6-2-5.

Table 6-2-5 RESULTS OF CHEMICAL ANALYSES

Borehole No.	Sample No.	Chloride (Cl), %	Sulfate (SO_4), %
UNDISTURBED SAMPLES			
1	2	0.010	0.034
1	3	0.010	0.036
1	4	0.017	0.040
3	3	0.008	0.060
3	4	0.008	0.018
3	5	0.009	0.039
6	2	0.010	0.020
6	3	0.010	0.020
6	4	0.009	0.018
DISTURBED SAMPLES			
1	1	0.005	0.008
2	1	0.004	0.004
2	2	0.010	0.008
3	1	0.005	0.033
3	2	0.006	0.010
4	1	0.005	0.012
5	1	0.005	0.045
5	2	0.006	0.012
6	1	0.006	0.599
7	1	0.008	0.085
8	1	0.008	0.387
8	2	0.008	0.018

6.2.2 Observation Underground-water

(1) General

The groundwater level was investigated by using the boreholes drilled for geological survey within the power plane site. Meanwhile, this investigation was carried out by subletting the actual work to ENERGO PROEKT of Sofia according to the following procedures:

Borehole used for investigatio: No.5 (Powerhouse building section)

(2) Investigation Method

After installing a piezometer with a 75 mm dia. PVC tube in the borehole No.5, the groundwater level was measured once every five days.

(3) Result of,observation

The result are shown in the Table 6-2-6.

Table 6-2-6 UNDERGROUND-WATER LEVEL

Date	Water level (depth) (m)	Elevation (m)
95' 10/10	6.10	101.121
95' 10/16	6.10	101.121
95' 10/20	6.10	101.121
95' 10/25	6.02	101.201
95' 10/30	6.02	101.201
95' 11/6	6.02	101.201
95' 11/10	6.01	101.211
95' 11/15	6.01	101.211
95' 11/20	5.98	101.241
95' 11/27	5.98	101.241

6.2.3 River Stream Gauging

(1) General

This stream gauging was carried out by subletting the actual work to ENERGO PROEKT of Sofia.

(2) Place and Period of Steam Ganging

This stream gauging was carried out at a place of railway crossing about 1 km upstream of the intake gate for the Pump Station along the Sazlika River as indicated In Figure 6-2-10.

(3) Stream Ganging Method

After measuring the cross section of the river at a horizontal interval of 1 m, the flow velocity according to the simplified measurement method, and the mean flow velocity was calculated. Finally, the river discharge was calculated from the product of the cross section.
Meanwhile, measurement of river discharge (stream gauging) was carried out three times per month.

(4) Results of Observation

The results of stream gauging are as presented in Table 6-2-7.

Table 6-2-7 MERSURED DISCHARGE

Date	Discharge (m^3/sec)	Date	Discharge (m^3/sec)
95' 9/14	5.04	95' 11/28	4.70
95' 9/21	4.89	95' 12/08	6.51
95' 9/28	5.30	95' 12/20	11.35
95' 10/5	4.78	95' 12/27	10.10
95' 10/10	5.05	96' 1/4	19.56
95' 10/26	5.00	96' 1/11	14.38
95' 11/10	5.27	96' 1/18	16.40
95' 11/17	4.60		

Agreement for LOCAL SURVEY for THE FEASIBILITY STUDY on MARITSA EAST NO.1 REPLACING THERMAL POWER PLANT for IMPROVEMENT of THE PERFORMANCE OF THE UNITS AND THE ENVIRONMENTAL PROTECTION in THE REPUBLIC OF BULGARIA

July, 1995

JICA Study Team
and
ENERGOPROEKT PLC

Agreement

This Agreement made and entered into on this 3th day of July, 1995 between the JICA Study Team, a Joint Venture composed of Electric Power Development Co., Ltd. (EPDC) and Tokyo Electric Power Services Co., Ltd. (TEPSCO), represented by MR. J. Inoue of EPDC, and ENERGOPROEKT-PLC. EPDC is the leading firm of the Joint Venture, a company duly organized and existing under the law of Japan with its principal office at 15-1, Ginza 6-chome, Chuo-ku, Tokyo 104, Japan (hereinafter referred to as "JICA Study Team"), and ENERGOPROEKT-PLC, with its principal place of business at AT 51 J. Boucher Blvd. 1407, Sofia, the Republic of Bulgaria (hereinafter referred to as "ENERGOPROEKT") (hereinafter referred to collectively as the "Partners").

WITNESSETH

WHEREAS, the Japan International Cooperation Agency (hereinafter referred to as "JICA") has agreed to perform certain service of work in connection with the Feasibility Study on Maritsa East No.1 Replacing Thermal Power Plant for Improvement of the Performance of the Units and the Environmental Protection in the Republic of Bulgaria (hereinafter referred to as the "Study") under the Scope of Work agreed upon between the Natsionalna Elektricheska Kompania (hereinafter referred to as "NEK") and JICA on February 9, 1995.

WHEREAS, JICA has entrusted the study to the JICA Study Team.

AND WHEREAS JICA Study Team desires to subcontract the work of certain consulting services (hereinafter referred to as the "Services") with ENERGOPROEKT, and whereas, ENERGOPROEKT is desirous of performing the Services in accordance with the provisions of this Contract, and more fully described in Article 1 contained herein.

Now, THEREFORE JICA Study Team and ENERGOPROEKT contract with each other as follows:

ARTICLE 1. THE SERVICES

1.1 ENERGOPROEKT shall perform the following Services:

a) Data collection of Existing Power Plant Equipment/Facilities
b) Reusable Existing Facilities
c) Environmental Study
d) Topographical Survey
e) Geological Survey
f) Hydrological Survey
g) Material and Equipment Survey

1.2 ENERGOPROEKT shall perform the Services as an independent contractor in accordance with the teams of this Agreement, applicable laws and regulations, and with satisfactory of JICA Study Team.

1.3 ENERGOPROEKT shall exercise reasonable skill, care and diligence in the discharge of its duties under this Agreement.

1.4 ENERGOPROEKT shall be deemed to have no proprietary interest in such data and information as ENERGOPROEKT creates, develops, improves, possesses, or receives as a direct or substantial consequence of this Agreement.

ARTICLE 2. SPECIFICATIONS

The scope of work performed by ENERGOPROEKT under this agreement is described in Attachment-1 attached hereto and forming integral part of this Agreement.

ARTICLE 3. LIABILITIES OF ENERGOPROEKT

3.1 ENERGOPROEKT shall be liable for the consequence of errors and omission arising from the gross negligence on its part in respect of the Services referred to in Article 1 contained herein.

3.2 ENERGOPROEKT shall indemnify and save harmless JICA Study Team from and against, in the respect of all actions, charges, claims, costs, damages, losses and proceedings occurring as a consequence of the performance by ENERGOPROEKT of the Services.

3.3 ENERGOPROEKT shall, at his own expenses, maintain third party liability insurance with respect to his obligation under this Agreement.

3.4 ENERGOPROEKT shall, in respect of the totality of all acts of omissions of ENERGOPROEKT in regard hereto, not be responsible or liable for delay or failure to JICA Study Team for the performance of the Services. In any event the liability of ENERGOPROEKT shall expire sixty (60) days after the termination date as specified in an Article 10.3 of this Agreement.

ARTICLE 4. OBLIGATIONS OF JICA STUDY TEAM

JICA Study agrees to render all possible assistance to ENERGOPROEKT in the collection of existing information, in the opinion of JICA Study Team would be of assistance to ENERGOPROEKT in the performance of its Services.

ARTICLE 5. INSPECTION OF RESULTS

ENERGOPROEKT shall submit a notice of completion of each work item in the Specification to the Study Team within three (3) days after the completion of the Services. The results of the Services to be included in the notice are shown in the attached Specifications. The Study Team shall inspect such results within ten (10) days after receipt of such results accompanied by a written notice of completion. If the Study Team reject such results as unacceptable, ENERGOPROEKT shall remedy such work items (s) to the satisfaction of the Study Team by the data specified by the Study Team and re-submit the results to the Study Team for inspection, provided however that the Study Team shall not unreasonably reject Work results.

ENERGOPROEKT shall remedy Work results without delay and shall obtain final acceptance of such results under the CONTRACT, if such remedy is required by the Study Team and/or JICA in one year after the Contract period.

ARTICLE 6. REPORTING

ENERGOPROEKT shall submit one (1) copy of report on the specified works of the Services in English to the Study Team's representative(s) in accordance with the date of delivery of the works.

ARTICLE 7. REMUNERATION AND PAYMENT

7.1 ENERGOPROEKT shall be remunerated by JICA Study Team for the performance of Services described in Article 1 and Attachment-1 of this Agreement on a lump sum basis.

7.2 Contract Price

The total contract price shall be US dollars 109,150.00 (one hundred nine thousand one hundred fifty US Dollars only) upon completion of the Services and not subject to price adjustment.

7.3 Payment of Invoice

ENERGOPROEKT shall submit their invoice for the payment, specifying bank name and account number.

"Sofia Bank" - Vitosha Branch
1000 Sofia, 6 Vitosha St., Bulgaria
Account No. 421 - 371 - 300 - 3

7.4 Terms of Payment

The advance payment of Forty percent (40 %) of the Contract Price shall be paid within fifteen (15) days after the Contract is signed by the parties.

The final payment of Sixty percent (60 %) of the Contract price shall be paid within fifteen (15) days after the completion of the entire works and after the approval by the JICA Study Team.

However, in case of delay in completing and submitting individual report of the works in the Specification, such terms of first and second payment shall be retained.

ARTICLE 8. NOTICES AND REQUESTS

Any notice or request required to be given or made in this Agreement shall be in writing in English language. Such notice or request shall have been delivered by hand, registered mail, telefax or acknowledged telex to the party to which it is required to be given as follows:

to ENERGOPROEKT

Attention	:	Mr. Boris Ivanov, ENERGOPROEKT PLC
Address	:	51 J. Boucher Blvd, 1407 Sofia, Bulgaria
Telephone	:	(3592) 665052, (3592) 689139
Telefax	:	(3592) 668951

to JICA Study Team

Attention	:	Mr. Juzo Inoue, Overseas Engineering Dept.
Address	:	Electric Power Development Co., Ltd. 15-1, Ginza 6-chome, Chuo-ku, Tokyo 104, Japan
Telephone	:	81 (3) 3546-9412
Telefax	:	81 (3) 3546-9533
Telex	:	EPDCTOK J26716

ARTICLE 9. FORCE MAJEURE

9.1 Neither Party shall be deemed to be in default or in breach of the Agreement if he is unable to perform his obligations under the Agreement owing to circumstances beyond his reasonable control. Such circumstances (hereinafter referred to as "FORCE MAJEURE") include, but shall not be limited to the following:

(a) Acts of God, including storm, earthquake, flood or any other such operation of the forces of nature as his reasonable foresight and ability could not foresee or reasonably provide against.

(b) War (declared or undeclared), hostilities, invasion, act of any foreign enemy, threat of or preparation for war, riot, insurrection, civil commotion, rebellion, revolution, usurped power, civil war and labor troubles or other industrial troubles, strikes embargoes, blockades, sabotage of labour, etc.

ARTICLE 10. GENERAL PROVISIONS

10.1 Laws Applicable

This Agreement shall be governed and construed according to the laws of the Republic of Bulgaria.

10.2 Effectiveness of Agreement

This Agreement shall be deemed to become effective on the date of execution by parties.

10.3 Termination of Agreement

ENERGOPROERT shall complete the Services described in detailed in Article 1, above in accordance with the following schedule.

Commencement : July 6, 1995

Completion : February 28, 1996

10.4 Amendment of Agreement

This Agreement may be amended from time to time only by mutual agreement in writing singed by both parties to this Agreement in the form of an amendment of this Agreement.

10.5 Assignment

Neither party hereto shall assign all or any part of the rights or obligation under this agreement or any interest therein without the prior written consent of the other party hereto.

IN WITNESS WHEREOF, JICA Study Team and ENERGOPROEKT have caused this Agreement to be signed in their respective names by their duly authorized representatives as of the day, month and year first written herein before.

Boris Ivanov
Chairman of the Board of Director
ENERGOPROEKT PLC

Juro Inoue
Team Leader
JICA STUDY Team

Attachment-1

SPECIFICATION for LOCAL SURVEY for THE FEASIBILITY STUDY on MARITSA EAST NO.1 REPLACING THERMAL POWER PLANT for IMPROVEMENT of THE PERFORMANCE OF THE UNITS AND THE ENVIRONMENTAL PROTECTION in THE REPUBLIC OF BULGARIA

Chapter 1 GENERAL

Section 1 Background

In compliance with the Scope of Work for the Feasibility Study on Maritsa East No.1 Replacing Thermal Power Plant for Improvement of the Performance of the Units and the Environmental Protection in the Republic of Bulgaria, which was agreed upon between the Natsionalna Elektricheska Kompania (NEK) and Japan International Cooperation Agency (JICA) on February 9, 1995, JICA has decided to carry out the feasibility study and assigned it to the JICA Study Team for the Study.

Section 2 Scope of Work

The work to be performed is to obtain the existing data of power plant, transmission line, substation, environment, equipment/material procurement, construction cost, constraints and measuring data of environment, geography, geology, hydrology meeting the JICA Study Team's instructions.

Section 3 Specification

Local Survey data shall be collected in accordance with the specification herein set out and detailed specification in the Minutes of Meeting.

Section 4 Language

Language to be used shall be the English language.

Chapter 2 DETAILED SPECIFICATION

Section 1 Method of Work

Data shall be collected from the related offices/organization and measured in accordance with the JICA Study Team's instructions.

Section 2 Contents to be collected

Data to be collected is stipulated in the attachment.

Chapter 3 WORK SCHEDULE

The work shall be completed by August 31,1995 for the first, December 31,1995 for the second, February 28, 1996 the balance.

Chapter 4 REPORT

A report and collected material of each work item will be delivered along with a list of contents to the JICA Study Team (in Japan) not later than the date of submission.

Detailed Specification
(Contents of Data to be collected)

Item	Scope of Study	Date of Submission
1. Survey of Existing Power Plant Facilities	1.1 Specification of Each Facility	August 31,1995
	1.2 Operational Records	August 31,1995
	1.3 Others	August 31,1995
2. Survey of Items Re-Usable in New Plant	2.1 Specifications and Drawings of Re-usable Equipment/Facilities	August 31,1995
	2.2 Structure Foundations	August 31,1995
	2.3 Site Survey of Re-usable Equipment/Facilities	August 31,1995
	2.4 Interface with New Plant	August 31,1995
	2.5 Specifications and Drawings of Regional Heating Steam Piping	August 31,1995
	2.6 History of Facility	August 31,1995
3. Survey of Existing Transmission Line and Substation Facilities	3.1 Facility Specifications and Drawings	August 31,1995
	3.2 Structure Foundations	August 31,1995
	3.3 Parameters/Constants for Power System Analysis	August 31,1995
4. Environmental Survey		
4.1 Geographical Map of Area	4.1.1 Geographical map of area within 30 km in radius from project site with contours	August 31,1995
4.2 Initial Environmental Evaluation (IEE)	4.2.1 Ground Meteorology	August 31,1995
	4.2.2 Pollution Survey	August 31,1995
	4.2.3 Natural Environment in the Environmentally Affected Area	August 31,1995
	4.2.4 Social Environment	August 31,1995
	4.2.5 Examples of environmental studies	August 31,1995
4.3 Environmental Impact Assessment	4.3.1 Environmental Impact Assessment (EIA)	February 28,1996
	4.3.2 Survey on the Temperature Rise of the Lake Water	February 28,1996

Item	Scope of Study	Date of Submission
5. Geographical Survey for Facility Construction	5.1 Topographical Map (Production of Land Survey Map: Scale=1/1,000, 1 meter contour intervals, for approximately 1.1 km^2 area)	August 31,1995
	5.2 Production of Facility Layout	August 31,1995
6. Geological Survey	6. Boring Survey (all-core, 30m/bore, 8 bores, 240m) and Production of Geological Cross Section Chart (Scale=1/1,000, 4 to 6 cross sections) within Power Plant Premises	August 31,1995
7. Hydrology Observation	7. Hydrological data are measured by water level gauges to be installed	February 28,1996
8. Study of Equipment/Material Procurement	8.1 Machine repair shops, their technology level, and past performance	August 31,1995
	8.2 Specification and prices of locally procurable items	August 31,1995
	8.3 Cost of Construction equipment, materials, and labor in each occupation	August 31,1995
	8.4 Taxes on construction materials	August 31,1995
	8.5 Current market prices and future prospect of limestone and gypsum	August 31,1995
9. Study of Construction Cost	9. Unit labor cost in each occupation engaged, major contractors in Bulgaria and their past performance	August 31,1995
10. Constraints on Power Plant Design	10.1 Regulation by national and local governments	August 31,1995
	10.2 NEK's internal regulations and standards	August 31,1995
	10.3 Operational rules other than legal provisions	August 31,1995
	10.4 Constraints on unloading, transportation route and transport of heavy articles	August 31,1995
11. Other Assistance and Advice required for the Site Survey	11. Assistance and advice required by the Study Mission for the on-site surveys	February 28,1996

The Feasibility Study
on
Maritsa East No.1 Replacing Thermal Power Plant
for
Improvement of the Performance of the Units
and
the Environmental Protection

THE MINUTES OF MEETINGS

between

ENERGO PROJEKT AND JICA F/S TEAM

in Sofia, July 3, 1995

BORIS IVANOV
Chairman
ENERGO PROJEKT

JURO INOUE
Leader of JICA F/S Study Team

This is to confirm that the contract agreement regarding local investigation reconsignment has been settled between ENERGO PROJEKT (hereinafter referred to as EGP) and JICA F/S Team (hereinafter referred to as JICA) through the following procedures.

1. JICA explained to EGP the contents of local investigation to be re-consigned, on June 16 (Friday), 1995.

2. EGP offered their proposal from JICA's requirements on June 22, 1995. Total estimated amount is US$ 208,126 only. It includes pricing for the below items newly stipulated by EGP, in addition to that for items 1 through 11 requested by JICA,

Item 12	DHI mailing cost	US$	1,000.-
Item 13	Project management cost	US$	17,500.-
Item 14	Contingency	US$	10,000.-

3. The meeting was held between EGP and JICA in ME-1 P/S on June 29(Thu.) and the following mutual agreement has been reached.
   (1) Total contract amount US$ 109,150.-
   (2) Local investigation items to be undertaken by EGP are as per the attached sheets.
   (3) Terms and conditions
      i) Each investigation shall be carried out as contractual liability, but <u>not on a man-month basis</u>.
      ii) Each pricing shall be deemed to include for items 12, 13 and 14.
      iii) All reports and data collected shall be written in English.
   (4) Other quoted unit prices such as translation and interpretation shall be applicable to optional jobs other than those listed in the attached sheets.

4. The contractual jobs shall be commenced immediate after sign of the contract.

5. EGP stated that they are prepared to do the best to satisfy JICA's requirements although some discrepancy may be caused by difference in practice between Bulgaria and Japan, and that eventually EGP's fullfilment and engineering capability/ability to be acknowledged and appreciated.

Spesicication for Local Survey for the Feasibility Study on Maritsa East No.1 Replacing Thermal Power Plant for Improvement of the Performance of the Units and The Environmental Protection in The Republic of Bulgaria

(All items are mentioned for ME-1 except the items with a note in the parentheses.)

