(3) Air pollution and control conditions in Mendoza province

Inspection of atmospheric environment in Mendoza province is performed by the measuring plants in 11 places arranged in the areas centering around Gran Mendoza conforming to the environmental control plan of province.
In this area, in the south side of capital, the steelworks, petroleum refining plants, metal works, thermal power plants, etc. and in the north side, the large scale fixed discharge sources such as cement works, etc. are located so as to sandwich the capital of overpopulation area where is in the geographical feature of basin type.
This area is also the geographical important position of traffic, so that the traffic of large scale vehicles is heavy.
The current conditions and problems and the countermeasures of atmospheric environment in Mendoza province are shown below. These are divided in two category 1) moving sources and 2) the fixed sources.

(a) Air pollution due to moving sources (Vehicles)

1) Areas to be problem
   Gran Mendoza, in particular, central portion
2) Type of contamination
   - Suspended particle type substances
   - Often smog formation is observed under specific weather condition
3) Causes
   - For "suspended particle", the exhaust gas from the diesel engine occupies 60%, (in the digits, the means of public transportation occupy 40%)
   - For "happen of smog phenomena", the exhaust gas from gasoline engine occupies 70%

4) Actions

- The second term reorganization of transportation system
- Betterment of regulation of traffic (Enating of traffic law)
- Countermeasure of diesel engine emission by use of Calalyst
- Changing over to natural gas engine vehicles from diesel engine vehicles (Public transportation vehicle)

(b) Air pollution due to fixed generation sources

1) Areas of problem

Industrial zone, in particular, Mendoza metropolitan area and other limited areas

2) Types of contamination

The physical and chemical contamination mainly caused by sulfur compounds and particles which contribute the local atmospheric contamination and smog formation in the Metropolitan area

3) Causes

- Calcium Carbide particles, metallic silicone, particles of Calcium Silicate particles of manganese iron, etc. exhausted from metallugical works
- Sulfur oxides from petroleum refining plants
- Particles from cement works (The degree is law)
- Lead from battery manufacturing works etc.

4) Actions

- Installation of the suitable treatment plan depend on the results monitoring of flue gas
- Submission of report on pollution including plan of the treatment measure
- Application of Ley 5100 related to limit and term of discharge
- Introduction of advanced measuring instruments and simulation software

(4) Others

In the recent atmospheric environment in Argentina, the air pollution due to the mobile sources caused by automobiles is obviously increasing in particular.
The recent trend related to the phenomenon mentioned above is concluded based on the information obtained during the site investigation.

Measurement of exhaust gas from automobiles in the atmospheric environment of Rosario

To grasp the impact to the atmospheric environments in the adjecent area of trunk roads due to automobiles, we have investigated the black smoke in the exhaust gases from automobiles centering around the National Rosario University (Universidad Nacional de Rosario) in the trunk roads from Rosario to San Nicolas of south.
It is said that the Environment Department in Rosario City uses the report of this investigated results to the air pollution preventive measures for public large scale automobiles.

Chapter 3 CURRENT CONDITIONS AND COUNTERMEASURES OF AIR POLLUTION BY THERMAL POWER PLANTS

Chapter 3. Current Conditions and Countermeasures of Air Pollution by Thermal Power Plants

3.1 Governmental Policy Related to Air Pollution Preventive Measures of Thermal Power Stations

3.1.1 Laws and Regulations Related to Atmospheric Environmental Protection

For atmospheric environmental protection on whole country of Argentina, as mentioned in item 2.5.1, the atmospheric environmental standards have been determined in 1973 by the law (Ley) 20284/73 "Preservacion de los Recursos de Aire", and the power sectors arrange the enforcement regulations (Resoluciones) in turn conforming to the standard.
As a part of these regulations, for the thermal power stations, "Resolución SE N° 718/87" has been enacted.

(1) Enactment of environmental control manual on thermal power plant

For the environmental protection on thermal power plant of conventional type, the enforcement regulation Resolución S.E.E. 149/90 "Manual de Gestion Ambiental de Centrales Termicas Convencionales" has been enforced in 1990.
The content of this enforcement regulation is to define the concrete measures required to maintain the atmospheric environments of power plant at satisfactory level by considering the factors influence the air, water, soil, and other environments at each step from the design to the operation for construction of the steam turbine thermal power plant of conventional type under the control of central government.

(2) Revision of environmental protection manual (Resolución SE N° 154/93)

The privatization of power sector is advanced, and most of the thermal power plant which were under the control of central government are already privatized and the privatization of the transmission companies and distribution companies followed.

Therefore, SE revised a part of enforcement regulation 149/90 shown above (1), and enacted the enforcement regulation 154/93 in 1993.

Namely, the conventional enforcement regulations were applied for the thermal power plant before privatization, however, in future, the enforcement regulations will be developed so as to be applied for all enterprises and organs holding the power plant under the control of central government, and during the operation or will start the operation, together with abolition of provisions which determined the targets of environmental protection to the air, water, soil, and other environmental factors to show the concrete targets and countermeasures newly.

(a) Enactment of emission standards

The emission standards for SO_2 and the dust included in the flue gas exhausted from stacks of thermal power plant are shown in Table 3-1-1.

