JAPAN INTERNATIONAL COOPERATION AGENCY [JICA]

MINISTRY OF INDUSTRY, TRADE AND TOURISM
THE REPUBLIC OF HUNGARY

THE FEASIBILITY STUDY ON THE FACILITY IMPROVEMENT AND ENVIRONMENTAL PROTECTION OF BORSOD POWER PLANT IN THE REPUBLIC OF HUNGARY

FINAL REPORT

Supporting Report

August 1997

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO
in association with
JAPAN ENVIRONMENT ASSESSMENT CENTER CO., LTD., TOKYO

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1.1 Large Capacity CFB Boilers in the World

Today, CFBs are used for a wide variety of applications, ranging from environmental consideration projects to the combustion of inexpensive waste fuel that cannot be burned in any other technology. By of early 1993, the technology had been widely commercialized with over 155 CFB units operating in the United States (11 units in Japan) having 5,300 MW cumulative installed capacity.

However, most of the units use bituminous coal with high calorific value. No large-scale units like Borsod Power Plant firing coal with high ash content and low calorific value like Lyuko coal have been found. Therefore, large-scale units with the evaporation of 350 t/h or more which are similar to the unit of this project were selected for the study and the fuels used were studied. Outline of these are shown in Tables 1.1.1 (1) through 1.1.1 (3).

According to Tables 1.1.1 (1) through 1.1.1 (3), units using the fuels with low calorific value such as lignite or brown coal are the following only three power plants.

a) Texas - New Mexico Thermal Power Plant, TNP-1 (USA), 499 t/h, 1990 startup
b) Goldenberg Power Station (Germany), 400 t/h, 1992 startup
c) Provence - Gardanne Power Plant (France), 700 t/h, 1995 startup

The JICA Team investigated the operational state and problems of the CFB boilers in above 3 power plants.

The results of the investigations are presented in the following sections. Then, overall analysis of these investigation results will be made in order to develop technical policy for the application of CFB boiler in Borsod Power Plant.

Table 1.1.1 (1) Outlines of Large - scale CFB Boilers in the World

Ahlström								
Plant Location	Boiler Manufacturer	Process	Capacity (MW) (Thermal)	Flow (t/h)	Steam Data Pressure (Bar)	Steam Data Temp. (SH/RH ℃)	Feed Stock	Start Up
Colorado - Utc Electric Association, Inc. Nucla, CO USA	PPC Ahlstrom	CFB	294	420	105	541	Coal	1987
Vaskiluodon Voima Oy Seiräjoki Finnland	Ahlstrom	CFB	299	400/356	156/44	540/540	Peat 100 % Coal 100 % Oil 63 %	1990
ACE COGENERATION Project Kerr Mc Gee Chemical Plant Trone, CA USA	PPC	CFB	284	414	105	541	Coal	1990
Nova Scotia Power Corp. Point Aconi, Nova Scotia Canada	PPC	CFB	409	525/464	128/35	540/540	Coal	1993

Table 1.1.1 (2) Outlines of Large - scale CFB Boilers in the World

Lurgi Lentjes Babcock Energietechnik GmbH								
Plant Location	Boiler Manufacturer	Process	Capacity (MW) (Thermal)	Flow (t/h)	Steam Data		Feed Stock	Start Up
					Pressure (Bar)	Temp. (SH/RH ℃)		
Robertson, Tx, USA (Texas-New Mexico I 175 MWe)	Combustion Engineering	CFB	474	499	138	540/540	Lignite	1990
Caring, France (Sodelif; 125 MWe)	Stein Industrie	CFB	322	367	134	545/540	Coal Water Slurry (CWM) Flotation Residues (dry)	1990
Gardenne, France (Provence Soprolif; 250 MWe)	Stein Industrie	CFB	650	700	169	565/565	Lignite Bitumenios Coal (put into operation)	1995

Table 1.1.1 (3) Outlines of Large - scale CFB Boilers in the World

GEC Alsthöm, ETV								
Plant Location	Boiler Manufacturer	Process	Capacity (MW) (Thermal)	Flow (t/h)	Steam Data		Feed Stock	Start Up
					Pressure (Bar)	Temp. (SH/RH ℃)		
Rheniseh-Westfalishes Elektrizitzätswerk AG, Essen, KW GOLDENBERGWERK	EVT	CFB	312.6	400	115	505	Rheinich Brown Coal (8.84 - 11.75 MJ/kg)	1992
HKW Zeran POLEN	RAFAKO	CFB	315	450	100	510	Bitumenios Coal	1996

1.2 Fuels in Use

As a result of the studies of the CFB boilers in the three power plants, many operating problems were found in a) and b). Erosion and crack of the nozzle by bed ash and bed ash removal system including ash cooler were major problems, which were common to both units. As the amount of discharged ash increases, the problem becomes more serious. Compositions of the fuels used in the three power plants are as follows.

a) Texas - New Mexico (499 t/h)

- Calorific value	15.5 MJ/kg (3,702 kcal/kg)
- Ash content	15.5 %
- Moisture content	30 %
- Sulfur content	1 %

b) Goldenberg (400 t/h)

- Calorific value	9 MJ/kg (2,150 kcal/kg)
- Ash content	7 %
- Moisture content	53.2 %
- Sulfur content	0.5 %

c) Provence - Gardanne (700 t/h)

- Calorific value	13 MJ/kg (3,100 kcal/kg)
- Ash content	28 to 32 % (of which 57 % is CaO)
- Moisture content	11 to 14 %
- Sulfur content	3.68 %

Compared with the fuel of Borsod Power Plant, ash contents in the fuel of a) and b) are much lower than that of Lyuko brown coal. Ash content of the fuel of a) is approx. 40 % of Lyuko coal and that of b) is only 18 %. However, much time has been spent on the correction of troubles caused by bed ash.

In order to avoid the reduction of electric power at the maintenance, a) and b) units employ the following countermeasures: a) is designed for achieving full load with multi-fuel firing capability such as natural gas, and b) has two stand-by oil boilers with a capacity of 145 t/h (70 % of full load) each in case of failure of CFB boiler.

1.3 Texas-New Mexico Thermal Power Plant (USA)

The study of the CFB boiler introduced in Texas-New Mexico Thermal Power Plant was conducted through the site investigation and literature.

1.3.1 TNP-One Unit 1 CFB Status and Solutions

The description below is a reproduction of main parts of the following report.

"TNP One Unit 1 - AFBC Status and Solutions: A Year on Lignite,"
Presented at the American Power Conference, April 29 - May 1, 1991, by T. Motley, TNP One, Plant Manager, Texas-New Mexico Power Company J.N. Darguzas, Project Manager, Sargent & Lundy

(1) Plant Design

CFBs have the design of multi-fuel capability with natural gas and western coal as well as lignite.

Texas lignite from the Wilcox formation is the primary fuel at TNP-One. The composition of the lignite sampled during operation through January 1, 1991 averaged as follows:

- Calorific value 15.7 MJ/kg (3760 kcal/kg)
- Sulfur content 1.02 %
- Ash content 15.82 %
- Moisture content 30.9 %

To enhance the availability of the units, TNP specified that the boilers be designed with the capability of carrying full load on natural gas and western coal as well as lignite. This capability proved to be a time-saving asset during startup when natural gas was used to test the turbine-generator and other plant components before solid fuel was available at the site. With this multifuel capability, it is also unnecessary to spend capital on large emergency stockpiles of lignite because natural gas can be used to fuel the plant. The following describes the major plant equipment.

1) Turbine and generator

A Westinghouse Electric Corporation turbine-generator guaranteed at 160,082 kW (160 MW) with initial steam pressure of 1,800 psig (126 kg/cm^{2}g) and initial steam temperature of 1,000 °F (538 °C), and reheat temperature of 1,000 °F (538

°C) at an exhaust pressure of 2.5 in. HgA (63.5 mmHg) was selected for Unit 1. The maximum generator design is 194 MVA, a 0.9 power factor, and 45 psi (3.16 kg/cm²) hydrogen pressure. The generator stator coils are half a double tube stack to yield better heat transfer. The end windings feature decoupled bracing to isolate the end winding from the core dynamically, thus reducing winding vibration. Voltage regulation control includes separate AC and DC regulators. All control systems permit on-line settings, adjustments, and tuning.

2) Steam generator

A single CFB combustor rated at 1,100,000 lb/hr (498.96 t/h) steam flow with 1,990 psi (139.90 kg/cm²) main steam pressure and 1,005 °F (540.6 °C) superheat and reheat temperature was supplied by Combustion Engineering. Engineering design was conducted jointly with Lurgi of Germany. The steam and water circuits are shown in Figures 1.3.1 through 1.3.5. As shown in Figures 1.3.4 and 1.3.5, the boiler has both natural and forced circulation.

Some of the most obvious features of the boiler are pant-leg lower combustor, four cyclones, water-cooled external fluid bed heat exchangers (hereinafter referred to as "EHE"), mechanical fly ash conveying, and heat pipe air preheaters.

The combustion chamber is of rectangular pant-leg design 40 feet 10-1/2 inches (12.46 m) in depth by 33 feet 7-1/2 inches (10.25 m) in width and 100 feet (30.48 m) in height with a combined total area of 19,600 square feet (1820.84 m²). The lower combustor waterwalls are lined up to 23 feet (7.01 m) from the grate for a wall area of 4,700 square feet (436.63 m²). Total grate area is 625 square feet (58.06 m²).

The cyclones are 74 feet (22.56 m) in height including the domes and have an inside diameter of 21 feet (6.40 m). Refractory lining consists of three layers of insulating and wear-resistant brick. The target zone is protected by Blue Ram refractory. The char return to the combustor is via refractory-lined siphon seal pots. A portion of char recycle is controlled and diverted through ash discharge valves and into the EHE. The valves are constructed of refractory on-wear surfaces and are water cooled.

Two EHE, which use sensible heat, are a key part of the TNP unit. The EHE operate in the conventional bubbling bed mode with low ash velocities and fine particle sizes to minimize erosion. Coupled with the low carbon content of 1 % to 2 % in the char, corrosion is avoided because the tubes are not exposed to a reducing atmosphere. A significant portion, about 30 %, of total heat duty is provided by the EHE. They also allow close control of the combustor temperature at lower loads.

Particulate is controlled by a 14-compartment, shake and deflate fabric filter baghouse. It is designed to clean 650,000 acfm (1,104,480 actual m^3/h) of flue gas. Design efficiency is 99.78 % with an inlet loading of 22,000 lb/hr (9979.2 kg/h) of ash.

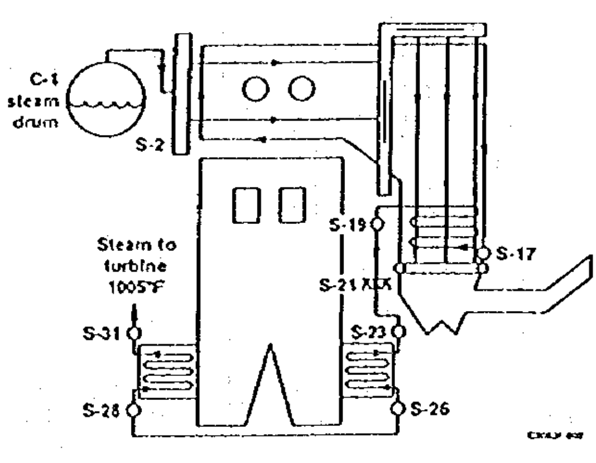

Figure 1.3.1 Superheater Circuits

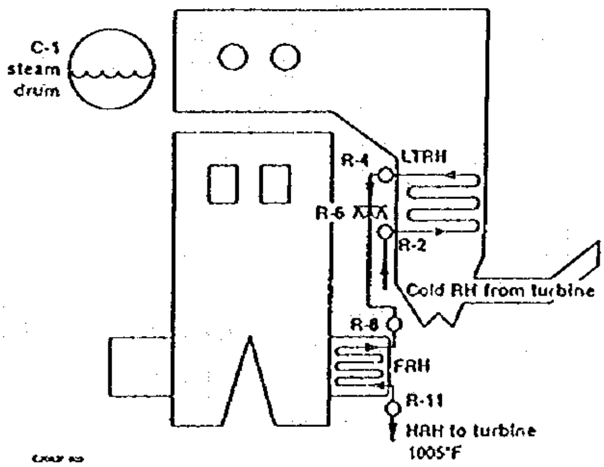

Figure 1.3.2 Reheater Circuits

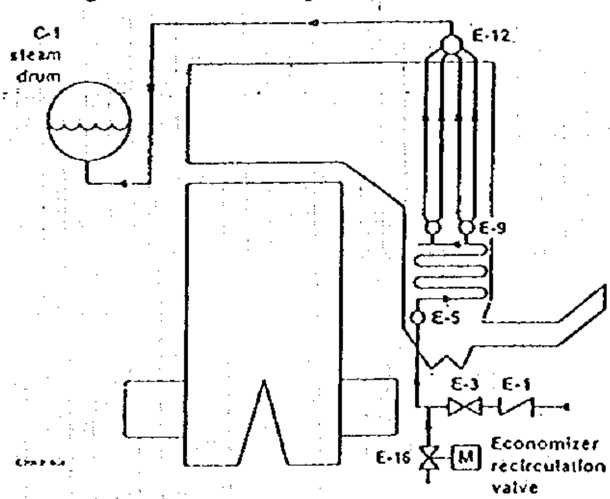

Figure 1.3.3 Economizer

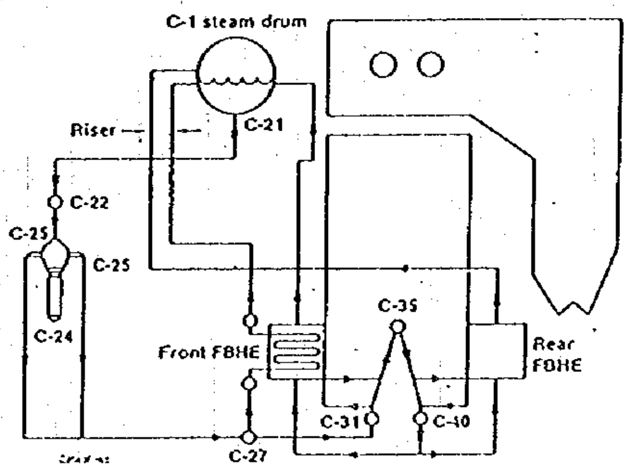

Figure 1.3.4 Controlled Circulation

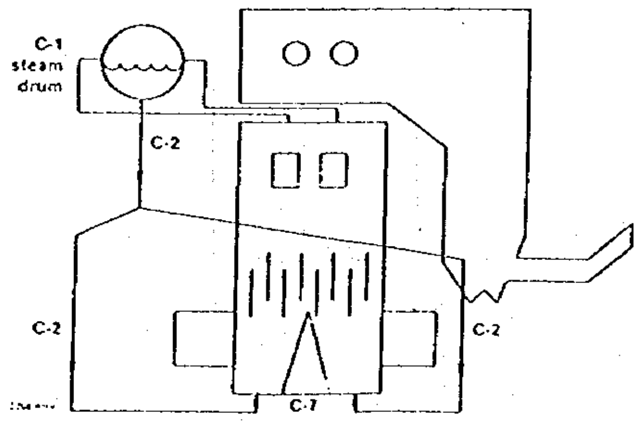

Figure 1.3.5 Natural Circulation

There are a total of 3,024 teflon-coated fiber-glass bags, each 11-1/2 inches (29.21 cm) in diameter and 33 feet 8 inches (10.26 m) in length.

3) Ash handling

Ash removal is via mechanical conveying. The system consists of 13 drag chain conveyors, and 2 bucket elevators for fly ash removal and 6 water cooled screw conveyors, 2 submerged scraper conveyors, and 2 belt conveyors for coarse ash removal.

4) Fuel feed

Natural gas is used for startup heating and can be used to supply heat to obtain full unit output when lignite is not available. The in-duct burners preheat the primary air coming to the combustor. They are equipped with ignition systems to light automatically on demand from the main control room. The startup and duct burners are used to preheat the combustor to 1100 °F (593 °C) for lighting lignite or 1200 °F (649 °C) for lighting the gas lances. They are designed for some on-line maintenance capabilities.

5) Sand feed

During startup, an inert bed material is needed to establish the circulation within the combustor and to distribute the heat to the nonradiated areas. Sand is used for this purpose and is supplied on batch demand by an injection system.

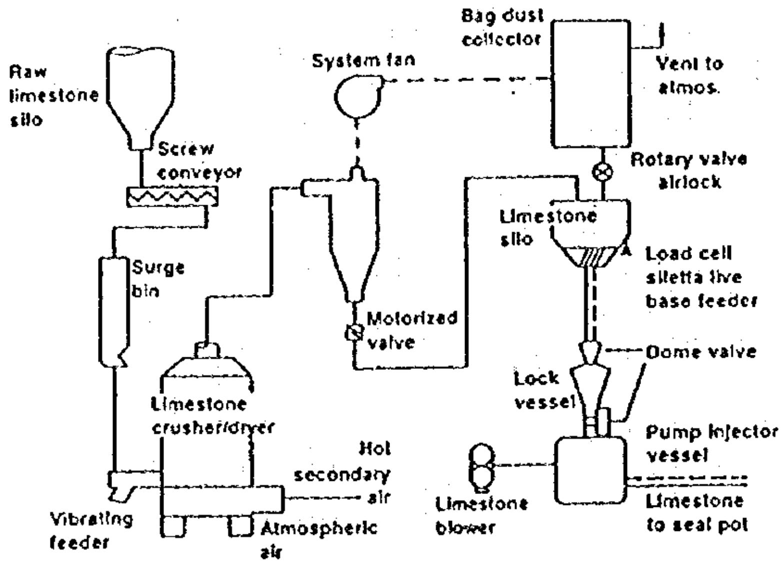

Figure 1.3.6 Limestone Feed System

6) Solid fuel feed system

Lignite is supplied via belt feeders and rotary valve to the combustor. The fuel is supplied to the seal pot char return to the lower combustor. Each train can be shut down for on-line maintenance. To control SO_2 emissions, three feeders are required to carry rated output.

Limestone is supplied by a limestone mill, which sizes the material to coarse grain sand consistency, and a limestone feed system. A limestone injection system supplies the required amount of product to control SO_2 at the desired level. The original limestone feed system is shown in Figure 1.3.6. Our new Delta system uses belt feeders in place of the pneumatic transporters.

(2) Problems Encountered

Ash handling system problems were responsible for 43 % of the lost generation, the steam generator for 35 %, and lignite handling for 7 %.

Since the beginning of plant operation, each forced load reduction has been compared to normal guaranteed unit output as a means of quantifying the impact on generation. This comparison process identified that ash handling system problems were responsible for 43 % of the lost generation, the steam generator for 35 %, and lignite handling for 7 %. The remainder is due to miscellaneous other causes including testing problems, SO_2 control, etc.

Some of the more significant problems experienced since the plant began operation and the corrections made to data are described in the following sections.

1) Trouble with ash handling system

A greater deal of effort has been put forth by TNP to expedite improvements in the ash handling area.

a) Failure of ash drain lines

Pluggage of the four ash drain lines has mandated constant attention of the operators and maintenance personnel. If even one of these lines is plugged, workers must reestablish flow or combustor differential pressure cannot be maintained and the unit must drop load. Fluidizing air has been proposed as a solution to maintain flow in the drains which have plugged the most frequently.

Ash drain line failures have been experienced at welds, expansion joints, and wear points adjacent to valves. Major cracking of the welded 304 SS line was attributed to improper manufacturing which produced a seal weld but not a full penetration weld. Carbon steel plate used to form the interface of the stainless steel lines to the combustor wall failed several times and was replaced with stainless steel. At best, we operated 3145 hours between failures.

b) Pluggage of screw coolers

Valves were added in an attempt to allow more maintenance access to the ash screw coolers. However, as soon as the combustor reaches operating temperature, the valves cease to move freely; thus, valve wrenches or other means of assist must be used to control flows to prevent pluggage or provide maintenance access. At one point, low-temperature gaskets were used, but these burned out and contributed to ash leaks.

The water-cooled screws require constant adjustment of ash flow to prevent pluggage even during common base load operation. When they are turned down to reduce throughput to allow the valve to be opened wide, drive motors trip out. To prevent further trips, larger 10 hp motors will be tested. The automatic bed differential pressure control has not been functional and is strictly a manual operation so far. Lubrication requirements are very high due to the high-temperature environment, therefore, a gang lubrication system will be provided.

c) Trouble with submerged scraper conveyors

The submerged scraper conveyors have worked well except for freezing up during a cold front, which required opening and chipping out the conveyors. In addition, they must be tensioned frequently.

Continuous difficulties have been experienced with the wet bottom ash belt conveyor. Although many man-hours are spent each day on each shift to monitor and correct the conveyor, satisfactory operation cannot be maintained. TNP staff has requested plastic chute lining to attempt to reduce buildup and eventual pluggage. The buildup is limited to everything underneath the conveyor including belt takeups.

d) Failure of fly ash system

As previously mentioned, the fly ash system is completely mechanical. Numerous failures have occurred even though it has been in service less than 1 year. Chain breaks, bearing failures, sealing problems, and tensioning problems have been experienced.

One of the major dusting problems was improved by the addition of an ash silo vent fan. Since this was added later, the fluidizing air and telescopic chute vent fans must be nurtured to prevent pressurizing the system again.

Another problem area has been the ash silo shutoff gates, which have required maintenance frequently, even when new. Smooth, leak-free operation has not been attained yet.

Dust accumulation has caused numerous maintenance problems. The blower room is within the silo and access is from the bottom up a ladder. All of the blowers and motors are constantly exposed to this dusty atmosphere. No further plans are defined as yet to correct this condition.

Because of the consortium's previous success with dry disposal for western coal fly ash, a dry unloading system was all that was furnished with the units. TNP has not always been successful in meeting our secondary source permit limit with this system. However, the consortium has not as yet been willing to furnish a wet system.

2) Trouble with steam generator

Compared with the experience other fluidized bed boiler owners have reported, TNP-One - Unit 1 has been relatively trouble free. However, the problems we have experienced have not been easily resolved.

Following is a summary of some of our significant issues related to the steam generator.

a) Tube movement in external fluid bed heat exchangers

The majority of combustor problems causing rework have been in EHE compartments. Tube movement and impacting of adjacent tubes have made extensive pad welding necessary three times thus far. During our first annual outage, some additional damage was discovered. By placing a temporary indicating device on the outside EHE wall, movement as much as 1/2 inch has been observed. To address this problem, the tube rows have received additional support and excess fluidized air has been reduced.

b) Troubles with controls and instruments, especially troubles with reliability of measurement of air flow

Control work has been a challenge due to working with high pressures and a constant sand blasting-like environment. Several unit trips occurred due to high cyclone temperature before it was discovered that the thermocouples (TC) had worn through and shorted out. We have exhausted efforts to find a TC that will last in the cyclone inlet for more than 5 days. However, the supplier has now determined that the TC are not needed due to the slight temperature difference between the inlet and outlet. We expect to replace the TC in the lower combustor annually, or more often if failures are experienced.

Initially, we were unable to reach design light-off permissives for both gas and lignite. The permissive temperatures were lowered and the associated TC lengthened.

Although air flow instruments were supplied with the units, to date they have been unable to provide reliable flows for boiler tuning needs. The instrument spares may not match calibrations that have been done on the unit due to averaging problems. As of this report, we have not had automatic boiler master or load demand control capability due to combustor instrumentation or other control problems.

c) Binding of air control valves

Valves appear to be subject to severe service on CFB, resulting in several operating problems. The first occurred after initial fan operation and steam blow, when several valves became difficult to adjust for balancing purposes. Internal inspection revealed the valves were warped. The manufacturer modified the design which appears to have solved the problem. Binding has also occasionally occurred on secondary air system valves. Stem movement to one side was suspected, so TNP installed a restricting collar to the operator side. This solution appears to be working.

d) Startup gas burners (rigid sparkplug support)

Gas startup and duct burners have required much maintenance during unit startup. All of the positioners have been changed out on Unit 1 due to malfunctions. The ignitors have a tendency to ground out and not spark properly. The sparkplug support was made more rigid.

e) Secondary air system (failure of thrust bearing and pluggage of combustor nozzle)

The secondary air fan is a single suction fan, so unbalance naturally exists. This is compensated for by a pad-type thrust bearing. The thrust bearing has failed or shown signs of heat damage three times and has been replaced. Stiffeners have been added to the fan housing to prevent movement, but we remain concerned because every inspection of the bearings by the manufacturer has resulted in thrust bearing repair.