Item	Detail
1. Survey of Existing Power Plant Facilities	1.1 Specification of Each Facility 1.1.1 Equipment layout of each floor (ME-1, ME-2, ME-3) 1.1.2 Plant sectional drawing (ME-2, ME-3) 1.1.3 Boiler cross section drawing 1.1.4 Various system diagrams 1) Pulverized coal combustion facility 2) Fuel oil receiving and delivery 3) Control air piping 4) Plant service air piping 5) Specification of overhead traveling crane (ME-1, ME-2) 6) Ash handling 7) Installation procedure of steam turbine and generation (ME-2, No.5-No.8) 8) Heat balance charts a) 100% b) 50% c) Minimum load 9) Safety and security system

Item	Detail
	1.2 Operational Records 1.2.1 Annual load factor 1.2.2 Daily load factor 1.2.3 Startup/shutdown mode curve 1.2.4 Cumulative operating hours since commissioning 1.2.5 Operating costs in the last 5 years (operating cost and repair cost) 1.2.6 Number of startups since commissioning 1.2.7 General load conditions 1.2.8 Daily load curve 1.2.9 Minimum operating load of plant 1.2.10 Plant thermal efficiency for operational load curve (boiler, turbine) 1.3 Others 1.3.1 Cooling Water Channel : Existing cooling water channel (box culvert, concreate pipe) 1) Internal strength 2) Damage conditions 3) Flow rate of existing channel (sand sedimentation, collapse, cracks, wall flaking off, corrosion) 1.3.2 Installation of temporary facility while existing channel is being dismantled, and repair of existing channel 1) Facility components which can be appropriated for new facility in Sections B7 to B10, and T5 to T6. 2) The components referred to above, but which require repair. 3) Facility components required for the new facilities in B1 to B6 and T1 to T4. 1.3.3 Scraping work 1) Items requiring particular attention, and their weight. 2) Selection of heavy construction equipment for scraping work, and their local availability. 3) Classification of locally available construction equipment 4) Disposal method of waste materials, and waste material strage yard. 5) The size of blocks to be scrapped and their weght. 6) Transportation plan 1.3.4 Water and electric power for scraping work 1) Supply sources of construction water and power plant service water, supply capacity and quality. 2) Supply sources of construction electric power (and air and steam), supply capacity and quality. 1.3.5 Buried objects 1) Names of buried objects inside the power plant construction site, maps of buried objects. 2) Connection diagram of buried objects 1.3.6 Hazardous objects 1) Residual coals (in bunkers, mills and transport piping), or the extent they have been disposed. 2) Residual fuel oils (in piping, heaters and pumps), or the extent they have been disposed. 1.3.7 Specification of each works

Item	Detail
2. Survey of Items Re-Usable in New Plant	2.1 Specifications and Drawings of Re-usable Equipment/Facilities 2.1.1 Turbine building 2.1.2 Stack 2.1.3 Cooling water system components 2.1.4 Fuel oil strage facility 2.1.5 Startup boiler 2.1.6 Discharge water flow diagram and piping rout layout from Power Station to ash pond 2.1.7 Water quality at discharge water 2.2 Structure Foundations (drawings, working drawings) 2.3 Site Survey of Re-usable Equipment/Facilities 2.4 Interface with New Plant 2.4.1 Interface of discharge water conduits 2.4.2 Makeup water piping 2.4.3 Equipment drain piping 2.4.4 Regional heating steam piping 2.5 Operational records of Regional Heating Steam Piping (daily load curves, monthly load curves, yearly load curves) 2.6 History of Facility (revision of purpose, modification, repair, etc.)

Item	Detail
3. Survey of Existing Transmission Line and Substation Facilities	3.1 Facility Specifications and Drawings 3.1.1 Transmission line 1) Owners 2) Voltage 3) Name 4) Length 5) Number of circuits, cable types 6) Type of conductor and suze 7) Commissioning year 8) Route 9) Power system diagrams 10) Power flow diagrams 11) Impedance maps 12) Grounding system 13) Protection system 14) Fault and accident records 15) Plans for new construction and expansion 16) Legal regulations on transmission line siting 3.1.2 Substation and switchyard 1) Owners 2) Voltage 3) Name 4) Location 5) Installed capacity 6) Number of transformer banks 7) Specification of equipments (circuit breakers, sisconnecting switches and etc.) 8) Commissioning year 9) Manufacturers 10) Fault and accident records 11) Plans for new construction and expansion 12) switchyard building 13) substation and Switchyard layout 14) Ground net layout 3.2 Structure and Foundations (drawings and working drawings) 3.3 Parameters/Constants for Power System Analysis

Item	Detail
4. Environmental Survey	4.1 Geographical Map of Area 4.1.1 Geographical map of area within 30 km in radius from project site with contours (with contours) 4.2 Initial Environmental Evaluation (IEE) 4.2.1 Ground Meteorology : Observation records at power plant site or its proximity (for last 5 to 10 years) (General Meteorogy in Meteorogical and Environmental Evaluation Area (within 30 km radius)) 1) Wind direction and velocity a) Frequency of wind direction and wind velocity (monthly) b) Wind rose in velocity (monthly) 2) Temperature a) Average temperature (monthly, annual average) b) Average highest daily temperature (monthly, annual average) c) Average lowest daily temperature (monthly, annual average) 3) Atmospheric pressure (monthly, annual average) 4) Precipitation (hourly maximum, monthly, annual) 5) Snowfall (monthly, annual average) 6) Average humidity (monthly, annual average) 7) Insolation (monthly, annual average) 8) Radiation balance 9) Average cloudiness (monthly, annual average) 10) Atmospheric stability 11) Locations and names of observatories, observation period 4.2.2 Pollution Survey 1) Air : Data on air quality of project area a) Survey of laws and regulations i) Environmental standards (EC standard, Bulgarian standard) ii) Emission standards (EC standard, Bulgarian standard) iii) Pollution prevention plans (in Bulgaria and power plant site) b) Emission Source Survey : No.1 thermal power plant, No.2 thermal power plant and No.3 thermal power plant i) Facilities of flue gas emission source Type, name, major specification and number of units of flue gas emission sources Type, consumption, characteristics (sulfur content, nitrogen content, ash content, etc.) of fuels use in the flue gas emission sources. Amount of polluting substance, pollutant concentrations, amount of flue gas, flue gas temperature and residual oxygen concentration of emissions generated by fuel combustion and raw material processing. ii) Flue gas treatment facilities : Flue gas treatment facilities installed at emission sources Type, name and processing capacity of flue gas treatment facility Processing efficiency and emission/emission concentration of pollutants (SO_x, NO_x, dusts, etc.) Operating hours in recent time iii) Stack Stack height and diameter at ground level (cross section drawing) Flue gas amount, flue gas temperature, concentration and rate of pollutant emissions iv) Others Information regarding the flue gas emission facilities inside the power plants and the stack locations will be collected. The distribution of the flue gas emission facilities will be surveyed by plotting the locations of facilities inside the environmentally affected area (within 30 km radius)

Item	Detail
	c) Environmental Concentration Survey : The following environmental concentration data measured by the Ministry of Environment or your Company in the past 3 years. i) Survey items : Sulfur oxides, nitrogen oxides, dust, hydrogen sulfide, name of observation area (locations to be plotted on maps), measurement period d) Site survey : On-site measurement will be conducted within the environmentally affected area using instruments belonging to NEK or your Company i) Survey items : Sulfur oxides, nitrogen oxides, dust, carbon monoxide ii) Measurement point : 12 points around No.1 Thermal Power Plant iii) Number of measurements : Twice at each point (first measurement in July, second measurement in December) 2) Water quality : Concerning the water quality of the study area a) Study of laws and regulations i) Environmental standards (EC standard, Bulgarian standard) ii) Emission standards (EC standard, Bulgarian standard) iii) Pollution prevention plans (in Bulgaria and power plant site) b) Survey of water quality measurement : The water quality measurement data on the Sazurika River and Rozovkladenetz Lake measured by the Ministry of Environment and your Company (water temperature pH, biochemical oxygen demands, chemical oxygen demands, suspended solids, dissolved oxygen, number of colon bacillus, cadmium, cyanides, organic phosphorous, lead, hexavalent chromium, arsenic, total mercury, alkyl mercury, polychlorinated biphenyl (PCB) c) On-site survey : The water quality of the Sazurika River and Rozovkladenetz Lake will be measured by instruments belonging to NEK or your Company. i) Measurement items : water temperature, pH, biochemical oxygen demand, suspended matters, dissolved oxygen, number of colon bacillus, cyanides, organic phosphorous, lead, hexavalent chromium, arsenic, total mercury, alkyl mercury, polychlorinated biphenyl (PCB) ii) Measurement site : Sazurika River (2 points near the power plant, upstream and downstream of power plant), Rozovkladenetz Lake (2 points, near the power plant discharge port and the opposite bank) iii) Number of measurements : Twice at each point (first measurement in July, second measurement in December) 3) Noise : Noise in the study area a) Study of laws and regulations i) Environmental standards (EC standard, Bulgarian standard) ii) Emission standards (EC standard, Bulgarian standard) iii) Pollution prevention plans (in Bulgaria and power plant site) b) Survey of noise generated by the power plant : The major noise sources of No.1 Thermal Power Plant will be plotted on the map of the study area on which the power plant premise boundary is surveyed and marked. 4) Vibration : vibration inside the study area a) Study of laws and regulations i) Environmental standards (EC standard, Bulgarian standard) ii) Emission standards (EC standard, Bulgarian standard) iii) Pollution prevention plans (in Bulgaria and power plant site) b) Survey of vibrations generated by the power plant : Major vibrations sources in No.1 Thermal Power Plant

Item	Detail
	5) Impact on lake water temperature a) Study of Rozovkladenetz Lake i) Existing reports on the temperature rise of lake water, lake water temperature measurement data, etc. ii) The position and design of the cooling water discharge port, amount of cooling water, intake/discharge water temperature difference, etc. during operation of Units 1-6 at No.1 Thermal Power Plant and after the decommissioning of Units 5 and 6. b) Measurement of lake water temperature at Rozovkladenetz Lake i) Measurement point : 5 points (near the intake port, the inside and outside of dike of the discharge port, the opposite bank, and center of the lake) ii) Measurement depth : depth (step of 1 meters down to 5m, 10m, 15m, 20m) iii) Number of measurements : Twice at each point (first measurement in July, second measurement in December) 4.2.3 Natural Environment in the Environmentally Affected Area 1) Geography and Soil Characteristics : Topographic map of the environmentally affected area, land use classification map, soil characteristics map, and other existing data 2) River data : Existing data on the rivers (Sazurika River, etc.) in the environmentally affected area. a) Name of rivers to be studied b) Flow conditions : Flow variation chart, cumulative flow chart, river flow in wet season, average season and dry season, annual average flow rate c) Water quality : Water temperate, pH, biochemical oxygen demands, dissolved oxygen, suspended solids, etc. d) Fish and major aquatic creatures : The plain water fish and their inhabiting status in the rivers to be surveyed. e) River water utilization status : Major facilities discharging water to the rivers to be surveyed other than the power plant, location of discharge facilities, amount of discharge, map of discharge points f) River fishing industry : General description of fishing industry on rivers to be surveyed. g) Collection of topographic maps of rivers to be surveyed 3) Lakes and swamps : Existing data on Rozovkladenetz Lake a) Data on Rozovkladenetz Lake : Topographic maps around the lake, maximum water storage capacity, maximum depth, effective water storage capacity, available drawdown, locations of water intake, lake cross section (cross section map) b) Data on rivers flowing into the lake : Name, amount of inflow, catchment area, etc. (for each season or month) c) Data on rivers flowing out of the lake : Name amount of outflow, catchment area, etc. (for each season or month) d) Water quality : Observatory records on Rozovkladenetz Lake (for last 3 years) (Water temperature, pH, chemical oxygen demands, dissolved oxygen, suspended solids, etc. e) Fish and valuable aquatic creatures : Plain water fish and their habitation status in the lake to be surveyed f) Lake water utilization status : Major facilities discharging water to the lake to be surveyed other than the power plant, location of discharge facilities, amount of discharge, map of discharge points g) Lake fishing industry : General description of fishing industry on to be surveyed. 4) Earthquakes : Magnitude and consequences of previous earthquakes

Item	Detail
	4.2.4 Social Environment 1) Population : The population and its trend in the last 5 to 10 years 2) Land utilization : Land classification map showing the classification of the land (urban area, agricultural area, forest area, etc.) in the area to be surveyed 3) Industrial activities : Industrial structures, industry distribution 4) Cultural assets : Name, location and scale of historical monuments, cultural assets, scenery places in the project area, and their relative locations to the power plant 4.2.5 Examples of environmental studies : Examples of environmental studies (environmental assessment reports, etc.) performed in the past in Bulgaria in relation to electric power development projects 4.3 Environmental Impact Assessment 4.3.1 Environmental Impact Assessment (EIA) 1) Support to IEE on assessment items which have not been performed or which must be performed again 2) IEE shall conduct on-site surveys if the data required for the flue gas diffusion analysis, heated discharge water diffusion analysis and noise analysis to be performed by the Study Mission are insufficient 4.3.2 Survey on the Temperature Rise of the Lake Water 1) On-site measurement and collection of information on data required for the heated water diffusion analysis

Item	Detail
5. Geographical Survey for Facility Construction	5. Details are in accordance with the attached "TOPOGRAPHIC SURVEY"
6. Geological Survey	6. Details are in accordance with the attached "GEOLOGICAL INVESTIGATION"
7. Hydrology Observation	7. Details are in accordance with the attached "HYDROLOGICAL SURVEY"
8. Study of Equipment/Material Procurement	8.1 Machine repair shops, their technology level, and past performance
	8.2 Specification and prices of locally procurable items : turbine oil, lubrication oil, paint, heat insulators, angle and channel steel, electrical/instrumentation/control equipment
	8.3 Cost of Construction equipment (type, number, and lease charge of heavy construction machines), materials (structural materials, temporary facility materials, finishing materials, building materials, equipment materials, etc.), and labor in each occupation
	8.4 Taxes on construction materials : custom duties, local government taxes
	8.5 Current market prices and future prospect of limestone and gypsum
9. Study of Construction Cost	9.1 Unit labor cost in each occupation engaged in installation work, major contractors in Bulgaria and their past performance
	9.2 Unit labor cost in each occupation engaged in civil construction work, major contractors in Bulgaria and their past performance
	9.3 Unit labor cost in each occupation engaged in demolition and modification work, major contractors in Bulgaria and their past performance
10. Constraints on Power Plant Design	10.1 Regulation by national and local governments (building standards, design standards, standards on materials, lightning rod installation standard, environmental regulations, water discharge standards, noise standards, technical standards, fire protection regulations, regulations on the preservation of scenery, standards on the preservation of vegetation inside plant premises, regulations on the import of materials, etc.)
	10.2 NEK's internal regulations and standards
	10.3 Operational rules other than legal provisions (material standards, measures against freezing, safety provisions, labor union rules, regulations on transport of heavy articles on public roads)
	10.4 Constraints on unloading, transportation route and transport of heavy articles (generators, boilers)
11. Other Assistance and Advice required for the Site Survey	11. Assistance and advice required by the Study Mission for the on-site surveys (power plant survey, transmission line survey, flue gas analysis, coal moisture measurement, collection of social/economic information, atudies of local coals and limestone)

THE FEASIBILITY STUDY

ON

MARITSA EAST NO. 1 REPLACING THERMAL POWER PLANT

FOR

IMPROVEMENT OF

THE PERFORMANCE OF THE UNITS

AND

THE ENVIRONMENTAL PROTECTION

THE MINUTES OF MEETINGS

between

ENERGOPROEKT AND JICA F/S TEAM

Agreed upon in Sofia Bulgaria
on March 1,1996.

Boris IVANOV,
Chairman
ENERGOPROEKT

J. Inoue

Juro INOUE,
Leader of F/S STUDY Team
JAPAN INTERNATIONAL COOPERATION
AGENCY

Abbreviations

EGP : ENERGOPROEKT
JICA : Japan International Cooperation Agency
JICA Team : Feasibility Study Team from Japan International Cooperation Agency

This is to confirm what were discussed, confirmed or agreed upon between EGP and JICA Team in the meeting held in EGP's Sofia Office on March 1, 1996.

1. JICA Team and EGP checked and clarified one by one the reconsigned items stipulated in the Specification in the contract between JICA Team and EGP, in comparison with the study results made and submitted by EGP, so far.
   JICA Team confirmed that EGP had completed their duties and submitted to JICA Team all outstanding data on March 1, 1996.
   The items (1 through 11) and data of receipt of each are clarified in the attached list.

2. JICA Team agreed that they will make the final payment, pursuant to an Article 7.4 of the contract, in due course.

Detailed Specification
(Contents of Data to be collected)

Item	Scope of Study	Date of Receipt
1. Survey of Existing Power Plant Facilities	1.1 Specification of Each Facility	August 31,1995
	1.2 Operational Records	August 31,1995
	1.3 Others	August 31,1995
2. Survey of Items Re-Usable in New Plant	2.1 Specifications and Drawings of Re-usable Equipment/Facilities	August 31,1995
	2.2 Structure Foundations	August 31,1995
	2.3 Site Survey of Re-usable Equipment/Facilities	August 31,1995
	2.4 Interface with New Plant	August 31,1995
	2.5 Specifications and Drawings of Regional Heating Steam Piping	August 31,1995
	2.6 History of Facility	August 31,1995
3. Survey of Existing Transmission Line and Substation Facilities	3.1 Facility Specifications and Drawings	August 31,1995
	3.2 Structure Foundations	August 31,1995
	3.3 Parameters/Constants for Power System Analysis	August 31,1995
4. Environmental Survey		
4.1 Geographical Map of Area	4.1.1 Geographical map of area within 30 km in radius from project site with contours	August 31,1995
4.2 Initial Environmental Evaluation (IEE)	4.2.1 Ground Meteorology	August 31,1995
	4.2.2 Pollution Survey	August 31,1995
	4.2.3 Natural Environment in the Environmentally Affected Area	August 31,1995
	4.2.4 Social Environment	August 31,1995
	4.2.5 Examples of environmental studies	August 31,1995
4.3 Environmental Impact Assessment	4.3.1 Environmental Impact Assessment (EIA)	February 28,1996
	4.3.2 Survey on the Temperature Rise of the Lake Water	February 28,1996

Item	Scope of Study	Date of Receipt
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	5.2 Production of Facility Layout	August 31,1995
6. Geological Survey	6. Boring Survey (all-core, 30m/bore, 8 bores, 240m) and Production of Geological Cross Section Chart (Scale=1/1,000, 4 to 6 cross sections) within Power Plant Premises	August 31,1995
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8. Study of Equipment/Material Procurement	8.1 Machine repair shops, their technology level, and past performance	August 31,1995
	8.2 Specification and prices of locally procurable items	August 31,1995
	8.3 Cost of Construction equipment, materials, and labor in each occupation	August 31,1995
	8.4 Taxes on construction materials	August 31,1995
	8.5 Current market prices and future prospect of limestone and gypsum	August 31,1995
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	10.2 NEK's internal regulations and standards	August 31,1995
	10.3 Operational rules other than legal provisions	August 31,1995
	10.4 Constraints on unloading, transportation route and transport of heavy articles	August 31,1995
11. Other Assistance and Advice required for the Site Survey	11. Assistance and advice required by the Study Mission for the on-site surveys	March 1,1996

CHAPTER 7 ACTUAL STATE OF THE ENVIRONMENTAL PRESERVATION MEASURES OF THE WORLD

CHAPTER 7 ACTUAL STATE OF THE ENVIRONMENTAL PRESERVATION MEASURES OF THE WORLD

Tremendous improvement has been brought about by the promotion of economic activities, but on the other hand, such problems as the destruction of the Ozone layer, Green House effect of CO_2 and others, Acid Rain caused by SO_x and NO_x, desertization, destruction of Tropical Rain Forest by indiscriminate felling, and trans-boundary movement of noxious waste are being actualized, and these problems are having a global effect that goes beyond a country's boarder.

Since the environmental problems of the earth are on a large scale and will have an effect on all the world, they are regarded as one of the most important issues of the present world that have to be grappled with by every country concentrating all the wisdom.

Among the environmental problems of the earth, the issue of the global warming and the issue of acid rain are of most importance and each issue is being studied internationally.