Table 3-1-1 EMISSION STANDARDS RELATED TO FLUE GAS

Fuels Items	Fuel oil	Natural gas	Coal
SO_2 (mg/Nm^3)	≤ 1,700	-	≤ 1,700
Dust (mg/Nm^3)	≤ 140	≤ 6	≤ 120

(b) Measuring items and frequency of flue gas

The measuring items and frequency of flue gas exhausted from stacks for steam turbine generators and gas turbine generators are shown in Table 3-1-2

Table 3-1-2 **MEASURING ITEMS AND FREQUENCY OF FLUE GAS**

Types Items	Steam turbine generators		Gas turbine generator
	Less than 50 MW	More than 50 MW	
SO_2	Once/month	Continuously 1)	Once/month
NOx	Once/month	Continuously 1)	Once/month
Dust	Once/month	Periodically 2)	Once/month

Notes: 1) The continuous measurement shall be performed using the continuous automatic measuring instrument with recorder.

2) The intermittent measurement shall be performed using the intermittent automatic measuring instrument.

(c) Countermeasures for NO_x

When a plant (unit) is installed newly, for the boiler of steam turbine generater whose output is more than 50 MW, a low NO_x burner shall be installed.

(d) Observation of regulations

When enterprises or organs having the responsibility of design, construction, and operation of thermal power plant did not observe the regulations above, the jurisdictional organ shall give the warning. Even when the term determined by the jurisdictional organ has passes, if this regulation is not observed, the jurisdictional organ can instruct the stop of the work or the operation of the corresponding generator until the causes are dissolved.

(e) Air pollution preventive measures for power plant except for the power plant under the control of central government

For the thermal power plant which are possessed by the provinces, cooperative societies, and other organizations (City management, etc.) except for the plant under the control of central government, the regulations of S.E.E. 149/90 or 154/93 are applied, if they are interconnected. And all basic policies to reduce the influence to the atmospheric environments due to the flue gas from the thermal power plant are in the same conditions regardless of owners. From this recognition, the future policies of regulations in each organ who controls the province managed thermal power stations or other thermal power stations are in the same direction as the policies for power companies under the control of central government.

Therefore, for power stations except for the plant under the control of central government, the future policies for regulations are advanced in the direction to apply correspondingly the serial targets and countermeasures such as emission standards or flue gas measurement, etc. shown in the enforcement regulation 154/93.

(3) Laws and regulations concerned

For the atmospheric environmental protection of thermal power plant, laws and regulations concerned are shown below;

1) Law (Ley) 24065/92 and governmental ordinance (Decreto) 634/91
These law and ordinance determine the partial charge of role accompanied by reorganization of power plant.

2) Law (Ley) 21608/77 "Promocion Industrial"
For the project to be constructed newly, when receiving the government encouragement plan, this law obliges to perform environmental impact predicting assessment.

3) Law (Ley) 24051/91 and governmental ordinance (Decrete) 831/93 "De Residuos Peligrosos"
These law and ordinance determine the standard for emission of contaminants generated from the industrial projects to the air.

3.1.2 Management Organs for Atmospheric Environmental Protection of Thermal Power Plant

(1) Management and supervision organs

As an organ to control the operation in each section from the power generation to the consumption of power sections properly, the Electrical Power Administrative Management System (Ente Nacional Regulador de la Electricidad, ENRE) was established conforming to the law (Ley) 24065/92.
The basic enterprise that ENRE performs is the supervision for execution sections of public services, which includes, effective supply, transmission, and distribution of power, in the jurisdiction area conforming to the governmental ordinance (Decreto) 1398/92.
In the supervision functions, the responsibility of setting up required regulations and standards related to the general safety and environmental protection is included, when each facility of power generation, transmission, transformation, and distribution is constructed or operated.

(2) Role of ENRE related to air pollution protection

ENRE is obliged to control the execution of various measures required for atmospheric environmental protection of thermal power plant determined by the enforcement regulation (Resolucion SE N° 154/93 including annexture regarding the air pollution control for privatization) and ENRE instructs the periodic presentation of measured data from power plant to control the flue gas data obtained in each power plants together with control the achievement condition of emission standards.
Also, ENRE may perform the cross check to the flue gas measurement of power plant.
In addition, ENRE performs examination of environment assessment report submitted by the power plants (Evaluacion de Impacto Ambiental) whose presentation is obliged by SE when each power plants is privatized.
ENRE is also in the situation to advice the power plant for selection of measuring methods and measuring instruments

suited to each power plants for the flue gas measuring performed by each power plants.

3.1.3 Execution System of Investigation Related to Air Pollution Prevention

In order to establish the system to perform the investigation of environmental problems related to power supply, SE concluded the technical cooperative agreement with the Argentine Atomic Energy Commission (Comision Nacional de Energia Atomica CNEA) in 1992.

(1) Contents of the technical cooperative agreement

The purpose of the technical cooperative agreement concluded between SE and CNEA is common creation and execution of the plan related to the investigation of the following environmental problems.

- The investigation related to drain or flue gas generated from the power generating facilities.
- Evaluation of environmental condition in the surounding area of power plants
- Deployment of talents related to the operation of measuring instruments for environmental monitoring and the data analysis.

(2) Relevance between SE and ENRE

As mentioned above, SE has the obligation for the enactment of environmental law and standards related to the power sector, and management of observation for these law and standards shall be performed by ENRE.
Therefore, according to the technical cooperative agreement between SE and CNEA, the inspection of environmental measurement for which ENRE is responsible can be performed smoothly by incorporating the inspection work into the investigation system of environmental problem by CNEA who has the personnel, system, and experience related to the whole environmental problems, such as, drain or flue gas, etc.

(3) Role of CNEA

CNEA performs through the Department of the New Sources and Rational use of Energy Department the work entrusted by the coordinative committee (Comite Coordinador) organized between CNEA and SE directly or through a third party, and performs management of the work shown in (1) above simultaneously.