Combustor nozzle pluggage, as shown in Figure 1.3.7, has been a problem with the fluidizing air system. Once plugged, a time-consuming natural cleaning is mandatory.

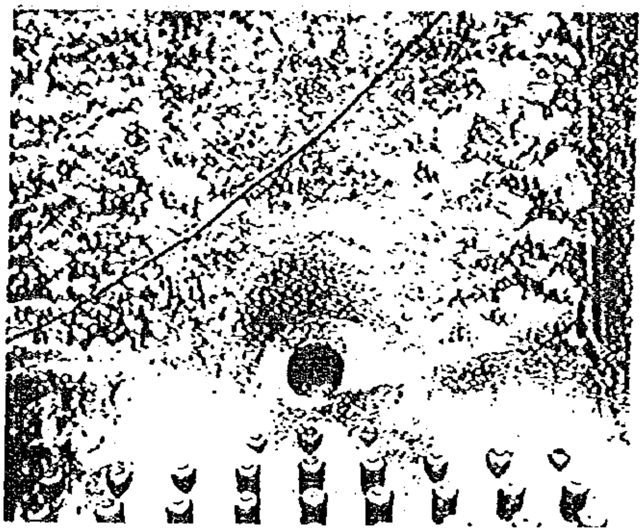

Figure 1.3.7 Bottom of Combustor

f) Trouble with limestone supply system, especially severe wear of crusher roll and failure of belt feeders caused by moisture of lignite

The limestone supply system has been maintenance intensive from the first day on. Plows diverting the limestone into the mill silo create spillage which requires constant cleaning. We have broken screws several times due to mill pluggage and inadequate shutdown instrumentation. Limestone mills have been rebuilt every 3 months. Fineness of the finished product can be controlled only by air flow if the mill is in good shape. As the rolls wear, the product becomes larger. The crushers have an unusual internal wick lubricator that requires shutdown and entry to replenish.

Limestone injection requires very delicate operation. Two to three people must be available to maintain the system on a 24-hour basis to minimize downtime. Problems have occurred with practically every component of the system. The vibrating feeder developed pluggage problems early and was modified with fluidizing air. Cracks that developed in the transport piping weld seams left one system in service while repairs were completed.

The transporter below the vibrating feeder could not consistently deliver the required rates due to pluggage or incomplete emptying of the chamber. Venting was moved to different locations and increased to attempt to solve the problem. Rubber sealed valves have been used in the venting scheme, but they rapidly deteriorate and affect filling. Expansion joints on the transporter and discharge piping have failed regularly. The screw shaft that meters the limestone to the air stream began leaking early and often. The weighing device did not indicate actual flows, particularly at full output. The injection line to the seal pot return line to the combustor plugs frequently. Line size was increased and turns straightened with minimal success.

Lignite belt feeders, although traditionally trouble-free, have experienced problems. Obviously the lignite is a high-moisture fuel. Due to the high combustor pressure, a positive sealing arrangement is provided to prevent back flow through the lignite feeders. This sealing arrangement causes moisture to be released inside the enclosures which, combined with dust, creates buildup.

(3) First Annual Outage Examinations

Since beginning operation as a primarily lignite-fired plant in March 1990, TNP-One Unit 1 came off-line on March 1, 1991 for its scheduled first annual outage. Although many accomplishments were achieved during that outage, for the purposes of this paper, we will focus on boiler-related activities.

1) Erosion caused by downward flow of particles along the walls of combustor

Before describing the condition of various internals, a comment on the importance of vertical alignment is in order. Simply stated, the need for almost perfect boiler tube alignment cannot be over emphasized.

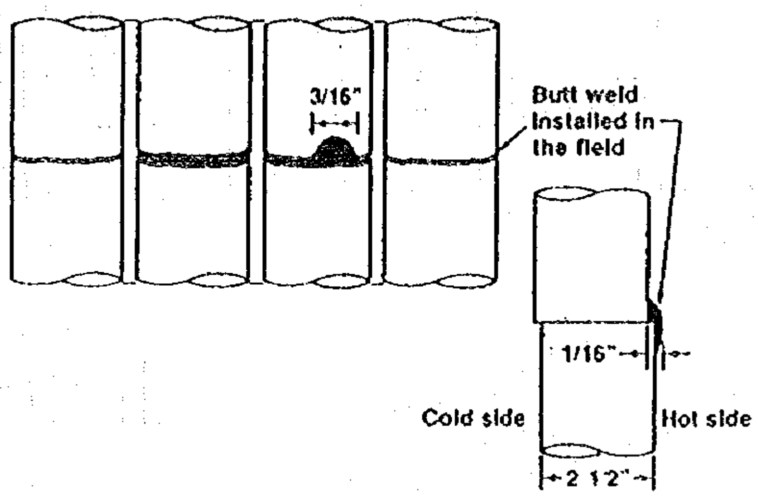

Figure 1.3.8 Erosion into Lower Tube Created by Misalignment

Although most people know about the upward travel of solid particles within a fluidized bed boiler, perhaps everyone is not as familiar with the downward flow of particles along the walls of the combustor, particularly in the lower regions. As shown in Figure 1.3.8, we found that if the disturbance was greater than about 1/16th of an inch and had a width of at least 3/16th of an inch, that was sufficient misalignment to cause flow disturbances and erosion. If the projection is severe enough or the flow path disturbance great enough, erosion will begin and can infringe on minimum wall thickness. We observed resulting damage not only on the misaligned tube, but sometimes on adjacent tubes and tubesheets.

2) Erosion caused by vibration between tubes in external fluid bed heat exchangers

In terms of both magnitude and concentration, most of the problems we found were in the integral external EHE. Figure 1.3.9 shows a portion of a EHE tube bundle that eroded to failure and caused one of Unit 1's forced outages. Most of this damage has been attributed to vibration between tubes in this high solids contact area.

Measurements during the first annual outage set baseline data for future trending.

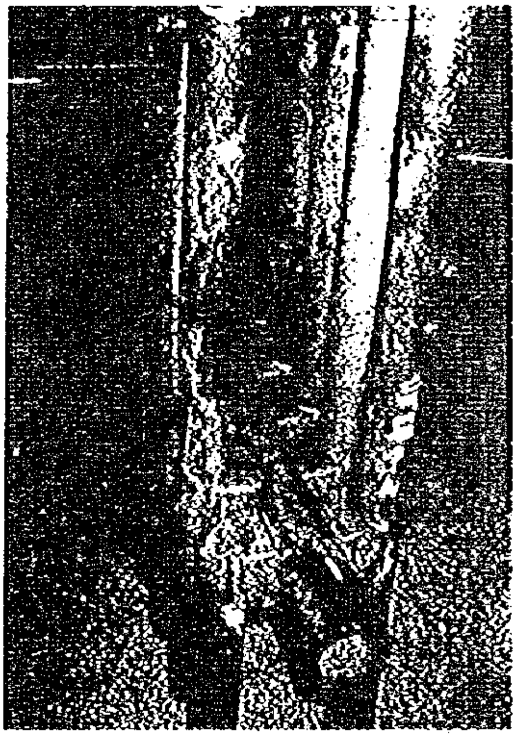

Figure 1.3.9 EHE Tube Erosion

3) Refractory damage of lower combustor and vertical shrinkage

Except for the refractory damage and misalignment induced wear, the lower combustor was found to be in good condition. Unit 1 does not have weld overlay at the refractory to tube interface nor an offset typical of some fluidized bed boilers.

There does appear to be as much as 1/2 to 1 inch of vertical "shrinkage" of the refractory. No significant tube wear was found. The vertical dimension controls established during this outage will allow for a better comparison at the next outage.

4) Severe waterwall tube damage of upper combustor

Somewhat surprisingly, waterwall tube damage and tube-sheet damage in the upper combustor was worse than in the lower sections. As shown in Figure 1.3.10, this appears to have resulted from a combination of original manufacturing defects, mechanical damage, and misalignment induced wear.

Figure 1.3.10 Waterwall Tube water

5) Erosion of convection pass

Some very minor erosion was seen around the cyclone outlet tubes. In addition, some flow induced vibration has been observed between some backpass tubes.

1.3.2 Report by Electric Power Research Institute (EPRI)

The description below is extracted from the following report.

"Texas-New Mexico Power Company, AFBC Plant Profile,"
Electric Power Research Institute (EPRI)

(1) Plant Highlights

1) ABB-CE/Lurgi CFB units with reheat
2) Utility Power-300 MW (net) total (two 150-MW units)
3) 1990 and 1991 startup
4) Largest operating CFB units in the world
5) $600 million greenfield facility (minemouth plant)
6) Medium-sulfur (1.0 %) Texas lignite fuel, with full-load capability on either subbituminous coal or natural gas
7) 123 plant employees

(2) Boiler Design and Sectional Side View of Boiler

Full load operation on natural gas in case of coal or ash handling problem

The units were designed for full load firing on both natural gas and western subbituminous coal. The ability to fire natural gas provides a great deal of flexibility. During startup, whenever coal or ash handling problems arose that necessitated a reduction in coal firing, natural gas was fired as a supplemental fuel to keep the unit at its dispatch rate until the balance of plant equipment problems were resolved and the unit returned to 100 % coal firing. The units have also been operated at full load on natural gas. In fact, this capability is one of the major reasons for the high capacity factors achieved at TNP.

An isometric view and a sectional side view of the CFB are shown in Figures 1.3.11 and 1.3.12. The design characteristics are as follows:

1) Two 150 MW (net) reheat units, each rated at 1,100,000 lbs/hr (498.96 t/h) primary steam 1890 psig (132.87 kg/cm^{2}g) and 1005°F (540.56°C) (superheat outlet) and 987,500 lbs/hr (447.93 t/h) and 382 psig (26.85 kg/cm^{2}g)/1005°F (540.56°C) (reheat outlet).

2) Two external fluid bed heat exchangers (EHE) per unit.

3) Four parallel hot cyclones per unit.

4) Combustor dimensions:

- width 41 ft (12.50 m)
- depth 34 ft (10.86 m) (excluding EHE)
- height 150 ft (45.72 m) (top of steam drum)

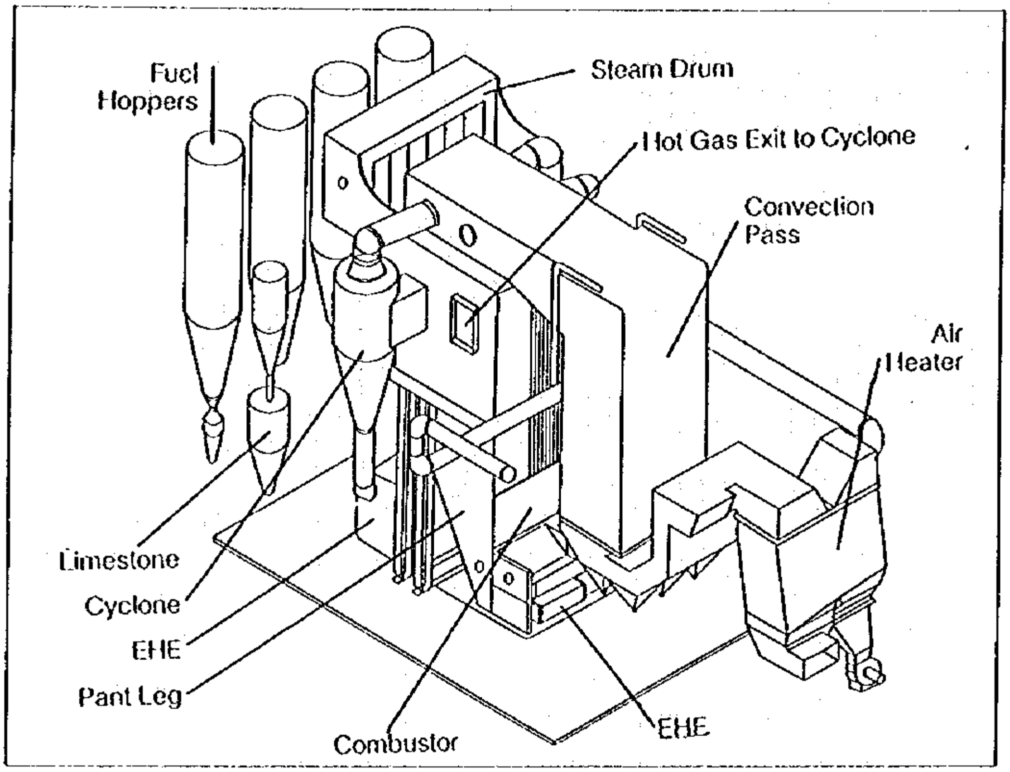

Figure 1.3.11 Isometric View of the 150-MW CE/Lurgi CFB Boiler at TNP-One

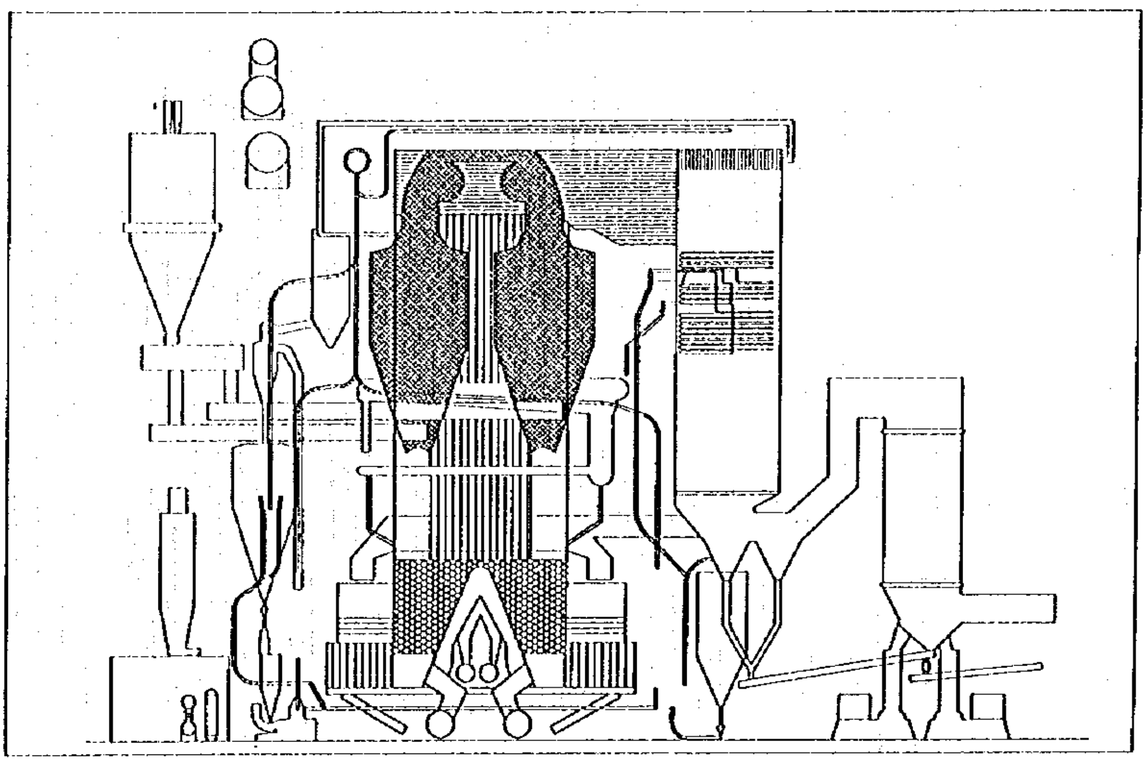

Figure 1.3.12 Sectional Side View of the 150-MW CE/Lurgi CFB Boiler at TNP-One

5) Heat duty distribution

a) Evaporative duty (%)

- Combustor 60
- EHE 20
- Economizer 20

b) Superheater duty (%)

- EHE 40
- Convection pass 60

c) Reheat duty (%)

- EHE 50
- Convection pass 50

6) Particulate control by reverse gas-type (shake and deflate) baghouse with teflon-coated fiber-glass bags.

7) Design fuel analysis, as received, weight %

- Carbon content 38.6
- Hydrogen content 3.1
- Oxygen content 10.4
- Nitrogen content 0.8
- Sulfur content 0.9

(SO2 equiv. = 2.67 lb/MM Btu (1.21 kg/251,000 kcal))

- Ash content 15.5
- Moisture content 30.7
- HHV = 6733 Btu/lb (15.6 MJ/kg, 3726 kcal/kg)

(3) Troubles Encountered

Lignite/limestone feeding and ash handling troubles, especially a significant problem of accumulation of wet bottom ash on the belt conveyors

The primary problems at TNP-One have been associated predominantly with the solids feeding and ash handling equipment. Pluggage, caused by moisture and fines in the volumetric feeders, has been eliminated by the recent addition of feeder ventilation systems. The remaining problems addressed by TNP and ABB CE include replacement of materials in the bottom ash drain lines with a high-nickel stainless steel to eliminate weld cracking; addition of pug mills to the fly ash system to reduce dusting problems; and pad-welding of tubes in the EHE, as needed, where contact fretting between adjacent hanger tubes and horizontal tubes (ash-enhanced contact abrasion) has resulted from tube vibrations. Accumulation of wet bottom ash on the belt conveyors continues to be a significant cleanup problem. Air-to-gas leakage in the heat pipe air heaters (because of seal weld problems) has not prevented the units from achieving guaranteed heat rate.

Representative performance data are summarized below:

1) Availability and capacity factor

- Unit 1 availability = 88.6 % (since October 1990) and capacity factor = 86.5%
- Unit 2 availability = 87.9 % (since October 1991) and capacity factor = 85.9%

2) Thermal performance

a) Boiler efficiency

- Unit 1 = 83.3 % (not tested under normal operating conditions)
- Unit 2 = not tested

b) Gross heat rate

- Unit 1 = 9500 Btu/kWh (10.0 MJ/kWh, 2385 kcal/kWh)
- Unit 2 = 9900 Btu/kWh (10.4 MJ/kWh, 2485 kcal/kWh)

c) Plant parasitic power = 33 MW (includes 2 MW for the brine concentrators since this is a zero discharge plant)

d) Carbon utilization > 99.7 %

3) Environmental performance

a) Air emissions

Table 1.3.2 Air Emissions

	Unit	Limit	Actual
SO_2	lb/MM Btu (g/251,000 kcal)	0.6 (272)	0.58 (263)
NOx	lb/MM Btu (g/251,000 kcal)	0.6 (272)	<0.25 (113)
CO	lb/MM Btu (g/251,000 kcal)	0.07 (32)	<0.002 (0.9)
Particulates	lb/MM Btu (g/251,000 kcal)	0.03 (14)	0.01 (5)
Opacity	%	20%	5-6%

SO2 equivalent in fuel: 2.97 lb/MM Btu (1347 g/251,000 kcal)
Ca/s Ratio: 1.4 based on limestone added (Because of the high calcium content in the lignite ash, the total Ca/S ratio is about 3 - 4.)

b) Ash spilt

- 30 % bottom ash
- 70 % fly ash

c) Solid waste (ash + spent sorbent), dry basis, with 1.0 % S fuel, Ca/S ratio = 1.4 and 80.5 % SO_2 capture

Table 1.3.3 Solid Waste

	lb/MMBtu (kg/kcal)	tons/MW-day	%
Ash	23 (10.43 kg/251,000 kcal)	2.98	79
Spent sorbent	6 (2.72 kg/251,000 kcal)	0.78	21
Total	29 (13.15 kg/251,000 kcal)	3.76	100

1.3.3 Site Study by the Study Team

The Study Team visited Texas-New Mexico Thermal Power Plant and studied the CFBC boiler of TNP One, and was given explanation by a plant supervisor. The result is summarized below.

(1) Fuel Used

Primary fuel is Texas lignite.

- Calorific value: approx. 6700 Btu/lb (15.5 MJ/kg, 3704 kcal/kg)
- Moisture content: approx. 33 %
- Ash content: approx. 15 %
- Sulfur content: approx. 1 %

Oil cokes is also used.

- Calorific value: 15,000 Btu/lb (34.7 MJ/kg, 8293 kcal/kg)
- Moisture content: approx. 7 %
- Ash content: 2 % or less
- Sulfur content: approx. 4.5 %

Car tire cut at the size of 1 inch square, oil filter and so on are also used. Moisture content in tire is very low and the S content is almost same as that of Texas lignite. However, cleanup is necessary every 3 months, since the wire of tire remains in the furnace and twines around the nozzle.

(2) Bed Ash

Bed ash of 800°F (427°C) is discharged from the furnace of 1350°F (732°C). Initially, worm ash cooler was used. But it was modified into straight ash cooler with higher cooling efficiency. In order to increase the performance of ash cooler, it is essential to enlarge and lengthen the duct. The engineer suggested the following three points to cool ash, though air-cooled system is employed in this TNP-One.

a) To provide water jacket with the duct
b) To increase the water flow
c) To enlarge the capacity of ash cooler itself

(3) Fuel Feeder

Initially, pressurized fuel feeder was employed. However, moisture of lignite deposited on the feeder and it resulted in the pluggage. A great deal of effort for the solution was put forth by TNP staff. Fuel feeder was modified into the system which connected the rotary valve with the inlet of cyclone (negative pressure) by pipe, sucked and fed the fuel.

(4) Erosion of Water Tube

Severe erosion was experienced on the water tube 30 cm high from the joint between the refractory in the lower combustor and the water tube due to the ash whirled up by the turbulence every three months. The erosion was avoided by adding the reflecting board.

(5) External Fluid Bed Heat Exchanger (EHE)

EHE has a function and role like mid-superheater. The efficiency is increased by reducing the ash flow speed. Numerous damages by ash and the vibration have occurred in EHE, and a great deal of time for maintenance was consumed.

(6) Others

They suffered from the leakage of water tube and EHE, erosion of valve, crack of spiece valve and so on in the beginning of the startup. After the spiece valve was modified into ceramic, problem has not occurred.

(7) Ash Disposal

1) 50 % of ash is sold to chemical company as a stabilizer for binding arsenic and so on.

2) 50 % of ash is dumped (after dumping, the surface is covered with clay). Fly ash is mixed with water at the ratio of 1 : 1 and transported to the ash disposal area by truck.

3) Bed ash is utilized as sub-base for roadways.

(8) Ash Content in Fuel

TNP-One has used lignite with ash content of maximum 25 % so far. The engineer of TNP-One suggested that it be better to mix with high quality coal in case of use of low quality coal. As ash content increases, heat efficiency declines and it causes pluggage and clogging. Once plugged, manual cleaning is mandatory.

(9) Construction Cost

Approx. 1000 US$ per 1 kW
150 million US$ for 150 MW

(10) Boiler Efficiency

Boiler efficiency is unexpectedly low. 82 ~ maximum 90 % (average 83.3 %)

1.4 Goldenberg Thermal Power Plant (Germany)

The description below is extracted from the following report (in German) on a 400 t/h CFB boiler in Goldenberg Thermal Power Plant.

"Outline of CFB Boiler and the First Operating Experiment,"
J. Wohlsein (RWE Energie AG), M. Hoffmann (RWE Energie AG), and
Dr. A. Kather (EVT)

1.4.1 Design of the Process Steam Generating Plant and the Block Diagram

Two stand-by oil fired boiler with a capacity 145 t/h each have been added to the plant to ensure process steam supply in case of a failure of the CFB boilers.

On the basis of the existing demand, a plant has been designed consisting of two steam generators, one with a capacity of 290 t/h and another with a capacity of

400 t/h. A CFB boiler has been preferred to pulverized brown-coal fired boiler, mainly because of the limited space required. In case of pulverized coal fired units, the auxiliary equipment (desulfurization devices) required to meet the regulatory SO_2 limits would have required considerably greater space. In addition to the primary function of steam generation, the CFB boilers were expected to permit RWE Energie to gain the first experience with this combustion technology with particular regard to large-scale application.