The first international conference on the environmental problems in general was the "United Nations Conference on the Human Environment (UNCHE)" held in June 1972 in Stockholm of Sweden. And "Declaration on Human Environment" and "International Action Plans of the Unite Nations" adopted there have come to be the basic guiding principles of the world's environmental policies and various international conferences have been held since then.

And in June 1992, exactly 20 years later, "United Nations Conference on Environmental Development (UNCED)" which has a by-name of "Global Summit" was held in Rio de Janeiro of Brazil. At this conference, with the participation of approximately 170 countries from all over the world, "Rio de Janeiro Declaration on Environment and Development", "Agenda 1 and 2", and "Statement of Principles on Forest" were adopted based on the discussion of strategies and/or prescriptions as to how to adequately cope with the environmental problems that arose in the course of the development activities of the international societies, and "Framework Conversion on Climate Change (FCCC)" and "Convention on Biological Diversity" were signed.

7.1 Issue of Global Warming

The issue of Global Warming is a problem that there is a possibility of an increase of atmospheric temperature as a result of the increment of the atmosphere's absorption of heat radiation from the earth that is caused by the increase of concentration of Carbon Dioxide, Methane and other gases (Green House Effect Gases) produced by consumption of Fossil Fuels and by destruction of Forests. Though there are some unknown areas as to the actual state of the emission of green house effect gases and their influencing mechanisms, this problem has come to attract an international attention rapidly since there is a possibility that it may influence the human being's life environment and ecosystem.

The issue of global warming was taken up on the occasion of Toronto Summit in June 1988 and Toronto Meeting that was held immediately after that, and it resulted in the establishment of the "Intergovernmental Panel on Climate Change (IPCC)" as a central organ to study the issue of global warming in November 1988 cosponsored by "United Nations Environment Program (UNEP)" and "World Meteorological Organization (WMO)", where evaluation of scientific knowledge and formularization of socioeconomic influences and countermeasures are being carried out, and the role to be performed by each country in preventing the global warming was determined by the above-mentioned "Framework Conversion on Climate Change (FCCC)" that was adopted at the Global Summit.

7.2 Issue of Acid Rain

Acid Rain is caused by such pollutants as SO_x and NO_x that are mainly produced in the process of combustion of fossil fuels and emitted into the atmosphere and resolved with the cloud and rain dew to generate sulfuric acid, nitric acid and other acids, and eventually fall down to the ground contained in the rain and/or thunderstorm. The damages have been reported mainly in European and American countries, and it especially came to be noticed in the 1970's in Europe.

The convention on the "Long Range Trans-boundary Air Pollution (LRTAP)" was concluded at the "United Nations Economic Commission for Europe (ECE)" in 1979 with regard to sulfur oxides, and cutdown of sulfur oxides by 30% (to be achieved by 1993 against the actual emission level in 1980) was officially adopted as a protocol for the convention in Helsinki in 1985 which came into effect in September 1987.

With regard to nitrogen oxides the "Conference on Long Range Trans-boundary Air Pollution" was held in Sofia of Bulgaria in 1988 sponsored by EC and a "Protocol on Restriction of the Emission or Trans-boundary Movement of Nitrogen Oxides to Prevent the Damages Caused by Acid Rain" (to request each country to freeze the emission of nitrogen oxides at the level of 1987 by the year of 1994) was adopted.

7.3 World's Environmental Standards and Emission Standards

Major countries' environmental standards are shown in Table 7-3-1 and their present emission standards which have taken the above-mentioned international agreements into account are shown in Table 7-3-2. It should be specifically noted that the emission standards have become severer in all the countries in comparison with the former standards.

7.4 Environmental Preservation Measures of the World

7.4.1 Countermeasures for Sulfur Oxides

(1) Types of Flue Gas Desulfurization (FGD) Process

A large variety of FGD methods are being used, but many of them are similar in their principles. Such methods are categorized also in a variety of ways, but they are generally categorized into wet, semi-dry and dry methods depending on the use of water in their absorption process.

Judging from the current trends of FGD technologies in the world, the limestone method, where limestone slurry is used as the absorbent, is popular among the wet methods, and being employed at many utility plants.

The spray-dryer method is popular among the semi-dry methods. The spray-dryer method corresponds to the semi-dry method. This method has not been employed in Japan at coal fired power plants although it has been employed at many plants in Europe and the USA.

Dry methods include the activated coke method which uses activated coke as adsorbent and the electron beam method where ammonia is injected into flue gas and irradiated with electron beam. The activated coke method is in the stage where data are accumulated at utility plants and the electron beam method is in the stage of testing at demonstration plants.

From such wet, semi-dry and dry FGD methods, the seven methods were selected, based on their past performance at coal fired utility power plants. The electron beam method described in the table, however, has not been at utility plants, but the method was included in the technical comparison just for reference because the method is attracting much attention worldwide and development activities are going with the pilot-scale plants.

These selected seven methods are outlined as follows

- Flue Gas Desulphurisation System
  - Wet Type
    - Limestone-Gypsum proces (Spray Tower Method)
    - Limestone-Gypsum proces (Jet-Bubbling Method)
  - Semi Dry Type
    - Spray-Dryer Method
    - Limestone Injectioninto Furnace Method
    - Slaked Lime Injection into Flue Gas Duct Method
  - Dry Type
    - Activated Coke Method (Regenerable)
    - *Electron Beam method*
      (As reference: Under R &D stage with Pilot Scale plant Test)

(2) Wet Type Limestone-gypsum Process - Spray Tower Method

Limestone ($CaCO_3$) slurry is sprayed to flue gas in a spray tower to absorb sulphur oxides (SOx) of the flue gas for desulphurization. The limestone slurry thus sprayed reacts with absorbed sulphur oxides and forms calcium sulphite ($CaSO_3$). Calcium sulphite thus formed is oxidized further and discharged in the form of gypsum ($CaSO_4$).

Major reactions which occur in this method are as follows:

[Absorption]

$$CaCO_3 + SO_2 + \frac{1}{2}H_2O \rightarrow CaSO_3 \bullet \frac{1}{2}H_2O + CO_2$$

[Oxidation]

$$CaSO_3 \bullet \frac{1}{2}H_2O + \frac{1}{2}O_2 + 1\frac{1}{2}H_2O \rightarrow CaSO_4 \bullet 2H_2O$$

The flow of these reactions is shown in Figure 7-4-1.

The process flow of this method is shown in Figure 7-4-2. This method consists of a draft system, a limestone slurry preparation system, an absorbing system, a gypsum recovery system, etc.

(a) Draft System

The flue gas from boiler is pressurized by a boost-up fan (BUF), subjected to heat exchange at a gas to gas heat exchanger (GGH) with treated gas from FGD outlet, and enters the spraying absorber. Here, the flue gas temperature is lowered to the saturation temperature by spraying part of the absorber circulating liquid. The cooled flue gas is then uniformly dispersed and rectified in the absorber, comes into contact, face to face, with slurry at the absorbing portion, where sulphur oxides in the flue gas are absorbed and dust in the flue gas is removed by the scrubbing in the absorber.

After the desulphurization, mist included in the flue gas are removed at the mist eliminator which is existing at the upper part of the spraying tower.

After removal of sulphur oxides and dust, the treated flue gas is led again to the GGH, where it is heated by flue gas from boiler, and then discharged from the stack.

(b) Limestone Slurry Preparation System

Limestone (powder), used as absorbent is stored in a limestone powder silo. The limestone powder is fed to a limestone slurry tank through a limestone metering feeder. Water is also added to the limestone slurry tank at a specified rate. Limestone powder and water are made into limestone slurry, and the limestone slurry is kept in the limestone slurry tank. Necessary amounts of limestone slurry are pumped from the tank by limestone slurry pumps to a circulation tanks existing at the bottom of the absorber. Waste water of gypsum dehydration is usually used for preparing the limestone slurry.

(c) Absorbing System

The absorbing system, where the mixed slurry of limestone and reaction products is sprayed in the absorber, is the most important system on the desulphurization and the dust removal efficiency of the FGD. The mixed slurry sprayed in the absorber falls while absorbing and removing sulphur oxides and dust of the flue gas and the slurry is stored in the circulation tank existing at the bottom of the absorber. Limestone slurry is added to the tank to maintain the desulphurization performance of the mixed slurry, and the mixed slurry is sprayed again in the absorber tower for desulphurization. The air is blown into the absorber circulation tank to oxidize calcium sulphite into gypsum (calcium sulphate).

(d) Gypsum Recovery System

When gypsum is to be recovered as a by-product, the gypsum slurry from the absorption system is dehydrated by dehydrators to obtain gypsum in this system. Waste water from dehydrators is usually used again as make-up water for the desulphurization process.

(3) Wet Type Limestone Gypsum Process - Jet Bubbling Method

In this method, the flue gas and the air for oxidation are blown into an absorption liquid of limestone slurry in a jet bubbling reactor (JBR). Sulphur oxides included in flue gas are absorbed and oxidized in this way, and gypsum is recovered as a by-product.

The major reaction which occurs in this method is as follows:

[Absorption and oxidation]

$$CaCO_3 + SO_2 + \frac{1}{2}O_2 + 2H_2O \rightarrow CaSO_4 \bullet 2H_2O + CO_2$$

The flow of this reaction is shown in Figure 7-4-3.
The process flow of this method is shown in Figure 7-4-4. This method consists of a draft system, an absorbing system, a limestone slurry preparation system, a gypsum recovery system, etc.

(a) Draft and Absorbing System

The flue gas from boiler is pressurized by a boost-up fan (BUF), subjected to heat exchange at a gas to gas heat exchanger (GGH) with treated gas from FGD outlet, and part of the makeup water is sprayed to lower the flue gas temperature to the saturation temperature.

The flue gas of saturation temperature is led to the JBR and blown into the absorption liquid through sparger pipes, and sulphur oxides and dust are absorbed and removed from the flue gas.

Mists included in the flue gas at desulphurization are removed at a subsequent mist eliminator. After desulphurization and dust removal, the treated flue gas is led again to the GGH, where it is heated by flue gas from boiler, and then discharged from the stack.

(b) Limestone Slurry Preparation System

Limestone (powder), used as absorbent is stored in a limestone powder silo. The limestone powder is fed to a limestone slurry tank through a limestone metering feeder. Water is also added to the limestone slurry tank at a specified rate. Limestone powder and water are made into limestone slurry, and the limestone slurry is kept in the limestone slurry tank. Necessary amounts of limestone slurry are pumped by limestone slurry pumps and fed to the JBR. Usually, waste water of gypsum dehydration is used as water for making the limestone slurry.

(c) Gypsum Recovery System

When gypsum is to be recovered as a by-product, the gypsum slurry from the JBR is dehydrated by dehydrators to obtain gypsum in this system. Waste water from dehydrators is usually used again as make-up water for the desulphurization process.

(4) Spray Dryer Method

In the spray dryer method, slaked lime slurry is sprayed in the form of very fine droplet in flue gas in a spray dryer absorber (SDA) to absorb sulphur oxides of the flue gas.

Water in the slurry evaporates by the heat of the hot flue gas. Sulphur oxides in flue gas reacts, at the same time, with slaked lime ($Ca(OH)_2$) of the slurry, resulting a dry powder mixture of calcium sulphite ($CaSO_3$) and gypsum ($CaSO_4$), which falls on the bottom of SDA or is collected and removed by a subsequent dust collector.

Major reactions which occur in this method are as follows:

[Absorption]

$$Ca(OH)_2 + SO_2 + ½H_2O \rightarrow CaSO_3 \bullet ½H_2O + H_2O$$

[Oxidation]

$$CaSO_3 \bullet ½H_2O + ½O_2 + 1½H_2O \rightarrow CaSO_4 \bullet 2H_2O$$

The flow of these reactions is shown in Figure 7-4-5.

The process flow of this method is shown in Figure 7-4-6. This method consists of a draft system, a slaked lime slurry preparation system, a slurry spraying system, a dust recirculation system, etc.

(a) Draft System

The flue gas from boiler is led to SDA usually by an induced draft fan (IDF). The absorbent is sprayed in the SDA and sulphur oxides are removed. The temperature of the flue gas in the SDA is adjusted to an optimal operating temperature range by the amount of concentration-adjusted slaked lime slurry sprayed in the SDA. The temperature of flue gas for optimal operation is controlled to be higher than the saturation temperature by 10 to 20°C so that the flue gas can be in a dry state. The reaction products generated in the flue gas are partly removed by the cyclone separation effect of the SDA. The rest of the reaction products is carried to a subsequent dust collector, where the dust including the reaction products are removed to achieve a level of concentration which meets regulations, and the treated flue gas is discharged from the stack.

(b) Slaked Lime Slurry Preparation System

Slaked lime or quick lime, used as absorbent, is stored in a storage silo, and fed to a slaked lime slurry tank through a slaked lime metering feeder. Water is also added to the tank at a specified rate to make supplied slaked lime into slurry and store it in the slurry form.

(c) Slurry Spraying System

The slurry spraying system sprays the absorbent slurry in the SDA. The absorbent slurry is a mixture of the slaked lime slurry and part of the reaction products fallen to the bottom of the SDA and collected at the subsequent dust collector.

The absorbent slurry must be sprayed in the form of very fine droplet, and rotary atomizers are used for that purpose in large scale systems.

(d) Dust Recirculation System

The dust recirculation system removes the reaction products fallen to the bottom of the SDA and collected at the subsequent dust collector, and recirculates part of the reaction products to the absorbent slurry to improve the utilization rate of slaked lime used in the method.

(5) Limestone Injection into Furnace Method

In this simplified FGD method, limestone ($CaCO_3$) is blown into the high temperature region (about 1,100°C) of furnace to decarbonate limestone and partly absorb sulphur oxides at the same time. In addition, water is sprayed in a reactor, installed at a low temperature region downstream of the air preheater, for further desulphurization when it is necessary to get better deSOx efficiency. The by-product along with dust is collected at following dust collector.

Desulphurizing reactions occur in the furnace and the reactor when water spray tower is applied. Reactions which occur in the furnace and water spray tower are as follows:

[Reactions in furnace]

$$CaCO_3 \rightarrow CaO + CO_2$$

$$CaO + SO_2 + \frac{1}{2}O_2 \rightarrow CaSO_4$$

[Reactions in reactor]

$$CaO + SO_2 + \frac{1}{2}H_2O \rightarrow CaSO_3 \cdot \frac{1}{2}H_2O$$

$CaO + SO_2 + ½O_2 + ½H_2O \rightarrow CaSO_4 \bullet 2H_2O$
$SO_2 + H_2O \rightarrow H_2SO_3$
$CaO + H_2SO_3 \rightarrow CaSO_3 \bullet ½H_2O + ½H_2O$

A process flow of this method is shown Figure 7-4-7.

(6) Slaked Lime Injection into Duct Method

In this simpliflied FGD method, an absorbent of slaked lime ($Ca(OH)_2$) is blown into the duct at a low temperature region following the air preheater. In addition, water is sprayed in a subsequent reactor for further desulphurization when it is necessary to get better deSOx efficiency. Slaked lime is used as absorbent because of its high reactivity. The by-product along with dust is collected at following dust collector.

Reactions which occur in this method are as follows:

[Reactions in duct]
$Ca(OH)_2 + SO_2 \rightarrow CaSO_3 \bullet ½H_2O + ½H_2O$
$Ca(OH)_2 + SO_2 + ½O_2 + H_2O \rightarrow CaSO_4 \bullet 2H_2O$

[Reactions in reactor]
$SO_2 + H_2O \rightarrow H_2SO_3$
$Ca(OH)_2 + H_2SO_3 \rightarrow CaSO_3 \bullet ½H_2O + 3/2\ H_2O$

A process flow of this method is shown Figure 7-4-3.

(6) Activated Coke Method

In the activated coke method, activated coke used as adsorbent is filled in an moving bed type adsorber in which activated coke moves by gravitation. Flue gas is passed through the adsorber for adsorption of sulphur oxides.

As the adsorption efficiency of the absorbent deteriorates gradually, the adsorbent is continuously heated for regeneration in a desorber. Sulphuric acid or sulphur is recovered as a by-product.

The adsorption and regeneration reactions which occur in this method are as follows:

[Adsorption]

$$1/2O_2 + [AC] \rightarrow Oad \cdot [AC]$$

$$SO_2 + Oad \cdot [AC] \rightarrow SO_3ad \cdot [AC]$$

[Regeneration]

$$SO_3ad \cdot [AC] + 1/2(C) \rightarrow SO_2 + 1/2CO_2 + [AC]$$

The flow of the adsorbing reaction is shown in Figure 7-4-9.

The process flow of this method is shown in Figure 7-4-10. This method consists of a draft system, an adsorption system, a regeneration system, a by-product recovery system, etc.

(a) Draft System

The flue gas is passed through the moving bed type adsorber, which is filled with activated coke and in which the adsorbent moves by gravitation, so that sulphur oxides of the flue gas is adsorbed.

(b) Adsorption System

The adsorbent (activated coke) is fed to the top of the adsorber and then the adsorbent is flowed down by gravity from the top of the adsorber to the bottom of it.

During the moving action, the flue gas from boiler is passed horizontally through the moving bed (cross-flow contact) and sulphur oxides are adsorbed. The used adsorbent is regenerated in the desorber, and then fed to the adsorber again.

(c) Regeneration System (Desorption System)

The used adsorbent (activated coke) from the adsorber, which adsorbed sulphur oxides, is regenerated in the desorber for reuse. In regeneration, the used adsorbent is heated to about 400°C to free SO_2-rich gas from the used adsorbent at the desorber.

(d) Recovery System

The recovery system recovers by-product from the SO_2-rich gas freed in the regeneration system. The by-product is recovered in the form of sulphuric acid or elemental sulphur.

(7) Electron Beam Method

Such radicals as OH, O and HO_2 are generated in flue gas by electron beam irradiation, and SOx are oxidized and adsorbed by such radicals. Nitrogen oxides are also adsorbed at the same time, and they undergo neutralizing reactions with ammonia (NH_3) which is injected in flue gas, and recovered as by-products in the forms of ammonium sulfate ($(NH_4)_2SO_4$) and ammonium nitrate (NH_4NO_3).

Oxidation and neutralization reactions in the process are as follows:

[Oxidation]

$$SO_2 \xrightarrow{OH} HSO_3 \xrightarrow{OH} H_2SO_4$$

$$HSO_3 \xrightarrow[O]{} SO_3 \xrightarrow[H_2O]{} H_2SO_4$$

[Neutralization]

$$H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$$

A flow diagram of these reactions is shown Figure 7-4-11, and the process flow of this method is shown in Figure 7-4-12.

(8) Tendency of Introducing Flue Gas Desulfurizer

Flue Gas Desulfurizers were introduced in Japan and in America in the 1970's for the first time.

These have adopted mainly the dehumidification method which utilizes coal and/or lime stones as the absorbent and obtains gypsum as a byproduct. The introduction of FGD increased by the adoption of severer standards of environmental standards and it increased rapidly especially in the 1980's in Europe, and is still on increase in the 1990's. Tendency of the introduction of FGD since 1972 is shown in Figure 7-4-13. As of the end of 1993 FGD's are in operation in 22 countries in the world and additional six countries are now considering its introduction.

In Figure 7-4-1 and Figure 7-4-2 are shown the state of new installation and renovation of the existing facilities of FGD. As shown in the Figures the wet system forms the mainstream accounting for 86% of the existing FGD capacity while semi-wet system accounts for approximately 11% and dry system accounts for the rest 3%.

Improvements have been made in not only the cost reduction but also in the effect of desulfurization as well as the purity of byproducts and the system's reliability with the recent FGD system, and a wet system has been developed which is capable of performing desulfurization and production of byproducts maintaining a desulfurization efficiency of more than 95% within one column.