CNEA also performs the measurement, for which ENRE judges necessary, to manage the observation condition in power companies, for the "emission standards related to solid wastes, flue gas, and drain generated from thermal power plant" set by SE.

3.2 Measurement of Pollutants from Flue Gas and in the Ambient Air in the Selected Model Plants

3.2.1 Outline of the Measurement of Pollutants from Flue Gas and in the Ambient Air

(1) Objective of Measurement

In order to develop a monitoring system for flue gas emission of power plants, it is very important to establish a standard procedure of measurement and analysis of pollutants in flue gas of the stack and in the area around the target emission source together with set-up of institutional measures by the Government.

Therefore, it was agreed by the both Government through several discussions that actual measurement of pollutants from selected model plants and in the ambient air around the area of these shall be conducted by the Study Team in cooperation with CNEA, counterpart organization of the Government of Argentina, and that technology transfer on overall technology of monitoring of pollutant emission from flue gas shall be carried out from the Team to CNEA.

In addition to the above, through the actual measurement, it is clear that investigation of the present state of pollutants emission from the thermal power plants shall be carried out to understand a contribution of pollutant emission from the thermal power sector to the air pollution level of the country.

(2) Plan and Procedure of Measurement

1) Targeted Model Plants

The following three thermal power plants have been selected as candidates for a model plant based on the first field Survey conducted from 6 to 30 of March, 1993.

(a) Nuevo Puerto Power Plant (Number 5 Unit for Turbine, 13 Unit for Boiler)

Nuevo Puerto Plant is located in the Federal Capital, that is one of the biggest cities in the world and its capacity is relatively large, and also, Nuevo Puerto is one of the biggest thermal power plants in view of their capacities, therefore, it is considered that its impact of emission from these shall be investigated as a typical model in the BSAS which is in an urban type air pollution.

(b) Lujan de Cuyo Power Plant (Number 12 Unit)

Lujan de Cuyo plant is deemed as one of the typical small and medium scale power plant in Argentina and its location characteristics of the area where various kind of manufacturing industries are located are also very interesting and its impact and influences to the area should be studied.

(c) San Nicolas Power Plant (Number 5 boiler, Turbine 5 Unit)

San Nicolas Plant is the only one coal-fuel power plant in Argentina, the use of coal can not be ignored at this moment, in view of the necessity of diversification of energy sources, and it is agreed that SO_2 impact test shall be conducted in this plant in consideration of the topographical characteristics of the land around the plant and non-existence of emission sources of SO_2 excluding ACEROS PARANA steel plant.

2) Pollutants to be Measured for Flue Gas and in Ambient Air

(a) Pollutants in Emission from Flue Gas

Important pollutants from flue gas emission are sulfuric dioxide (hereinafter referred to as SOx excluding in the analytical definition in this report, because this SO_2 is converted to SO_3 in the process of oxidation in the air), Nitrogen Monoxide (hereinafter referred to as NOx as same in case of SOx) and Dust.

Therefore, it was determined that these three pollutants including oxygeon as an important parameter for operational control of combustion of boiler shall be measured and analyzed in the measurement of flue gas for the model plants.

(b) Pollutants in the Ambient Air

In general, air contaminants to be measured for the ambient air are primary air pollutants composed of fine particles less than 100 μm, sulfur compound (SOx), oxides of nitrogen (NOx), carbon monoxide, halogen compounds, organic compounds, and radioactive compounds and secondary air pollutants consists of ozone, formaldehyde, peroy acetyl nitrate, photochemical smog and acid mist etc.

However, any other pollutants except SOx, NOx, and dust were deleted to our measurement because these are not included in our target stationary sources, boiler and/or secondary air pollutants to be generated together with other stationary or mobile sources.

Therefore, measurement of these pollutants (SOx, NOx, and Suspended particulate matter, SPM) was planned with the major aim contributing to technology transfer from the Study Team to CNEA.

In addition to the above, impact test of SOx emission from a thermal power plant was planned to evaluate how much impact of stack emission was observed in the surrounding area of the plant.

Regarding the site, San Nicolas plant was recommended as a model plant for this test because topographical condition is desirable in view of its flatness of land and there are few other stationary sources except Acero Parana Steel plant against the recognition of existence of many complicated condition for other sites of Nuevo Puerto and Lujan de Cuyo Plant and only SOx measurement shall be conducted among the target pollutants to eliminate any other measurement which may disturb to exact evaluation of the impact of emission source.

3) Outline of Analytical method and Analyzers utilized in the measurement

During the site survey conducted in July and November in 1992 and the first survey by this Study Team, it was found that there are few instrument analyzers popularily used in Argentina and also there are few institutional organizations and/or private research institutes which are conducting actively a measurement of pollutants in ambient air and also from emission sources.

However, it was observed in several thermal power plants which are actively going to introduce the instrument to monitor the emission of flue gas in accordance with the agreement with SE concerning on a privatization of the power plant.

Therefore, in principle, analytical methods and analyzers to be utilized in this measurement are determined in accordance with following criteria:

(a) EPA and/or WHO popularly used in the USA and European countries including some Latin American countries shall be adapted if there are no obstacles in the procurement of the instruments and/or small supporting equipment or chemical reagents.

(b) Chemical analysis methods shall be a major method because they are very important for the Government of

Argentina to promote and establish a further institutional set-up of own measurement procedures.

(c) Instrument analyzers shall be arranged and prepared in consideration of the time when fuel oil for boiler are converted to natural gas due to characteristics of the present system in the power plants.

(d) Portable instrument analyzers are principally selected in consideration of easy transportation and inspection promotion by the CNEA staff and also, some portable analyzer being introduced to some thermal power plants are provided in view of necessities of internal checking of measured value of pollutants by the power plants and consultation of difficulties on the analyzer.