As illustrated in Figure 1.4.1, steam at a pressure of 115 bar and a temperature of 505 ℃ generated by the CFB boilers is fed to a bus, expanded in the existing turbines, and then coupled out at 17 bar for process steam and at 3.2 bar for district heat, to be supplied to the process steam consumers and the district heating plant, respectively.

With respect to possible fluctuations in process steam supply as well as to the planned parallel operation of both boilers, the CFB boilers must be reliably serviceable at loads above 30 %.

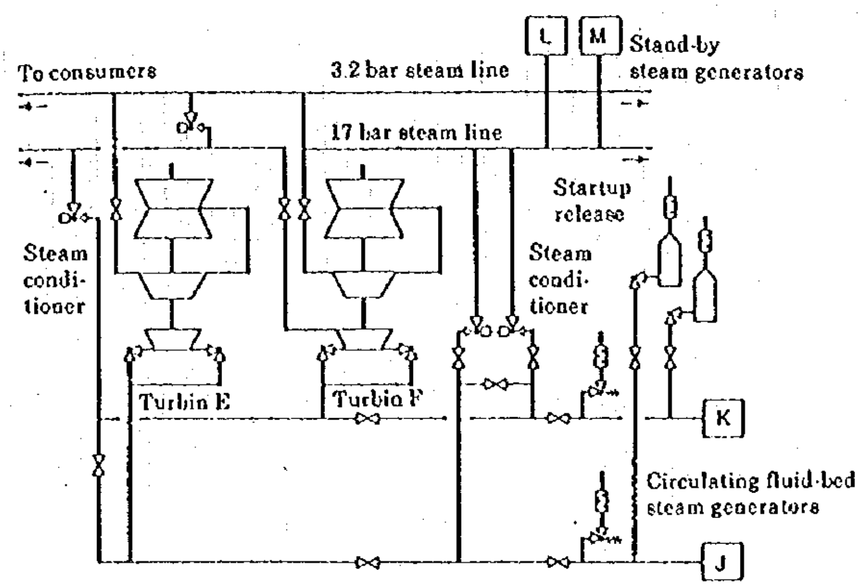

Figure 1.4.1 Block Diagram of the Plant

To ensure process steam supply in case of a failure of the CFB boilers, two stand-by oil fired boilers with a capacity 145 t/h each (70 % of CFB boiler) have been added to the plant to feed the 17 bar bus directly and to supply the 3.2 bar bus through a pressure reducer.

1.4.2 Plant Description and Specification

The 400 t/h CFB boiler has been designed and constructed by the consortium EVT/L & C. Steinmüller under the supervision of EVT Energie- und Verfahrenstechnik GmbH, Stuttgart.

Characteristics of the boiler illustrated in Figure 1.4.2 is essentially the fluidized bed combustion (hereinafter referred to as "FB") chamber in flue 1.

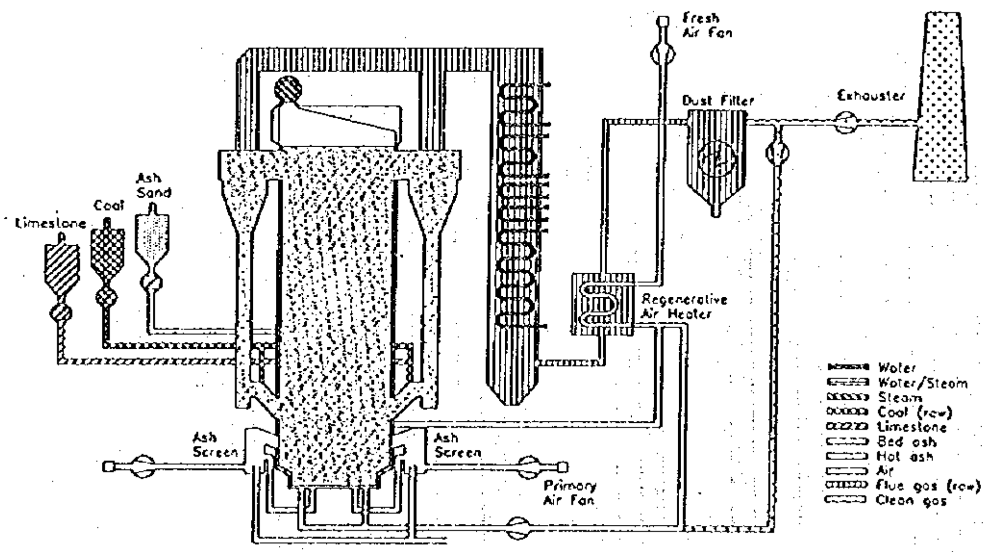

Figure 1.4.2 Flowsheet of a Natural-circulation CFB Boiler

1) The solid matter and air streams enter the rammed funnel region of the FB chamber.

2) The flue gas leaving flue 1 gets to four cyclone separators where the circulating solid matter particles are separated from the flue gas.

3) Flue 2, of the conventional design, is connected after the cyclones, and contains the heating surfaces of the economizer and superheater, while flue 1 is operated as an evaporator.

4) A three-layer antiabrasion type refractory masonry is provided for the connecting pipes between the FB chamber and the cyclones, for the cyclones themselves, for the flue gas pipes as well as for the ash return pipes.

5) The fuel is fed through eight ash return pipes available as a result of four double ash discharging vessels installed under the cyclones. This layout results in an ideal distribution of the fuel entering the FB chamber.

Rhenish raw brown coal, available in the region, is used as a fuel. The calorific value and composition are tabulated below:

Table 1.4.1 Fuel Characteristics

	Unit	Value	Range
Calorific value H_u	kJ/kg	8845	7600 - 11720
Ash content	%	7.0	2 - 15
Moisture content	%	53.2	40 - 60
Sulfur content	%	0.5	0.15 - 0.9

Each of the offers contained a boiler system operating on the basis of the classic natural circulation principle so that the existing turbines, requiring steam parameters of 115 bar and 505°C, can be used in the future, too.

With respect to the required experience with FB techniques to be used in future power station constructions, RWE Energie intentionally ordered boilers with different technology. The second boiler required for the Goldenberg power station, utilizing the "circofluid"-system, was supplied by German Babcock Energie-und Umwelttechnik AG, Oberhausen.

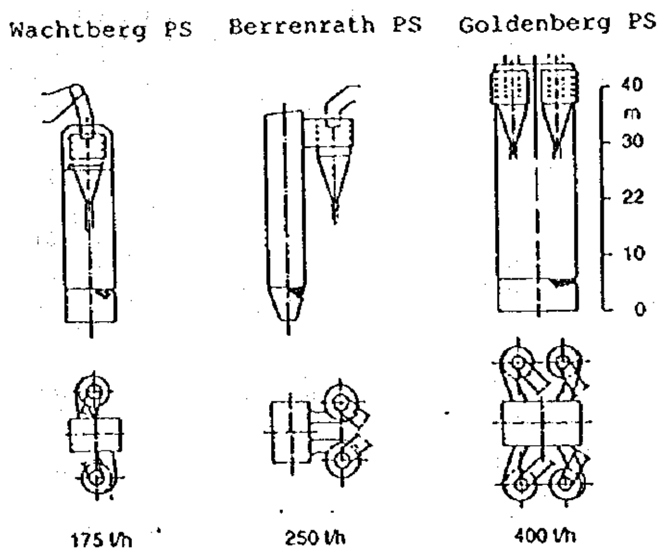

Figure 1.4.3 Comparison of the Size of ZAWS CFB Boilers

Figure 1.4.3 shows a comparison of the size of the coal fired CFB boilers constructed by EVT in the Rhineland. The boiler with a capacity of 400 t/h at the Goldenberg Power Station is the largest coal fired CFB boiler that has been constructed in Europe so far (1993).

1.4.3 Problems Encountered

Discussed below are problems which have required corrections as early as in the course of the commissioning and trial run of the plant. Figure 1.4.4 shows the flowsheet of the plant, indicating the points where the problems listed below have occurred.

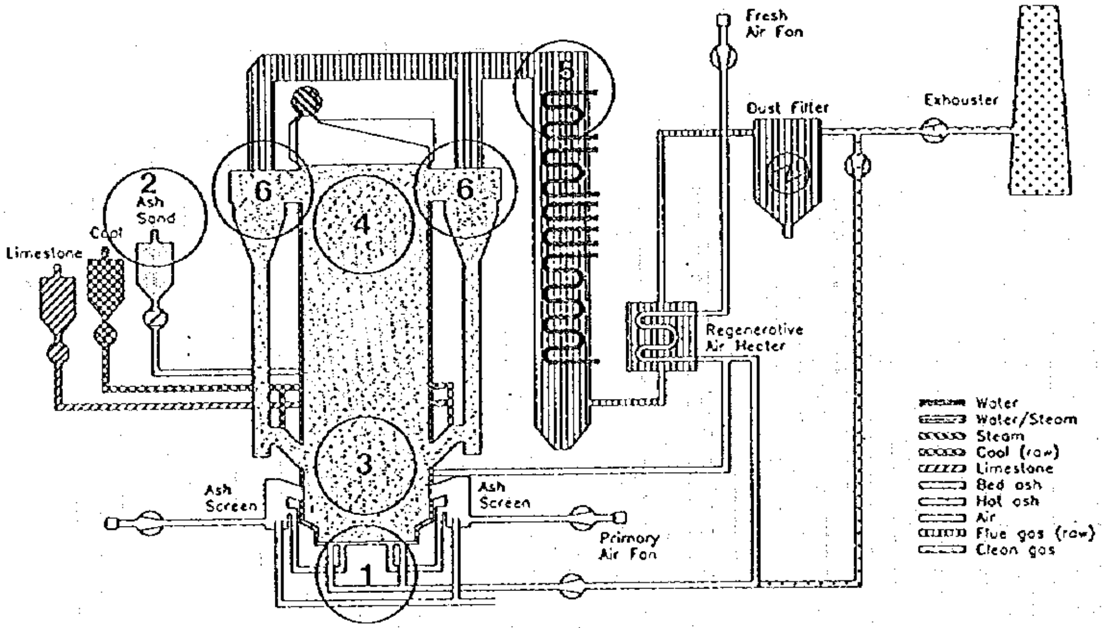

Figure 1.4.4 Troubles Needed Correction (○ mark)

(1) Ash Removal From the Bed

> Bed ash removal systems always cause problems due to high temperature and abrasive substances.

In accordance with the local conditions, ash is removed from the FB chamber through four nozzle-bottom discharge pipes and is transported to the ash separators by means of four bucket chain conveyors. The temperature of the ash to be transported ranges between 500 and 800°C. Operating problems of different types as well as damages to these conveyors, partly caused by the high temperatures, necessitated repairs and improvements in a number of steps.

The four worm coolers connected after the ash separators have frequently got clogged up due to agglomerated ash and spots of erosion have been detected in the inlet region of the worms (Figure 1.4.5).

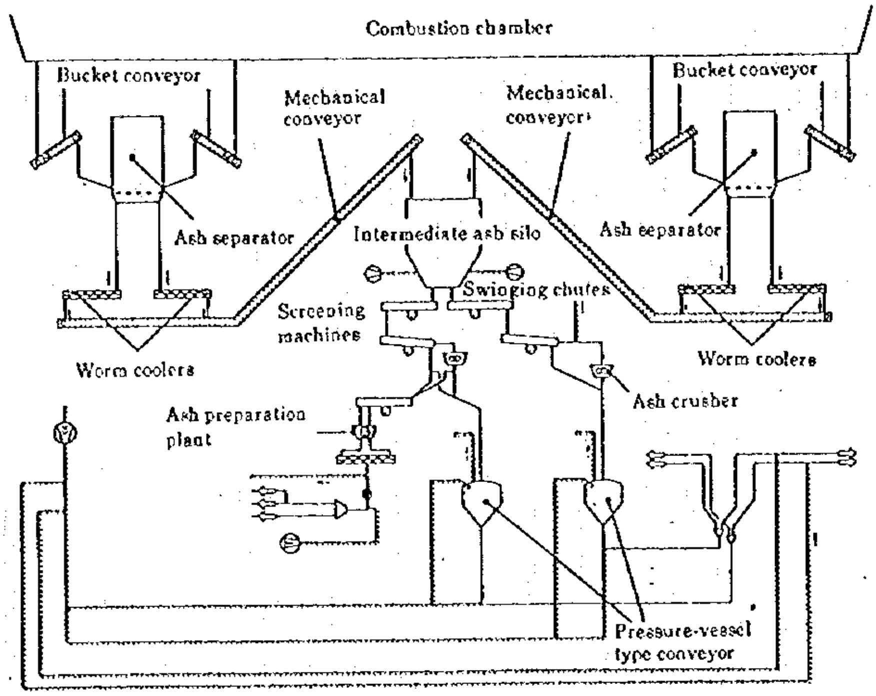

Figure 1.4.5 Flow Diagram of Ash Removal from Combustion Chamber

These problems could be eliminated in several steps by way of constructional changes and by use of additional antiabrasion measures in the inlet region of the worm box (ash cooler). A considerable wear-and-tear could be detected at that part of both bucket chain conveyors connected to the ash separators where ash is discharged into the intermediate silo. This problem could be eliminated by making this section of the conveyor straight as well as by modification of the friction rails. At the same time, the chains have been replaced with chains of an increased strength.

A two-strand pneumatic conveyor for disposal of the ash that cannot be recycled is connected to the bed ash removal system. Within a short time after this conveyor system had been put into service, spots of heavy erosion were detected in different elbows lined with fused basalt. This can also be attributed to the highly abrasive behavior of the bed ash. At the same time, pulsations during transport resulted in damage to the conveying lines, which again led to operating troubles in the systems connected to the conveyor. These problems were eliminated by means of different partial repairs and improvements as well as optimization of the transport of dense medium (bed ash) with regard to the low speed of transport of solid matters (ash).

In summary, the problems and damages outlined above can be attributed to the special conditions, such as the high temperature and the especially abrasive material, prevailing in the bed ash removal system.

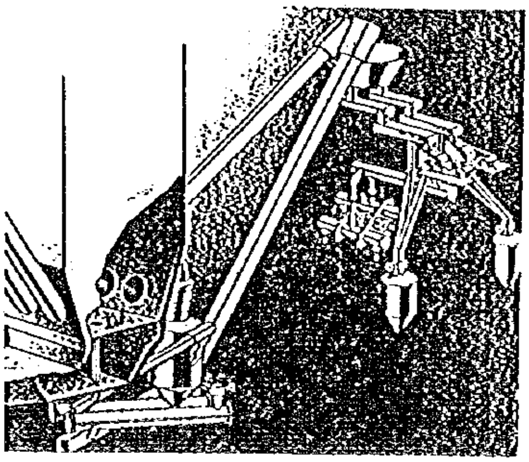

Figure 1.4.6 Bed Ash Preparation Plant

(2) Fluidized Bed

Modification of operation mode of the ash separator was needed.

In spite of the measures outlined above, like

- highly efficient separation by the cyclone,
- screening, grinding and recycling of bed ash to the FB chamber,

there has been a considerable demand for some additive to be fed from outside to the bed.

As a result of modification of the operation mode of the ash separator, as well as subsequent installation of an ash return line from flue 2 to the FB chamber at the time of the last standstill of the plant, a considerable reduction in the quantity of this additive is expected.

(3) FB Chamber Nozzles

Erosion and tear on the nozzles due to ash and heavy burns

Inspections during standstill revealed heavy burns, and at some places considerable damages due to erosion, on the primary air nozzles within the FB chamber after around 4500 hours of operation. The reasons for this slag formation visible in Figure 1.4.7 have not been fully identified yet, and the phenomenon is therefore being investigated by systematic experiments at the pilot plant in the Niederaussem Power Station of RWE Energie.

The wear-and-tear that can be clearly seen in the lower part of Figure 1.4.7 results from ash drawn in, damaging the outlet holes of the nozzles, and/or from blowing-in by the adjacent nozzles. To our present knowledge, these erosion problems can be prevented by replacing the existing nozzles with modified ones. Flow experiments are being run for this purpose in the EVT Polytechnical School, Stuttgart.

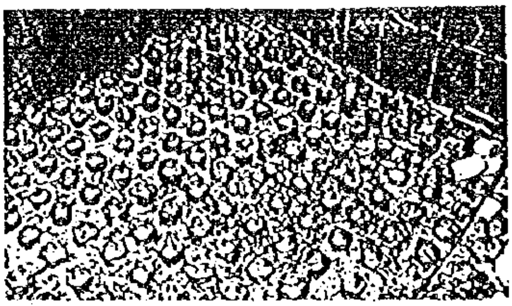

Figure 1.4.7 FB Chamber Nozzles: Scale Formation, Abrasion and Tear

(4) Pressurized Region of the Boiler, Flue 1

Erosion over the rammed funnel region and around the outlets towards the cyclones

Systematic inspections of the tube-plate type walls and ceiling of flue 1 detected local material corrosion over the rammed funnel region in the FB chamber as well as around the outlets towards the cyclones.

The erosion over the rammed funnel region in the FB chamber resulted from the non-smooth (stepped) transitions in the region surrounded by flame. To cope with this problem, the rammed funnel region was pulled up above the region surrounded by flame.

Erosion in the region of the outlet holes towards the cyclones can be attributed to bunching in this region. As a remedy, the rammed area was extended to replace part of the evaporator pipes.

(5) Pressurized Region of Boiler, Flue 2

Erosion of the grating and stand pipes due to high-temperature-chlorine corrosion

The significant erosion of the grating and stand pipes has been caused by of high-temperature-chlorine corrosion. To cope with this problem, protection has been provided for the pipes exposed to corrosive conditions.

A reasonable explanation of the process resulting in damage due to high-temperature-chlorine-corrosion have not been found so far. Investigations are still being made to find a satisfactory explanation of the process.

(6) Flue-gas Cyclone System and Ash-circulation Locks

A preliminary study on the heat-resistant temperature of masonry, expansion coefficient as well as the material of the lining itself, and the heat-resistant temperature of the fastening is essential.

Heating of the lining at a higher than desirable rate upon drying of the masonry as well as the original layout of the masonry itself, including the fastening thereof, resulted in damages to the masonry and the lining. The portions affected were repaired, and where required, the layout of the masonry, including the fastening, was modified.

Inspections on the occasion of the last standstill showed damaged spots of the materials of the cyclone lining near the lids and the cyclone coils. Therefore, a new lining was provided for the lid of all the four cyclones, while the cyclone coils were repaired using an antiabrasion material.

1.5 Provence-Gardanne Power Plant (France)

The Study Team visited Provence-Gardanne Power Plant (hereinafter referred to as "Provence Power Plant") in the southern France from Dec. 20 to 22, 1996, studied CFB boiler, and was given explanation by Messrs. Robert Pentel, C. Gourichon and

M. Michel. The result is summarized below. Flow of CFB unit at the Provence Power Plant is shown in Figure 1.5.1.

(1) Outline of Boiler, and Water and Steam Circuit

The boiler is atmospheric CFB boiler, whose design specifications are:

Superheated steam:	700 t/h at 163 bar and 565℃
Reheated steam:	651 t/h at 34.3 bar and 565℃
Gross power generation:	250 MWe
Net power generation:	231.7 MWe
Flue gas temperature:	145 ℃
Boiler efficiency:	90.5 % (LHV)
Plant efficiency:	38.8 %
Coal consumption:	149 t/h
Limestone consumption:	15 t/h

This boiler is a natural convection type. Steam is generated not only in the furnace water walls, but also in pant-leg tapered walls and the top walls of the back pass. As the first convective exchanger, low and intermediate temperature superheaters are provided in the external fluidized bed heat exchangers (hereinafter referred to as "EHE") and the high temperature superheater is located at the top of the back pass. As the second convective exchanger, high temperature reheaters are located in the EHE, while the low temperature reheater is in the back pass. The operating characteristics of the boiler are governed by the existing turbine units.

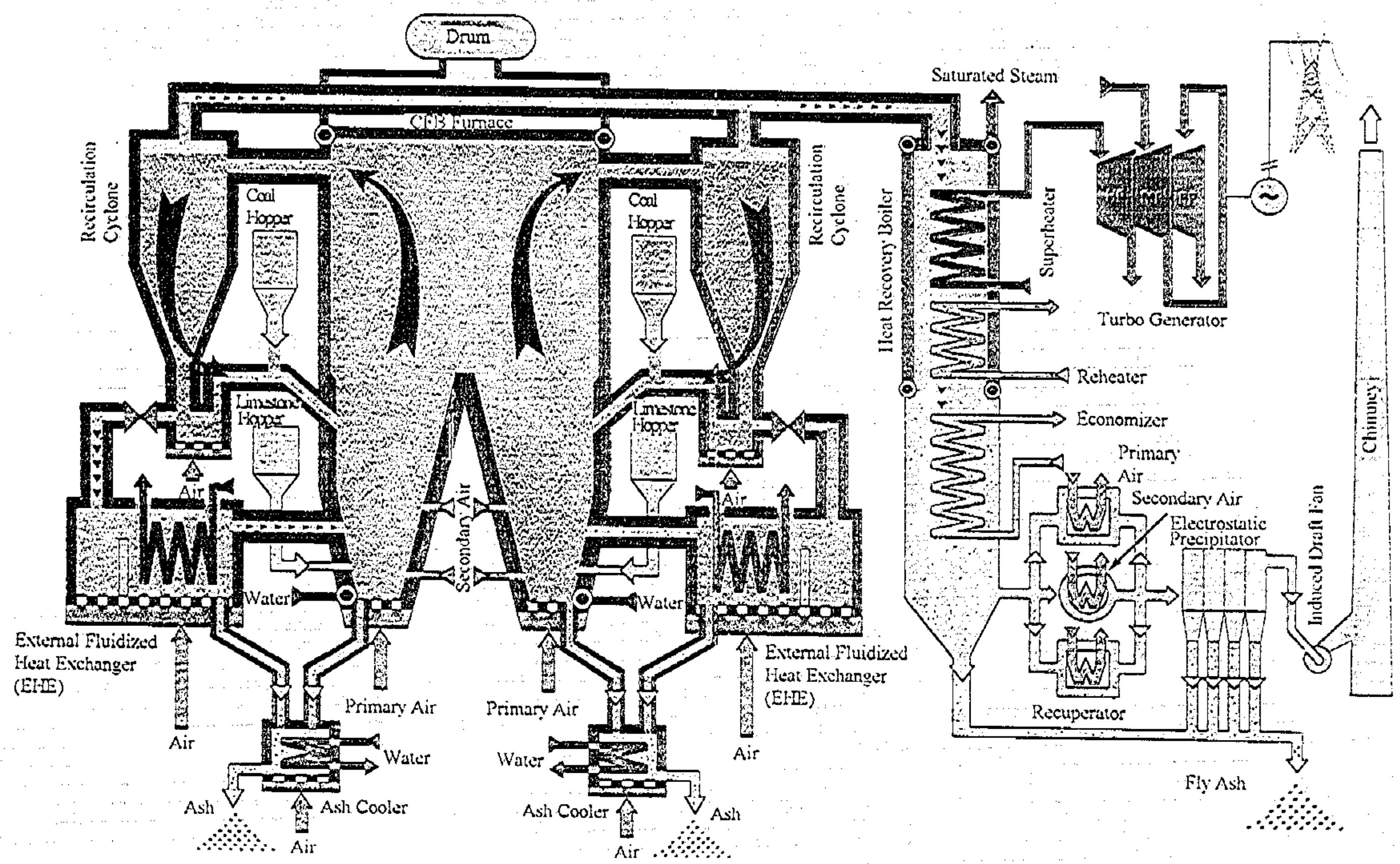

Figure 1.5.1 Flow of CFB Unit at the Provence Power Plant

(2) Fuel Planned for CFB Unit at Provence Power Plant

Provence Power Plant uses a high sulfur coal from the nearby Gardanne mine. This main fuel is a unique, young sub-bituminous high-ash coal (close to a lignite), with a high sulfur content. It is highly volatile coal which requires sizing in the range of 0 - 10 mm, with a D_{50} 1 mm, for smooth feeding to the furnace. This coal is characterized by limestone inclusions leading to a high natural calcium-to-sulfur ratio (1.5 to 2.5), very favorable for desulfurization in a CFB boiler. Adding some limestone from the mine waste will ensure 97 % SO_2 removal efficiency.