7.4.2 Countermeasures for Nitrogen Oxides

There are two generation processes available for NO_x that is generated in the course of combustion reactions. One is Thermal NO_x that is generated when nitrogen molecules in the atmosphere are bonded with oxygen at a high temperature, and the other is Fuel NO_x that is generated when nitrogen compounds contained in fuels are oxidized in the process of combustion.

Technologies for reducing nitrogen oxides are roughly classified into Combustion Improvement Technology that is to control the generation of NO_x in the process of combustion and Flue Gas Denitration Technology that is to remove the generated NO_x from the exhaust gas. At the present thermal power plants in the countries which have imposed rigorous environmental standards these two technologies are applied in combination.

(1) Combustion Improvement Technology

The following methods have been adopted as a combustion method to restrain the generation of NO_X in the boiler.

(a) Reduction of Excess Air Factor

This is a method to restrain the generation of NO_x by reducing the air supply to the boiler in order to reduce the excess air in the combustion area.

(b) Reduction of Temperature of Air for Combustion

In general a boiler is operated with combustion air of approximately 250 to 350 degrees Celsius and it is possible to restrain the generation of NO_x by lowering this temperature to lower the combustion temperature.

(c) Two-Stage Combustion

The two-stage combustion method is to supply the combustion air in two stages; at the first stage (in the burner section) combustion is made with an air ratio of less than 1; then from the 2nd stage insufficient air is made up for to make a complete combustion. The less is the air at the first stage, the more is the effect to reduce the NO_x; but sufficient caution is necessary as there is a possibility of instable combustion or increased generation of dust.

(d) Recirculation of Flue Gas

This is to reduce the generation of NO_x by maintaining combustion at a slow pace with lowered temperature which is made possible by reduced concentration of O_2 in the combustion air by sending a part of the flue gas into the combustion air. The more is the quantity of recirculation, the more instable is the combustion. Therefore 20 to 30% is thought to be maximum against the quantity of the combustion air.

(e) Improvement of Burner (Low-NO_x Burner)

Roughly speaking there are following three methods to restrain NO_x by means of the structure of the burner.

1) to slow down the combustion, diffusion and mixing of air
2) to enhance the ununiformity of combustion
3) to enhance the heat radiation of the flame

The method (a) is to aim for the effect of temperature restraint which means to lower the flame temperature by lowering the heat generation ratio of the flame.

The method (b) is to use some burners in the state of excessive combustion while arranging some burners of excess air and/or feed pipes of air around them, or to control the distribution of combustion of a burner flame to be uneven. In other words this is a combustion method not to match the fuel supply with the air allocation, which is a kind of method to cause a nonstoichiometric combustion.

The method (c) is to aim for reducing the convection time of the combustion gas at a high temperature by making the flame shape have the largest heat radiation by means of controlling the mixing method of fuel and air.

Actual low-NO_x burners have adopted various methods to combine the above mentioned (a), (b) and (c) methods. In Figure 7-4-15 and Figure 7-4-16 are shown the structure of the burner flame and the principle of NO_x reduction.

Heat decomposition is enhanced while the initial mixing of the fuel with the inner-circle secondary air and outer-circle secondary air is restrained in order to enhance the ignition of powdered coal and to generate high-temperature, fuel-excessive flame for reduction in a stable manner in the combustion area of volatile component that is denoted as A in the figure. By consuming oxygen in the primary air to maintain stable ignition and flaming, Fuel NO is discharged that is generated from the volatile organic nitrogen compound in the coal at the initial stage of combustion (when the combustion of volatile components precedes).

In the figure, B is the area to generate reducing agent such as the intermediate products of hydrocarbon family (*HC) by having the carbon content of coal that is discharged in the process of heat decomposition to react with hydrogen in the low-oxygen atmosphere in the central part of the flame in the slip stream of A. In the NO_x-decomposition area C the denitration reaction occurs between the Fuel NO that is generated in A and intermediate products of hydrocarbon family (*HC) that is generated in B and existing in the flame, and they are reduced to N_2 via nitrogenous intermediate products (*NX).

In the figure, D is the outer flame part that has contact with the inner-circle secondary air and it is the Char Combustion Enhancement area which is formed in the slip stream of C by the revolving force of the outer-circle secondary air to generate stable high-temperature flame while a small amount of NO is generated by the oxidation reaction of N components that remain in the Coal Char (Char-N) when combustion of coal particles proceeds. In the Complete Combustion area of the flame's slip stream combustion of char is enhanced while restraining the phenomena that N components in the char is converted into NO. This burner has the characteristic to volatilize the nitrogen compounds contained in the coal particles turning them into the gaseous layer at an initial stage of combustion by enhancing ignition, and to restrain the succeeding conversion into NO.

(f) Furnace Denitration

Furnace Denitration is to reduce NO that is generated in the combustion chamber using hydrocarbon within the combustion chamber. Furnace Denitration consists of two processes. The first process is the reduction of NO by hydrocarbon. The following three conditions have to be satisfied to materialize this process.

- Atmospheric temperature has to be more than the hydrocarbon's decomposition temperature (= approximately 900 degrees C).
- Existence of Oxygen
- The quantity of reducing hydrocarbon to be mixed has to be more than the chemical equivalent of the existing Oxygen.

Under these conditions NO in the exhaust gas is decomposed in accordance with the following formula.

$$CnHm + O_2 \rightarrow Cn'Hm'^{*} + CO + H_2O$$
$$NO + Cn'Hm'^{*} \rightarrow Cn''Hm''^{*} + N_2 + H_2O + CO$$

or

$$NO + Cn'Hm'^{*} \rightarrow Cm''Hm'' + NHi + H_2O + CO$$

In the above formula * denotes the radicals at an initial stage of chemical reactions and NHi represents N compounds.

The second process is the complete combustion of components that are yet to be combusted and the following two conditions are needed there.

- The atmospheric temperature is to be more than the reaction temperature of the compounds to be combusted.
- To supply such amount of oxygen as enough to eliminate the yet-to-be-combusted compounds, provided that the supply of oxygen is to be preferably made gradually with a low oxygen concentration.

Under these conditions the following formula are possible for the combustion reaction of the yet-to-be-combusted compounds.

$$Cn''Hm'' + O_2 \rightarrow H_2O + CO_2$$
$$CO + O_2 \rightarrow CO_2$$
$$NHi + O_2 \rightarrow N_2 + H_2O$$
$$NHi + O_2 \rightarrow NO + H_2O$$

In the case of actual boilers the reduction fuel is added at the top of the main burner with a ratio of approximately 10% against the main fuel. Then add air for combustion of the yet-to-be-combusted fuel with a ratio of 20% against the entire air for combustion, from the position higher than the port that is used to throw the reduction fuel in. In Figure 7-4-17 is shown the Furnace Denitration model. In the figure, UB denotes the port used to throw the reduction fuel in, and AA denotes the port used to add air for combustion of the yet-to-be-combusted fuel. A part of the main fuel may be used as the reduction fuel and it is good for any fuel to include heavy (crude) oil, gas, and coal and the denitration efficiency is 30 to 50%. The height of furnace becomes higher by a few meters in comparison with the regular furnace when Furnace Denitration is adopted.

(2) Flue Gas Denitration Technology

The Selective Catalytic Reduction Method is the mainstream in the world as an flue gas denitration technology and is in use most widely. Only this method is adopted as the Flue Gas Denitrater for large-scale boilers especially.

(a) Characteristics

This method is to reduce NO_x into N_2 and H_2O by making it to react with ammonia on a catalyst selectively and it has the following characteristics.

- Operation is easy as it has simple processes, and it is a very reliable denitrater which has little troubles.
- It has no necessity of waste water treatment as it is a dry method, and it does not need reheating of flue gas either.
- A high denitration performance is obtainable.
- No byproduct is generated.
- Because of its simple operation procedures, it can easily act in concert with the source of gas generation.

(b) Outline of Processes

Basically the said processes consist of the denitrater itself which conducts denitration reactions, NH_3 injector to inject the reducer, i.e. NH_3 into exhaust gas, and NH_3 supplier.

The general process flow as applied to Flue Gas Denitration for Coal Fired Boilers is as shown in Figure 7-4-18. Though an actual process flow varies depending on the manufacturer of the denitrater and on the conditions of the site where it is installed, explanation on the outline of the process is hereby given based on this figure.

The flue gas from the boiler is mixed with NH_3 injected from the NH_3 injection nozzle, and is led into the denitration reactor by way of gas distribution board etc. Here NO_3 in the flue gas reacts with NH_3 selectively on the surface of a catalyst in accordance with the following chemical formula and is reduced to N_2 and H_2O, and then sent to the tail-end facility.

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$
$$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$$

There may be a case that a soot blower equipment is installed in the upstream of the denitration reactor in the event that there is any problem of clogging with the denitration reactor such that a lot of dust is contained in the gas.

On the other hand, NH_3 used for reduction is transported by tank trucks or something and is stored in the liquefied ammonia tanks.

And after being diluted by a part of the air of Forced Draft Fan for boilers (hereinafter referred to as FDF) it is injected into the exhaust gas evenly from the NH_3 injection nozzle. It is a general practice to obtain the quantity of NH_3 to be injected by obtaining the quantity of NO_x that flows into the reactor from the NO_x concentration at the entrance of the denitrater and from such signals as the boiler load signal that represents the total gas quantity, and by multiplying the obtained quantity of NH_3 by a certain NH_3/NO_x (hereinafter referred to as Mole Ratio simply).

As for the shape of catalysts, lattice, plate, grain and other shapes have been made for practical use as shown in Figure 7-4-19.

In general the denitration catalysts are filled in a catalyst container (which is called as pack, module, basket, unit, and block etc.) when in use.

(3) Trend of Countermeasures for Nitrogen Oxides

Most boilers have adopted a Combustion Improvement Method when they need countermeasures for nitrogen oxides.
However, the aforementioned SCR is also used in the countries where they have very rigorous emission standards for NO_x.

The introduction of SCR technology into coal-fired boilers was first made in Japan in 1980, then it came to be introduced in such other countries as Germany and Australia in Europe initiated by the commencement of operation in FRG in 1985.

In Figure 7-4-20 is shown a change of the world's total plant capacity where SCR technology has been introduced.

Table 7-3-1 Air Quality Standards in Major Countries

(mg/m³N)

Country	Conditions	SO_2	NO_X	Dust
Bulgaria	Maximum transitori value	0.5	0.6 (NO_2 0.6)	0.5
	Daily.av.	0.15	0.1 (NO_2 0.06)	0.25
	Annual av.	0.05	0.1	0.15
EC **	Daily		(NO_2 0.1 - 0.15)	(0.1 - 0.15)
	Year(median)	0.08 ／ 0.12 *		0.08
	Winter	0.13 ／ 0.18 *		0.13
	Year(mean)	0.25 ／ 0.35 *	(NO_2 0.04 -0.06)	0.25(0.04-0.06)
Italy	30min av.	0.75 (0.3ppm)	0.6 (0.3ppm)	
	2 hr. av.			0.75
	Daily av.	0.38 (0.13ppm)	0.2 (0.1ppm)	0.3
France	Daily av.	1 (0.35ppm) Spesial Area of Paris 0.75 (0.29ppm)		
Germany	Daily av.	0.40 (0.14ppm)	0.30 (0.15ppm)	0.20
	Annual av.	0.14 (0.05ppm)	0.10 (0.05ppm)	0.10
Japan	1 hr. av.	0.1ppm		0.20
	Daily av.	0.04ppm	0.04-0.06ppm	0.10
U.S.A.	3 hr. av.	1.3 (0.46ppm)		
	Daily av.	0.36 (0.13ppm)		0.15
	Annual av.	0.08 (0.03ppm)	0.1 (0.05ppm)	0.065

* Note : Associated value for Dust ＞0.04 mg/m³N ／ ≦0.04 mg/m³N

** Parenthesized values mean guide values for NO_2 and Dust

Table 7-3-2 Emission Standards of Coal Fired Plants in Major Countries

Country	Conditions Mwt	SO_2 mg/m³	No_x mg/m³	Dust mg/m³	Remarks
Bulgaria	–	650	600	100	domestic coal
	–	650	600	80	imported coal
EC	>500	400 mg/m³N or >90% S removal	650	50	
France	≧500	800	650	50	Boiler operating time≦2200 h/y
	≧500	400	650	50	Plants using coal with special unable to meet standards to achieve 90% S removal
Italy	FBC300-500	1600-400	300	50	
	300-500	1600-400	650-200	50	
	>500	400	200	50	>2200 h/y
Japan *	–	individually set according to nationally-defined formura	200ppm	100	actually, more strict limits are set under agreement with local government
USA	>73	1480	740 and 65%	40 and 99%	bituminous coal-fired utility plants
	>73	1480	615 and 65%	40 and 99%	subbituminous coal-fired utility plants
	>73	1480	740-980	40 and 99%	lignite fired plants depending on mine location and furnace type

* Note : In Japan, for SO_2 more stringent 'special' standards are set based on a national formula, called the 'K-value control standards', which determines the emission limits.

$$\text{emission limit } (m^3/h) = K \times 10^{-3} \times He^2$$

where K = constant, determined for 100 areas by the national government based on air quality (general standards K = 3.0 - 17.5 (16 levels) ; special standards, applied only to new plant, K = 1.17 - 2.34 (3 levels)

and He = effective stack height in meters (the effective stack height is the sum of actual stack height plus the average plume rise height)

Furthermore, within particularly polluted regions, there are also limits for SO_2 and No_x on the total mass emissions from each region.

Tablo 7-4-1 New and retrofit existing FGD installations on coal-fired units (to end 1993) (IEA Coal Research, 1994b)

Country	New no	New MWe	Retrofit no	Retrofit MWe	Not known no	Not known MWe
Austria	4	1102	7	748	–	–
Canada	2	750	2	306	–	–
China	2	720	–	–	–	–
Czech Republic	–	–	1	200	–	–
Denmark	4	1265	4	1690	–	–
Finland	1	560	13	2062	–	–
France	1	600	–	–	2	210
Germany	27	6363	178	37184	–	–
Hong Kong	–	–	1	350	–	–
India	–	–	1	500	–	–
Italy	–	–	1	30	1	77
Japan	19	9923	27	5286	1	40
Netherlands	2	1295	5	2777	–	–
Norway	–	–	–	–	1	30
Poland	–	–	8	906	–	–
Russian Federation	–	–	1	130	–	–
Sweden	7	255	1	3642	–	–
Switzerland	–	–	1	100	–	–
Taiwan	–	–	2	1000	–	–
Turkey	3	36	2	300	–	–
United Kingdom	–	–	2	1320	–	–
USA	129	60830	104	22810	30	1572

Table 7-4-2 New and retrofit planned FGD installations on coal-fired units (after 1993) (IEA Coal Research, 1994b)

Country	New no	New MWe	Retrofit no	Retrofit MWe	Not known no	Not known MWe
Austria	–	–	1	110	–	–
Bulgaria	–	–	1	210	–	–
Canada	–	–	2	1020	–	–
Czech Republic	–	–	5	640	2	660
Denmark	1	415	1	600	–	–
France	–	–	–	–	3	1800
Germany	8	4690	14	5740	–	–
Hong Kong	–	–	1	350	–	–
Italy	10	5240	9	3380	–	–
Japan	9	6112	–	–	–	–
Poland	6	2160	8	2240	–	–
Russian Federation	–	–	2	515	–	–
Slovak Republic	–	–	2	220	–	–
Slovenia	–	–	1	275	–	–
Spain	4	1150	4	1380	–	–
Taiwan	4	2200	6	2800	–	–
Thailand	2	600	–	–	–	–
Turkey	–	–	16	3090	–	–
Ukraine	1	300	–	–	–	–
United Kingdom	–	–	8	4648	–	–
USA	31	14420	39	19077	11	3917

Table 7-4-3 Types of existing FGD installations on coal-fired units (to end 1993) (IEA Coal Research, 1994b)

Country	Sorbent injection process		Spray dry scrubber		Regenerable & combined SO_2/NO_x removal		Wet lime/ limestone/ gypsum scrubber		Other wet scrubber	
	no	MWe	no	MWe	no	MWe	no	MWe	no	MWe
Austria	2	205	4	835	–	–	5	810	–	–
Canada	3	606	–	–	–	–	1	450	–	–
China	–	–	–	–	–	–	2	720	–	–
Czech Republic	–	–	–	–	–	–	1	200	–	–
Denmark	–	–	3	1100	1	295	4	1560	–	–
Finland	1	250	5	423	–	–	8	1949	–	–
France	3	810	–	–	–	–	–	–	–	–
Germany	22	960	35	3234	12	1917	134	37337	2	99
Hong Kong	–	–	–	–	–	–	1	350	–	–
India	–	–	–	–	–	–	–	–	1	500
Italy	–	–	1	77	1	30	–	–	–	–
Japan	1	175	–	–	–	–	43	14867	3	207
Netherlands	–	–	–	–	–	–	7	4072	–	–
Norway	–	–	–	–	–	–	–	–	1	30
Poland	6	820	–	–	1	36	–	–	1	50
Russian Fed.	1	130	–	–	–	–	–	–	–	–
Sweden	11	420	9	477	–	–	–	–	–	–
Switzerland	1	100	–	–	–	–	–	–	–	–
Taiwan	–	–	–	–	–	–	2	1000	–	–
Turkey	–	–	–	–	–	–	5	336	–	–
UK	–	–	–	–	–	–	2	1320	–	–
USA	12	1202	65	10705	21	5244	23	9454	142	58607
Total	63	5678	122	16851	36	7522	238	74426	150	59493

Table 7-4-4 Types of planned FGD installations on coal-fired units (after 1993) (IEA Coal Research, 1994b)

Country	Sorbent injection process		Spray dry scrubber		Wet lime/ limestone/ gypsum scrubber		Other wet scrubber		Process not known/ selected	
	no	MWe	no	MWe	no	MWe	no	MWe	no	MWe
Austria	1	110	–	–	–	–	–	–	–	–
Bulgaria	–	–	–	–	–	–	–	–	1	210
Canada	–	–	–	–	2	1020	–	–	–	–
Czech R	–	–	1	450	5	640	–	–	1	210
Denmark	–	–	–	–	2	1015	–	–	–	–
France	–	–	–	–	3	1800	–	–	–	–
Germany	2	187	–	–	20	10243	–	–	–	–
Hong Kong	–	–	–	–	1	350	–	–	–	–
Italy	–	–	–	–	17	7960	–	–	2	660
Japan	–	–	–	–	9	6112	–	–	–	–
Poland	–	–	–	–	14	4400	–	–	–	–
Russian Fed.	–	–	–	–	2	515	–	–	–	–
Slovak Rep.	–	–	–	–	2	220	–	–	–	–
Slovenia	–	–	–	–	1	275	–	–	–	–
Spain	–	–	3	600	5	1930	–	–	–	–
Taiwan	–	–	–	–	10	5000	–	–	–	–
Thailand	–	–	–	–	2	600	–	–	–	–
Turkey	–	–	–	–	–	–	4	840	12	2250
Ukraine	–	–	–	–	1	300	–	–	–	–
UK	–	–	–	–	8	4648	–	–	–	–
USA	4	830	15	2856	31	14588	28	17971	3	1169
Total	7	1127	19	3906	135	61616	32	18811	19	4499