(e) It was decided by the Japanese Government that analyzer to be needed for a further promotion of measurement of pollutants from flue gas and in the ambient air shall be provided to the Government of Argentina if these analyzers will be technically transferred to the counterpart during the measurement period and being effectively used in the counterpart for NOx, SOx, and SPM monitor.

Major analytical methods and analyzers used in this measurement are shown in Table 3-2-1.

Table 3-2-1 OUTLINE OF ANALYTICAL METHODS AND ANALYZERS UTILIZED IN THE STUDY

Analysis method	: Analyzer	: Remarks
1. Measurement of Flue Gas		
1) Electro-chemical	Portable Analyzer MSI-2000	SOx, NOx, O_2, CO
2) Infrared Absorption	Auto-mated Continuous analyzer	SOx

	IRA-107	
3)Chemiluminescence	Auto-mated Continuous Analyzer NOA-7000	NOx,O_2
4)Zinc-NEDA	Chemical Analysis	NOx
5)Precipitation Titration	Chemical Analysis	SOx
6)Direct Weight Measurement	Dust Sampler	Dust,Sampling of NOx,SOx
7)Light Scattering	Portable Dust Monitor	Dust
8)Chemical Absorption	Orsat Apparatus	O_2, CO, CO_2
2. Measurement of Ambient Air		
1)Saltzman	Chemical Analysis Absorption: Air Sampler and Impinger set S601, 8003-2	NOx
2)Pararosaniline	Chemical Analysis Absorption: Air Sampler and Impinger set S-601, 8003-2	SOx
3)Direct Weight Measurement	High Volume Air Sampler HVC-1000N	SPM
4)Beta-Ray Absorption	Auto-mated Continuous Monitor BAM-102S	SPM
5)Chemiluminescence	Auto-mated Continuous Monitor APNA-350E	NOx
6)Ultraviolet Absorption	Auto-mated Continuous Monitor APSA-350E	SOx
7)Beta-Ray Absorption	Auto-mated Continuous Monitor APDA-350E	SPM

3. Supporting Equipment		
1)Wind Speed Meter	Propeller type	Wind direction and speed
2)Electric Balance	3100gr x 10mg	for chemical analysis
3)Personal Computer	486, IBM Compatible	for data analysis and simulation
4)Chemical Reagent	Zinc-NEDA, Precipitation Titration, Saltzman, Pararosaniline	
5)Glass Ware	Same as above	
6)Incubator		for cooling and storage of sample
7)Transportation Vehicle	Renault	for circular measurement services to the plants

(3) Overall Schedule of Measurement

Measurement was conducted for eight weeks at three model plants. The overall schedule is shown in Figure 3-2-1.