The following are typical characteristics of the coal used at the power plant:

Moisture:	11 to 14 %
Ash:	28 to 32 % (of which 57% is CaO)
Carbon:	40 %
Nitrogen:	0.97 %
Total sulfur:	3.68 %
LHV:	14,775 kJ/kg (3,525 kcal/kg), [min. 13 MJ/kg (3,100 kcal/kg)]
HHV:	15,565 kJ/kg (3,700 kcal/kg)

Locally produced heavy residual oil will also be burned in the boiler. This oil is a high viscosity and high sulfur content fuel with the following characteristics:

Moisture:	0.4 %
Ash:	0.07 %
Carbon:	85 %
Nitrogen:	0.92 %
Sulfur:	5 %
Asphalt:	17.4 %
LHV:	38,050 to 39,980 kJ/kg (9,100 to 9,600 kcal/kg)
Viscosity:	1,500 to 3,500 cSt at 100 ℃
Flash point:	200 ℃

The furnace is designed to enable this fuel to be fired together with coal, up to a 50% - 50 % mixture (thermal proportion). Igniting fuel is natural gas, with burners located in primary air ducts and in the furnace, and heavy fuel-oil to be fed through to 10 in-bed lances.

(3) Ash Handling

1) Combustor ash

The fluidized ash collector is installed. These large ash collector boxes have an inside surface consisting of a series of flat ridges. In between these ridges approx. 60 cooling water pipes are installed in each collector. Ash is fluidized by the forced air and transported to the bucket type conveyor through the funnel outlet. The only problem is that a large aggregate of ash blocks the flat ridge. To solve this problem, gravity pipes with two valves at the corner of the ash collector were installed to remove hot ash from the flat ridge.

In the case of Texas-New Mexico Plant 1 (hereinafter referred to as "TNP-1"), Mr. Motely and Mr. Daguzas have pointed out many problems on cooling of combustor ash and transportation. Clogging on the spiral cooling unit or on the line has been usual. When the Study Team visited TNP-1, Mr. G. Pettyjohn told that he was always carrying out changes or redesigns of the ash collector for solving this problem. He implied that the fluidized collector may probably be introduced.

2) Fly ash

The purpose of the fly ash system is to transport fly ash into the silo, but the system does not have a silo gate as in TNP-1. The bottom of the fly ash silo is coned-shaped and water is introduced only into the bottom or cone of the silo.

3) Ash disposal

Combustor ash and fly ash are stored in the ponds. There is a rumor that such ash is dumped in an obsolete mine. In fact, such dump has never been done. According to Mr. Pentel, it is illegal in France to dump ash in an obsolete mine. Storage of such ash is not a permanent solution for ash handling. Study program for solution is currently perfomed in a long prospective.

4) Limestone supply system

This power plant is equipped with the limestone supply system. There has been no trace of use. The coal from Gardanne contains much CaO, and there is no need to add limestone. The system will not be used until the Gardanne mine is closed in 5 - 10 years.

5) Cyclone, NOx and fly ash distribution

There were two significant problems related to the cyclone. This is because the Study Team could go inside the cyclone after Lurgi has just finished their work and closely observe the modification at the neck of the cyclone. The problems are shown below:

a) Due to too short and wide neck of the cyclone, the temperature of the cyclone went up higher than the designated temperature. In result, the amount of NOx emission has been increased. The nominal value of NOx at the Gardanne Power Plant is 250 mg/Nm^3. The current emission is "slightly higher" than the nominal value (Exact figure was not given.).

b) The nominal distribution of recycled particle loaded in the furnace and fly ash leaving out of the cyclone is 50:50. In fact, 70% is leaving out of the cyclone. The ratio is 70:30. In result, undesirable two problems are encountered:

a. Loss of fuel due to discharge of unburned fuel
b. Overload on the electrostatic precipitator (EP).

To solve these problems, Lurgi has lengthened and modified the cyclone neck. Not only Lurgi extended the neck by 1 m, but also angled the cyclone neck with uneven length. Also they reduced the size of the opening by 12 - 18% (Photograph was not allowed inside the cyclone.). The planned annual outage is scheduled to complete on November 1. It is obvious that the design improvement has not been tested yet.

(4) EHE

The Study Team went inside the EHE to examine the condition of the heat exchanger tube in the EHE and had an extensive and informative discussion with Mr. Robert Pentel in various aspects for the difference between general heat exchangers and the Lurgi system. First of all, Ahlstrom is not using EHE. In this point, the Lurgi system is superior to Ahlstrom. Mr. Pentel thinks that their EHE is the best in Lurgi products. Among all CFB systems, EHE is a very sensitive controlling factor. He said Lurgi's EHE enabled them to control the combustor temperature "exquisitely".

At TNP-1, heat exchanger tubes of the EHE has experienced many failures. The tubes were vibrating extensively and impacting one another, resulting in weld failure and leaks. The Study Team observed the heat exchanger tubes at Provence Power Plant. The heat exchanger tubes were firmly seated in steel plate. According to Mr. Michel, there is little vibration.

(5) Cybernetic Linkage of Primary Air Fan, Combustor and EHE

Computer operated very tight feedback linkage has been made between the EHE, the combustor and the primary air fans. The primary air fans are equipped with variable pitch propellers. If the EHE has caused temperature rise in the combustor, the pitch in the propeller of the primary air fans deepens and the amount of air into the combustor is accordingly increased. This constant cybernetic self-adjustment undoubtedly leads to a close approach to the desired temperature, providing a minute-by-minute or perhaps second-by-second adjustment to the desired temperature.

(6) Electrostatic Precipitator

A large FLS-Miljø electrostatic precipitator is installed at Provence Power Plant. According to Mr. Pentel, this electrostatic precipitator has functioned well and there is no further discussion on this point.

(7) Remaining Questions

According to the power plant, only one forced outage at Provence Power Plant was experienced in a year due to leakage from the heat exchanger tube caused by incomplete welding. Provence Power Plant has been operated without any specific failure.

However, some of the steel plates between the layers of refractory had to be replaced during this annual outage of six weeks, because they were too thin and somewhat warped.

One thing everyone remarked on was the condition of the refractory in the combustor after a year's operation was almost brand new without any trace of use. Another point Mr. Michel kept emphasizing was that everything worked well as long as the fuel as small particle distribution 0 - 10 mm, but failure has occurred when the particles are large.

1.6 Analysis of Problems in Large-scale CFB Boilers and Considerations for Application in Borsod Power Plant

Table 1.6.1 summarizes the result of investigations of the large-scale CFB boilers in the world operated in three power plants. The CFB at the Goldenberg Power Station is of the EVT type, and those at TNP-1 and Provence Power Plant are of the Lurgi type. The largest difference between these two types is that EHE is provided in the later. This chapter focuses on the problems of CFB at TNP-1 and Provence Power Plant with the EHE. The findings in these problems will be reflected on the new CFB at the Borsod Power Plant.

The commission of TNP-1 in U.S.A. was 1991. The CFB at the Provence Power Plant in France started operation in 1995 and has been operated for only a year. During this 4 year period, however, the capacity was increased from 499 to 700 t/h. Findings in failures at TNP-1 were also applied to the CFB unit at the Provence Power Plant, reducing number of plant outage of the first operation year. As a result of many improvement made in the CFB design, the capability of the CFB unit has increased to 700 t/h. Based on these examples, the following issues were examined for the application of the CFB technology to Borsod Power Plant.

(1) Appropriate Loading on the Separation and Recycle System or EHE System of Ash from the Combustor

To reduce loading on separation and recycle system or EHE system of ash from the combustor to a similar level of the CFB unit at the Provence Power Plant that has already been proven, the ash yield of the new CFB unit at the Borsod Power Plant should be reduced from 80 t/h to 44 t/h by mixing Lyuko brown coal and import coal at a ratio of 1:1 in calorific value.

Ash is the most significant cause of failure of the CFB units in TNP-1 and Provence Power Plant. Accordingly, the ash yields of the CFB units at TNP-1 and Provence Power Plant are compared.

The fuel coal for TNP-1 is Texas lignite. The ash yield of Texas lignite mixed with limestone as sorbent is 27 t/h.

Table 1.6.1 (1 of 2) Problems in Large-scale CFB Boilers in Power Plants and Feedback to Borsod Power Plant

	Goldenberg Power Plant (Germany)	Texas-New Mexico Power Plant (USA)	Provence Power Plant (France)	Borsod Power Plant (Hungary)
Boiler specification	Main steam (400 t/h, 505°C, 115 bar)	- Main steam (499 t/h, 540.6°C, 132.9 bar) - Reheated steam (448 t/h, 540.6°C, 26.9 bar) - Combustor dimension (Width: 12.5 m, Length: 10.4 m, Height: 45.7 m) - Heat load Steam (Combustor: 60%, External fluidized bed heat exchanger: 20%, Economizer: 20%) Superheater (External fluidized bed heat exchanger: 40%, Convection pass: 60%) Reheater (External fluidized bed heat exchanger: 50%, Convection pass: 50%)	- Main steam (700 t/h, 565°C, 163 bar) - Reheated steam (651 t/h, 565°C, 34.3 bar) - Combustor dimension (Width: 11.5 m, Length: 7.4 m)	- Main steam (460 t/h, 540°C, 165 bar) - Reheated steam (424 t/h, 540°C, 45 bar)
Characteristics of fuel	- Rhine brown coal Moisture content: 53.2 % Ash content: 7.0 % Sulfur content: 0.5 % Calorific value: 88 MJ/kg	- Texas lignite Moisture content: 30.7 % Ash content: 15.5 % Sulfur content: 0.9 % Calorific value: 156 MJ/kg - Oil cokes Moisture content: 7.0 % Ash content: Less than 2.0 % Sulfur content: 4.5 % Calorific value: 34.7 MJ/kg - Texas lignite and oil cokes are mixed for combustion.	- Gardanne lignite Moisture content: 11-14 % Ash content: 28-32 % Sulfur content: 3.7 % Calorific value: 14.8 MJ/kg - Residual fuel oil Carbon content: 85.0 % Nitrogen content: 0.9 % Moisture content: 0.4 % Ash content: 0.07 % Sulfur content: 5.0 % Asphalt content: 17.4 % Calorific value: 38-40 MJ/kg - Gardanne lignite and residual fuel oil are mixed so that the ratio of the calorific value becomes 1:1.	- Lyuko brown coal Moisture content: 24.8 % Ash content: 36.5 % Sulfur content: 2.2 % Calorific value: 9 MJ/kg - Import coal Moisture content: 9.5 % Ash content: 11.3 % Sulfur content: 0.8 % Calorific value: 24.5 MJ/kg - Lyuko brown coal and import coal are to be mixed so that the ratio of the calorific value becomes 1:1 (under discussion).
Feature of Fuel	- Rich in moisture content and poor in ash content. At dry base coal contains only 15.0 % of ash content and 1.1 % of sulfur content.	- Due to high CaO content in the ash content of Texas lignite, the total Ca/S ratio becomes approx. 3-4.	- No CaO is supplied because 56% of the ash content is CaO.	- Lyuko brown coal is rich in ash content. Ash content at dry base reaches 48.5%.
Action taken for boiler failure	- Oil fired boilers (145 t/h x 2 units) are established as an alternative boiler for failures of the CFB boiler.	- CFBs have the design of multi-fuel capability with natural gas and western coal as well as lignite.	- Combustion with 100 % of natural gas or residual fuel oil is possible.	-

Table 1.6.1 (2 of 2) Problems in Large-scale CFB Boilers in Power Plants and Feedback to Borsod Power Plant

	Goldenberg Power Plant (Germany)	Texas-New Mexico Power Plant (USA)	Provence Power Plant (France)	Borsod Power Plant (Hungary)
Boiler issues	- Erosion over the rammed funnel region around the outlets towards the cyclone - Erosion of the grating and stand tubes due to high temperature chlorine corrosion - Erosion and tear on the nozzles due to ash and heavy burns	- While solid particles flow down along the water tube in the lower regions of the combustor interior, disturbances grew at the butt weld of the tube, which caused mis-alignment and erosion. - Vertical shrinkage of the refractor - Serious damage on membrane water-wall at the upper part of combustor	- The steel plates between the layers of the refractory material warped due to their insufficient thickness. Several plates have been replaced.	- Experiences of the three power plants are to be reflected on the new boiler.
Ash yield	- Approx. 15 t/h	- Approx. 27 t/h when only Texas lignite is used	- Approx. 45 t/h when only Gardanne lignite is used - Approx. 22 t/h when the mixture of Gardanne lignite and residual fuel oil at the ratio of 1:1 is used	- Approx. 80 t/h when only Lyuko brown coal is used - Approx. 44 t/h when the mixture of Lyuko brown coal and import coal is used at the ratio 1:1 of the calorific value
Ash problem	- Damage of conveyor due to discharged hot ash (500-600°C) - Erosion and cracks of the bucket chain conveyor	- Pluggage and failure of the ash drain line - Pluggage of the screw ash cooler - Freezing and pluggage of the submerged scraper conveyor - Breakage of chain and bearing and maladjustment of seal tension due to fly ash - Ash and water are mixed at the ratio of 1:1 to make thick sludge for discharge. The thick sludge is carried in a dump track to an ash disposal site.	- Ash accumulated between the flat ridges in the ash collector, which disturbed the ash flow. - Although the disposed ash is currently stored in a pond, from a long-term perspectives, a study program is being carried out to solve the ash disposal problem.	- A test is carried out to mix ash and water at a ratio of 1:1 to make thick sludge and for forced discharging, but has not always been successful. The test is on a trial-and-error stage. Currently ash and water are mixed at a ratio of 1:2 to make thin slurry for transportation. Thin slurry may cause elusion of heavy metals in the limestone, which may lead to ground water pollution.
Problems due to circulated ash	- Pluggage and erosion of these screw ash cooler	- Vibration and erosion of water tube, breakage of welded part, leak or damage because of circulated ash and other problems	- There has been a water leak from the tube.	- Ash heat is to be utilized.
Problems of cyclone	- A preliminary study on the heat-resistant temperature of masonry, expansion coefficient as well as the material of the lining itself, and the heat resistant temperature of the fastening is essential.	- Extremely slight erosion was found around the outlet tube of the cyclone. - Vibration was induced between the back pass tube by the flow.	- Due to too short and wide neck of the cyclone, the temperature of the cyclone went higher than the desired temperature. In result, the amount of NOx emission has been increased. - Nominal distribution of recycled particles loaded in the combustor and fly ash out of the cyclone is 50% to 50%, but in the actual operation, this ratio became 30% and 70%. This caused unburned fuel loss and overload of EP.	- The findings at the three surveyed power plants are to be reflected on the new plant.
Issue of limestone supply	-	- Problems occur frequently in parts of the limestone feeder such as plows and screws. Serious erosion of milling roller, blockage due to feeder vibration, cracks and blockage at the butt weld of the transport tube and failure occurred frequently in the limestone weighing equipment.	- Gardanne lignite contains 1.5-2.5 of CaO by the Ca/S ratio. Limestone feeder will not be used until the shut down of the Gardanne coal mine which is scheduled in 5 to 10 years.	- Limestone feeder at the Provence Power Plant is not used. The findings at TNP-1 is to be incorporated.

The fuel for the CFB boiler in Provence Power Plant is Gardanne lignite or a mixture of Gardanne lignite and residual oil up to a ratio of 1:1. The ash yield is 45 t/h when only Gardanne lignite is used and 22 t/h when the mixture is used. The ash yield of this CFB boiler is twice as large as that of TNP-1.

Almost the half of ash is recycled to the combustor through cyclone and EHE. TNP-1 had frequent failures in the EHE water tube. The EHE of the Provence Power Plant had much fewer problems and all of them have been resolved. The only failure found in the first year since commission was a leak from a water tube due to improper welding. This proves the improvement of the EHE at the Provence Power Plant to a sufficient level for combustion of only Gardanne lignite with ash yield of 45 t/h.

Since Lyuko brown coal, which is to be used at the new CFB boiler in Borsod Power Plant, contains as much ash content as 36.5%, it generates a large amount of ash. It is extremely important to utilize the heat from this ash to improve heat efficiency. However, if only Lyuko brown coal is used, the ash yield including the sorbent becomes 80 t/h, approximately twice as large as that of the CFB boiler in the Provence Power Plant, while the steam generation by the CFB boiler in the Borsod Power Plant is only 65% of that at the Provence Power Plant. There has been no experience of operating ash separation and recycle system or EHE system with a 80 t/h loading capacity; such attempt is almost certain to fail. To cope with this situation, ash yield must be reduced to the same level of the EHE of the CFB unit in the Provence Power Plant. Therefore, a mixture of Lyuko brown coal and import coal must be used as fuel.

Based on these findings, desirable solutions are to reduce the ash yield of the new CFB unit in the Borsod Power Plant from 80 t/h to 44 t/h by mixing Lyuko brown coal and import coal at a ratio of 1:1 in calorific value, and to reduce the ash load on the ash separation and recycle system or EHE system to a similar level to that of the CFB unit in the Provence Power Plant that has been proven already. Such improvement in the EHE technology of the Provence Power Plant must be incorporated to the new unit in the Borsod Power Plant.

(2) Quality of Import Coal

Import coal to be mixed must be of high quality with 25 MJ/kg or higher calorific value and 0.8-1.0% of sulfur content.

As mentioned above, import coal must be mixed to reduce ash yield of the combustor. The next issue is the quality of import coal. To minimize ash yield, high-quality coal with 25 MJ/kg or higher calorific value is required. Desirable sulfur content of the import coal is 0.8-1.0% to minimize the use of limestone.

(3) Limestone Feeder

Limestone feeder also has frequent failure. The findings from these problems of TNP-1 must be reflected on the new CFB unit at the Borsod Power Plant.

Because of the high CaO content of the coal used for the CFB unit at the Provence Power Plant, no limestone feeder is currently used. The limestone feeder of TNP-1 has frequent failures. Therefore the findings from these problems must be incorporated to the new CFB unit at the Borsod Power Plant.

(4) Heat Load Balance

Heating load of the superheating and reheating at the superheater, reheater, ash separator and recycle system or EHE system must be well-balanced.

Steam and ash yields of the CFB unit at the Provence Power Plant are 700 t/h and approx. 45 t/h respectively. At the Borsod Power Plant, steam generation is to become 460 t/h and ash yield with mixed fuel is to be approx. 44 t/h. Comparing these figures with those at the Provence Power Plant, the new CFB unit at the Borsod Power Plant will have heavier load of superheating and reheating in the ash separator and recycle system or EHE system. Therefore, heating load must be balanced between superheating and reheating processes at the superheater, reheater, ash separator and recycle system or EHE system.

(5) Control of Ash Separator and Recycle System or EHE System

Close connection and adjustment by minutes or seconds is carried out between ash separator and recycle system or EHE system, combustor and primary air fan. Use computers to monitor each process, receive any fed-back data, and provide close linkage.

Study results have revealed that the EHE at TNP-1 and Provence Power Plant have significant impact on the temperature control of the combustor and that highly sensitive control is required for the EHE. Above all, the CFB boiler in the Provence Power Plant uses computer for close linkage and adjustment by minutes or seconds between EHE, combustor and the primary air fan to monitor each function, to receive any fed-back data, and to provide close coordination between each function. Comparing the CFB units of the Provence Power Plant and Borsod Power Plant, that of Borsod has smaller combustor and almost the same size of ash separator and recycle system as that of Provence. The impact on the combustor at Borsod will be larger than that at Provence, which requires more sensitive control. Therefore, computerized control is indispensable for the linkage between ash separator and recycle system or EHE system, combustor, and primary air fan for the Borsod Power Plant.

(6) Others

The first annual outage of the CFB unit in the Provence Power Plant found warps in some of the steel plates between the layers of refractory of the combustor, resulting in replacement of the plates. Results of the next annual outage must be reflected on the new CFB unit at the Borsod Power Plant.

2. Environmental Data

2.1 Environmental Standards and Emission Standards

2.1.1 Air Quality

(1) Air Pollutant

Table 2.1.1.1 Standard of air pollutant in Hungary

Air Pollutant	Concentration (mg/m3) [(ppm 20°C)]		
	Specially Protected Area	Protected Area I	Protected Area II
SO_2			
- Annual average	0.030 [0.011]	0.070 [0.026]	0.100 [0.038]
- 24-hours average	0.100 [0.038]	0.150 [0.056]	0.300 [0.113]
- 30-minutes value	0.150 [0.056]	0.250 [0.094]	0.400 [0.150]
NO_2			
- Annual average	0.030 [0.016]	0.070 [0.037]	0.120 [0.063]
- 24-hours average	0.070 [0.037]	0.085 [0.044]	0.150 [0.078]
- 30-minutes value	0.085 [0.044]	0.100 [0.052]	0.200 [0.105]
NOx			
- Annual average	0.030 [0.016]	0.100 [0.052]	0.150 [0.078]
- 24-hours average	0.070 [0.037]	0.150 [0.078]	0.200 [0.105]
- 30-minutes value	0.085 [0.044]	0.200 [0.105]	0.400 [0.209]
CO			
- Annual average	1.0 [0.86]	2.0 [1.72]	5.0 [4.29]
- 24-hours average	2.0 [1.72]	5.0 [4.29]	10.0 [8.59]
- 30-minutes value	5.0 [4.29]	10.0 [8.59]	20.0 [17.17]
SPM			
- Annual average	0.030	0.050	0.100
- 24-hours average	0.060	0.100	0.200
- 30-minutes value	0.100	0.200	0.300
O_3			
- 24-hours average	0.100 [0.050]	0.100 [0.050]	0.100 [0.050]
- 30-minutes value	0.110 [0.055]	0.110 [0.055]	0.110 [0.055]
Dust			
- Monthly total (g/m2/30days)	12	16	21
- Annual total (g/m2/year)	100	120	150
Lead			
- 24-hours average	0.0003	0.0003	0.0007
- 30-minutes value	0.0003	0.0003	0.0007

Notes:
1. Specially Protected Area : Nature conservation area
2. Protected Area I : Country's total territory except for "Specially Protected Area" and "Protected Area II".
3. Protected Area II : Regions which have industrial character

(2) Proposed Future Health Ambient Air Quality Standards of Air Pollutants regulated by Limit Values

Proposed Future Health Ambient Air Quality Standards of Air Pollutants regulated by Limit Values is shown in Table 2.1.1.2. This standard applies to residential area, recreational and nursing facilities and green-belt area. Standard limit is defined for both short-term and long-term periods (30 minutes and 24 hours).

Other standards concerning human health and ecosystem are as follows:

- Proposed Future Combined Health Ambient Air Quality Standards in the Case of Continuous and Parallel Measurements of SO2 and Total Suspended Matter (TSP) [Table 2.1.1.3]
- Proposed Future Health Ambient Air Quality Standards of TSP and Its Certain Components [Table 2.1.1.4]
- Proposed Future Ecological Ambient Air Quality Standards(Concentration) [Table 2.1.1.5]
- Proposed Future Ecological Ambient Air Quality Standards of Sedimentation [Table 2.1.1.6]
- Proposed Future Limit Values Imposing Smog-alarm Measures [Table 2.1.1.7]

Table 2.1.1.2 Proposed Future Health Ambient Air Quality Standards of Air Pollutants regulated by Limit Values

unit: concentration (mg/m^3)

Air Pollutant	Hazardous Level	Short Time Limit Values 30 minutes	Short Time Limit Values 24 hours	Long Time Limit Values
SO_2	3	0.300	0.150	0.050
NO_2	2	0.150	0.100	0.070
O_3	1	0.150	0.100	-
TSP	3	0.300	0.200	0.100
CO	2	10.0	5.0	3.0
Hydrochloric	2	0.200	0.050	0.030
Benz(o)pyrene	1	-	0.000001	0.000001

Source: Ref.B-20

Notes: 1. Short time limit values: the limit values for 30 minutes and 24 hours which are to be applied according to the following:
- to prevent the development of acute health problems;
- to evaluate the polluting effect to the largest extent; and
- to impose the permissible specific emission limit values of industrial air polluting sources within the frame of transmission calculations.

2. Long time limit values: the limit values referring to a period of half a year (heating, non-heating half year) and one year which are to be applied according to the following:
- to prevent the development of chronic health problems and environmental damage;
- to characterize the air quality of certain regions;
- to evaluate the results of air pollution abatement; and
- to conduct trend assessment.