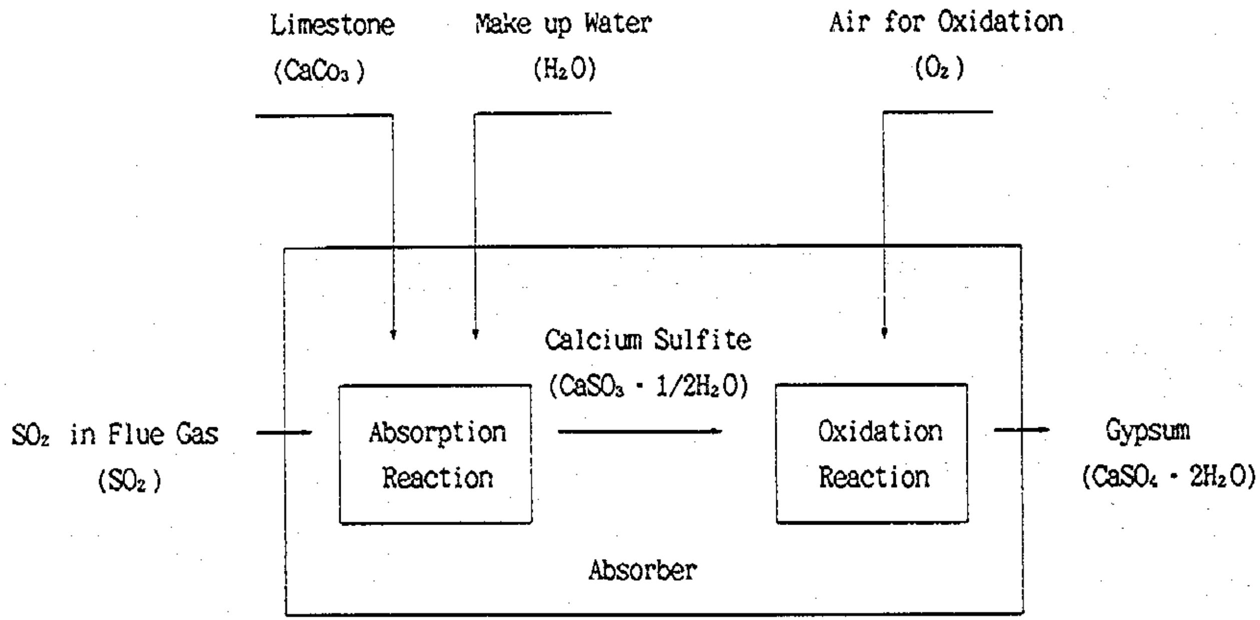


Figure 7-4-1 REACTION FLOW OF WET LIMESTONE-GYPSUM PROCESS (SPRAY TOWER METHOD)

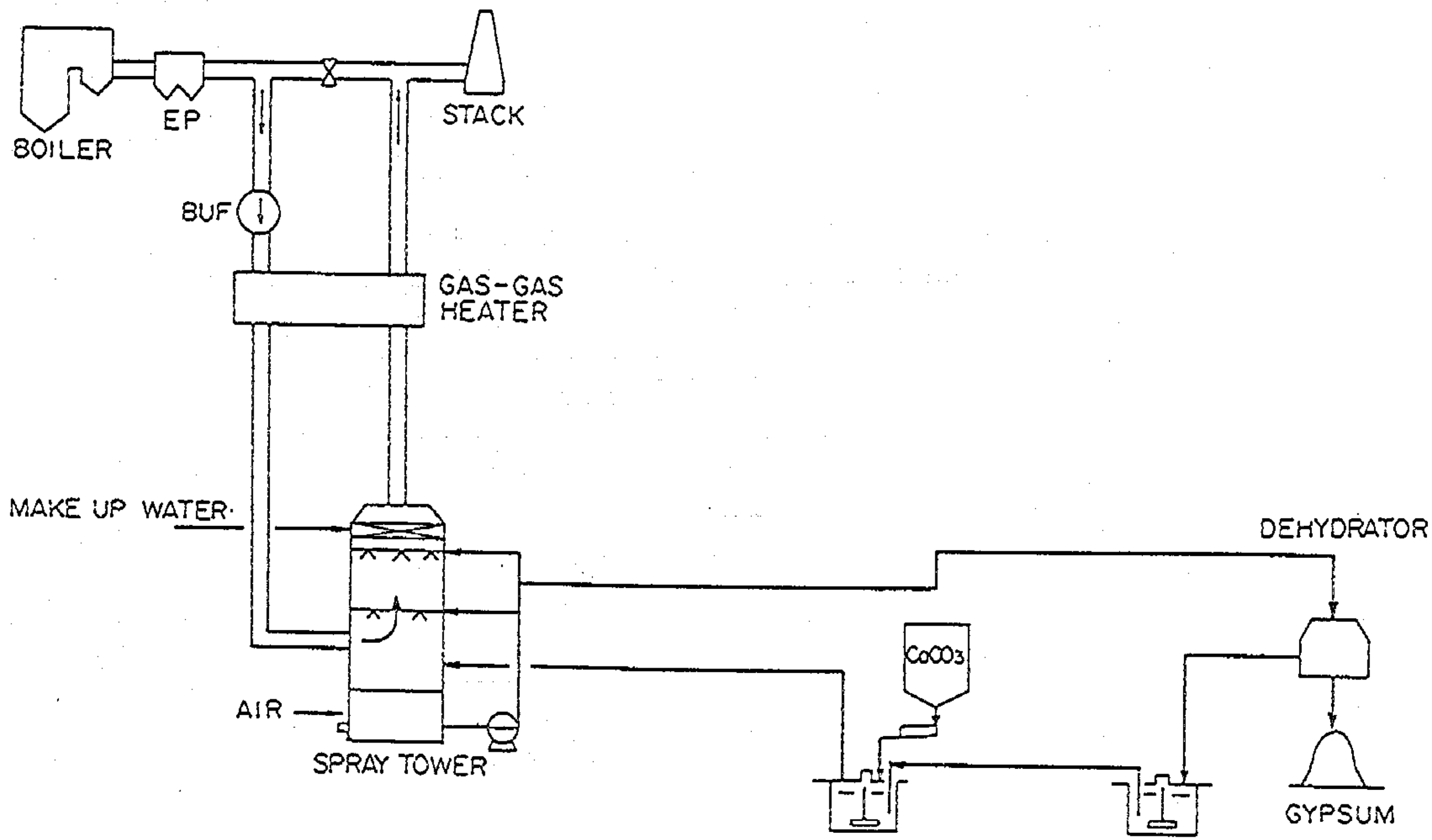


Figure 7-4-2 Process Flow of Wet Limestone-Gypsum Process
(Spray Tower Method)

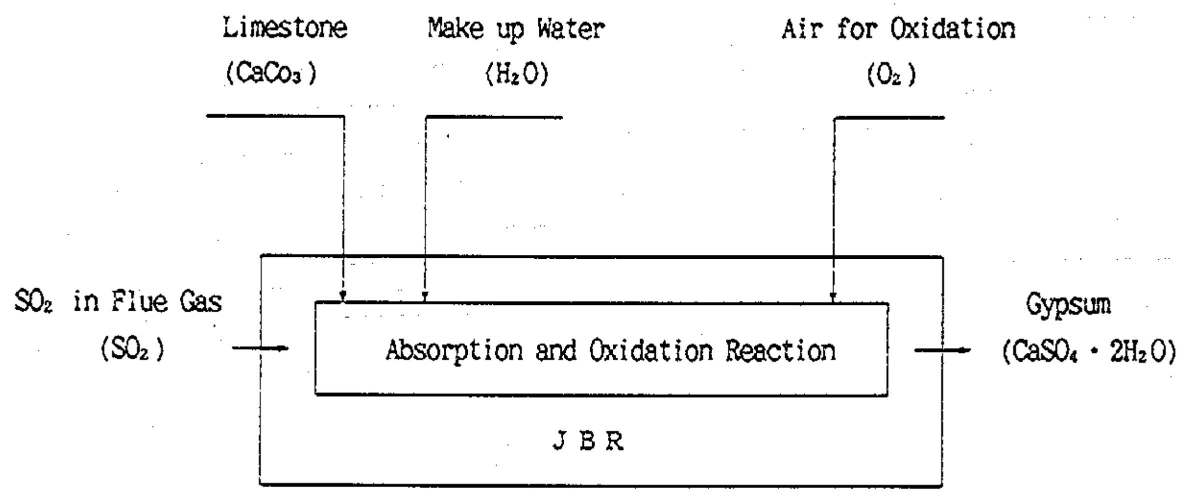


Figure 7-4-3 REACTION FLOW OF WET LIMESTONE-GYPSUM PROCESS
(JET-BUBBLING METHOD)

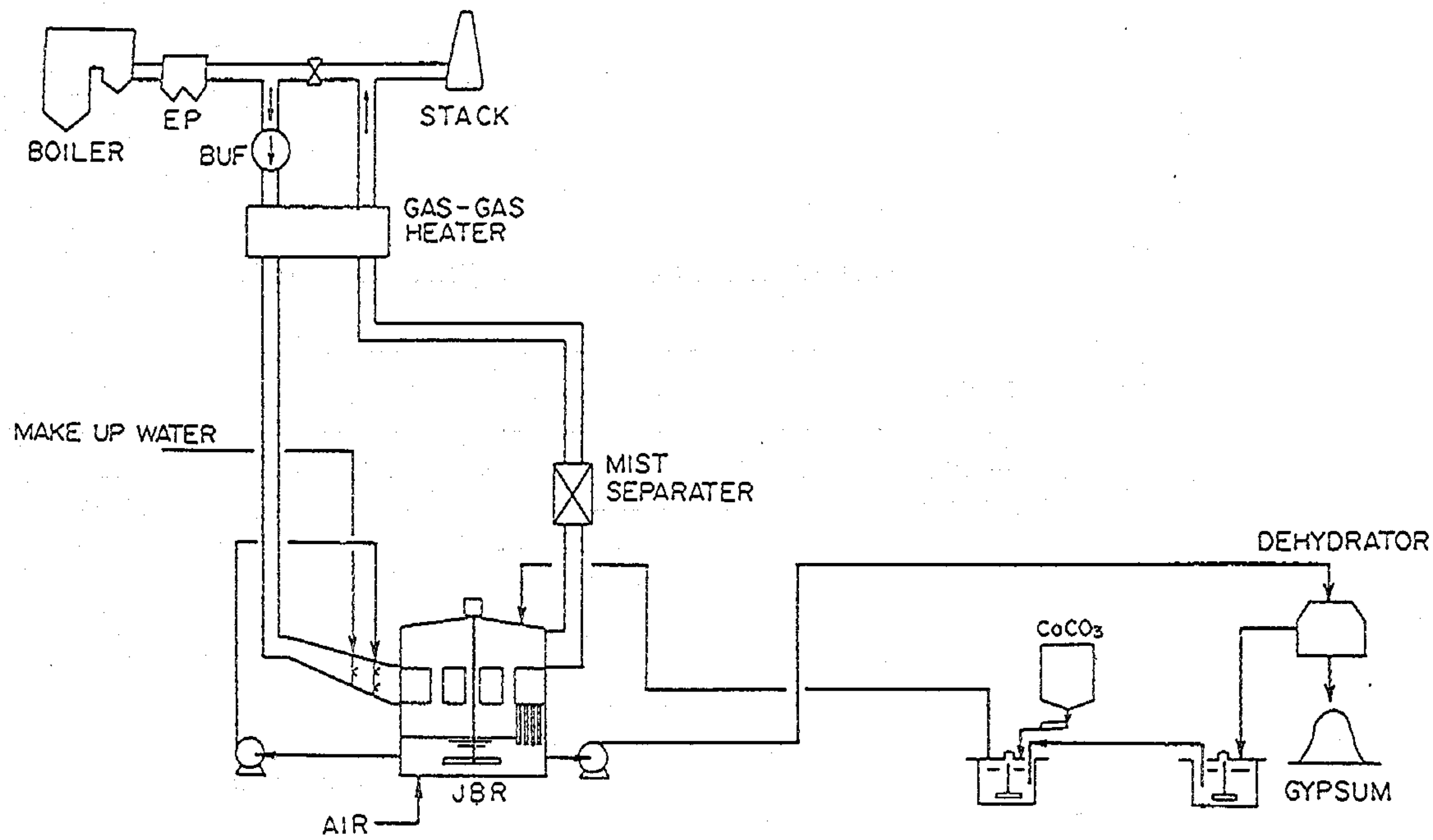


Figure 7-4-4 Process Flow of Wet Limestone-Gypsum Process
(Jet-Bubbling Method)