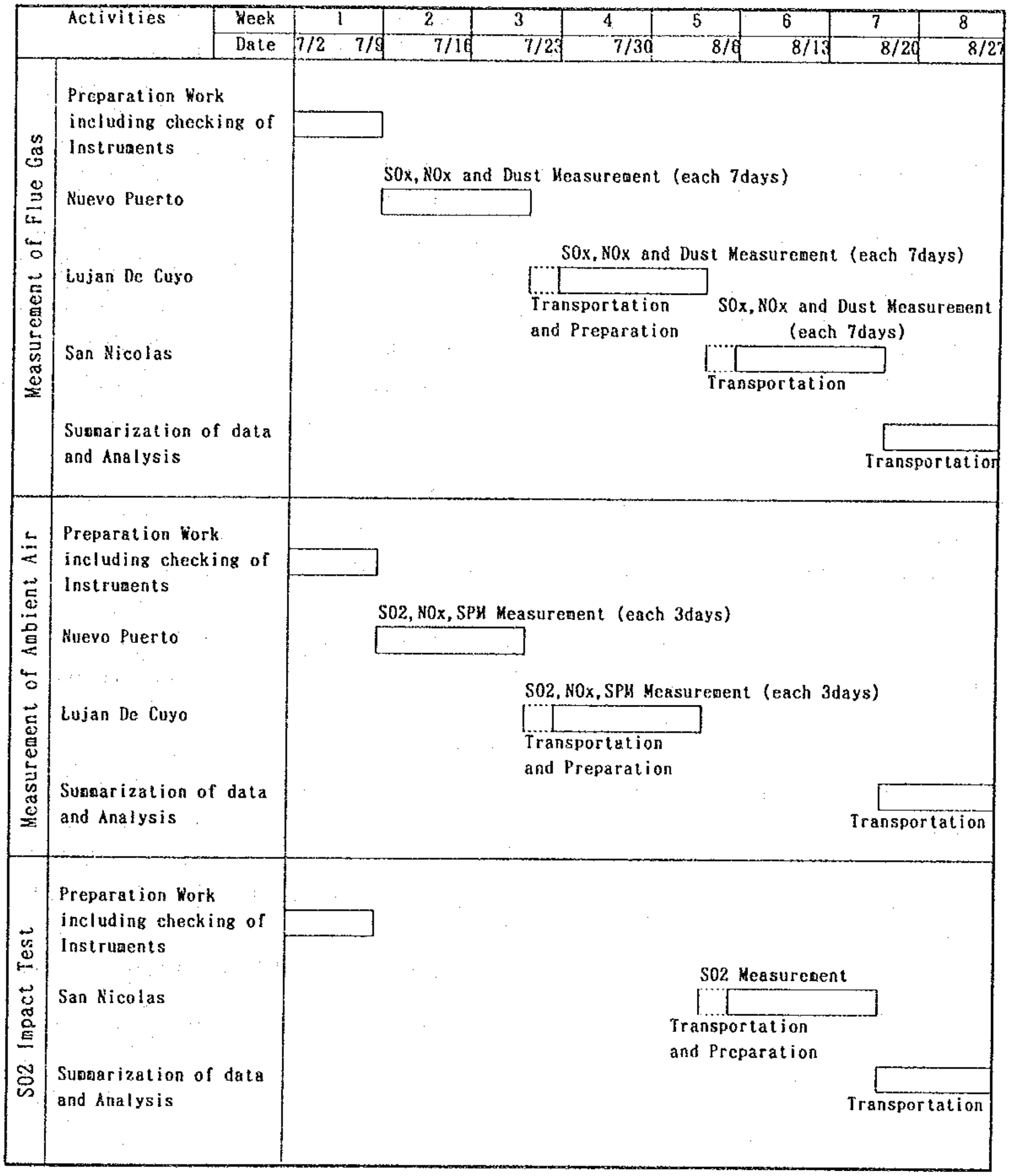


Figure 3-2-1 MASTER SCHEDULE FOR MEASUREMENT OF FLUE GAS AND AMBIENT AIR IN THE TARGETED MODEL THERMAL GENERATION PLANTS

3.2.2 Outline of Laws, Regulations, Standards and Analytical Method concerning Measurement made in Process of This Study

The measurement of flue gas and ambient air is internationally made in accordance with provisions by the Environmental Protection Agency (referred to as "EPA"), the World Health Organization (referred to as "WHO"), the Japan Industrial Standers (referred to "JIS"), and American Standards for Testing Materials (referred to as "ASTM"). The following points should be noted from the viewpoint of desirable testing methods to be adopted by Argentina in future.

a) The method should be recognized as internationally acceptable standard.
b) The implementation should be easy and produce accurate results.
c) The backing-system method for correcting and repairing measurement instruments should be provided within Argentina.

Based on these considerations, we have studied instruments measuring and analyzing flue gas and other air pollutants in Argentina as described below. The study on flue gas-measuring instruments mainly focuses on an automatic continuous analysis to be supported by a chemical (manual) analysis method, while the study on analytical tools measuring ambient pollutants focussed on a chemical (manual) analysis method to be supported by an automatic continuous analysis.

(1) Flue Gas Measurement

1) SOx

As Table 3-2-2 shows, EPA, WHO and JIS provide method for measuring SOx in flue gas, of which the EPA standards admit the automatic continuous methods by way of the infrared absorption method and ultra-violet fluorescent method, while a chemical analysis method is not admitted, the WHO standards, which are not selective measurement methods, admit the automatic continuous method like the solution conductivity method and electrochemical method, while the chemical analysis method is not admitted. Consequently, IRA-107 type, which is an infrared absorption method, has been chosen because it is being widely used by petrochemical factories and thermal power stations in Argentina with acceptable accuracy. Furthermore, MSI-2000, which is a portable analyzer of the electrochemical methods accepted by WHO, has also been used.

Since neither EPA nor WHO stipulates a chemical analysis method, an appreciate method has been chosen among JIS, of which neutralization titration method is not accurate enough and turbidimetric method tends to produce errors depending upon conditions producing barium sulphate. On the other hand precipitation titration method is accurate because it dose not rely on conditions producing barium sulphate and is easy to operate. For these reasons, precipitation titration method has been chosen which can be chosen as SE's future analytical method.
Incidentally in Argentina, studies and examinations into SOx-analyzing methods of internationally acceptable standards should be continued in future mainly by technical team in SE.

2) NOx

For methods to analyze SOx in flue gas, the EPA method, WHO method, JIS method and ASTM method are available (Table 3-2-3). The EPA accepts an automatic continuous analysis by way of the Chemiluminescence method, but not a chemical analysis, WHO accepts only the Chemiluminescence method as a selected method, as well as an electro chemical method and the fluorescent method though they are not selected measurement methods. The WHO accepts Saltzman Method and Detecting Column Method as a selected measurement method. Consequently, NOA-7000, which is a Chemiluminescence accepted by EPA and WHO, has been chosen as an automatic continuous analyzer. MS-2000 has also been chosen, because it is an electrochemical method accepted by WHO and by German DIN as a portable analyzer.

As regards a chemical analysis method, Saltzman Method of WHO is unsuitable for measuring NOx in flue gas because it measures nitrogen dioxide only and dose not measure nitrogen monoxide. Being a semi-quantitative analyzer, Detecting Column Method is inaccurate. Therefore, a chemical analysis method has been chosen among the JIS methods, of which Saltzman Method measures nitrogen dioxide only as the WHO method dose. The PDS method (Phenol disulphon dioxide light absorption method) needs complicated operations and skills. On the other hand, the Zn-NEDA method (Zinc reduction, naphthyl-ethylene diamine light absorption method) is simple and accurate, requiring attention to the reduction ratio due to difference is quality of zinc powder. Therefore, this method has been chosen because it can be one of methods to be adopted by SE in future.

Incidentally in Argentina studies and examinations into NOx-analyzing methods of internationally accepted standards should be continued in future mainly by technical team in SE. The PDS method, which ASTM covers, may be one of methods to be looked at.