Table 2.1.1.3 Continuous and Parallel Measurements of SO2 and Total Suspended Matter (TSP)

unit: concentration (mg/m^3)

Air Pollutant	Limit Values			
	Heating half-year		Year	
	TSP	SO_2	TSP	SO_2
If there is more TSP than S_2	0.200	0.130	0.150	0.080
If there is less TSP than SO_2	-	-	0.120	0.150

Source: Ref.B-20

Note: The median of the daily mean values measured in the heating half-year and the whole year.

Table 2.1.1.4 Proposed Future Health Ambient Air Quality Standards of TSP and Its Certain Components

Air Pollutant	Hazardous Level	Long Time Limit Values	
		30 days	Half-year, Year
TSP	3	20 g/m^2/30days	150 t/km^2/year
[from TSP] Lead	1	12 mg/m^2/30days	-
Cadmium	1	0.15 mg/m^2/30days	-
Water-soluble Fluorides, as F	2	50 mg/m^2/30days	-
Benz(o)pyrene	1	0.017 mg/m^2/30days	-

Source: Ref.B-20

Table 2.1.1.5 Proposed Future Ecological Ambient Air Quality Standards(Concentration)

unit: concentration (mg/m^3)

Air Pollutant	Sensitivity Category	Limit Values		Remarks
		24 hours	Long term,Year	
SO_2	A	0.070	0.020	-
	B	-	0.030	
	A	0.060	0.030	Growing half-year (Apr.- Oct.)
NO_2		0.040	-	Non-growing half-year (Nov.-Mar.)
	B	-	0.040	
NH_3	A and B	0.600	0.008	Monthly ave.: 100
O_3	A and B	-	0.050	Average between 9-16h
		-	0.150	1 hour max. ave.

Source: Ref.B-20

Table 2.1.1.6 Proposed Future Ecological Ambient Air Quality Standards of Sedimentation

Air Pollutant	Sensitivity Category	Limit Values	Unit of Measurement
NO_X (as N)	A	15	kg/ha/year
	B	25	kg/ha/year
SO_X (as S)	A	24	kg/ha/year
	B	40	kg/ha/year
Aerosols	A and B		kg/ha/year
Ca		140	
Mg		175	
Pb		2.5	
Cu		2.5	
Zn		10	
Cd		0.05	
All Acids	A	2800	mol/ha/year
	B	4000	mol/ha/year

Source: Ref.B-20

Table 2.1.1.7 Proposed Future Limit Values Imposing Smog-alarm Measures

unit: concentration (mg/m^3)

Air Pollutant	Preparing Period	Classes I	Classes II
SO_2	0.400	0.600	0.800
NO_2	0.350	0.600	0.800
CO	20.0	30.0	40.0
TSP	0.600	0.800	1.000
SO_2 + TSP(Note 1)	0.600	0.800	1.000
O_3	0.200	0.300	0.400

Source: Ref.B-20

Notes:

1. If TSP is greater than 200.
2. The period exceeding the limit values given hereinabove which is necessary to order a smog-alarm:
   - Preparing period: 3 hour-long period exceeding the limit values
   - Class I: 3 hour-long period exceeding the limit values
   - Class II: 3 hour-long period exceeding the limit values
3. Classes I and II come into force if the standards defined referring to the preparing period and Class I exists for 24 hours.
4. The measurement data derived from automatic registering instruments consist of values of 30 minute periods out of which a concentration average for a 3 hour period shall be calculated (e.g. the average for 3 hour is the average of 6 consecutive values of 30 minute periods).
5. Periods exceeding the limit values, which are listed in Note 2, shall occur in at least two stations. In case there is only one measuring station at a given settlement, the smog-alarm can be ordained on the basis of its measurement data.

(3) Emission standard

1) Current emission standard for fixed emission source

Emission sources are defined for each area. The emission standard (En) of the fixed source distributed in November 1993 and enacted in January 1994 is calculated with the following expression:

$En = E_f \cdot K_1 \cdot K_2$ (kg/h)

where Ef: Emission coefficient determined by the stack height. Found with the following expression and table:

$E_f = E_{fi} / n$ (kg/h m³/mg)

Emission Height:H(m)	$E_{f,i}$(kg/h · m³/mg)
0<H≦10	2
10<H≦20	6
20<H≦35	90
35<H≦50	700
50<H≦80	2000
80<H≦100	4000
100<H≦120	6000
120≦H	30000

En : Coefficient to find the stack height
n : Number of sources of smoke
K_1 : Limit of each air pollutant emission up to 24 hours for each district (mg/m3)
K_2 : Values calculated according to the following expression:

K_2 = (100-Loading Index) / 100

The loading index depends on each condition of air pollution in the area. Loading indexes of major cities and towns in Sajo Valley district is shown in the following table:

Area Name	Dust	Gas(SO_2,NOx,CO, etc.)	Others
Alsozsolca	60	50	30
Felsozsolca	60	50	50
Kazincbarciha	60	40	70
Tiszaujvaros	70	50	50
Malyi	60	50	50
Miskolc	70	60	50
Nyekladhaza	40	30	30
Ozd	80	70	50
Sajobabony	60	50	50
Sajokersztur	60	50	50
Sajoszentpeter	70	50	50
Serenyfalva	60	50	50

Kazinobarcika, where the Borsod Power Plants are located, is classified as "Protection II."

K2 and Loading indexes are as follows:

SPM : K2 = (100 · 80)/100 = 0.4
Fume contaminant : K2 = (100 · 40)/100 = 0.6

2) Planned emission standard of fixed sources

Source: Environmental policy for each district concerning the technical emission standard for combustors with heat load of 15 MWth or above (extract) is shown in Tables 2.1.1.8 through 2.1.1.11.

The emission standard must be enacted on the date of issuance for new combustors and on January 1, 2004. for the existing combustors.

Table 2.1.1.8 Proposed Future Technological Emission Limit Values concerning New Firing Equipment Operated with Solid Fuels

Input Load : P_{th} (MW_{th})

Air Pollutant	Emission Limit Value (mg/m^3)		
	15-100 MW	100-500 MW	> 500 MW
Solid Material	100	50	50
CO	250	250	2650
NOx(given in NO_2)	600(1)	400(1)	400(1)
SO_2 and SO_3 (given in SO_2)	2000(2)	2400 - 4 x P_{th} (3)	400
Chlorides(given in HCl)	200	100	100
Fluorides	30	15	15

Source: Ref.B-32

Notes

(1) In case of domestic lignite maximum 300 mg/m^3 (calorific value:<7000 kJ/kg)

(2) In case of firing domestic coal 2000 mg/m^3 ,or at least 60 % Desulphurating efficiency

(3) Limit value except for the following conditions is obtained by interpolating the interval between the value for [15-100MW] and that for [>500MW].
Here it is in the table.

* In case of firing domestic brown coal and lignite, at least 90 % desulphurating efficiency.
* In case of firing imported coal maximum 400 mg/m^3.
* In case of Fluidized Bed Combustion Boiler using domestic coal, at least 75 % desulphurating efficiency.

(4) Concentration given in mg/m^3 refer to dry smoke-gas with 6 % O2 content at a normal state [273 K, 101.3kPa].

The items except for application :

In case of the Firing Equipment using Solid Fuels and exchanging to old Hybrid Fluidized Bed Combustion System, the following regulations must be obeyed from the day when the law is effectuated. law.

a) SO_2 emission is at least desulphurating efficiency in smoke gas.

b) NOx concentration in smoke gas is less than 800 mg/m^3.

(Concentration given in mg/m^3 refer to dry smoke-gas with 6 % O2 content at a normal state [273 K, 101.3kPa]).

Table 2.1.1.9 Proposed Future Technological Emission Limit Values concerning New Firing Equipment Operated with Liquid Fuels

Input Load : P_{th} (MW_{th})

Air Pollutant	Emission Limit Value (mg/m^3)		
	15-300 MW	100-500 MW	> 500 MW
Solid Material	50	50	50
CO	175	175	175
NOx(given in NO_2)	350	350	350
SO_2 and SO_3 (given in SO_2)	1700	3650 - 6.5 x P_{th} [(2)]	400
Chlorides(given in HCl)	30	30	30
Fluorides	5	15	5
Heavy Metals[(1)] and Arsenic	2	2	2

Source: Ref.B-32

Notes

(1) The following elements are to taken into consideration:
Arsenic, Cadmium, Cobalt, Nickel, Chromium and Lead

(2) Limit value except for the following conditions is obtained by interpolating the interval between the value for [15-300MW] and that for [>500MW].
Here it is in the table.

(3) Concentration given in mg/m3 refer to dry smoke-gas with 3 % O2 content at a normal state (273 K, 101.3kPa).

The items except for application :

In case of the existing Firing Equipment using Liquid Fuels.

a) As of 1. January 2000, SO_2 concentration in smoke gas is less than 2100 mg/m3.

(Concentration given in mg/m^3 refer to dry smoke-gas with 3 % O2 content at a normal state [273 K, 101.3kPa]).

b) As of 1. January 1988, total concentration of As, Cd, Co, Ni, Cr, Pb is less than 2 mg/m^3 in smoke gas of firing equipment having nominal heat gain load more than 500 MW_{th}.

(Concentration given in mg/m^3 refer to dry smoke-gas with 3 % O2 content at a normal state [273 K, 101.3kPa]).

c) As of 1. January 2000, the standard given to item b) is applied overall equipment.

Table 2.1.1.10 Proposed Future Technological Emission Limit Values concerning New Firing Equipment Operated with Gaseous Fuels

Input Load : P_{th} (MW_{th})

Air Pollutant	Emission Limit Value (mg/m^3)
	> 15 MW
Solid Material	5
CO	100
NOx(given in NO_2)	200
SO_2 and SO_3 (given in SO_2)	35

Source: Ref.B-32

Notes

Concentration given in mg/m3 refer to dry smoke-gas with 3 % O2 content at a normal state (273 K, 101.3kPa).

Table 2.1.1.11 Proposed Future Technological Emission Limit Values concerning New Firing Equipment (Gas Turbines)

Input Load : P_{th} (MW_{th})

Air Pollutant	Emission Limit Value (mg/m^3)	
	<300 MW	>300 MW
Solid Material	4	2
CO	100	100
NOx(given in NO_2)		
Oil Combustion	200	170
Gas Combustion	150	90
SO_2 and SO_3 (given in SO_2)		
Oil Combustion	115	115

Source: Ref.B-32

Notes

The number of blackening is according to the Bacharach scale.

Concentration given in mg/m3 refer to dry smoke-gas with 15 % O2 content at a normal state (273 K, 101.3kPa).

In case of less than 200hours for annual operated time of Gas Turbine, NOx concentration is 850 mg/m^3.

In case of application of this standard for planning equipment, annual operated time must not be over 199 hours. And existing equipment must not be operated over 199 hours.

(4) Other emission regulations and standards of fixed emission sources

General emission standards of fixed emission sources are shown in Tables 2.1.1.12 and 2.1.1.13.

Table 2.1.1.12 Proposed Future General Emission Limit Values of Stationary Sources concerning Solid Materials and Inorganic Dust Materials

Air Pollutant	Air Pollutant Mass Flow (kg/h)	Limit Values (Permissible Max. Concentration) (mg/m^3)
Class 0 (Solid Materials)	no greater than 0.5 greater than 0.5	150 50
Class I (Cd, Hg, Tl)	0.001 or above	0.2
Class II (As,Pb, etc.)	0.005 or above	1.0
Class III (Cr, Cu, etc.)	0.025 or above	5.0

Source: Ref.B-32

Notes: 1. Materials which are not listed in Classes I to III shall be considered as solid materials.
2. In case several materials belonging to different classes are present simultaneously, the emission limit values are:
Classes I and II together: 1 mg/m^3;
Classes I and III or Classes II and III together: 5 mg/m^3;
however, the limit value referring to the material's own class cannot be exceeded.

Table 2.1.1.13 Proposed Future General Emission Limit Values of Stationary Sources concerning Inorganic Materials Vapor or Gaseous State

Air Pollutant	Air Pollutant Mass Flow (kg/h)	Limit Values (Permissible Max. Concentration) (mg/m^3)
Class I (Arsenic hydrogen, etc.)	0.01 or above	1
Class II (HCN, H_2S, etc.)	0.05 or above	5
Class III (Inorganic chlorine)	0.3 or above	30
Class IV (SO_X, NO_X)	5.0 or above	500

Source: Ref.B-32

The limit value for all comfurtion Focilibes operated by Hungarian Electric Power Company is shown in Table 2.1.1.14

Table 2.1.1.14 The limit value for all comfurtion Focilibes operated by Hungarian Electric Power Company

Pollutants	The day of Enforcement	Emission Limit Values(t/year)
SO_2	after January 1, 1996	max. 380,000
	after January 1, 2000	max. 280,000
	after January 1, 2004	max. 150,000
NOx	after January 1, 1996	max. 40,000
	after January 1, 2000	max. 35,000
	after January 1, 2004	max. 30,000
Solid materials(Dust)	after January 1, 1996	max. 25,000
	after January 1, 2000	max. 20,000
	after January 1, 2004	max. 10,000

2.1.2 Soil, Groundwater and Drinking Water

(1) Limit value of soil by category for protection of grand water (Dangerous substances)

Limit value of soil by category for protection of grand water is shown from Table 2.1.2.1(1) to table 2.1.2.1(2).

List I. covers the materials belonging to the 3 types and groups of materials enlisted below, except those which are of a low risk for the [human] body in terms of toxicity, decomposition and accumulation and therefore are not to be included into List I.

Those materials which are to be enlisted in List II. in terms of toxicity and decomposition are to be included into List II.

List I. Dangerous materials of TI category

1./ Organic halogen compounds and such materials which may became organic halogen compounds in water environments.
2./ Organic phosphorus compounds
3./ Organic tin compounds.
4./ Materials having cancer-inducing mutagenic or tetragenic attributes in water environments or in other organizations through water.
5./ Mercury and its compounds.
6./ Cadmium and its compounds.
7./ Mineral oils and other hydrocarbons.
8./ Cyanides.

List II. Dangerous materials of T2 category [1]

List II. contains the materials and material categories belonging to the following t3rpes and groups of materials exerting harmful effects on sub-surface waters.

1./ The following semi-metals, metals and their compounds:

1. Zinc
2. Copper
3. Nickel
4. Chromium
5. Lead
6. Selen
7. Arsenic
8. Antimony
9. Molybdenum
10. Titanium
11. Tin
12. Barium
13. Beryllium
14. Boron
15. Uranium
16. Vanadium
17. Cobalt
18. Thallium
19. Tellurium
20. Silver

2./ The bio-cides and their derivatives not covered by List I.

3./ Materials which damage the taste and/or smell of sub-surface waters as well as compounds which give rise to the production of such materials in sub-surface waters and thereby render waters unsuitable for human consumption.

4./ Toxic or decomposition-resistant silicon compounds as well as compounds which give rise to the produc6on of such silicon compounds in water, except those which are biologically harmless or rapidly transform into harmless materials in water.

5./ Inorganic phosphorus compounds and elementary phosphorus.

6./ Fluorides.

7./ Ammonia and nitrites.

(1) If some materials of List II. are having cancer-inducing, mutagen or tetragen attributes, such materials are covered by section 4. of List I.

Table 2.1.2.1 (1) Limit Value of Soil by Category for Protection of Grandwater

unit : mg/kg of dry material

*The term "prohibited material" is to be applied if the material is introduced into subsurface waters.

Metals

	A	B	C_1	C_2	C_3	Prohibited Material
Chromium	30	100	150	400	800	T2
Chromium VI	0	1	2.5	5	10	T2
Cobalt	15	50	100	200	300	T2
Nickel	25	50	150	200	250	T2
Copper	30	100	200	300	400	T2
Zinc	100	250	500	1000	2000	T2
Arsenic	10	15	30	40	60	T2
Molybdenum	3	10	20	50	100	T2
Cadmium	0.5	1	2	5	10	T1
Tin	5	30	50	100	300	T2
Barium	150	250	300	500	700	T2
Mercury	0.15	0.5	1	3	10	T1
Lead	25	70	100	500	600	T2

Inorganic Compounds

	A	B	C_1	C_2	C_3	Prohibited Material
Cyanid 4.5pH	0.2	2	5	10	20	T1
Cyanid Total	2	20	100	300	650	T1
Thiocyanates	0	1	3	5	20	T1
Fluoride	200	300	500	1000	2000	T2

Table 2.1.2.1 (2) Limit Value of Soil by Category for Protection of Grandwater

unit : mg/kg of dry material

*The term "prohibited material" is to be applied if the material is introduced into subsurface waters.

Metals

	A	B	C_1	C_2	C_3	Prohibited Material
Chromium	1	50	100	150	200	T2
Chromium VI	k	10	20	30	40	T1
Cobalt	1	20	40	75	150	T2
Nickel	5	20	50	75	100	T2
Copper	10	100	300	500	1000	T2
Zinc	65	200	300	500	1000	T2
Arsenic	10	25	50	75	100	T2
Molybdenum	5	20	75	150	300	T2
Cadmium	0.4	2	3	6	10	T1
Tin	2	10	40	100	150	T2
Barium	100	700	1000	1500	2000	T2
Mercury	0.1	1	1.5	2	3	T1
Lead	3	10	25	50	100	T2

Inorganic Compounds

	A	B	C_1	C_2	C_3	Prohibited Material
Cyanide 4.5pH	20	100	150	300	500	T1
Cyanide Total	20	200	500	1000	2000	T1
Thiocyanates	k	50	100	300	1500	T1
Boron	100	300	500	750	1000	T2
Fluorides	500	1500	2000	3000	4000	T2
Sulphate$^{(1)}$	200	300	500	700	1000	-
Phosphate	200	500	1000	1500	2000	T2
Nitrate$^{(1)}$	10	40	80	100	200	T2
Ammonium	500	1000	2000	3000	4000	T2
Chlorid$^{(1)}$	100	350	500	1000	1500	-

$^{(1)}$ mg/l

(2) Drinking Water Physical and Chemical Quality Criteria

National Standard MSZ 450/1-1989 (Substituting MSZ 450/1-1978)

The validity of State Standards is regulated in §5-12 of the 78/1988 (XI.16) Government Decree.

The application of this Standard is compulsory. Permission of deviation from its prescriptions can be granted by the Supervisor-in-Chief of the State Chief Supervisory Agency for Public Health and Epidemiology, based on the authorization of the Chairman of the Hungarian Bureau of Standards.

The subject of this Standard is the physical and chemical quality criteria for the drinking water as it enters the water-pipe network and reaches the consumer as well as for the water-supply by individual wells. Pre-treatment (raw) water is not subject to this Standard, except the case when treatment is restricted to disinfection and/or de-gasification [gas-extraction].

1) Definition of terms

a) Drinking water from surface-waters: water processed by artificial cleaning, natural shore-line filtering or water-enrichment from flowing or standing water resources.

b) Non-protected sub-surface water (hereafter: underground water): the water of any well or source based on a primary water-supply stratum not covered by a stratum impenetrable by water, most generally karst-water, as well as any sub-surface water (regardless of the depth of the well) the nitrate content of which exceeds the 20 mg/L value.

Date of approval: 10 June 1989 Date of entering enforcement: 1 January 1990

c) Protected sub-surface water [ground-water] (hereafter: protected stratum-water): from the point of view of qualifying for drinking water, the water of such a well or source which originates from a protected stratum, i.e. where the water-supplying stratum is securely protected by a water-isolating stratum from any pollution of surface origin near to the well (source).

Note: In case of karst-water, even a deep-karst is permitted to be registered as protected if it is justified by hydro-geological expert investigation.

d) Individual supply of well-origin: from the point of view of qualifying for drinking water, if the water of the water resource (well, source, etc.) does not enter a water-pipe on public area, or if it does not serve the water supply of an establishment (factory, etc.) being on premises different from the one where the water-resource is located. The water-supply cannot be regarded as an individual one of well origin even within the same premises, if the water-supply provides water for more than 50 persons or for a child-care establishment.

2) Criteria

a) Limit values for toxic substances

The limit values for toxic substances are listed in Table 2.1.2.2

Table 2.1.2.2 The limit Values for Toxic Substances are Listed

Designation of toxic Substances	Permitted Concentration (ug/l)	Examination by The Standards Below
Arsenic	50	MSZ 448/47
Barium	1000	MSZ 448/38
Cyanides,can by freed by...	10	MSZ 260/30
Mercury,Total	1	MSZ 448/48
Cadmium	5	MSZ 448/39
Chromium,Total	50	MSZ 260/32
Lead	50	MSZ 448/9
Selenium	10	MSZ 448/37
Atrazine(Aktinit PK)	2	MSZ 448/41
Bentazon	25	MSZ 12750/49
Benzo(a)pyrene	0.01	MSZ 448/45
Benzen	10	MSZ 448/52
2,4-D	100	MSZ 12750/27
Carbaryl	50	MSZ 448/40
Chloroform*	30	MSZ 448/50
Lyndane	3	MSZ 448/42
Malathion	10	MSZ 448/40
MCPA	0.5	MSZ 12750/27
Methylparation	5	MSZ 448/40
Metachlor	5	MSZ 12750/39
Methoxychlor	30	MSZ 448/12
Molinat	7	MSZ 12750/37
Pendimetalin	17	MSZ 448/44
Propanil	175	MSZ 12750/46
Prepachlor	50	MSZ 12750/29
Simazin(Aktinit DT)	17	MSZ 448/41
CarbonTetrachloride*	3	MSZ 448/51
Tetrachloroethylene*	10	MSZ 448/51
Trifluraline	170	MSZ 12750/43
Trichloroethylene*	10	MSZ 448/51
Trichlorofon	10	MSZ 448/40

*under preparation

b) Limit values of the substances and attributes defining the physical and chemical quality of drinking water

The regulation is according to the specifications set in Tables 2.1.2.3 and 2.1.2.4, with the exceptions listed here as follows:

1./ For some characteristics of water-supply from individual wells (total hardness, iron, manganese, iron and manganese together, COD and nitrate), instead of the limit-values with the "*" sign listed in the second ("tolerable") column of Tables 2.1.2.3 and 2.1.2.4, the less strict limit-values presented in Table 2.1.2.5 are in force.

2./ From the point of view of ammonium-content, the water of the wells with shore-line filtering can be qualified as surface-type water-supply if:

- a hydro-geological expert assessment demonstrates that the ammonium- content is from surface water, or it is due to marshland-type conditions;
- the protection area (protection structure) was developed both towards the surface-water and towards the background (on the side opposite to the river);
- the possibility of the continuous disinfection of the water is guaranteed.

If any one of these conditions is not met, only the limit-values set for underground water are applicable. From the point of view of COD the water with shore-line filtering can be classified as underground water.

In the cases of water gained from underground or surface sources, the limit-values related to the type of water resource are to be applied for the not-yet-mixed water of individual water-supplying equipment's (e.g. individual wells), except for nitrate. The quality criteria for the water supplied by new water plants should meet the regulations of section 3.2.1.

The limit-values independent from the type of the water-resource (drinking water from surface, underground or protected stratum water resources) are listed in Table 2.1.2.3, the limit-values depending on the type of water resource are set in Table 2.1.2.4, while the less strict limit-values related to the "tolerable" category of individual well supply are covered by Table 2.1.2.5.