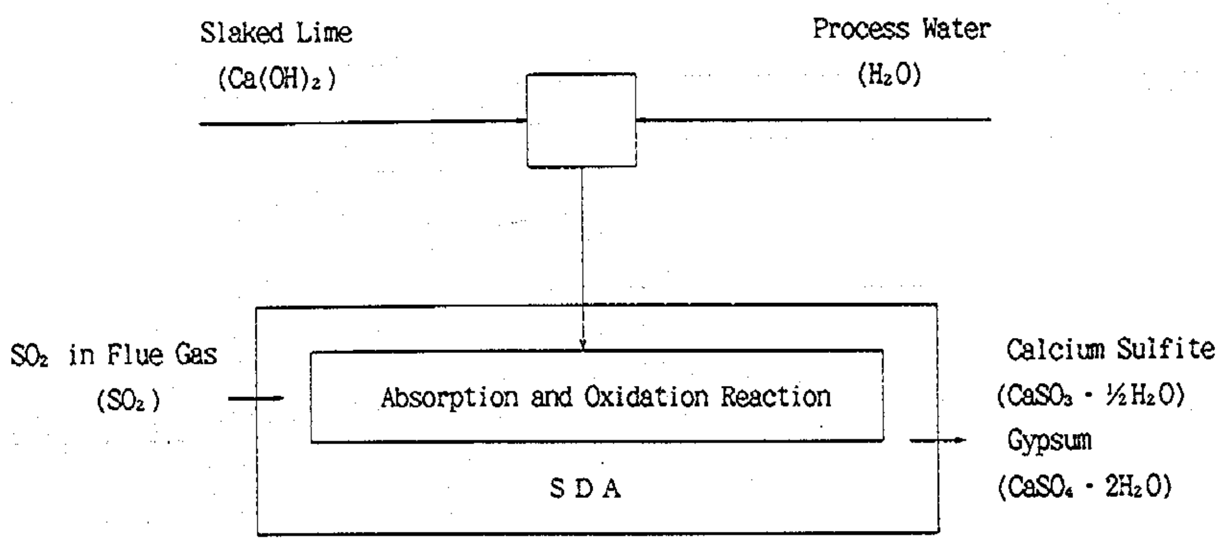


Figure 7-4-5 REACTION FLOW OF SPRAY DRYER METHOD

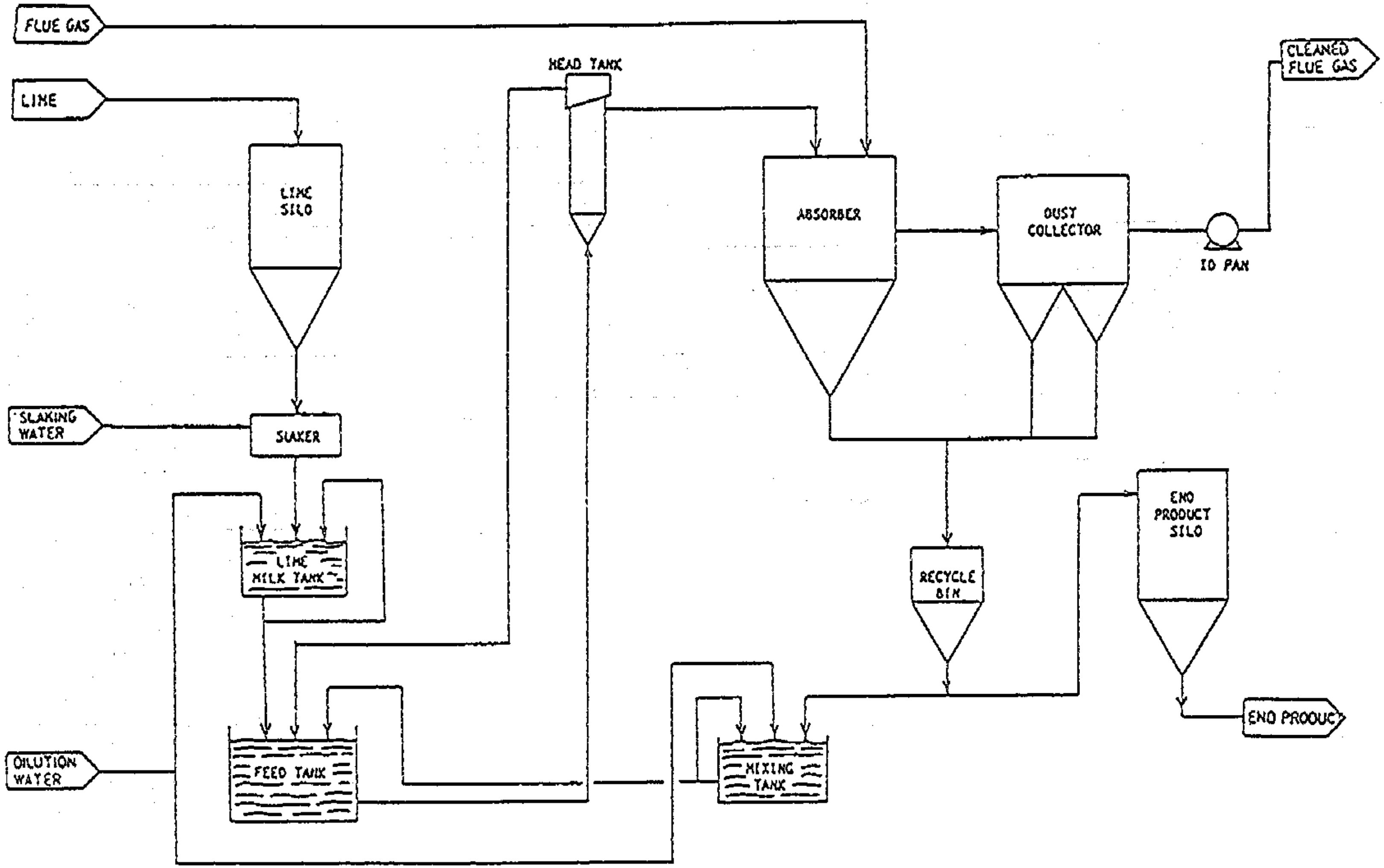


Figure 7-4-6 Process Flow of Spray Dryer

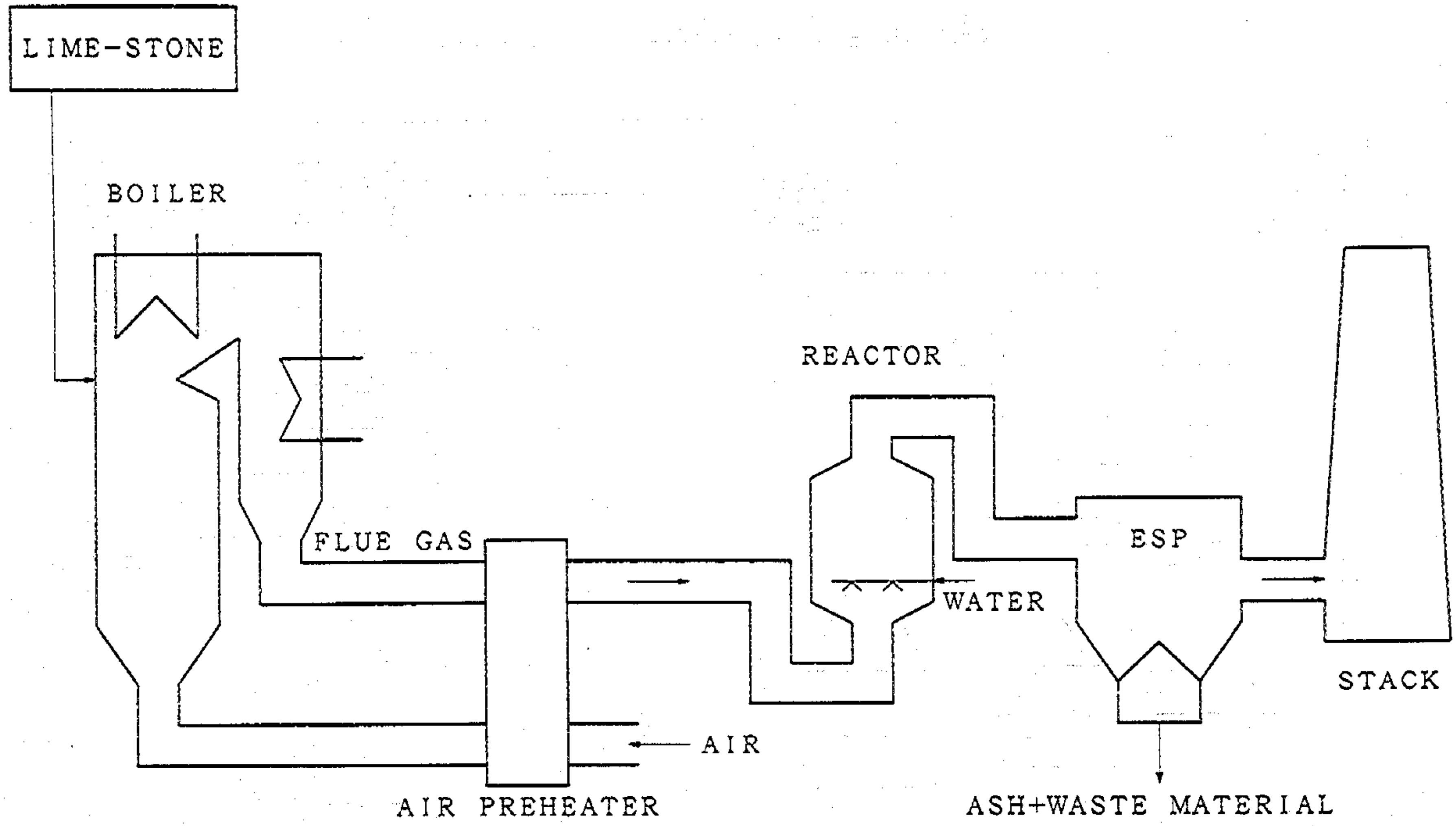


Figure 7-4-7 PROCESS FLOW OF DRY ABSORBENT FURNACE INJECTION SYSTEM

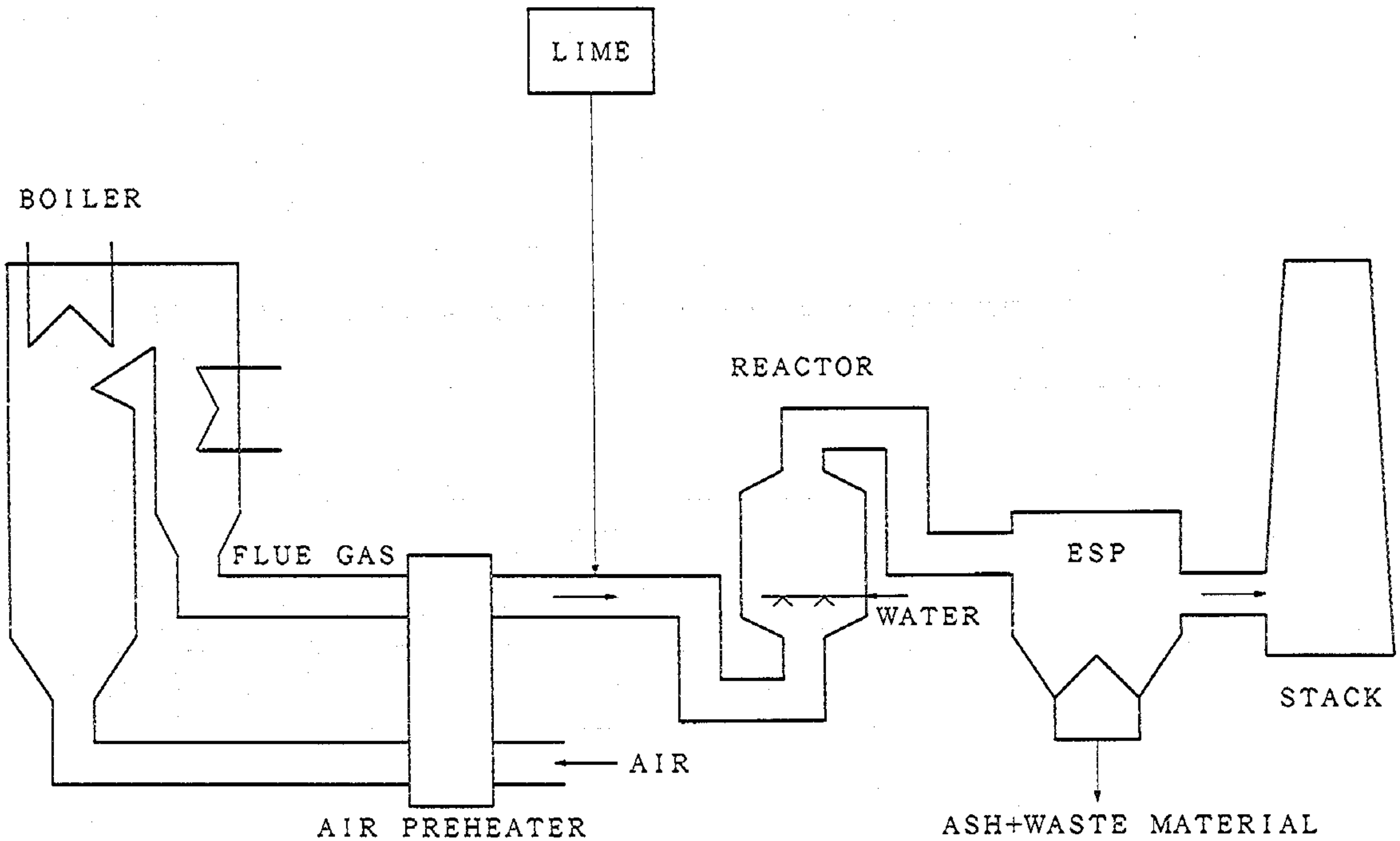


Figure 7-4-8 PROCESS FLOW OF DRY ABSORBENT DUCT INJECTION SYSTEM

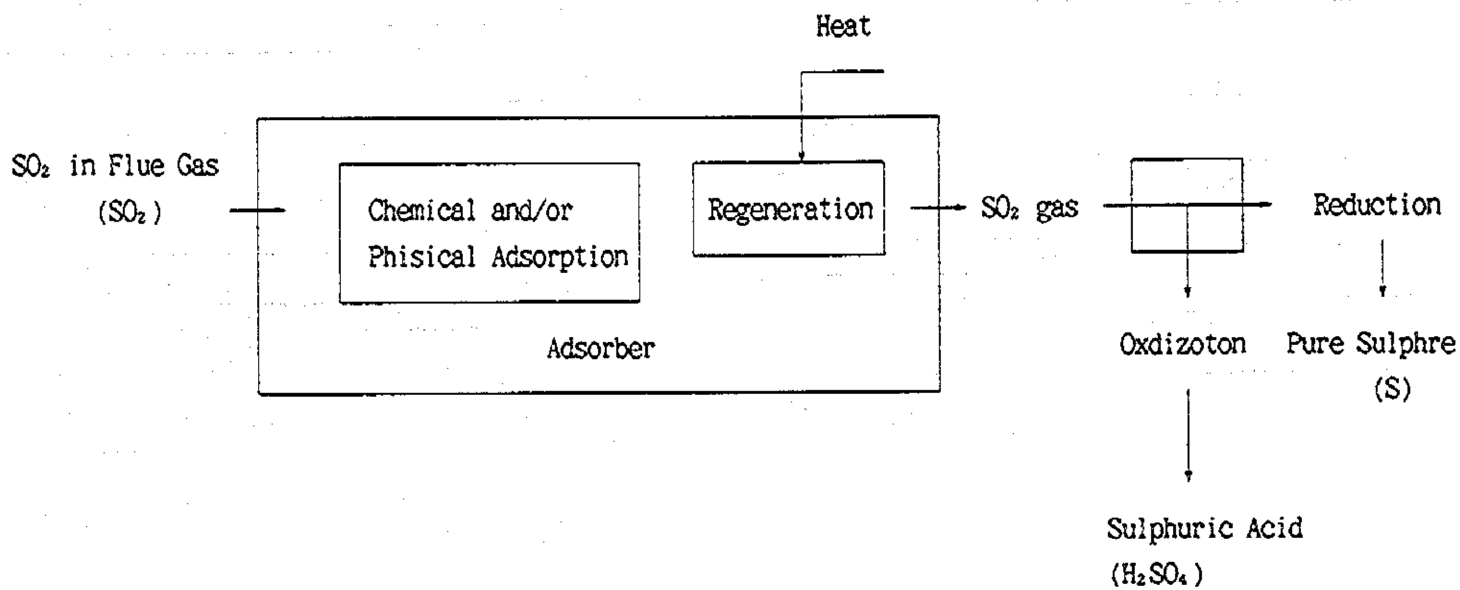


Figure 7-4-9 ADSORPTION AND REGENERATION FLOW OF ACTIVATED COKE METHOD

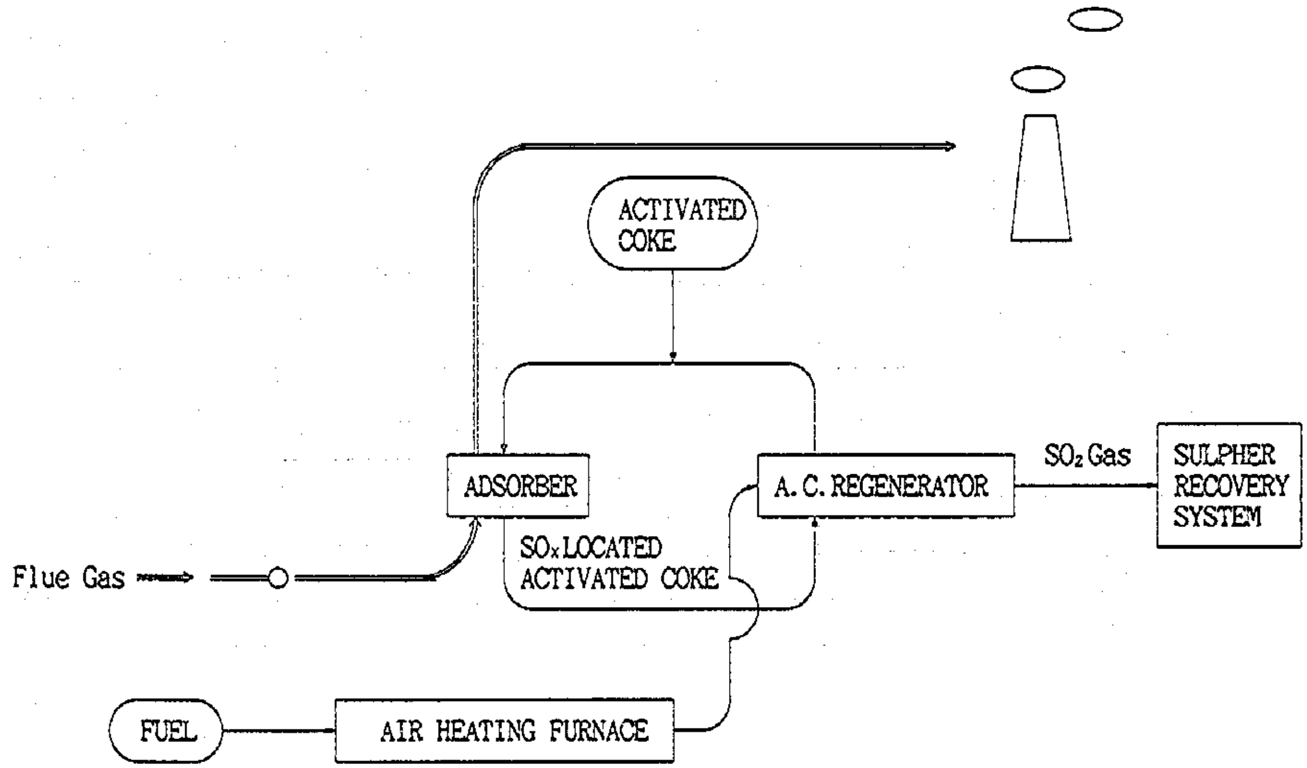


Figure 7-4-10 PROCESS FLOW OF ACTIVATED COKE METHOD

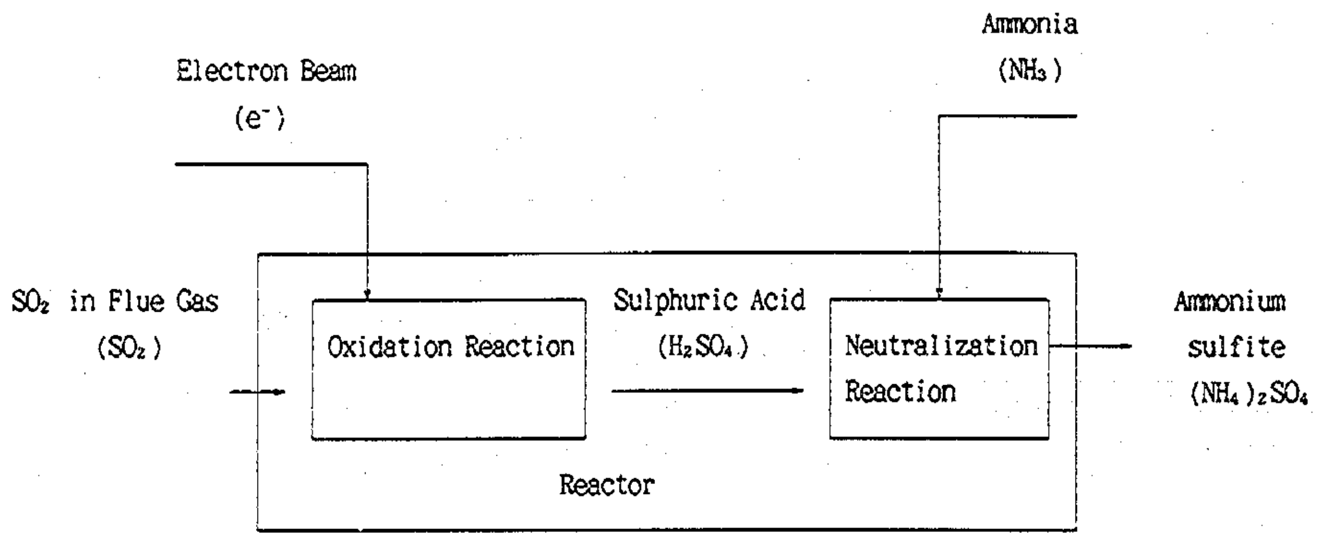


Figure 7-4-11 REACTION FLOW OF ELECTRON BEAM SYSTEM WITH AMMONIA

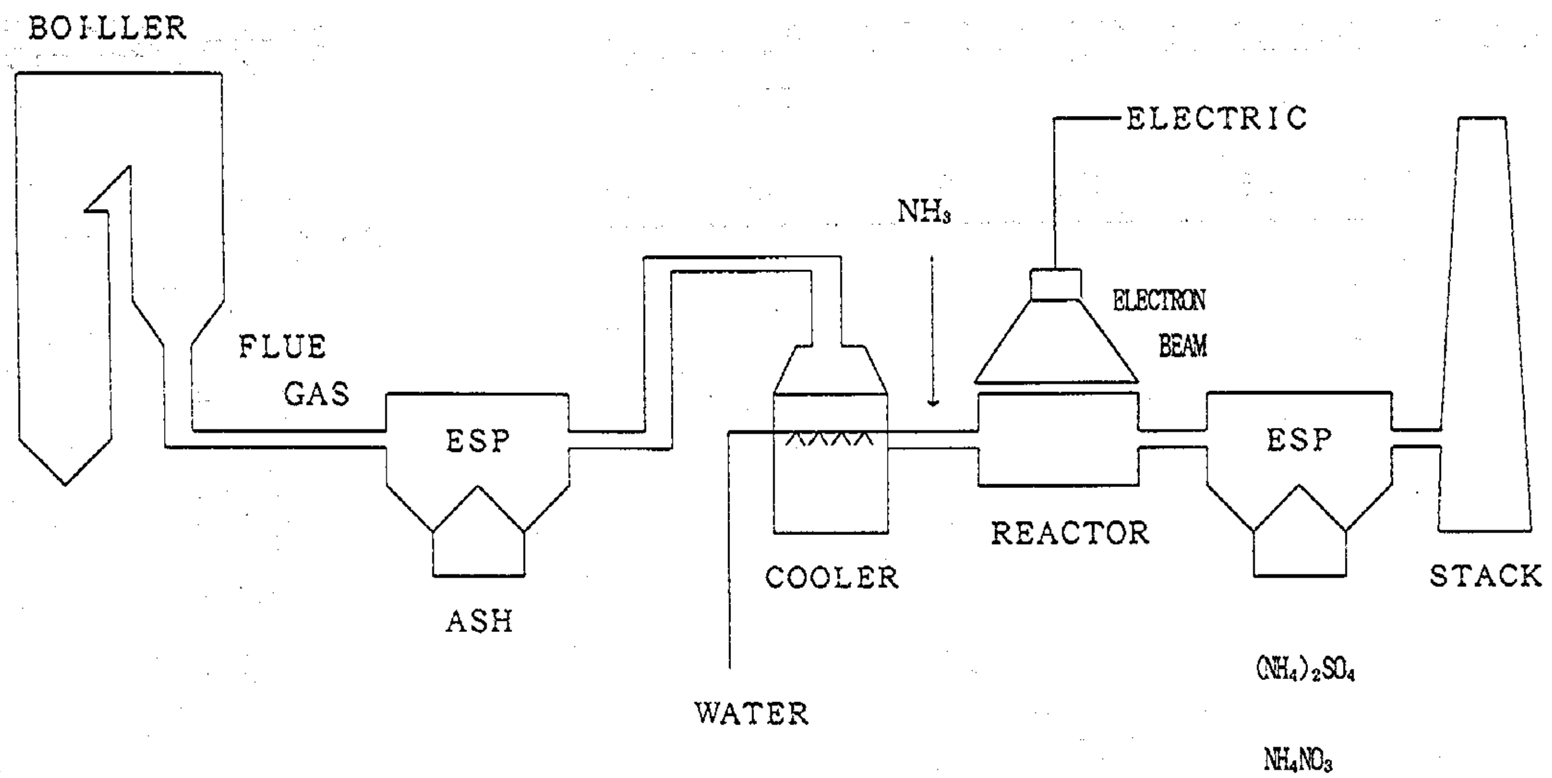


Figure 7-4-12 PROCESS FLOW OF ELECTRON BEAM SYSTEM WITH AMMONIA

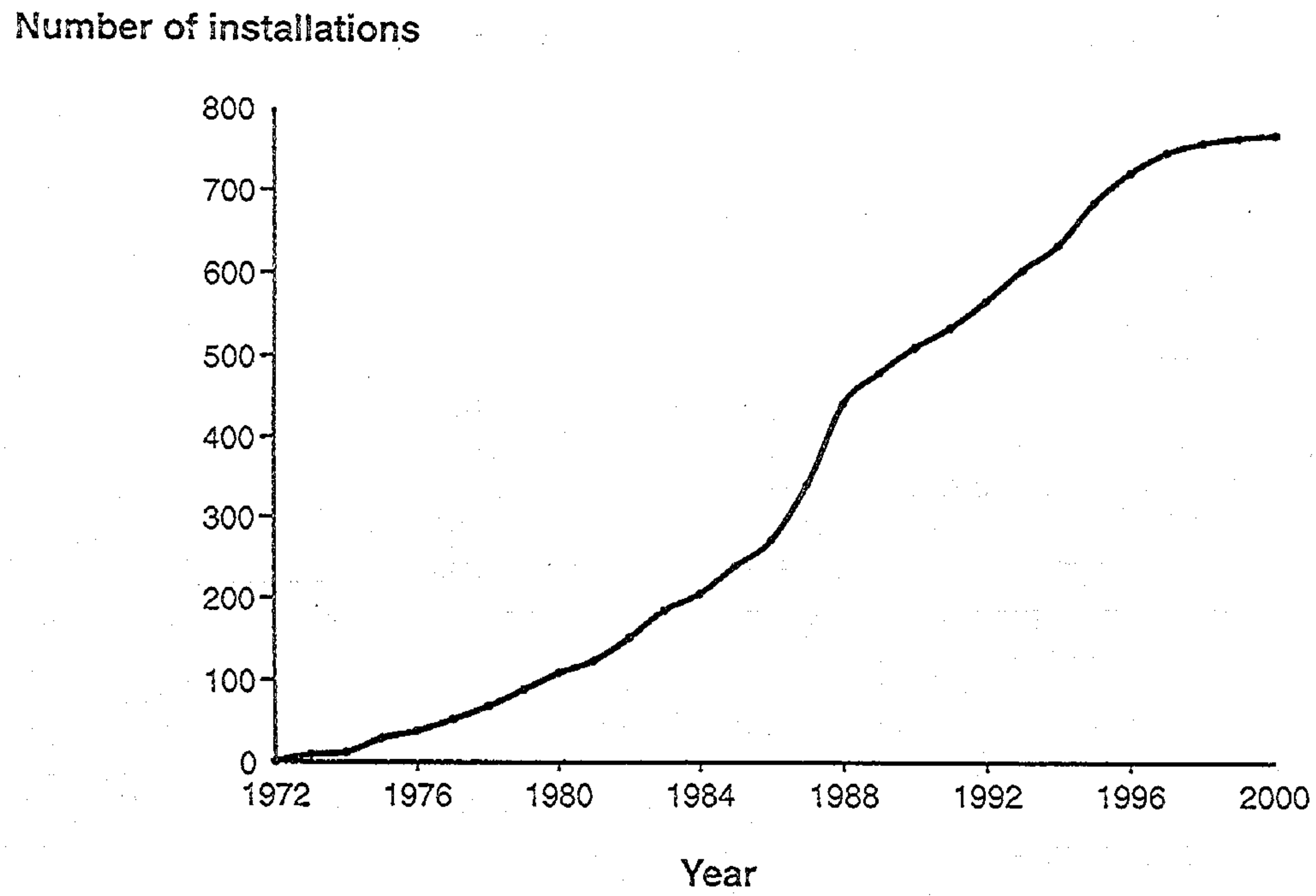


Figure 7-4-13 Growth in the number of FGD on coal-fired plants since 1972 (IEA Coal Research, 1994b)