3) Dust

As Table 3-2-4 shows, WHO, JIS and ASTM provide flue gas analyzing methods, the WHO standards do not include the selected measurement methods but accept light scattering method, which is an in-plant type. The method, however, requires detecting devices covering a whole conduct of smoke duct and smoke stacks, and therefore is not an appropriate method for monitoring flue gas. On the other hand, the direct measurement method of dust weight provided by JIS simultaneously measures speed, temperature, moisture of flue gas streams, allows discretion in deciding the number of sampling sites and is a simple manual analytical method with an extensive range of applications. Therefore, this method has been chosen, because it may be one of SE's future analytical tools. The principle of this method is the same with that of the dust weight measuring method stipulated by ASTM. In addition, a portable dust monitor, which is light scattering method and AP-710N have also been chosen. Incidentally in Argentina, studies and examinations into dust-analyzing methods of internationally accepted standards should be continued in future mainly by technical team.

(2) Measurement of Ambient Pollutants

1) SOx

The method for analyzing atmospheric SOx is provided by EPA, WHO, JIS and ASTM as Table 3-2-5 shows. EPA accepts pararozaniline method as a chemical analyzing method and Infrared absorption method and ultra-violet fluorescent method as an automatic continuous analytical method as well. WHO accepts pararozaniline method and acid titration method (hydrogen peroxide method) as a chemical analysis method. WHO also accepts the automatic continuous analytical method by way of the solution conductivity method electrochemical method and the chemiluminescence method although they are not selected measurement methods.
As regards the chemical analysis method, WHO's acid titration method is affected by co-existing substances and is not accurate. Therefore, pararozaniline method has been chosen as both EPA and WHO accept it. As an automatic continuous analyzer, APSA-350E, which is ultra-violet fluorescent method accepted by EPA, has been chosen.
The SOx-measuring methods used internationally are listed below.

a. Solution Conductivity Method

The method is designated by Japan for constant monitoring and known for its good sensitively.

b. Pararozaniline Method

This is the US reference method, has few disturbants and good selectivity. The method is selected by EPA, WHO and ASTM.

c. Ultra-violet Fluorescent Method

This method is most extensively used in the US and other countries as an automatic continuous analyzer for constant monitoring and is a selected method of EPA.

d. Acid Titration Method (hydrogen peroxide method)

The method is designed in the UK and selected by WHO.

2) NOx

Among the methods to measure ambient NOx, EPA, WHO, JIS and ASTM have been looked at as Table 3-2-6 lists.
EPA accepts an automatic continuous analysis method by way of the chemiluminescence method, but does not accepts a chemical analysis methods, WHO accepts saltzman method, detecting column method and Jacob Hocheizer method as chemiluminescence methods, although the last is not a selected method. WHO also accepts a chemiluminescence method as an automatic continuous method and spectrophotometric method, electrochemical method and so forth, which are not selected measurement methods.
Detecting column method is semi-quantitative and inaccurate. Jacob Hocheizer method used to be the US reference method but no longer is used. Therefore, saltzman method has been chosen being the most extensively used. As an automatic continuous analyzer, APNA-350E has been chosen, which is a chemiluminescence method accepted by both EPA and WHO. Incidentally the NOx-measuring methods used internationally are listed below;

a. Saltzman Method

The method is designed by Japan for constant monitoring and is known for its few disturbants. It is the selected method of WHO and ASTM.

b. Chemiluminescence

This is the reference method of the US and is most extensively used as an automatic continuous analyzer for constant monitoring. This is the selected method of EPA and WHO.

c. Jacob Hocheizer Method

The method used to be the US reference method but is not used any longer.

3) SPM

As Table 3-2-7 shows, the methods provided by EPA, JIS and ASTM have been looked at EPA's only accepted manual analyzing method is the high volume method. WHO accepts, as manual analyzing methods, the high volume/weight method, EPA high volume method, OECD reflection ratio method, OECD weight method and ASTM penetration rate method.
In addition, as automatic continuous analyzing method, WHO accepts a beta ray absorption method though it is not a selected measurement method.
As a manual method, WHO's high volume/weight method, EPA's high volume method and OECD's weight method and designed to catch dust with a filter and measure the weight. Their principle is the same with the EPA method.
The OECD's reflection ratio method and ASTM's penetration rate method measure filter's blackness is terms of a reflection rate and penetration rate respectively, and therefore do not directly measure quantity of dust.
Therefore, the high volume method has been chosen as it is accepted by both EPA and WHO. As an automatic continuous analyzer, APPA-350E has been chosen as it is a beta ray absorption method accepted by WHO.

Incidentally, dust-measuring methods used internationally are listed below;

a. High Volume Method

The method is designed by the US and is most extensively used internationally. It is a selected method of EPA and WHO.

b. OECD's Weight Method

The method is designed by UK and other OECD countries and is selected by WHO.

c. Filter Blackness Method (Penetration Rate Method)

This is ASTM's designed measuring method and WHO's selected method.

d. Beta Ray Absorption Method

This Japan's designed method for constant monitoring and is accepted by WHO.