Table 2.1.2.3 Limit Values for Toxicological Substances

Characteristics and substances	Limit values			Examination by	Other Prescriptions	Remarks
Designation	Unit	Adequate	Tolerable			
Temperature	℃	20	25	MSZ 448/2		Desirable:℃7-15
Intensity of taste and smell	-	1	3	MSZ 448/35		Measured:℃20
Turbidity(muddiness)	NTU	1	2	MSZ 448/53		
Suspended particle	mg/l	1	2	MSZ 448/33		
pH/min	pH	7.0	6.8	MSZ 448/22		
max	pH	8.0	8.5			
Specific electric conductivity at ℃ 20	uS/cm	1350	1600	MSZ 448/32		
Total dissolved substance	mg/l	1000	1200	MSZ 448/32		
Total hardness/min	CaO mg/l	50	50(1)	MSZ 448/19		
max	CaO mg/l	250	350(1)			
Halogen-carbonate min	mg/l		30(2)	MSZ 448/11		
Sulphate	mg/l	200	300	MSZ 448/13	If magnesium-content is over 50mg/l, the sulphate-content should not exceed 200mg/l.	
Iron	mg/l	0.2	0.3(3)	MSZ 448/4	The max.combind iron and manganese content is 0.3mg/l.	
Copper	mg/l	0.2	1.0	MSZ 448/53	In stagnant water max.3mg/l(by 12hours of stagnation).	
Zinc	mg/l	0.2	1.0	MSZ 12750/8	In stagnant water max.5mg/l(by 12hours of stagnation).	
Aluminum	mg/l	0.1	0.2	MSZ 448/7		
Boron	B mg/l	1	5	MSZ 10889/2		
Natrium	mg/l	200		MSZ 448/10		
Fluorides/min	mg/l	0.9		MSZ 448/17	The attainment of a concentration of 0.9mg/l is desirable.	
max	mg/l	1.5	1.7			
Total phosphorus	P_2O_5mg/l	0.5	5	MSZ 448/18	In case of applying chemicals of phosphate content, also stricter limitvalue can given.	
Silver	ug/l	10	50	MSZ 12750/13	In case of consumption by babies, the 10ug/l limit should be observed	
Anion active detergents	mg/l	0.2	0.5	MSZ 448/49		
Phenols	ug/l	2	20	MSZ 448/34	Values between the "adequate" and the "tolerable" may be accepted only if there is no adverse or smell effect.	
Oil derivatives	ug/l	10	100	MSZ 12750/23(4)		
Methane	l/m³	0.8	0.8	MSZ 448/43	In case of networks serving one-floor buildings, or buildings with public or yard-way outlets 3l/m³ is permissible.	

(1) Now under preparation.

(2) Valid only for desalinated waters.

(3) When making an assessment,also table 4 has to be taken into consideration.

(4) The oil-derivatives have to be ascertained by the methods of ultra-violet spectro-photometry,applying it after aluminum -oxid type column-chromatographic separation.

Table 2.1.2.4 Phisical-Chemical Specification for Drinking Water

Designation	Type of water resource	Adequate limits (mg/l)	Tolerable limits (mg/l)	Examin.
COD	ground water	2.5	3.5[1]	MSZ 448/2
	surface resource	3.0	3.5[2]	
	protected stratum water	6.0	10.0	
Chlorides	ground water	80	100	MSZ 448/15
	surface resource	80	100	
	protected stratum water	250	350	
Ammonium	ground water	0.1	0.2	MSZ 448/6
	surface resource	0.2	0.5	
	protected stratum water	1.0	2.0	
Nitrite	ground water	0.1	0.3	MSZ 448/12
	surface resource	0.1	0.3	
	protected stratum water	0.5	1.0	
Nitrate	ground water	20	40[1]	MSZ 448/12
	surface resource	20	40	
	protected stratum water	20.0	20[3]	
Sulfide	ground water	0.00	X	MSZ 448/14
	surface resource	0.00	X	
	protected stratum water	0.05	1.0	

[1] When making an assessment,also Table 4.has to be taken into consideration.

[2] If the COD values are larger in the row water than 5 mg/l, the limit-values are as follows.

If the COD in the row water is:	Then the limit-value is:
5-7 mg/l	3.8mg/l
7-9	4.2
9-12	4.6
above 12	5.0

[3] If the nitrate concentration in the in sub-surface water exceeds the 20 mg/l level,it should be classified as ground-water.

X Should not be detectable

Table 2.1.2.5 While the less strict limit values related to the "tolerable" category of individual well supply are covered

Designation	Unit	Limit-value
Total hardness	CaO mg/l	450
Iron(Fe)	mg/l	1.0
Manganese	mg/l	0.5
Iron and Manga	mg/l	1.0
COD	mg/l	1.0[1]
Nitrate	mg/l	80[2]

[1] For protected stratum water: 10 mg/l

[2] When making an assessment,also the last sentence of section 3.2.2.has to be considered.

(3) Limit Values for the Discharge of Communal and Industrial Waste Waters

- Order 3/1984. (VII.7) OVH, sets limit values for the discharge of communal and industrial waste waters to surface waters;
- Order 4/1984. (VII.7) OVH, sets limit values for the discharge of communal and industrial waste waters to public sewer.

All discharges to surface water and sewer in Hungary must comply with the standards laid down in these Orders. Failure to do so, may result in imposition of a fine. Fines are based on the total amount of pollutant discharged and increase progressively if the pollution continues.

The Orders set limit values for a broad range of substances. For each substance the limit value depends on the nature of the receiving water. Both Orders define six categories of receiving water:

- Category I - prominent water quality areas
- Category II - sources of drinking water supply and recreation areas
- Category III - industrial areas
- Category IV - Sources of irrigation water
- Category V - non-priority areas on the Danube and Tisza
- Category VI - non-priority areas

The discharge stndards for surface water and sewer are shown in Tables 2.1.2.6 and 2.1.2.7.

Table 2.1.2.6 (1) Hungarian effluent standards for industrial and municipal waste water discharged into receiving waters(Limit concentration "CL" in mg/l unless indicated otherwise)

No.	List of component	Area Categories					
		I	II	III	IV	V	VI
	I. Polluting substances						
1.	Dichromate oxygen consumption	50	75	100	100	150	75
2.	Oil and grease [1]	2	5	10	10	10	10
3.	Organic solvent cm3/m3	0.05	0.05	0.05	0.05	0.05	0.05
4.	pH [2]						
	- under	6.5	6.5	5	6	5	6
	- over	8.5	9	9	9	10	9
5.	Total dissolved matter						
	-natural	1000	1000	2000	1000	-	2000
	-technological	1000	1000	2000	1000	-	2000
6.	Sodium equivalent [3](%)	45	45	45	45	-	45
7.	Phenols	0.1	0.1	3	3	3	3
8.	Total suspended solids	100	100	200	200	500	200
9.	Tar	0.1	0.1	2	2	2	1
10.	Ammonia- ammonium ion [4]	2	5	30	10	30	10
11.	Total iron	10	10	20	20	20	20
12.	Total manganese	2	2	5	5	5	5
13.	ANA detergents	2	2	5	5	5	5
14.	Sulfides	0.01	0.01	2	2	5	2
15.	Active chlorine	2	2	2	2	2	2
16.	Fluorides	2	2	10	5	10	10
17.	Total phosphorus [5]	1.8	2	2	2	-	2
18.	Nitrate [5]	40	50	80	80	-	80
19.	Coliform count [6](i/cm3)	10	10	10	10	10	10

Notes:

1. Three-fold increased limit value for grease and oil of animal or vegetal origin (organic solvent extract).
2. In terms of the respective HCl or NaOH quantities.
3. The quantity of sodium in kg above the amount required to balance 45 equivalent % of the calcium, magnesium and potassium content of the water.
4. Total ammonium and ammonia, expressed as N in mg/l.
5. For categories I and II, it is to be applied in all cases, while for categories III, IV and VI it is should be applied only to waste waters discharged to standing water bodies.
6. $n < 4$

Table 2.1.2.6 (2) Hungarian effluent standards for industrial and municipal waste water discharged into receiving waters(Limit concentration "CL" in mg/l unless indicated otherwise)

No.	List of component	Area Categories					
		I	II	III	IV	V	VI
	II. Toxic Substances						
20.	Easily releasable cyanides	0.1	0.2	0.2	0.2	0.2	0.2
21.	Total cyanides	2	10	10	10	10	10
22.	Total copper	0.5	1	2	2	2	2
23.	Total lead	0.05	0.1	0.2	0.2	0.2	0.2
24.	Total chromium	0.2	0.5	1	1	1	1
25.	Chromium VI	0.1	0.3	0.5	0.5	0.5	0.5
26.	Total arsenic	0.05	0.05	0.1	0.1	0.1	0.1
27.	Total cadmium	0.005	0.01	0.005	0.05	0.05	0.05
28.	Total mercury	0.001	0.005	0.01	0.01	0.01	0.01
29.	Total nickel	0.5	0.5	1	1	1	1
30.	Total zinc	1	2	5	5	5	5
31.	Total silver	0.01	0.05	0.1	0.1	0.1	0.1
32.	Toxicity	dilution rate CL 50%					

Table 2.1.2.7 (1) Hungarian effluent standards for industrial and municipal waste water discharged into public sewers (Limit concentration "CL" in mg/l unless indicated otherwise)

No.	List of component	Area Categories					
		I	II	III	IV	V	VI
	I. Harmful substances						
1.	Dichromate oxygen consumption	1000	1000	1200	1200	1500	1000
2.	Oil and grease [1]	40	40	50	50	60	50
3.	Phenols	5	5	10	10	10	10
4.	Tar	1	2	5	5	5	5
5.	ANA detergents	20	20	50	50	80	50
6.	pH [2]						
	- under	6.5	6.5	6.5	6.5	6.5	6.5
	- over	10	10	10	10	10	10
7.	Sulfides	1	1	1	1	1	1
8.	Sulfate	400	400	400	400	400	400
9.	Ammonia- ammonium ion	100	100	150	150	150	150
10.	Active chlorine	10	10	30	30	50	30
11.	Total dissolved matter						
	-natural	1500	1500	2500	2500	3000	2500
	-technological	1500	1500	2500	2500	3000	2500
12.	Total fluoride	20	20	50	50	50	50
13.	Total iron	10	10	20	20	20	20
14.	Settleable matter [3](10 min.)	100	100	150	150	150	150

Notes:

1. For grease and oil of animal or vegetal origin the limit value should be trebled up to 100 m3/d sewage discharge, while at and above 100 m3/d discharge rate the limit value shall be doubled.
2. In terms of the respective HCl or NaOH quantities.
3. It is to be applied only when after a settling of 10 minutes duration the suspended solid content exceeds 3 x 10^{-3} m3/m3.

Table 2.1.2.7 (2) Hungarian effluent standards for industrial and municipal waste water discharged into public sewers (Limit concentration "CL" in mg/l unless indicated otherwise)

No.	List of component	Area Categories					
		I	II	III	IV	V	VI
	II. Toxic Substances						
15.	Easily releasable cyanides	0.05	0.05	0.1	0.1	0.1	0.1
16.	Total cyanides	0.5	0.5	1	1	1	1
17.	Total copper	1	1	2	2	2	2
18.	Total lead	0.2	0.2	0.4	0.4	0.4	0.4
19.	Total chromium	0.5	0.5	1	1	1	1
20.	Chromium VI	0.2	0.2	0.5	0.5	0.5	0.5
21.	Total arsenic	0.1	0.1	0.2	0.2	0.2	0.2
22.	Total cadmium	0.01	0.02	0.1	0.1	0.1	0.1
23.	Total mercury	0.005	0.01	0.05	0.05	0.05	0.05
24.	Total nickel	0.5	0.5	1	1	1	1
25.	Total tin	0.3	0.3	0.5	0.5	0.5	0.5
26.	Total zinc	2	5	10	10	10	10
27.	Total silver	0.1	0.1	0.2	0.2	0.2	0.2
28.	Organic solvent (10^{-3}m3 / m3)	0.05	0.05	0.1	0.1	0.1	0.1
29.	Carbon disulfide (10^{-3}m3 / m3)	0.05	0.05	0.1	0.1	0.1	0.1
30.	Benzene (10^{-3}m3 / m3)	0.05	0.05	0.1	0.1	0.1	0.1
31.	Toxicity	dilution rate CL 50%					

(4) Surface water classification

Hungary has also developed a surface water classification scheme based on various defined uses of water (MI-1-172/3-85), specifically:

1) Classified water uses

- the overall biological quality of surface water;
- surface water abstracted for drinking water supply;
- industrial water supply;
- irrigation;
- fish farming;
- the integrated classification of surface waters;
- bathing waters.

2) Types of standard

For each water use two sets of standard are set:

- Desirable (D) standards relate to high quality waters;
- Acceptable (A) standards relate to waters that are moderately polluted but acceptable for the designated use.

Waters below the Acceptable (A) standards are highly polluted and the use of the water is significantly affected.

3) Monitoring

For each water use, three monitoring frequencies are stipulated:

- High frequency monitoring (at least 26 annual measurements) is required for those parameters most relevant to aquatic life and the use of the water as well as those close to the minimum standards;
- Low frequency monitoring (at least 1-4 times annually) is required for parameters which have concentration well below the desirable concentration and which change slowly with time;
- Occasional monitoring is applied under special monitoring programmes to check on parameters that are unlikely to be present in the water or for parameters for which no routine monitoring is feasible.

4) Operation of the classification scheme:

The classification scheme consists of three elements:

- an assessment of the quality of surface waters on the basis of monitoring data;
- an assessment of discharge data;
- analysis of the trends in water quality.

2.2 Present Situation of the Environment

2.2.1 Map Around Borsod Power Plant

Locations of Borsod Power Plant, coal ad limestone mines, and related facilities are shown in Figure 2.2.1.1.

Figure 2.2.1.1 Map Around Borsod Power Plant

2.2.2 Meteorological Data at Avas Observatory

Table 2.2.2.1 Frequency and Average Wind Velocity of Every Wind Direction (1991)

		CS	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	WNW	NNW	N	Total
Jan.	%	28.6	8.1	6.9	0.4	1.6	0.4	1.2	4.4	7.7	2.8	4.4	0.4	0.4	2.0	7.3	12.9	10.5	100
	m/s	0.0	5.0	5.9	1.0	1.0	1.0	1.3	1.3	2.1	2.9	2.5	1.0	1.0	2.0	2.4	1.9	2.0	1.9
Feb.	%	5.8	6.3	7.6	2.2	3.6	1.8	1.8	4.5	21.0	4.5	3.6	2.7	2.2	3.6	8.0	10.3	10.7	100
	m/s	0.0	3.3	2.8	3.6	2.0	1.3	1.5	2.1	2.9	1.8	2.4	1.8	3.0	2.5	1.4	2.3	2.0	2.3
Mar.	%	4.4	8.5	8.9	4.8	4.4	4.4	6.0	4.0	9.7	6.9	2.8	1.6	1.6	4.0	10.5	10.1	7.3	100
	m/s	0.0	4.6	5.5	1.6	1.7	2.2	1.7	2.5	3.0	3.2	1.6	1.3	1.5	1.8	1.8	2.4	2.3	2.6
Apr.	%	0.4	9.6	10.0	2.1	5.8	1.3	1.7	3.7	7.1	5.4	5.0	0.4	1.3	7.5	16.7	10.8	11.2	100
	m/s	0.0	3.0	4.0	3.4	3.1	2.7	2.2	1.7	2.4	3.4	2.2	2.0	3.0	2.6	2.6	2.6	2.4	2.8
May	%	*	15.7	9.3	4.8	3.2	3.2	2.0	0.8	10.5	3.6	4.8	0.8	2.8	2.4	11.7	13.3	10.9	100
	m/s	*	5.1	3.9	3.4	2.1	2.5	2.2	4.0	3.1	4.0	3.2	2.5	2.1	3.3	3.9	3.3	3.1	3.6
June	%	0.4	7.1	4.2	*	3.3	1.7	2.1	4.6	14.2	10.0	6.7	1.7	1.3	7.1	15.8	10.4	9.6	100
	m/s	0.0	2.9	2.4	*	1.8	2.2	2.0	1.9	3.3	3.1	2.6	1.8	1.3	2.3	3.9	3.6	2.5	2.9
July	%	0.4	11.3	11.3	5.6	2.0	0.4	2.4	1.6	3.2	2.8	2.8	1.2	2.4	6.0	13.3	11.7	21.4	100
	m/s	0.0	5.6	6.1	4.6	4.2	2.0	2.0	2.2	2.4	2.0	2.0	2.3	3.2	2.3	2.3	2.9	3.2	3.5
Aug.	%	*	5.2	4.8	4.8	2.0	1.2	2.4	4.0	5.6	1.2	3.2	1.6	3.2	7.7	20.6	19.8	12.5	100
	m/s	*	2.8	3.1	2.9	2.0	1.3	2.5	1.8	2.4	3.3	2.1	3.2	1.4	2.1	2.4	2.3	2.6	2.4
Sep.	%	*	2.1	3.7	2.9	3.7	1.3	4.2	3.3	11.7	10.0	9.2	2.1	3.3	7.5	17.5	12.5	5.0	100
	m/s	*	2.6	3.7	2.0	2.6	1.3	1.3	2.0	2.7	3.1	3.3	2.8	2.5	1.8	2.6	2.4	2.1	2.5
Oct.	%	0.8	5.2	7.3	3.6	2.0	4.8	6.5	6.5	8.5	4.8	6.5	1.6	2.0	4.0	15.7	10.9	9.3	100
	m/s	0.0	4.8	5.6	3.2	2.4	1.7	2.9	2.5	2.2	3.5	2.7	2.2	2.0	2.4	3.2	3.1	2.7	3.0
Nov.	%	1.7	2.9	6.7	1.7	1.3	2.5	5.0	9.2	18.8	8.3	5.0	0.8	2.1	5.4	9.6	7.9	11.2	100
	m/s	0.0	1.9	1.5	1.3	1.3	1.3	1.6	1.7	3.1	3.2	3.2	1.5	2.8	2.1	1.8	2.1	2.0	2.2
Dec.	%	3.2	9.3	4.0	1.2	2.4	3.2	4.4	7.3	10.5	6.5	4.0	*	1.6	2.8	10.1	13.7	15.7	100
	m/s	0.0	4.2	4.7	1.0	2.3	1.0	1.5	1.7	2.6	2.7	2.6	*	1.5	1.4	1.8	2.6	2.6	2.4
Total	%	3.8	7.6	7.1	2.9	2.9	2.2	3.3	4.5	10.6	5.5	4.8	1.2	2.0	5.0	13.1	12.1	11.3	100
	m/s	0.0	4.2	4.3	2.9	2.3	1.8	1.9	1.9	2.8	3.1	2.7	2.1	2.2	2.2	2.6	2.6	2.5	2.7

Table 2.2.2.2 Frequency and Average Wind Velocity of Every Wind Direction (1992)

		CS	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	WNW	NNW	N	Total
Jan.	%	12.5	5.6	6.9	1.2	2.8	2.8	2.4	8.1	9.3	3.2	4.4	1.6	2.0	2.0	8.5	11.7	14.9	100
	m/s	0.0	4.2	4.1	1.0	1.1	1.4	1.2	1.3	1.5	1.5	1.4	1.3	1.6	1.8	4.0	2.1	1.6	1.9
Feb.	%	2.2	4.3	9.1	3.0	0.9	1.7	6.9	10.8	12.9	4.3	4.7	3.4	3.9	5.2	12.9	7.8	6.0	100
	m/s	0.0	3.9	2.7	3.0	1.0	1.8	1.3	1.5	2.3	2.6	3.3	2.0	1.2	3.2	4.7	4.4	2.4	2.7
Mar.	%	0.8	3.2	3.6	1.6	4.4	2.0	6.5	6.0	12.9	6.9	10.1	3.2	3.2	4.4	18.5	4.8	7.7	100
	m/s	0.0	4.4	3.7	2.5	2.7	1.6	2.1	2.2	2.7	3.4	4.8	5.2	4.4	4.6	4.3	4.0	2.9	3.5
Apr.	%	0.4	5.4	9.2	4.2	6.3	2.5	3.3	4.6	10.4	3.7	10.4	1.7	2.1	4.6	13.3	6.3	11.7	100
	m/s	0.0	4.8	4.6	4.2	2.3	2.7	1.4	2.0	3.5	2.9	4.1	1.5	2.2	3.2	2.9	4.1	3.5	3.4
May	%	*	5.2	9.7	11.3	7.3	2.0	3.2	3.2	5.6	1.6	5.2	0.8	3.2	4.4	15.3	9.3	12.5	100
	m/s	*	3.9	5.1	4.7	4.0	5.2	3.0	3.1	3.0	2.2	2.5	2.5	2.2	2.4	2.2	2.5	2.6	3.3
June	%	*	5.8	13.8	8.3	6.3	5.0	7.1	4.2	5.4	2.5	3.3	1.3	1.3	3.7	11.2	7.9	12.9	100
	m/s	*	3.9	3.8	4.9	3.6	3.2	2.9	2.6	2.8	3.5	3.9	4.0	1.7	1.6	2.1	2.2	3.1	3.2
July	%	0.8	6.5	5.2	6.0	5.6	4.0	4.4	6.0	8.9	3.2	6.5	2.8	1.6	6.5	13.7	8.5	9.7	100
	m/s	0.0	3.4	4.0	3.7	2.7	1.9	2.4	2.0	2.5	2.7	3.2	1.9	1.5	1.9	2.1	2.0	2.1	2.5
Aug.	%	0.8	1.2	8.5	3.6	4.8	2.8	4.0	7.7	12.1	4.8	5.6	3.6	3.6	5.2	16.5	8.5	6.5	100
	m/s	0.0	2.3	2.4	1.9	2.5	2.1	1.6	2.0	3.0	3.5	2.9	3.1	2.3	3.0	1.9	2.6	1.8	2.4
Sep.	%	*	3.7	5.0	2.5	5.8	5.0	5.8	7.5	5.0	4.2	7.1	1.3	1.7	6.3	21.7	9.6	7.9	100
	m/s	*	2.8	2.8	2.3	2.5	1.9	1.8	2.0	2.3	2.5	3.1	3.3	2.2	2.2	4.3	4.2	2.3	3.0
Oct.	%	0.4	3.2	4.0	2.0	3.6	4.0	4.4	7.3	12.1	7.3	9.3	4.0	3.2	4.0	13.7	10.1	7.3	100
	m/s	0.0	2.0	2.3	1.6	2.1	2.1	1.8	1.3	2.8	2.7	2.7	1.5	2.7	3.5	4.7	2.2	1.7	2.6
Nov.	%	1.3	2.9	2.9	3.3	2.9	2.9	6.3	5.8	17.9	5.8	3.7	1.3	2.1	7.5	20.0	7.5	5.8	100
	m/s	0.0	2.0	1.9	1.4	1.3	1.4	1.3	2.2	2.7	2.4	1.7	1.0	1.2	3.2	3.7	3.2	2.2	2.5
Dec.	%	3.2	6.9	7.7	3.2	2.4	2.4	5.2	10.5	10.9	5.2	6.5	3.6	1.2	2.4	8.1	6.9	13.7	100
	m/s	0.0	2.5	5.1	1.4	2.2	1.2	1.2	2.0	2.7	3.2	2.2	1.0	1.0	1.2	2.8	2.1	1.8	2.3
Total	%	1.9	4.5	7.1	4.2	4.4	3.1	5.0	6.8	10.3	4.4	6.4	2.4	2.4	4.7	14.4	8.2	9.7	100
	m/s	0.0	3.5	3.7	3.5	2.6	2.2	1.8	1.9	2.7	2.8	3.2	2.3	2.2	2.7	3.4	2.9	2.3	2.8

Table 2.2.2.3 Frequency and Average Wind Velocity of Every Wind Direction (1993)