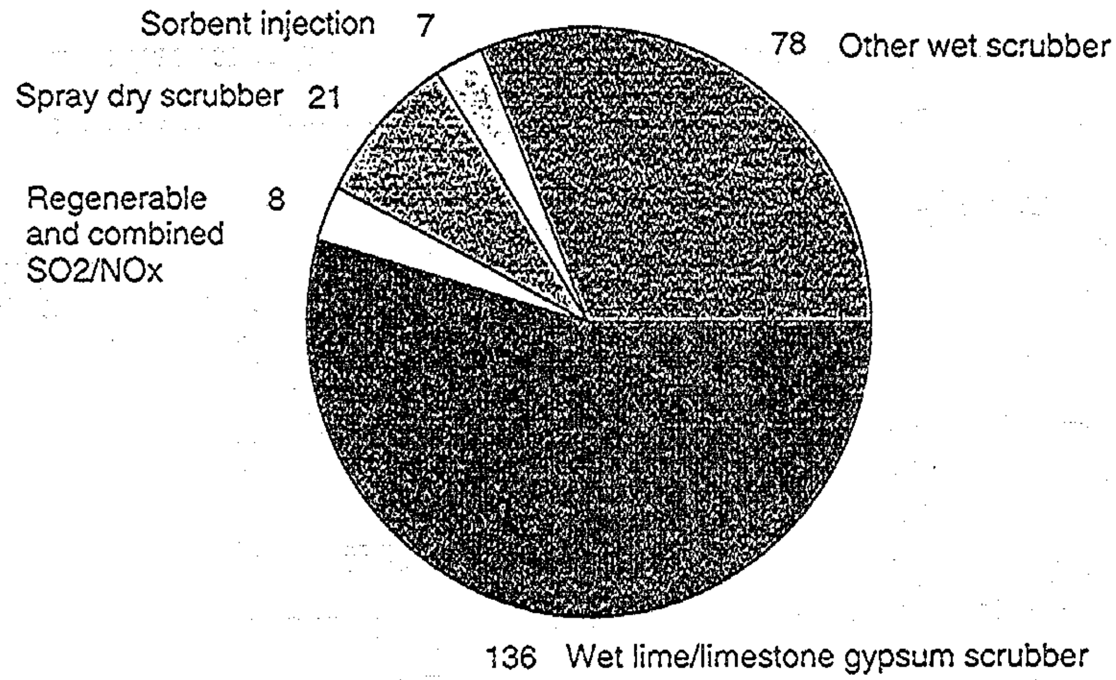
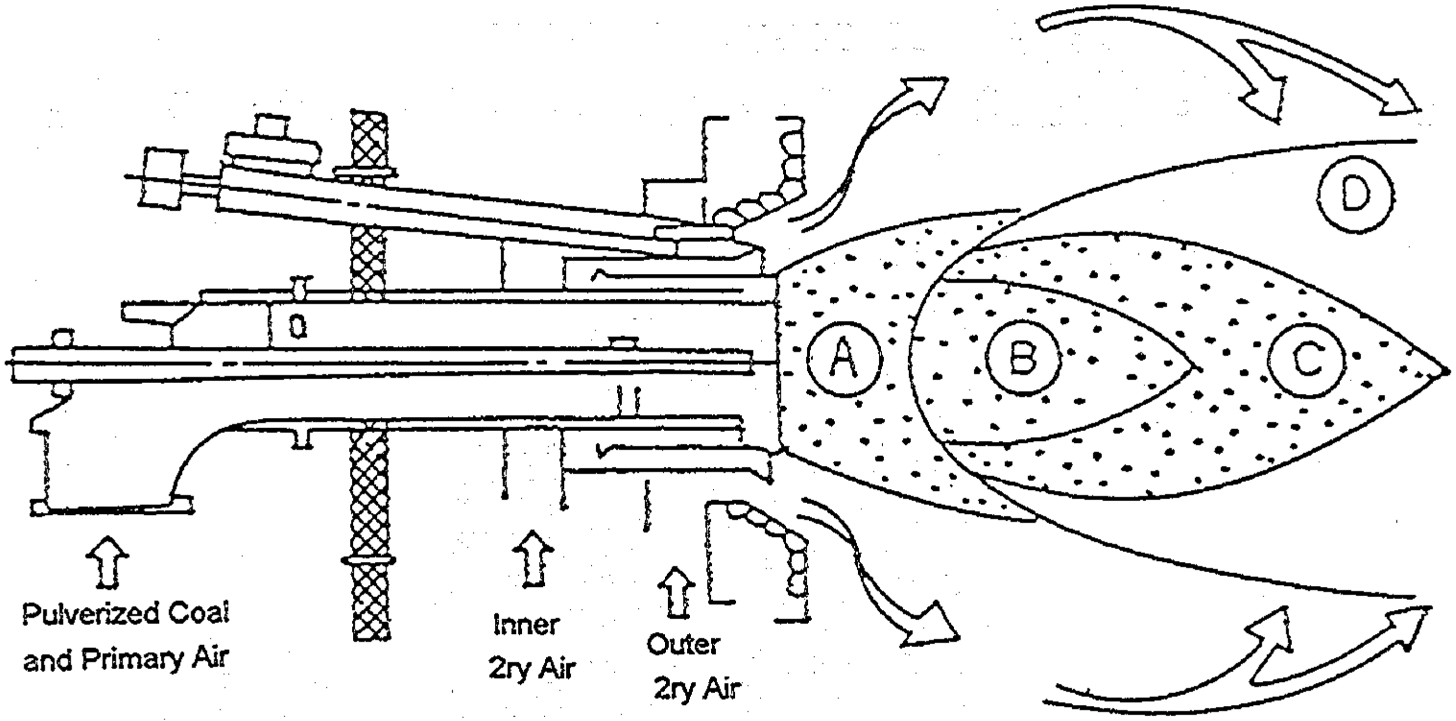


Figure 7-4-14 Market of distribution of FGD systems, GWe (IEA Coal Research, 1994b)