Table 3-2-2 METHODS FOR DETERMINATION OF SO_x IN FLUE GAS

Method		Principle	Measuring Range	Interferences	Repeatability	Treatment time or Response time	Linearlity	Flow Rate Variation	Warming-up Time	Valtage Variation	Zero-drift	Span-drift	Remarks
Chemical Analysis	Neutralization titration method	SO_x in flue gas are absorbed by H_2O_2 to form H_2SO_4. The H_2SO_4 is neutrally titrated with NaOH and the concentration of SO_x is determined	70-2800 ppm	NO does not interfere. CO_2 produces positive interference in more than PH5.5	Coefficient of variation Less than 1%	Approximately 1 hr.	-	-	-	-	-	-	JIS Method
	Precipitation titration method	SO_x in flue gas is absorbed by H_2O_2 to form H_2SO_4. The H_2SO_4 reacts with $(CH_3COO)_2Ba$ and forms precipitate of $BaSO_4$. In this process excess Ba^{2+} react with arsenazo III and blue complex is formed. The concentration of SO_x is determined from the amount of $(CH_3COO)_2Ba$ titrated.	140-700 ppm	Coexistence of Cl^- 10mg, CO_3^{2-} 5mg, NO_3^- 5mg, NO_2^- 2mg is permissible. PO_4^{3-} as little as 1 mg produces positive interference.	Coefficient of variation Less than 1%	Approximately 1 hr.	-	-	-	-	-	-	JIS Method
Continuous Analysis	Infrared absorption system	SO_2 absorbs infrared radiation at wavelength 7300 nm. Using this property of SO_2 the concentration of SO_2 in a sample gas is measured with a non-dispersion type infrared gas analyzer.	0-2000 ppm	A positive interfering gas is water vapor and CO_2.	within ±0.3% of max. scale	10 sec. (Fast) 45 min. (Slow)	within 1% for 0-500 ppm	within ±0.5% for 1L±0.5 L/min.	45 min.	within ±0.5% for AC 100V ±10V	within ±1%/day	within ±1%/day	EPA Method JIS Method
	Ultra-violet absorption system	This method is to measure photoelectrically the change of absorption by SO_2 of ultra-violet light at wavelength of 280-320 nm and to find the concentraiton of SO_2 contained in sample gas.	0-2000 ppm	A positive interfering gas is NO_2	within ±2% of max. scale	4 min.	-	-	-	within ±1% of max. scale	within ±2% of max. scale	within ±2% of max. scale	EPA Method
	Electro-chemical system	SO_2 in flue gas passes through a gas sensor. The gas sensor is electrochemical transducer. They generate electric current whose size depends on the SO_2 concentration. These signals are analyzed by the electronics.	0-4000 ppm	-	5% of max. scale	60 sec.	1 ppm for 0-4000 ppm	-	30 min.	-	-	-	WHO Method DIN Method

Table 3-2-3 METHOD FOR DETERMINATION OF NO_x IN FLUE GAS

Method		Principle	Measuring Range	Interferences	Repeatability	Treatment time or Response time	Linearlity	Flow Rate Variation	Warming-up Time	Valtage Variation	Zero-drift	Span-drift	Remarks
Chemical Analysis	Zn-NEDA method	NO_x in flue gas are absorbed into the absorbing liquid in the presence of O_3 to be converted to NO_3. NO_3^- is reduced to NO_2^- with zinc powder and reacted with Sulfanilamide and naphthylethylenediamine. Then the absorbance of azo dye obtained by the diazotization coupling reaction is measured.	5-250 ppm	-	-	Approximately 20 min	-	-	-	-	-	-	JIS Method
	PDS method	NO_x in flue gas are absorbed into the absorbing liquid in the presence of O_3 to be converted to NO_3^-. The solution thus obtained is reacted with phenol disulfonic acid, and its absorbance is obtained from the luminous liquid.	50-1600 ppm	-	-	Approximately 2hr	-	-	-	-	-	-	JIS Method ASTM Metho
Continuous Analysis	Chemiluminescence system	NO reacts with O_3 and forms NO_2. When NO_2 returns from an excited state to ground state, it emits near infrared radiation. The chemiluminescent intensity is proportional to the concentration of NO at wavelengths between 590 and 875 nm.	0-2000 ppm	A negative interfering gas is CO_2	within ±0.5% of max. scale	20-60 sec.	within ±2% of max. scale	±2% of max. scale	-	±1% of max. scale	within ±1% of max. scale	within ±1.5% of max. scale	EPA Method WHO Method JIS Method
	Infrared absorption system	NO absorbs infrared radiation in the vicinity of wavelength 5300 nm. NO contained in a sample gas is measured with a non-dispersion type infrared gas analyzer.	0-2000 ppm	A positive interfering gas is water vapor and CO_2.	within ±2% of max. scale	within 2 min.	-	±2% of max. scale	-	±1% of max. scale	within ±2% of max. scale	within ±2% of max. scale	JIS Method
	Electrochemical system	NO in flue gas passes through a gas sensor. The gas sensor is electrochemical transducer. They generate electric current whose size depends on the NO concentration. These signals are analyzed by the electronics.	0-1000 ppm	-	±5% of max. scale	60 sec.	1 ppm for 0-1000 ppm	-	30 min.	-	-	-	WHO Method DIN Method

Table 3-2-4 METHODS FOR DETERMINATION OF DUST CONCENTRATION IN FLUE GAS

Method		Principle	Measuring Range	Interferences	Repeatability	Treatment time or Response time	Linearlity	Flow Rate Variation	Warming-u Time	Valtage Variation	Zero-drift	Span-drift	Remarks
Manual Analysis	Dust Measuring Method	Insert the suction nozzles of sampling apparatus for dust into the duct through the measuring holes and place the tips of the nozzles to meet the measuring points. Aspirate the flue gas according to equal velocity aspiration and obtain the dust concentration by quantity of the dust collected by filtering with dust collector and the volume of gas sucked in it.	0-10 mg/m3	-	Coefficient of Variation 6-7%	2hr.	-	±5%/hr	15 min.	within ±2%	-	-	JIS Method ASTM Method
Continuous Analysis	Light Scattering System	Sample is introduced in a dark chamber and is radiated by a light beam. The light is scattered by particle. The intensity of the scattered light is measured and the mass concentration of dust is obtained.	0-10 mg/m3	-	within ±2%	-	within ±20%	within ±5%/day	3hr.	within ±1% for AC 100V	within ±2% for max. scale	within ±2% for max. scale	WHO Method JIS Method