		CS	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	WNW	NNW	N	Total
Jan.	%	2.0	6.5	4.8	4.0	3.6	1.2	3.6	6.0	10.9	6.9	7.7	1.6	1.6	4.8	14.9	9.7	10.1	100
	m/s	0.0	2.7	4.2	1.8	1.8	2.3	1.4	1.7	2.3	3.6	2.7	1.8	2.2	4.0	7.6	3.6	2.0	3.3
Feb.	%	1.3	7.1	8.5	3.1	3.1	3.6	3.1	9.4	8.9	7.6	10.7	1.3	1.8	2.2	8.0	7.1	12.9	100
	m/s	0.0	5.6	3.1	3.1	2.0	2.2	1.4	1.4	2.0	3.5	3.7	2.3	2.2	1.4	1.8	2.8	2.0	2.6
Mar.	%	*	13.3	13.3	4.0	4.4	2.0	3.6	12.5	6.0	3.6	4.4	2.0	1.2	4.4	10.5	4.4	10.1	100
	m/s	*	6.2	5.6	4.4	2.6	2.6	1.4	1.8	1.9	2.1	2.5	1.8	1.0	2.1	4.3	2.2	2.6	3.4
Apr.	%	*	3.3	6.3	4.2	3.7	3.3	7.5	9.6	13.3	3.3	6.7	1.3	1.3	6.3	15.8	7.9	6.3	100
	m/s	*	5.6	4.6	2.1	2.9	3.4	2.6	2.2	3.0	2.7	2.2	1.3	1.7	3.1	2.3	2.2	2.0	2.7
May	%	*	4.4	10.1	3.2	7.3	6.9	5.2	2.4	2.4	4.0	3.6	1.6	3.2	6.9	23.4	6.0	9.3	100
	m/s	*	2.7	3.1	3.5	3.4	3.1	2.4	4.5	3.7	2.1	2.4	3.2	2.4	2.9	2.2	2.5	2.1	2.7
June	%	*	2.5	3.7	5.0	5.0	3.3	4.2	5.0	11.7	5.4	3.3	2.9	1.3	9.2	19.2	9.2	9.2	100
	m/s	*	2.8	2.6	4.3	2.9	2.4	2.3	2.2	2.6	3.5	2.7	2.7	4.7	3.5	4.7	3.5	2.0	3.3
July	%	0.4	5.6	3.6	2.8	0.8	0.4	3.6	7.7	8.5	6.5	6.0	1.6	2.4	7.3	19.4	14.1	9.3	100
	m/s	0.0	2.1	2.7	2.3	2.0	3.0	1.4	2.2	2.8	3.8	2.1	1.8	2.2	2.6	4.3	4.1	2.9	3.1
Aug.	%	0.8	6.5	6.5	4.8	4.4	2.4	7.3	9.3	16.1	2.8	4.4	*	0.4	4.0	10.5	12.1	7.7	100
	m/s	0.0	2.7	3.7	2.6	2.2	2.8	2.4	2.3	2.7	2.1	2.5	*	3.0	1.9	2.2	2.3	1.9	2.5
Sep.	%	0.8	3.7	4.6	2.9	2.1	2.1	3.3	4.2	14.6	9.6	7.1	1.7	7.1	7.5	15.8	5.4	7.5	100
	m/s	0.0	2.9	3.5	3.7	2.0	1.6	2.1	2.3	3.0	3.3	2.6	2.5	2.0	2.6	2.3	2.0	2.4	2.6
Oct.	%	3.2	1.6	6.5	4.0	4.0	2.0	5.2	10.9	17.7	6.5	7.3	1.6	1.6	4.4	6.9	10.1	6.5	100
	m/s	0.0	4.5	4.0	2.4	2.1	2.0	1.6	2.4	2.3	3.7	2.8	3.0	1.8	2.7	2.1	1.8	1.7	2.4
Nov.	%	5.8	12.1	6.3	3.3	2.9	2.9	7.1	5.0	11.7	4.2	2.1	0.4	0.4	2.9	11.2	7.9	13.8	100
	m/s	0.0	3.0	3.3	1.9	1.4	3.0	2.3	1.6	2.1	1.8	2.0	1.0	1.0	1.7	1.8	1.8	1.8	2.0
Dec.	%	2.4	1.6	0.8	0.4	1.2	1.6	5.2	7.3	21.4	14.5	7.7	2.8	2.0	6.5	14.9	4.4	5.2	100
	m/s	0.0	3.0	1.0	1.0	1.7	1.5	1.2	1.6	3.1	4.0	2.9	4.3	2.8	4.7	4.9	2.6	2.5	3.2
Total	%	1.4	5.7	6.2	3.5	3.6	2.6	4.9	7.4	12.0	6.2	5.9	1.6	2.0	5.5	14.2	8.2	8.9	100
	m/s	0.0	3.9	3.8	2.9	2.5	2.6	2.0	2.1	2.6	3.3	2.7	2.6	2.2	3.0	3.5	2.8	2.1	2.8

Table 2.2.2.4 Frequency and Average Wind Velocity of Every Wind Direction (1994)

		CS	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	WNW	NNW	N	Total
Jan.	%	0.8	2.8	1.6	2.0	3.6	1.2	1.6	5.2	18.5	10.5	8.5	1.2	2.4	4.4	15.3	8.9	11.3	100
	m/s	0.0	1.3	2.7	1.4	1.8	1.3	1.3	1.8	3.3	4.4	2.8	3.0	2.2	2.2	5.1	2.2	2.5	3.1
Feb.	%	7.1	7.1	13.4	1.3	3.1	2.2	2.7	7.6	13.8	3.6	2.2	*	1.8	2.2	5.4	12.1	14.3	100
	m/s	0.0	2.7	3.7	3.7	1.3	2.8	1.2	1.9	2.1	1.5	1.6	*	1.0	1.2	2.2	1.8	1.7	2.0
Mar.	%	2.0	1.2	3.6	2.8	2.0	2.0	2.4	5.2	12.9	8.1	7.7	2.0	3.2	12.5	23.8	3.6	4.8	100
	m/s	0.0	1.3	3.1	2.9	1.4	2.6	2.5	2.7	2.7	4.0	3.9	5.0	2.4	5.2	6.2	4.2	1.8	4.0
Apr.	%	1.7	5.0	6.7	2.1	3.7	2.9	7.1	7.5	15.8	9.6	4.6	1.3	2.9	4.6	10.4	7.9	6.3	100
	m/s	0.0	3.7	2.6	3.0	2.2	2.0	2.5	2.7	3.4	3.2	3.3	2.0	2.7	2.0	2.1	2.5	2.3	2.7
May	%	2.0	3.6	6.0	5.6	3.2	2.8	4.8	6.9	12.5	7.7	6.0	0.8	2.4	6.9	12.5	5.6	10.5	100
	m/s	0.0	3.4	4.0	4.5	2.1	2.9	1.8	2.5	3.0	2.8	3.0	4.0	2.2	2.5	3.2	2.5	2.3	2.8
June	%	0.8	7.5	11.2	3.7	3.7	0.4	2.5	3.7	6.7	3.3	5.4	0.4	3.3	7.5	17.5	11.2	10.8	100
	m/s	0.0	2.4	4.6	3.7	2.8	2.0	2.3	2.1	2.1	3.4	2.8	1.0	2.1	2.9	3.3	3.7	2.5	3.1
July	%	*	7.7	10.9	4.8	4.4	4.4	4.8	6.9	3.6	0.4	1.6	*	1.2	9.3	18.5	11.7	9.7	100
	m/s	*	2.9	4.4	4.1	2.6	3.0	3.4	2.2	2.2	2.0	2.2	*	2.0	2.7	2.3	2.2	2.3	2.8
Aug.	%	2.4	6.0	6.0	2.8	1.2	0.8	4.0	6.0	9.3	3.2	4.4	0.8	4.0	10.5	21.8	10.9	5.6	100
	m/s	0.0	2.8	2.2	1.4	2.0	1.0	2.4	2.2	2.5	1.9	2.2	3.0	2.2	3.8	4.2	2.3	1.7	2.8
Sep.	%	4.2	2.9	2.5	2.9	2.9	0.4	5.0	7.1	12.1	8.3	5.4	2.9	5.0	5.8	15.8	6.7	10.0	100
	m/s	0.0	1.4	2.0	1.6	1.3	1.0	1.6	1.8	2.8	2.7	2.3	2.3	2.5	2.9	1.9	2.1	1.5	2.0
Oct.	%	3.6	6.0	6.9	4.8	2.4	3.2	6.0	6.9	8.5	4.0	5.2	2.0	4.8	12.1	9.3	8.1	6.0	100
	m/s	0.0	3.6	4.0	3.1	2.2	3.0	1.9	1.9	2.4	4.5	2.2	2.0	1.3	2.1	2.4	1.7	1.7	2.4
Nov.	%	7.5	8.8	3.7	2.5	3.7	2.1	5.4	7.5	10.8	5.8	3.3	0.8	2.5	6.7	8.3	10.4	10.0	100
	m/s	0.0	2.8	2.7	1.3	1.3	1.6	1.5	1.7	2.1	2.1	2.5	1.5	1.5	1.7	2.9	2.2	1.9	1.9
Dec.	%	6.5	5.2	2.8	1.2	2.4	2.0	8.9	11.7	10.9	5.2	2.4	0.8	1.2	4.8	12.9	11.3	9.7	100
	m/s	0.0	3.8	2.6	2.0	1.2	1.0	1.7	1.7	2.0	3.4	1.8	1.0	3.3	3.8	4.3	2.4	2.1	2.4
Total	%	3.2	5.3	6.2	3.1	3.0	2.1	4.6	6.8	11.3	5.8	4.8	1.1	2.9	7.3	14.4	9.0	9.0	100
	m/s	0.0	2.9	3.6	3.0	1.9	2.3	2.1	2.1	2.7	3.2	2.7	2.7	2.1	3.0	3.6	2.4	2.0	2.7

Table 2.2.2.5 Frequency and Average Wind Velocity of Every Wind Direction (1995)

		CS	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	WNW	NNW	N	Total
Jan.	%	6.5	8.5	4.8	3.6	4.0	2.4	7.3	8.9	13.3	8.9	2.8	1.2	2.4	4.4	10.9	4.8	5.2	100
	m/s	0.0	4.1	2.5	1.3	1.9	1.2	1.5	1.6	3.3	4.2	2.6	2.7	3.2	4.5	3.8	1.9	1.6	2.7
Feb.	%	*	1.8	4.5	1.8	2.7	1.8	4.0	7.6	22.3	13.8	5.8	3.1	6.3	7.1	6.3	6.3	4.9	100
	m/s	*	1.5	2.1	2.2	2.0	1.8	1.4	2.2	2.7	3.7	3.0	3.7	3.5	2.7	2.7	2.4	2.2	2.7
Mar.	%	2.0	9.3	3.6	2.4	2.8	3.2	2.0	4.8	15.3	11.7	3.2	3.2	2.8	4.8	10.1	6.9	11.7	100
	m/s	0.0	5.2	3.8	2.7	3.0	3.1	4.0	2.1	3.2	3.6	3.2	4.1	1.9	5.7	5.2	3.1	3.9	3.7
Apr.	%	0.8	1.7	4.2	3.7	3.7	4.2	4.6	3.7	12.5	8.3	1.7	1.3	5.0	17.1	14.2	6.7	6.7	100
	m/s	0.0	3.7	1.9	2.7	2.3	3.1	2.5	2.9	3.4	3.5	2.2	1.7	3.2	4.9	4.6	2.1	3.1	3.5
May	%	1.2	9.3	8.5	4.0	3.2	2.8	3.2	4.0	12.1	8.1	1.6	0.8	5.2	8.9	11.7	6.0	9.3	100
	m/s	0.0	4.9	5.3	3.3	2.1	1.9	1.8	2.3	3.1	3.0	1.8	3.5	2.2	2.5	2.3	2.2	2.8	3.0
June	%	2.5	3.7	2.5	1.7	2.9	2.1	5.4	8.3	10.8	5.8	3.3	*	2.9	10.0	14.6	9.2	14.2	100
	m/s	0.0	3.7	2.2	3.2	1.3	1.6	2.2	2.5	2.5	3.0	3.4	*	1.7	1.9	2.3	2.4	2.0	2.3
July	%	*	7.7	7.7	7.7	4.0	2.8	2.0	2.4	5.6	2.0	2.0	1.6	5.6	14.1	11.7	12.9	10.1	100
	m/s	*	2.6	3.4	3.1	2.8	3.0	2.0	1.5	2.7	1.4	2.6	1.5	2.6	1.9	2.2	2.2	2.7	2.5
Aug.	%	4.4	6.9	2.4	2.0	3.6	2.4	4.0	4.4	4.8	2.4	1.6	0.8	5.6	14.5	20.6	8.9	10.5	100
	m/s	0.0	2.9	2.5	3.2	2.0	2.3	3.1	2.2	2.3	2.3	1.5	3.5	1.7	2.4	2.5	2.3	2.5	2.3
Sep.	%	3.3	2.9	2.1	1.7	4.2	1.3	3.7	5.8	14.2	10.4	3.3	2.1	5.8	17.1	13.8	3.7	4.6	100
	m/s	0.0	1.6	1.8	1.8	1.5	1.0	1.6	2.1	2.5	3.1	2.4	2.4	1.9	2.8	2.2	1.7	1.9	2.2
Oct.	%	3.2	2.8	2.8	1.6	4.0	2.4	9.3	8.1	8.5	5.6	1.6	3.2	10.5	14.1	10.1	5.6	6.5	100
	m/s	0.0	1.7	2.1	3.5	1.3	1.2	1.9	2.1	1.8	2.1	1.0	2.1	1.3	2.2	2.1	1.7	1.6	1.8
Nov.	%	4.2	10.0	4.2	4.6	1.3	1.7	8.3	2.9	10.4	6.3	2.1	1.3	3.3	8.8	8.3	10.0	12.5	100
	m/s	0.0	4.3	2.4	1.5	1.7	2.0	1.5	2.1	2.5	3.6	2.8	2.0	2.7	3.0	1.8	2.2	4.0	2.6
Dec.	%	2.8	10.1	3.6	2.8	2.4	6.0	7.7	11.3	6.0	4.8	1.2	*	1.2	1.2	8.9	12.1	17.7	100
	m/s	0.0	3.0	2.6	1.7	1.5	1.6	1.8	1.4	2.9	2.8	1.0	*	1.3	1.3	1.7	2.1	2.6	2.1
Total	%	2.6	6.3	4.2	3.2	3.3	2.8	5.1	6.0	11.2	7.3	2.5	1.5	4.7	10.2	11.8	7.8	9.5	100
	m/s	0.0	3.7	3.0	2.5	2.0	2.1	1.9	2.0	2.8	3.3	2.5	2.8	2.2	2.9	2.8	2.2	2.7	2.6

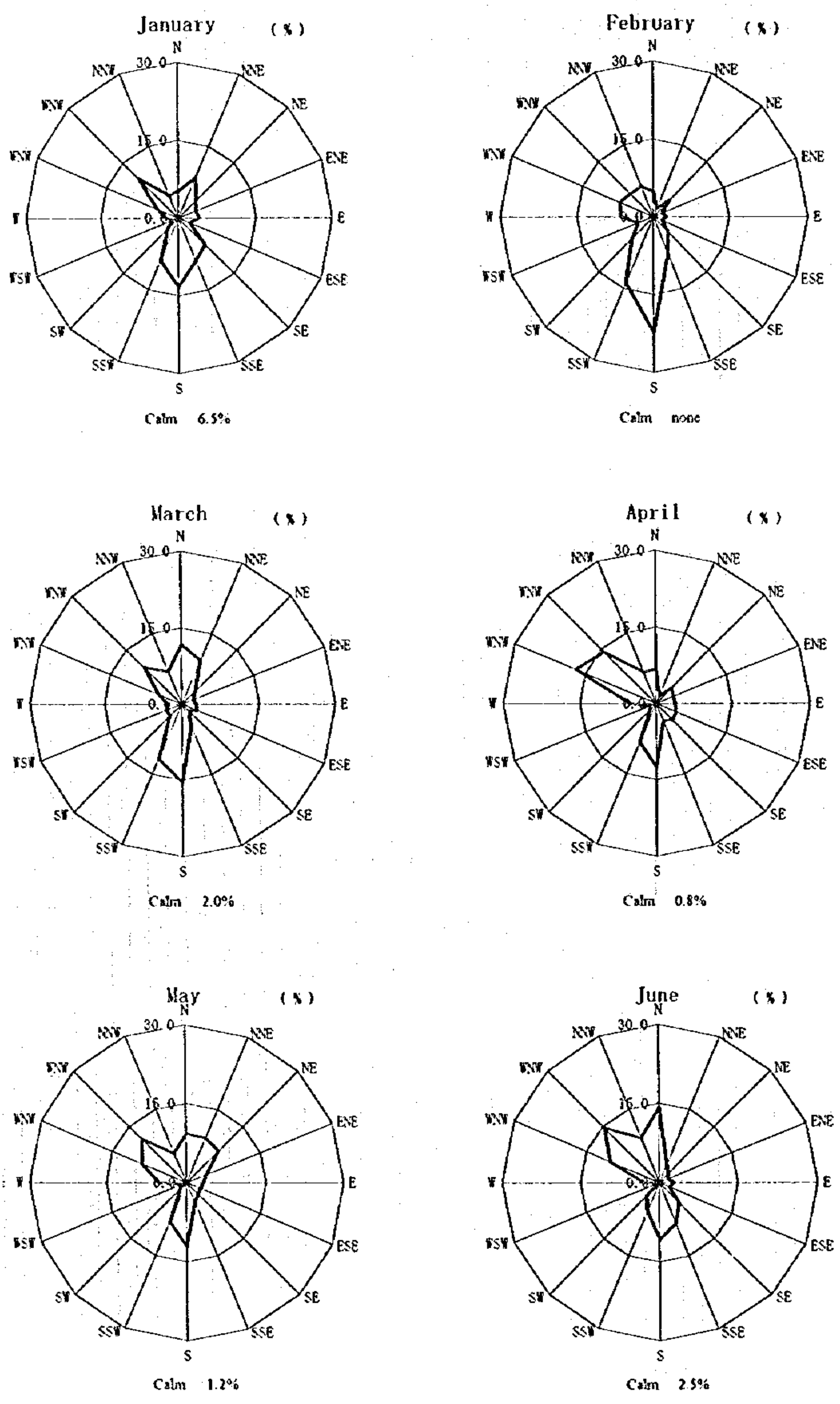

Figure 2.2.2.1 (1) Monthly Wind Rose in 1995

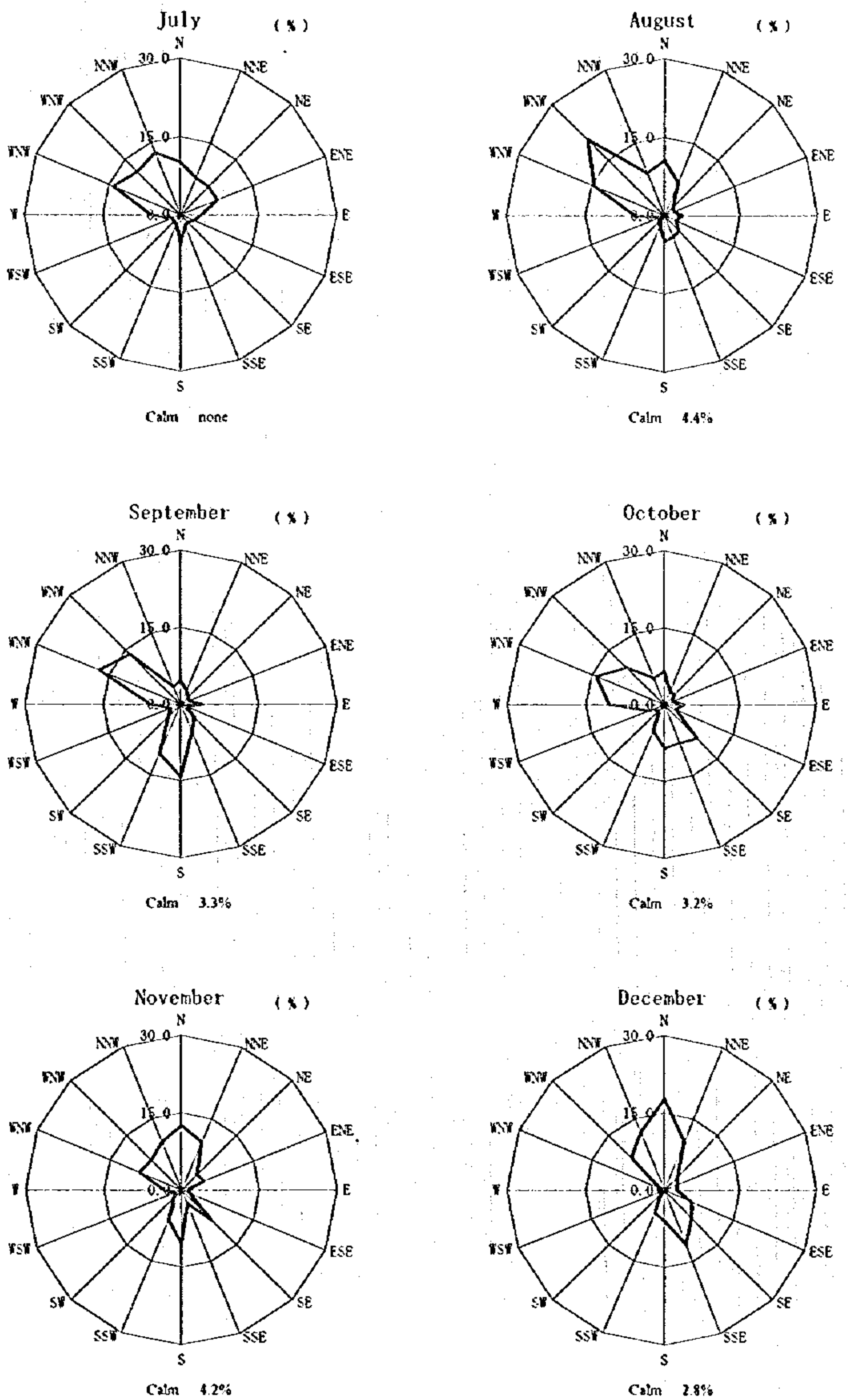

Figure 2.2.2.1 (2) Monthly Wind Rose in 1995

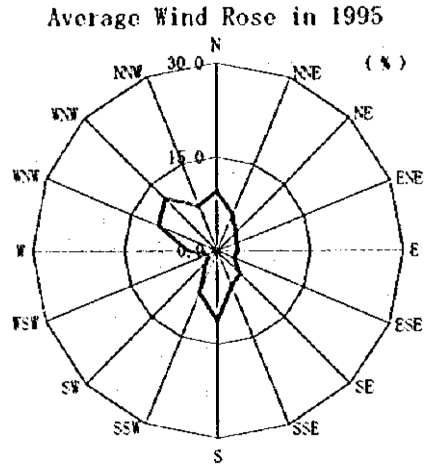

Figure 2.2.2.2 Average Wind Rose in 1995

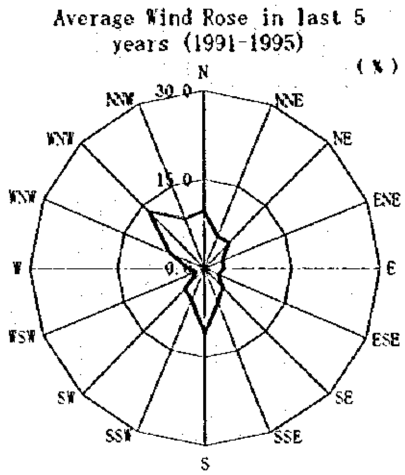

Figure 2.2.2.3 Average Wind Rose in last 5 years (1991-1995)

Table 2.2.2.6 Monthly Average Wind Velocity

MISKOLK (Avas Observatory) (m/sec)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1991	1.9	2.3	2.6	2.8	3.6	2.9	3.5	2.4	2.5	3	2.2	2.4
1992	1.9	2.7	3.5	3.4	3.3	3.2	2.5	2.4	3	2.6	2.5	2.3
1993	3.3	2.6	3.4	2.7	2.7	3.3	3.1	2.5	2.6	2.4	2	3.2
1994	3.1	2	4	2.7	2.8	3.1	2.8	2.8	2	2.4	1.9	2.4
1995	2.7	2.7	3.7	3.5	3	2.3	2.5	2.3	2.2	1.8	2.6	2.1

JM1 (m/sec)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1993					2.4	2.8	2.7	2.2	2.3	1.8	1.6	2.4
1994	2.4	2	3.8	2.7	2.5	***	***	***	***	***	1.9	1.8
1995	2.3	2.3	3.2	3.3	2.6	2.0	2.1	2.3	2.2	1.8	2.2	1.6
1996	1.3	***										

EC2 (m/sec)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1993												
1994						2.1	2.1	1.9	1.4	1.2	0.8	0.9
1995	1	1.3	1.8	2.3	2	0.9	1.2	1.5	1.1	0.9	1.4	0.9
1996	1.0	1.1										

Table 2.2.2.7 Monthly Maximum Instantaneous Wind Velocity in last 10 years (1986-1995)