A : Volatile Matter Burning Zone C : De-NOx Zone

B : Reduction Zone D : Oxidization Zone

Figure 7-4-15 Illustration of Low NOx Burner

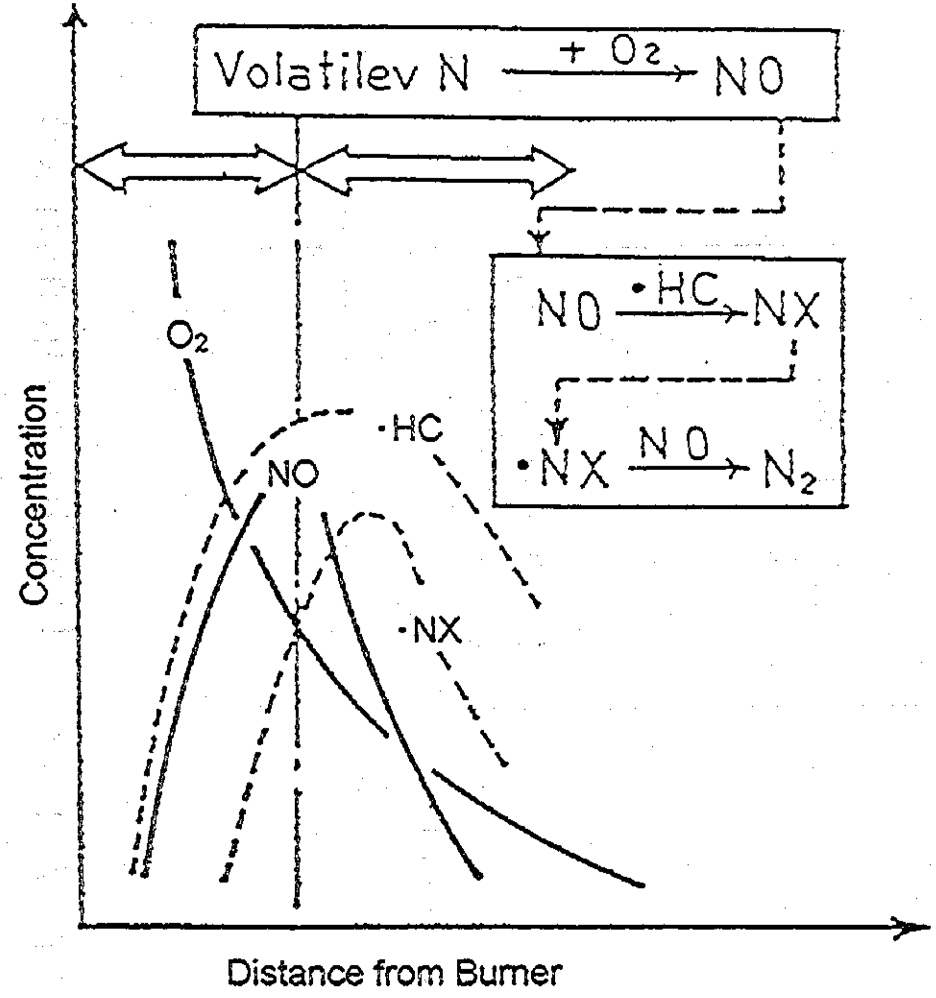


Figure 7-4-16 Principle of NOx reduction

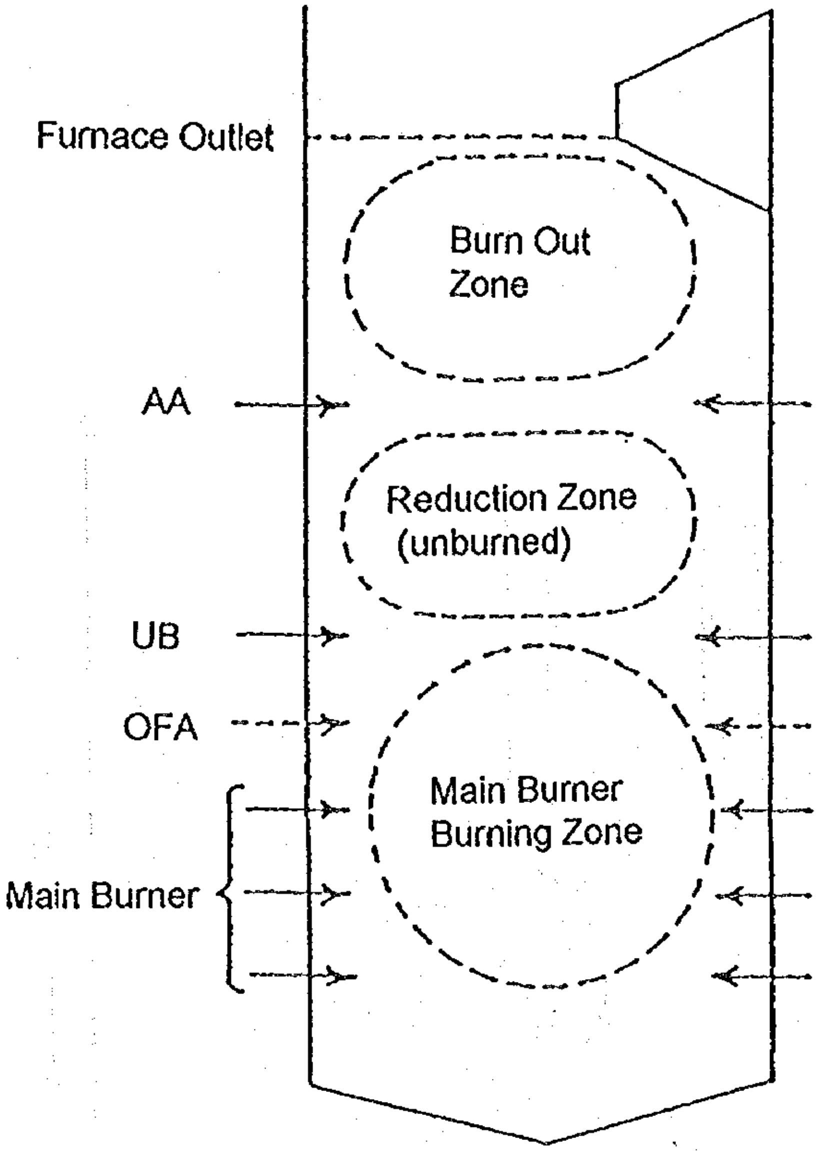


Figure 7-4-17 Denitlation in furnace

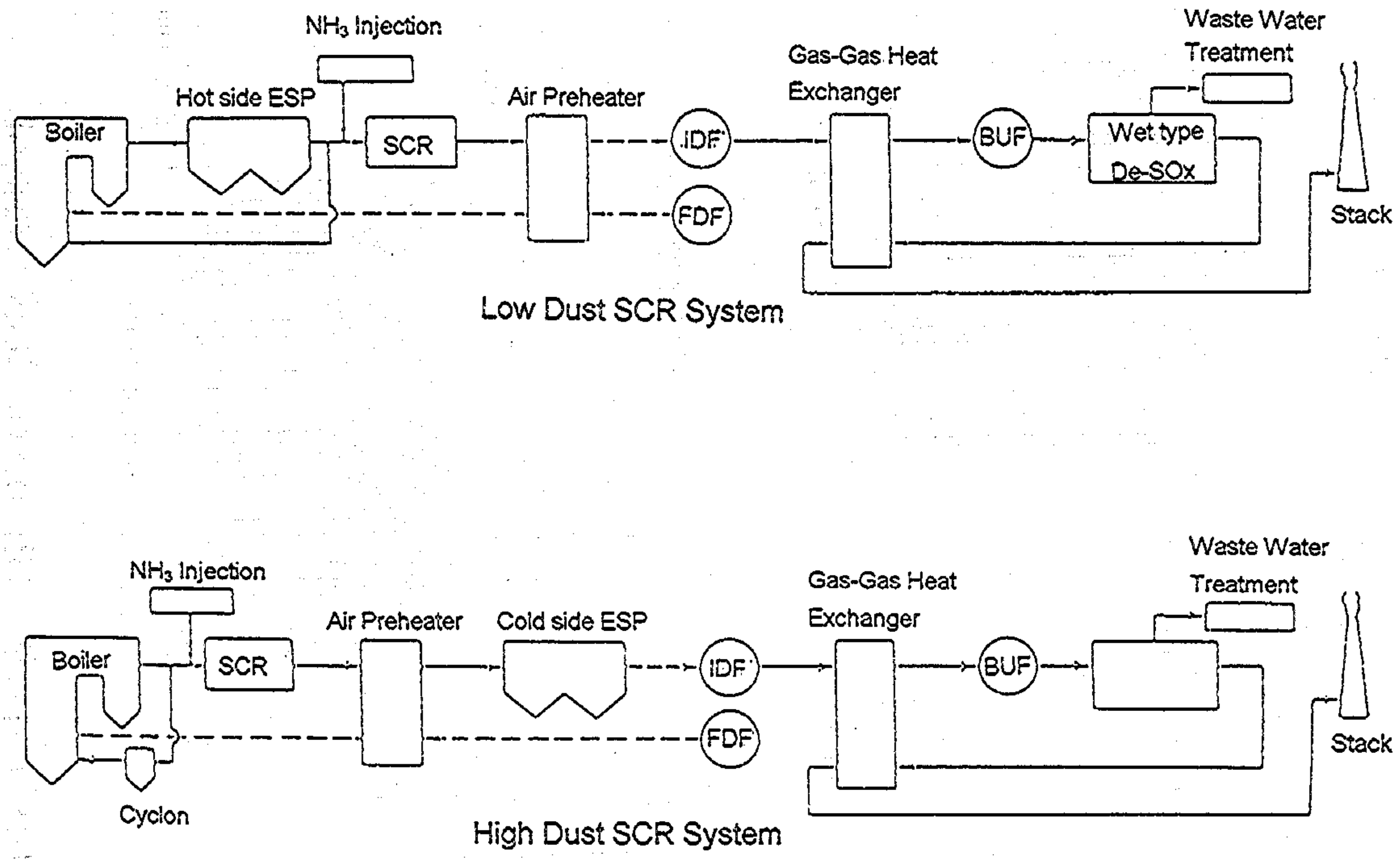


Figure 7-4-18 Flue gas treatment process

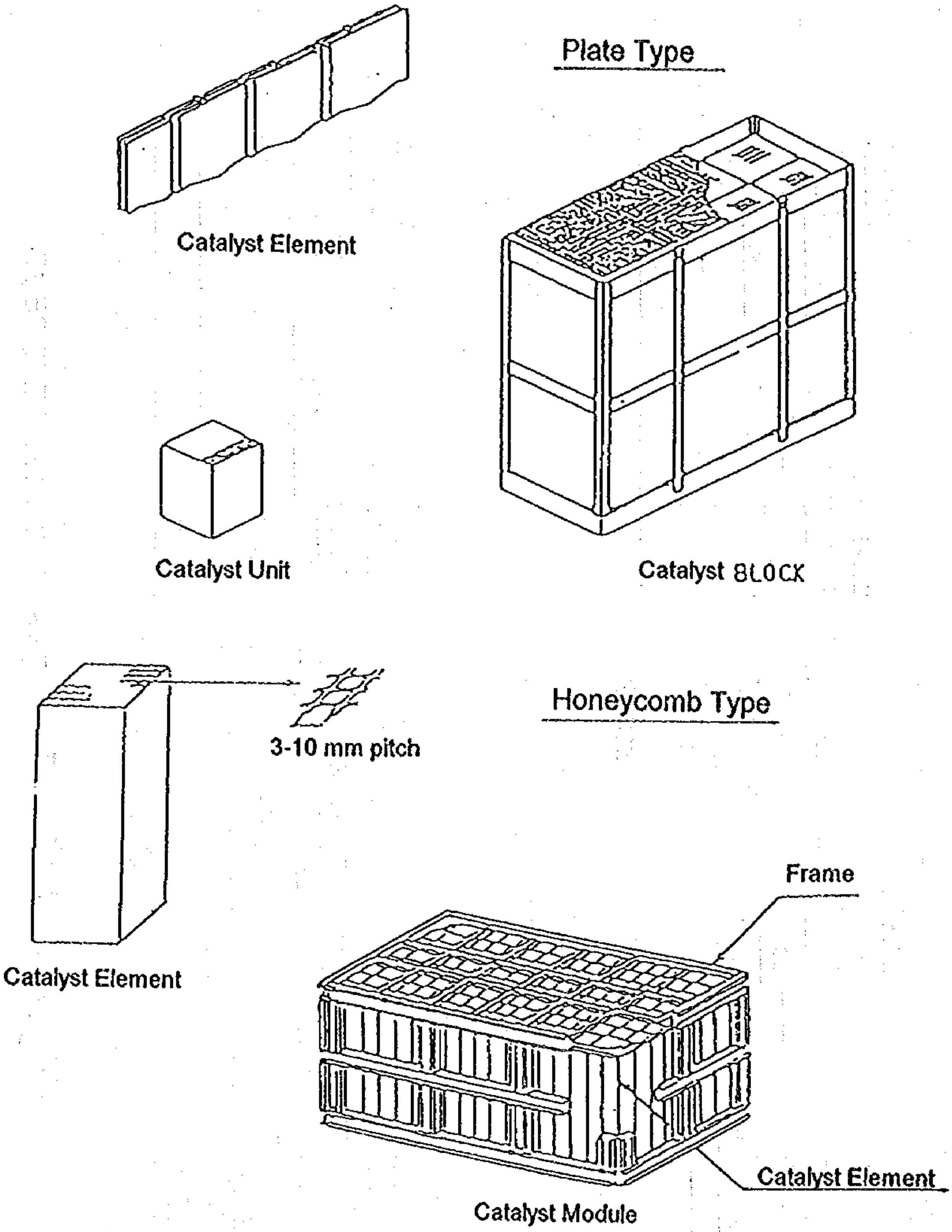


Figure 7-4-19 Shape of SCR catalyst

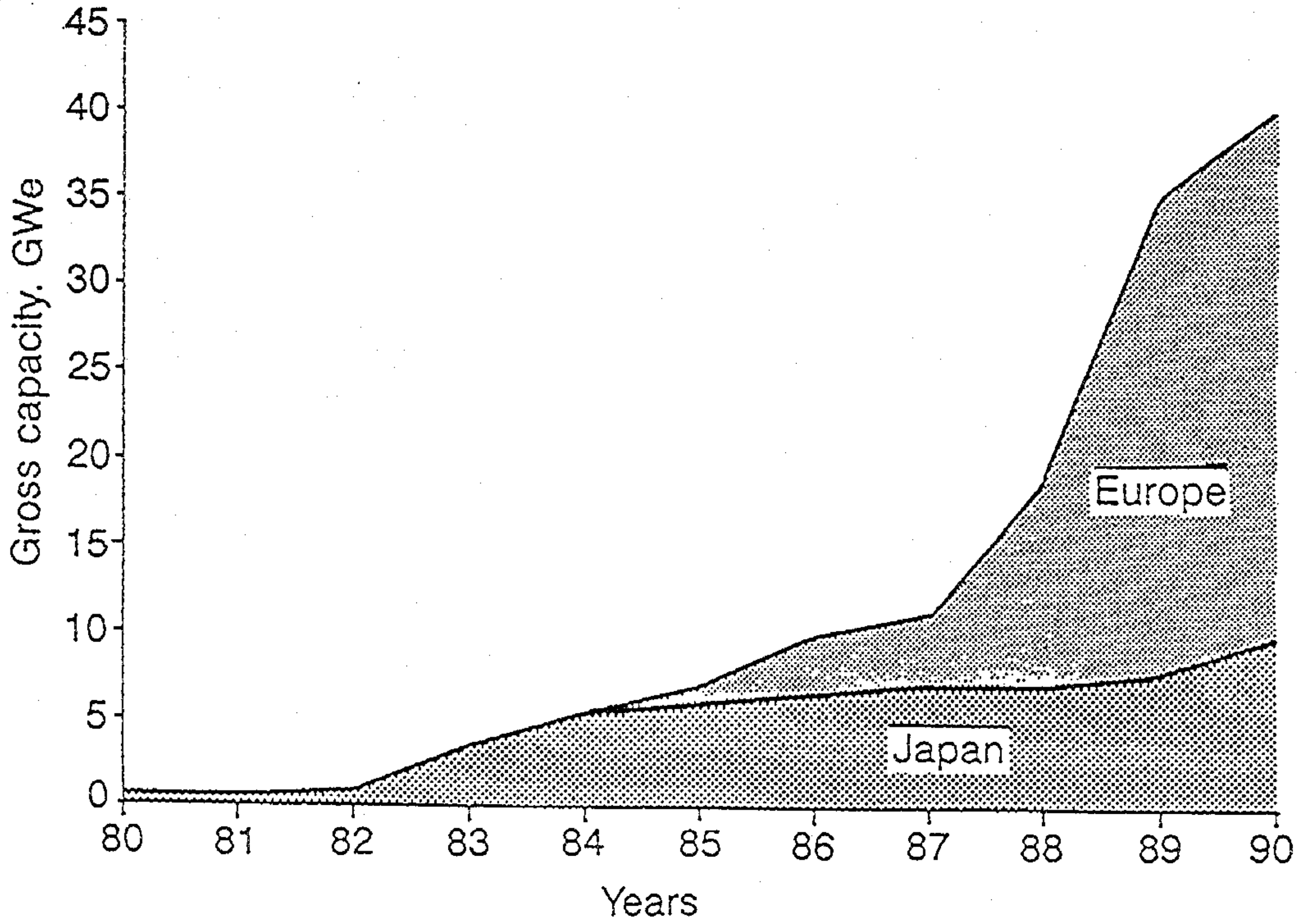


Figure 7-4-20 Total installed capacity of SCR, worldwide
(IEA Coal Research database)

CHAPTER 8 TECHNICAL TRANSFER ACCOMPANYING SUPPLY OF EQUIPMENT AND MATERIALS

CHAPTER 8 TECHNICAL TRANSFER ACCOMPANYING SUPPLY OF EQUIPMENT AND MATERIALS

8.1 Provided Equipment

8.1.1 Specifications of Atmosphere and Flue Gas Measurement Devices

The specifications of the equipment and materials to be supplied to NEK from JICA are as follows:

(1) Flue gas analyzer

Measuring system:	Controlled potential electrolysis	
Measuring item:	SO_2, NOx, O_2 in flue gas	
Measuring range:	SO_2	0~500/2000/8000ppm
	NOx	0~200/500/2000ppm
	O_2	0~5/10/25%
Dimensions:	320W × 260D × 450H	
Weight:	15kg or less	

(2) Orsat apparatus (CO, CO_2, O_2, N_2)

Measuring system:	Orsat	
Measuring item:	CO, CO_2, O_2, N_2	
Measuring range:	CO	0~100%
	CO_2	0~100%
	O_2	0~100%
	N_2	0~100%

(3) Dust measuring devices

Measuring system:	To be in accordance with JIS Z8808.
Measuring item:	Gas velocity, gas temperature, water content, concentration of dust.

(4) SO_2 meter for atmosphere

Measuring system:	UV pulse fluorescent
Measuring item:	Sulfur oxides in atmosphere
Measuring range:	0~0.1/0.2/0.5/1/2/5/10 ppm

Dimensions:	440W×230D×590H
Weight:	22kg or less

(5) NOx meter for atmosphere

Measuring system:	Chemiluminescence
Measuring item:	Nitrogen oxides in atmosphere
Measuring range:	0~0.05/0.1/0.2/0.5/1/2/5/10/20 ppm
Dimensions:	440W×230D×590H
Weight:	20kg or less

8.1.2 Confirmation of Equipment

The equipment provided from JICA were confirmed for their identification and performance in a warehouse of Maritsa East No.1 thermal power plant (ME-1) in the presence of the person representing ME-1. The result of confirmation indicated that all the scheduled equipment was sent and operated properly (refer to Table 8-1-1).

Date of confirmation:	March 5 (Tuesday), 1996.
Participant:	Mr. Slivkov (Chemical Dept.) for ME-1.

8.2 Technical Transfer

The theoretical explanation on the desk and demonstration of actual measurement of flue gas and its effect on the environment were made using the provided equipment.

8.2.1 Technical Transfer through Theoretical Explanation on the Desk

The technologies were transferred though the theoretical explanations on the desk during the period from December 18 to 20, 1995.

(1)	Place of technical transfer	Training room at Maritsa East No.1 thermal power plant.
(2)	Participants:	20 persons
(3)	Hours for transfer:	9:30 ~ 12:00
		13:30 ~ 16:00
(4)	First transfer:	December 18 (Mon.), 1995.

- Explanations were made as to general procedure of measurement and cautions to be exercised in the measuring site.
- Guidance was given concerning how to measure and calculate the velocity of flue gas.

- Guidance was given concerning how to measure and calculate the water content in flue gas.
- Guidance was given concerning how to sample and calculate the dust content in flue gas.
- Guidance was given on how to use Orsat gas analyzer.

Second transfer: December 19 (Tu.), 1995

- Explanations were made as to the functions of NOx, SO_2 and O_2 meters for flue gas.
- Technical guidances were given concerning the maintenance of analyzers for flue gas.

Third transfer: December 20 (Wed.), 1995

- Explanations were made as to the meters for measuring NOx, SO_2 and O_2 in atmosphere.
- Technical guidance on the maintenance of the analyzers for atmosphere.

8.2.2 Technical Transfer by Demonstration

For the transfer of the technology through demonstration, NOx, SO_2 and O_2 in the flue gases and atmosphere were actually measured using the provided equipment.

(1) Place of demonstration: Maritsa East No.1 thermal power plant.

(2) Period of demonstration: From March 5 (Tu.) to 11, 1996.

(3) Participants:
Mr. Peter Slivkov (ME1-ENGINEER)
Mr. Nikolai Karaliev (ME1-ENGINEER)
Ms. Bonka Peneva (ME1-ENGINEER)
Ms. Syefka Doneva (ME1-ENGINEER)
Mr. Sasho Keremedchiev (ME1-ENGINEER)
Ms. Katya Dimitrova (ME1-ENGINEER)
Mr. Todor Panchev (EGP-ENGINEER)
Ms. Katya Mihalova (EGP-ENGINEER)

(4) Contents of demonstration

Prior to actual demonstration, explanations were made on how to operate the equipment, how to measure using the equipment and safety measures to be observed in the site of measurement.

Then, demonstrations of the measurement of flue gases and atmosphere by the instructor were conducted two times. The locations of the sites where the flue gases were measured are shown in Fig.8-2-2-1, and the locations of the sites of the measurement of atmosphere are shown in Fig.8-2-2-2.

(a) Preparation

The preparation for the actual measurements of the flue gas were made on March 5 (Tu.), 1996 along with the explanation of operating method.

- How to determine the measuring point.
- Preparation for the use of measuring instruments and materials:
  Preparations of sampling tube for water content measurement, dry filter paper for dust sampling and weighing scale.
- How to operate gas meter
- Explanation of matters that demand special attention for safety in the site operation:
  The site of measurement (outlet of ESP) and neighboring area was not safe for the measuring work, since the handrail installed there was not high enough, and there was an opening that may involve anyone in a falling accident. So we recommended the person in charge to install higher handrail for safety.

(b) First-time measurement of flue gas

The first measurement of flue gas was carried out on March 6 (Wed.), 1996. The result of measurement is shown in Table 8-2-2-1.

- Measurement of gas velocity, water content and dust.
- Analysis of composition of flue gas.

(c) Second-time measurement of flue gas

The second-time measurement of flue gas was carried out on March 7 (Thu.), 1996. The result of measurement is shown in Table 8-2-1-1.

- Measurement of gas velocity, water content and dust.
- Analysis of composition of flue gas.
- How to use automatic meters for flue gase (NOx, SO_2, and O_2):
  Water content of each sampled gas should be removed adequately.
- How to use gas cylinder
  Learn how to use the regulator.

- Coordination among existing SO_2 meters:

  We have confirmed with an engineerof ME-1 that indicated value of existing SO_2 meters at the outlet of the boilers corresponded with one of provided SO_2 meter. We have also confirmed that the difference in the concentration of the flue gas among different boilers is mainly caused by the formation of the drain resulting from the temperature drop in the sampling tube.

  Then, we have recommended to improve the sampling condition by providing the sampling tube with the heat insulator (or heating device) as the pretreatment of the gas. The result of the measurement is shown in Table 8-2-2-2.

(d) First-time measurement of atmosphere

NOx and SO_2 in the atmosphere were measured for the first time on March 8 (Fri.), 1996.

- Handling of SO_2 meter for stmosphere.
- How to calibrate meter.
- Explanations concerning the replacement and maintenance of filter
- Result of measurement:

  Weather condition (Data obtained by the lake observation post at 14:30)

Weather:	Fine
Direction of wind:	East
Wind velocity:	9 m/s
Temperature:	3.6°C
Humidity:	73%

Place of measuring point (1): Site located about 1km apart in southwest of the power plant (refer to Fig.8-2-2.)

Time	13:10	13:20	13:30	13:40	13:50	14:00
SO_2 (ppm)	0.008	0.112	0.168	0.206	0.182	0.166

Place of measuring point (2): Site located about 2km apart in southwest of the power plant .(refer to Fig.8-2-2.)

Time	15:10	15:20	15:30	15:40	15:50	16:00
NO (ppm)	0.002	0.001	0.003	0.001	0.001	0.014
NO_2 (ppm)	0.013	0.013	0.014	0.014	0.014	0.014
NOx (ppm)	0.015	0.014	0.017	0.016	0.015	0.014

(e) Second-time measurement of atmosphere

The second-time measurement of atmosphere was carried out on March 9 (Sat.), 1996.

- Handling of NOx meter for atmosphere.
- How to calibrate meter.
- Explanations concerning the replacement and maintenance of filter
- Result of measurement

Weather condition (Data obtained at 10:30 in the data analysis room of ME-1)

Weather:	Snow
Direction of wind:	East
Wind velocity:	Wind gauge was not installed.
Temperature:	3.0°C
Humidity:	Hygrometer was not installed.

Place of measuring point (3): Site in the analysis room of the power plant (under the stack). (refer to Fig. 8-2-2.)

Time	11:15	11:30	11:45	12:00
SO_2 (ppm)	0.007	0.007	0.007	0.007
NO (ppm)	0.000	0.000	0.000	0.000
NO_2 (ppm)	0.004	0.004	0.005	0.005
NOx (ppm)	0.004	0.004	0.005	0.005

(f) Summary

The transfer of the technology was summarized on March 11 (Mon.), 1996.

- Explanation concerning the maintenance of automatic measuring instruments: In the explanation, we recommended to change the filter from time to time.

8.2.3 Expendable Supplies and Spare Parts

The suppliers of the expendable supplies and spare parts (genuine parts) for the equipment provided by (JICA) are as follows:

(1) SO_2 and NOx meters for atmosphere

YSSELBACH UMWELTTECHNIK GMBH
Mr. Peter C. Schmid
A-1050 Vienna Wiedner Hauptstrasse 98
TEL : 0043-1-545-4240
FAX : 0043-1-544-4471

(2) Flue gas analyzer

BEST INSTRUMENTS
97-28, MAKISHIMA-CYO FUKIMAE
UJI-CITY, KYOTO-FU
611 JAPAN

(3) Pump for dust sampling

KNF Neuberger GMBH
Alter Weg 3
D-79112 Freibueg-munzingen
TEL : 49-(0)07664 5909-0
FAX : 49-(0)07664 2124

(4) Others

DEVELOPMENT TECHNICAL CENTER CO., LTD
2-6-10 NIHONBASHI BAKURO-CHO, CYUO-KU
TOKYO, 103 JAPAN
TEL : 03-3668-3761
FAX : 03-3668-3766

Table 8-1-1 Supply List of Measuring Instruments

No.	Item	Quantity
	Stack gas measuring instrument	
1	Portable gas analyzer	1 set
2	Sampling tube	1 set
3	Standard gas with-in cylinder (101: 200 kg/cm^2)	
	NO gas 1200 ppm	1 pc
	SO_2 gas 4000 ppm	1 pc
	O_2 gas 5%	1 pc
4	Regulator	3 pcs
5	Dust sampling equipment	
5-1	Measuring apparatus of velocity	
5-1-1	Pilot tube	1 set
5-1-2	Inclined manometer	1 set
5-1-3	Dynamic pressure gauge	1 set
5-1-4	Measuring tube for static pressure	1 set
5-2	Measuring apparatus of temperature	
5-2-1	Digital electric thermometer	1 pc
5-2-2	Thermo-couple	1 pc
5-3	Measuring apparatus of water content	
5-3-1	Suction tube	1 set
5-3-2	Moisture absorption tube with case	1 set
5-3-3	Cooling waterbath with stand	1 set
5-3-4	Three arm balance	1 pc
5-3-5	Suction pump	1 pc
5-4	Dust sampling apparatus	
5-4-1	Dust collecting tube with case	1 set
5-4-2	Metal fitting for support with drain catcher	1 set
5-4-3	Gas washing bottle set	1 set
5-4-4	Suction pump	1 pc
5-4-5	Gas meter with case	1 pc
5-4-6	Suction rubber tube	1 set
5-4-7	Holder (Type 2) of thimble filter paper	1 set

No.	Item	Quantity
5-5	Expendable supplies	
5-5-1	Calculum chloride	5 pcs
5-5-2	Silica gel, blue	4 pcs
5-5-3	Glass fiber	1 pc
5-5-4	Silicon grease	1 pc
5-5-5	Absorbent cotton	1 pc
5-5-6	Silicon tube	1 pc
5-5-7	Teflon tube	1 pc
5-5-8	Seal tape	10 pcs
5-6	Spare parts	
5-6-1	dust collection tube	30 pcs
5-6-2	Moisture absorption tube	20 pcs
5-6-3	Thimble filter paper	30 pcs
6	Orzat gas analyzing equipment	
6-1	Main body	1 set
6-2	Spare parts	
6-2-1	Gas bullets	1 pc
6-2-2	Gas absorption bottle	3 pcs
6-2-3	Distribute cock	1 pc
6-2-4	Leveling bottle	1 pc
	Air pollution monitoring instrument	
7	NO_x monitor	1 set
8	SO_2 monitor	1 set
9	Standard gas with-in cylinder (10l; 200 kg/cm^2)	
	NO 0.05 ppm	1 pc
	SO_2 0.1 ppm	1 pc
	N_2 pure	1 pc
10	Regulator	2 pcs
11	Dust fall sampler, deposit gauge	4 pcs
12	DC/AC converter	1 pc

Table 8-2-2-1 Measured Results at ESP Outlet

Items		1st	2nd
Flow rate (wet)	m^3N/h	239,000	235,000
Flow rate (dry)	m^3N/h	213,000	209,000
Gas temperature	°C	150	151
Gas velocity (ave.)	m/s	19.4	19.1
H_2O	%	11.0	11.0
O_2	%	12.6	12.1
CO_2	%	8.5	7.8
Dust	g/m^3N	0.114	0.128
SO_2	ppm	–	3,032
NO_x	ppm	–	129

Table 8-2-2-2 SO_2, NO_x at Boiler Outlet

Unit	SO_2	SO_x	O_2
	ppm	ppm	%
1	2,600	200	8.80
3	4,146	242	5.70
4	3,960	186	5.15
5	1,260	178	6.95
6	5,900	296	5.10

Unit 2: not operated

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