(m/sec)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Min.	Max.
1986	20.4	11.9	10.1	12.2	11.0	10.1	9.4	11.1	10.0	11.7	11.1	14.0	11.9	9.4	20.4
1987	11.4	9.0	12.8	12.8	17.8	12.3	10.2	11.2	10.3	8.5	9.5	11.1	11.4	8.5	17.8
1988	7.6	14.5	12.6	14.0	12.8	7.2	8.0	15.9	13.0	9.0	19.4	19.2	12.8	7.2	19.4
1989	6.3	14.6	11.0	13.3	15.6	11.4	11.4	10.8	8.6	10.0	12.8	12.2	11.5	6.3	15.6
1990	9.0	14.5	20.9	15.3	12.0	16.2	26.5	16.3	21.6	21.4	29.3	17.0	18.3	9.0	29.3
1991	17.6	18.6	20.8	15.7	20.8	16.9	19.0	15.3	15.2	21.6	14.6	20.1	18.0	14.6	21.6
1992	24.2	23.0	24.6	18.1	26.0	19.6	19.1	18.8	23.9	24.2	21.5	19.3	21.9	18.1	26.0
1993	34.3	21.1	23.7	20.4	28.0	18.5	17.4	14.1	16.2	23.8	15.9	26.0	21.6	14.1	34.3
1994	20.2	14.6	40.0	16.7	21.6	16.2	14.9	17.9	13.7	17.4	17.1	20.9	19.3	13.7	40.0
1995	20.0	15.8	20.4	20.6	17.1	20.8	15.0	14.3	14.1	13.3	19.0	16.6	17.3	13.3	20.8
Ave.	17.1	15.8	19.7	15.9	18.3	14.9	15.1	14.6	14.7	16.1	17.0	17.6	16.4	14.6	19.7
Min.	6.3	9.0	10.1	12.2	11.0	7.2	8.0	10.8	8.6	8.5	9.5	11.1	9.4	6.3	12.2
Max.	34.3	23.0	40.0	20.6	28.0	20.8	26.5	18.8	23.9	24.2	29.3	26.0	26.3	18.8	40.0

Table 2.2.2.8 Monthly Average Wind Velocity in last 5 years (1991-1995)

(m/sec)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Min.	Max.
1991	1.9	2.3	2.6	2.8	3.6	2.9	3.5	2.4	2.5	3.0	2.2	2.4	2.7	1.9	3.6
1992	1.9	2.7	3.5	3.4	3.3	3.2	2.5	2.4	3.0	2.6	2.5	2.3	2.8	1.9	3.5
1993	3.3	2.6	3.4	2.7	2.7	3.3	3.1	2.5	2.6	2.4	2.0	3.2	2.8	2.0	3.4
1994	3.1	2.0	4.0	2.7	2.8	3.1	2.8	2.8	2.0	2.4	1.9	2.4	2.7	1.9	4.0
1995	2.7	2.7	3.7	3.5	3.0	2.3	2.5	2.3	2.2	1.8	2.6	2.1	2.6	1.8	3.7
Ave.	2.6	2.5	3.4	3.0	3.1	3.0	2.9	2.5	2.5	2.4	2.2	2.5	2.7	2.2	3.4
Min.	1.9	2.0	2.6	2.7	2.7	2.3	2.5	2.3	2.0	1.8	1.9	2.1	2.2	1.8	2.7
Max.	3.3	2.7	4.0	3.5	3.6	3.3	3.5	2.8	3.0	3.0	2.6	3.2	3.2	2.6	4.0

Table 2.2.2.9 Monthly Average Atmospheric Temperature in last 10 years (1986-1995)

(oC)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Min.	Max.
1986	-1.4	-4.4	3.2	12.3	17.0	18.3	19.6	20.7	15.4	8.8	2.8	-3.3	9.1	-4.4	20.7
1987	-6.9	-1.8	-0.6	10.3	13.9	19.0	22.0	17.7	17.0	9.9	4.6	-0.6	8.7	-6.9	22.0
1988	1.3	1.8	3.7	9.8	15.8	17.4	21.1	19.2	14.9	8.1	-2.1	-0.1	9.2	-2.1	21.1
1989	-2.1	2.3	7.0	12.1	15.0	16.5	19.7	19.1	15.3	9.0	2.5	-0.8	9.6	-2.1	19.7
1990	-1.4	2.9	8.0	9.6	15.2	17.8	19.7	20.5	13.7	9.9	5.0	-0.6	10.0	-1.4	20.5
1991	-1.4	-3.3	6.3	8.8	12.3	18.0	21.1	19.4	16.5	9.0	4.6	-3.8	9.0	-3.8	21.1
1992	-2.6	0.7	5.0	11.0	15.0	19.3	21.3	24.8	15.4	8.9	4.3	-1.3	10.2	-2.6	24.8
1993	-1.3	-2.5	3.0	10.1	18.2	19.1	19.3	20.5	15.0	11.0	1.0	2.0	9.6	-2.5	20.5
1994	2.2	-0.2	7.6	10.5	14.9	19.1	23.2	21.5	18.5	8.4	4.0	-0.1	10.8	-0.2	23.2
1995	-2.1	4.0	4.8	10.0	14.5	17.9	22.6	19.7	14.3	11.4	1.0	-1.2	9.7	-2.1	22.6
Ave.	-1.6	-0.1	4.8	10.5	15.2	18.2	21.0	20.3	15.6	9.4	2.8	-1.0	9.6	-1.6	21.0
Min.	-6.9	-4.4	-0.6	8.8	12.3	16.5	19.3	17.7	13.7	8.1	-2.1	-3.8	6.6	-6.9	19.3
Max.	2.2	4.0	8.0	12.3	18.2	19.3	23.2	24.8	18.5	11.4	5.0	2.0	12.4	2.0	24.8

Table 2.2.2.10 Monthly Minimum Atmospheric Temperature in last 10 years (1986-1995)

(oC)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Min.	Max.
1986	-13.9	-19.8	-16.6	-1.9	4.6	5.9	6.8	5.0	0.8	-2.6	-6.0	-19.1	-4.7	-19.8	6.8
1987	-26.9	-24.0	-16.0	-2.4	0.2	6.0	8.5	5.8	2.1	-6.3	-6.0	-12.0	-5.9	-26.9	8.5
1988	-5.1	-7.2	-7.5	-2.5	2.8	6.7	8.3	6.1	6.5	-6.6	-15.5	-13.4	-2.3	-15.5	8.3
1989	-13.8	-6.7	-3.0	1.4	4.2	6.0	8.1	7.2	3.0	-0.9	-12.2	-15.0	-1.8	-15.0	8.1
1990	-13.0	-7.7	-6.5	-4.2	1.1	3.8	10.5	9.5	5.4	-3.0	-2.5	-8.5	-1.3	-13.0	10.5
1991	-14.0	-15.2	-4.5	-0.6	3.2	8.7	12.0	9.5	3.9	-4.5	-4.1	-13.4	-1.6	-15.2	12.0
1992	-11.2	-7.1	-2.6	-0.2	5.5	11.6	11.2	12.6	6.6	-1.0	-3.5	-13.0	0.7	-13.0	12.6
1993	-14.0	-11.1	-3.9	-2.2	9.4	7.8	8.9	8.3	2.9	0.1	-10.8	-3.2	-0.7	-14.0	9.4
1994	-5.5	-11.2	-1.3	1.0	3.5	9.1	12.7	12.5	7.4	-2.4	-2.9	-9.4	1.1	-11.2	12.7
1995	-10.8	-3.2	-1.7	-1.7	3.2	10.4	14.3	9.0	3.2	-0.4	-9.0	-13.2	0.0	-13.2	14.3
Ave.	-12.8	-11.3	-6.4	-1.3	3.8	7.6	10.1	8.6	4.2	-2.8	-7.3	-12.0	-1.6	-12.8	10.1
Min.	-26.9	-24.0	-16.6	-4.2	0.2	3.8	6.8	5.0	0.8	-6.6	-15.5	-19.1	-8.0	-26.9	6.8
Max.	-5.1	-3.2	-1.3	1.4	9.4	11.6	14.3	12.6	7.4	0.1	-2.5	-3.2	3.5	-5.1	14.3

Table 2.2.2.11 Monthly Maximum Atmospheric Temperature in last 10 years (1986-1995)

(oC)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Min.	Max.
1986	9.8	6.6	20.6	27.9	27.0	32.3	31.8	32.4	29.6	25.2	13.4	9.5	22.2	6.6	32.4
1987	10.0	11.0	15.8	22.6	25.8	32.2	35.8	29.8	32.6	23.0	12.2	13.1	22.0	10.0	35.8
1988	8.0	11.4	15.0	22.6	26.1	28.0	34.3	34.2	26.2	21.9	10.2	11.6	20.8	8.0	34.3
1989	3.8	16.4	24.3	25.4	27.0	27.7	32.8	32.2	27.6	19.8	16.4	16.6	22.5	3.8	32.8
1990	10.4	18.5	23.6	20.9	27.4	31.1	32.9	32.9	30.8	22.1	14.4	4.8	22.5	4.8	32.9
1991	7.1	6.8	21.9	19.0	22.1	32.0	32.4	30.8	29.1	24.1	10.0	5.7	20.1	5.7	32.4
1992	4.8	9.3	15.4	25.7	26.7	29.6	32.1	36.2	28.2	22.2	13.9	8.6	21.1	4.8	36.2
1993	14.5	6.2	19.4	24.9	28.4	31.2	31.2	34.3	27.8	24.0	13.8	13.1	22.4	6.2	34.3
1994	9.4	11.0	19.0	23.0	29.2	33.8	35.5	35.0	30.4	23.4	14.6	12.6	23.1	9.4	35.5
1995	11.6	12.0	14.1	25.6	28.1	28.5	32.3	30.3	26.3	23.6	12.8	12.6	21.5	11.6	32.3
Ave.	8.9	10.9	18.9	23.8	26.8	30.6	33.1	32.8	28.9	22.9	13.2	10.8	21.8	8.9	33.1
Min.	3.8	6.2	14.1	19.0	22.1	27.7	31.2	29.8	26.2	19.8	10.0	4.8	17.9	3.8	31.2
Max.	14.5	18.5	24.3	27.9	29.2	33.8	35.8	36.2	32.6	25.2	16.4	16.6	25.9	14.5	36.2

Table 2.2.2.12 Monthly Relative Humidity in last 10 years (1986-1995)

(%)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Min.	Max.
1986	87.0	84.0	83.0	68.0	71.0	72.0	69.0	70.0	68.0	75.0	87.0	91.0	77.1	68.0	91.0
1987	84.0	86.0	75.0	67.0	70.0	68.0	66.0	71.0	73.0	79.0	88.0	89.0	76.3	66.0	89.0
1988	93.0	83.0	77.0	69.0	72.0	74.0	70.0	74.0	80.0	79.0	82.0	86.0	78.3	69.0	93.0
1989	92.0	86.0	75.0	70.0	69.0	79.0	70.0	79.0	80.0	86.0	85.0	86.0	79.8	69.0	92.0
1990	90.0	83.0	67.0	68.0	65.0	64.0	60.0	56.0	66.0	72.0	86.0	84.0	71.8	56.0	90.0
1991	84.0	81.0	74.0	66.0	70.0	69.0	68.0	73.0	70.0	76.0	86.0	87.0	75.3	66.0	87.0
1992	82.0	73.0	63.0	58.0	58.0	61.0	57.0	52.0	56.0	72.0	80.0	86.0	66.5	52.0	86.0
1993	77.0	81.0	73.0	66.0	61.0	60.0	64.0	63.0	69.0	79.0	83.0	83.0	71.6	60.0	83.0
1994	83.0	84.0	63.0	71.0	68.0	60.0	55.0	60.0	70.0	75.0	77.0	82.0	70.7	55.0	84.0
1995	81.0	73.0	68.0	63.0	63.0	70.0	58.0	60.0	72.0	71.0	80.0	86.0	70.4	58.0	86.0
Ave.	85.3	81.4	71.8	66.6	66.7	67.7	63.7	65.8	70.4	76.4	83.4	86.0	73.8	63.7	86.0
Min.	77.0	73.0	63.0	58.0	58.0	60.0	55.0	52.0	56.0	71.0	77.0	82.0	65.2	52.0	82.0
Max.	93.0	86.0	83.0	71.0	72.0	79.0	70.0	79.0	80.0	86.0	88.0	91.0	81.5	70.0	93.0

Table 2.2.2.13 Monthly Precipitation in last 10 years (1986-1995)

(mm)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Min.	Max.
1986	37.7	41.3	13.0	21.1	48.9	64.7	29.9	40.6	0.5	12.0	5.8	18.8	27.9	0.5	64.7
1987	58.6	14.1	65.8	43.0	48.7	86.0	29.0	15.3	24.5	19.8	43.1	26.3	39.5	14.1	86.0
1988	36.7	35.7	36.6	21.7	46.4	63.0	34.8	160.9	57.1	7.0	11.9	34.7	45.5	7.0	160.9
1989	8.5	31.6	28.1	78.9	66.1	153.2	86.0	58.0	19.6	15.9	39.8	4.8	49.2	4.8	153.2
1990	5.3	26.7	10.5	66.0	43.9	52.6	62.1	27.8	46.8	63.7	36.6	33.0	39.6	5.3	66.0
1991	2.3	56.1	6.7	76.4	52.6	48.4	143.7	26.8	9.4	103.3	73.5	23.1	51.9	2.3	143.7
1992	6.3	5.2	21.1	32.9	16.0	71.9	53.8	6.0	31.1	64.3	33.9	20.9	30.3	5.2	71.9
1993	3.3	5.7	26.6	26.3	22.8	52.2	49.0	21.4	27.5	67.6	31.5	30.6	30.4	3.3	67.6
1994	15.2	18.5	8.2	87.4	55.3	32.4	28.1	67.8	33.5	44.4	13.9	8.4	34.4	8.2	87.4
1995	12.1	44.1	28.6	67.0	37.1	178.1	37.8	112.7	72.9	1.1	27.1	30.0	54.1	1.1	178.1
Ave.	18.6	27.9	24.5	52.1	43.8	80.3	55.4	53.7	32.3	39.9	31.7	23.1	40.3	18.6	80.3
Min.	2.3	5.2	6.7	21.1	16.0	32.4	28.1	6.0	0.5	1.1	5.8	4.8	10.8	0.5	32.4
Max.	58.6	56.1	65.8	87.4	66.1	178.1	143.7	160.9	72.9	103.3	73.5	34.7	91.8	34.7	178.1

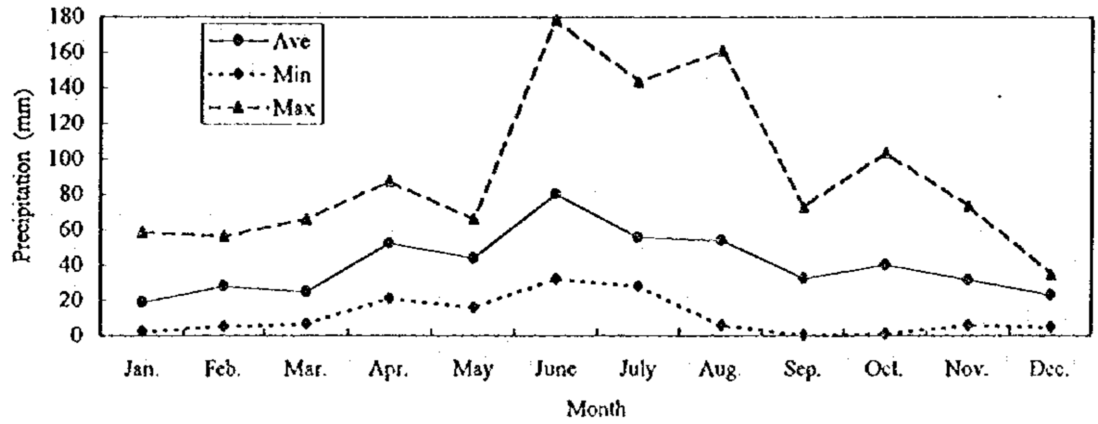

Figure 2.2.2.4 Average, Maximum and Minimum Values of Monthly Precipitation in last 10 years (1986-1995)

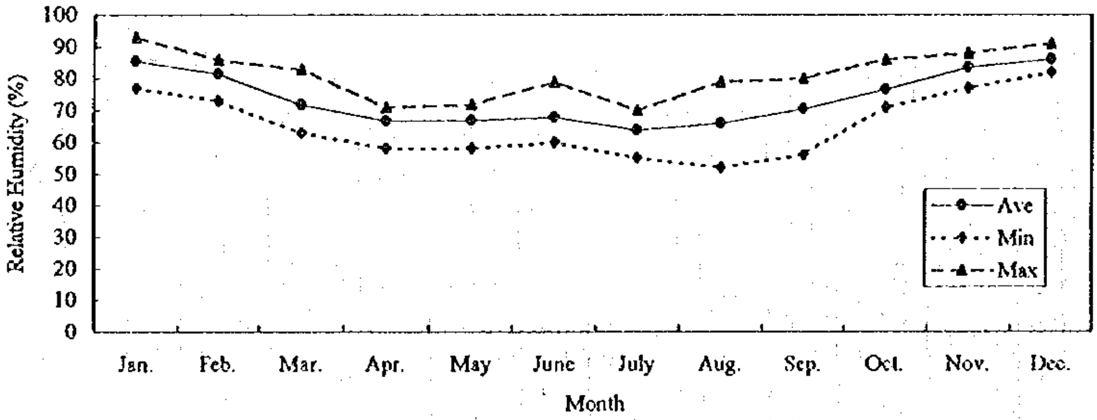

Figure 2.2.2.5 Average, Maximum and Minimum Values of Monthly Relative Humidity in last 10 years (1986-1995)

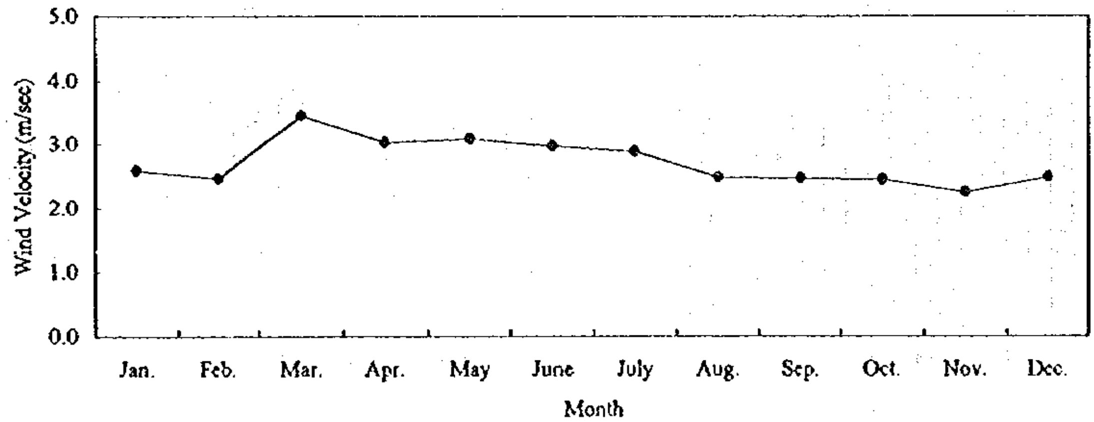

Figure 2.2.2.6 Monthly Average Wind Velocity in last 5 years (1991-1995)

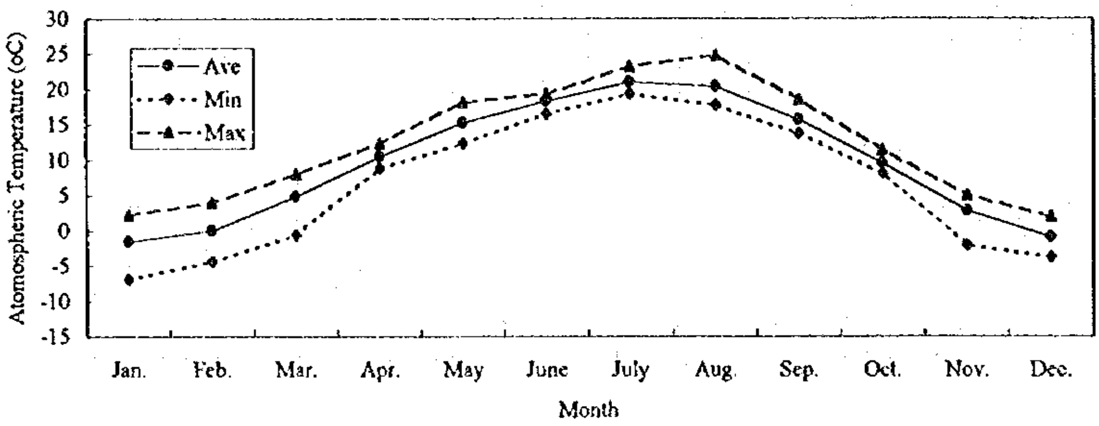

Figure 2.2.2.7 Average, Maximum and Minimum Values of Monthly Average Atomospheric Temperature in last 10 years (1986-1995)

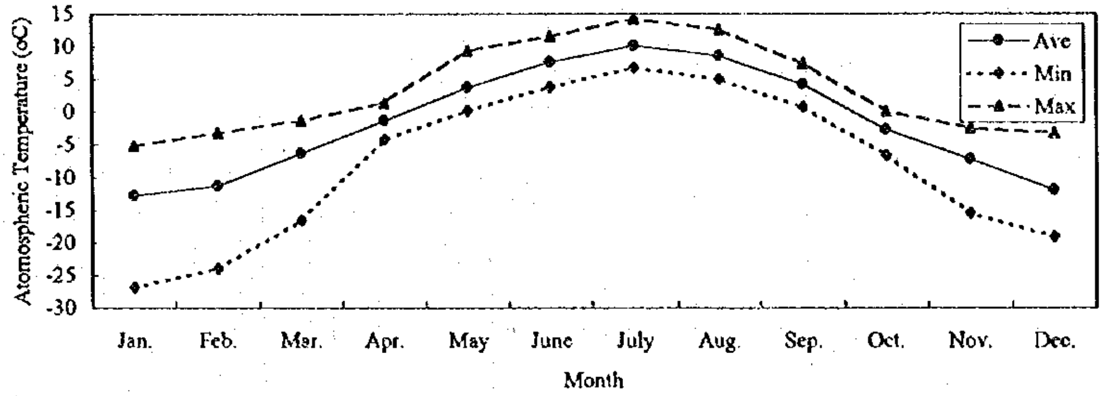

Figure 2.2.2.8 Average, Maximum and Minimum Values of Monthly Minimum Atomospheric Temperature in last 10 years (1986-1995)

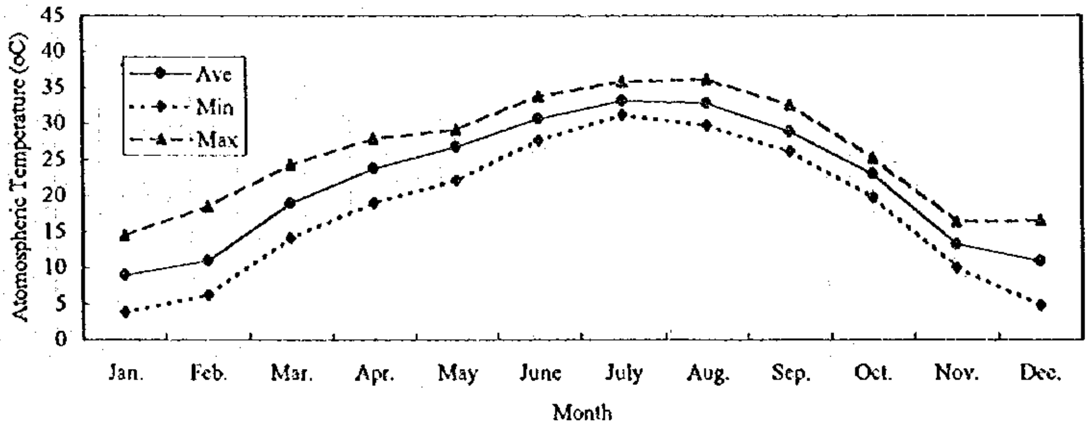

Figure 2.2.2.9 Average, Maximum and Minimum Values of Monthly Maximum Atomospheric Temperature in last 10 years (1986-1995)