Table 3-2-5 METHODS FOR DETERMINATION OF SO_2 IN THE ATMOSPHERE

Method		Principle	Measuring Range	Interferences	Repeatability	Treatment time or Response time	Linearlity	Flow Rate Variation	Warming-up Time	Valtage Variation	Zero-drift	Span-drift	Remarks
Chemical Analysis	Pararosanilin method	The SO_2 in the air reacts with potassium tetrachloromercurate solution to form a monochlorosulfonatomercurate complex. The complex is reacted with pararosaniline and formaldehyde to form on pararosaniline methyl solfonic acid. The optical density of this species is determined spectrophotometrically.	13-1130 $\mu g/m^3$	A positive interfering gas is NO_2. Masking by EDTA prevents interference by heavy metals.	Coefficient of variation 4.6%	Approximately 2 hr.	-	-	-	-	-	-	EPA Method WHO Method ASTM Method
	Acidimetric method	The air sample is bubbled through a dilute H_2O_2 where SO_2 is absorbed and oxidized to form H_2SO_4. The acidity of resulting solution can be estimated by titration with alkali.	Detection limit 1000 $\mu g/m^3$	HCl, HNO_3 and CH_3COOH produce positive interference. NH_3 produces negative interference.	-	Approximately 1 hr.	-	-	-	-	-	-	WHO Method
Continuous Analysis	Ultraviolet fluorometry system	This is a method to continuously measure the concentration of sulfer dioxide in ambient air with fluorescence intensity emitted from the SO_2 molecules excited by ultraviolet light.	0-0.5 $\mu g/m^3$	Water vapor and aromatic hydrocarbons produce positive interference.	within ±2% of max. scale	within 3 min.	within ±2% of max. scale	-	120 min.	within ±1% for AC 100V ±10V	within ±2ppb/day of max. scale	within ±2ppb/day of max. scale	EPA Method
	Infrared absorption system	SO_2 gas absorbs infrared radiation at wavelength 7300 nm. Using this property of SO_2 the concentration of SO_2 in a sample gas is measured with a non-dispersion type infrared gas analyzer.	0-1330 $\mu g/m^3$	Positive interfering gases are water vapor and CO_2.	within ±2% of max. scale	within 4 min.	-	within ±2% of max. scale	-	within ±1% of max. scale	within ±2% of max. scale	within ±2% of max. scale	EPA Method
	Conductmetric system	The SO_2 in the air is absorbed in diluted H_2SO_4-H_2O_2 solution. SO_2 is oxidated and converted into H_2SO_4. Measurement of the increase of electric conductivity of the H_2SO_4 gives the concentration of SO_2.	0-2000 ppm	HCl, Cl_2, CO_2, NO_2 and H_2S produce positive interference. NH_3 produces negative interference.	within ±2% of max. scale	within 5 min.	within ±4% of max. scale	within ±7%/10days	-	within ±1% of max. scale	within ±2%/day of max. scale	within ±2%/day of max. scale	WHO Method JIS Method

Table 3-2-6 METHODS FOR DETERMINATION OF NO2 IN THE ATMOSPHERE

Method		Principle	Measuring Range	Interferences	Repeatability	Treatment time or Response time	Linearlity	Flow Rate Variation	Warming-up Time	Valtage Variation	Zero-drift	Span-drift	Remarks
Chemical Analysis	Saltzmann method	NO2 contained in the sample gas is made to pass through the absorbing luminous liquid. The absorbance of azo dye obtained by the coupling reaction with sulfanilic acid and naphthyl ethylene diamine is measured, and thereby the concentration of NO2 is determined.	Detection limit 9400μg/m3	O3 and NO produce interference	-	Approximately 20 min.	-	-	-	-	-	-	WHO Method JIS Method
Continuous Analysis	Chemiluminescence system	NO reacts with O3 and forms NO2. When NO2 return from an excited state to the ground state, it emits near infrared radiation. The chemiluminescent intensity is proportional to the concentration of NO at wavelengths between 590 and 875 nm.	0-0.5 ppm	A negative interfering gas is CO2.	within ±2% of max. scale	within 180 sec.	within ±2% of max. scale	-	-	±1% for AC 100V ±10V	within ±2ppb/day	within ±2%/day of max. scale	EPA Method WHO Method JIS Method ASTM Method
	Spectrophotometry system	It is a method of simultaneously and continuously measuring the NO and NO2 contained in the ambient air by the spectrophotometry that uses Saltzmann Reagent as a absorbing reagent.	0-0.5 ppm	O3 produces interference.	within ±2%	-	within ±4%	within ±7%/10days	2 hr.	within ±1%	within ±2%	within ±2%	WHO Method JIS Method

Table 3-2-7 METHODS FOR DETERMINATION OF SPM IN THE ATMOSPHERE

Method		Principle	Measuring Range	Interferences	Repeatability	Treatment time or Response time	Linearlity	Flow Rate Variation	Warming-up Time	Valtage Variation	Zero-drift	Span-drift	Remarks
Manual Analysis	High-volume method	SPM in ambient air is collected with a high-volume air sampler (flowrate: 1.1-1.7 m3/min.) After collection, the weight of the filter paper is measured.	2-750 μg/m3	Loss of volatiles produces negative error	Coefficient of variation 3.0%	30 min.	-	within 0.02 m3/min.	-	-	-	-	EPA Method WHO Method ASTM Method
	Filter soiling method	SPM in air is collected using a diaphagm suction pump with a nominal rating of 55 l/min. After collection, the darkness of the stain produced by drawing air through filter paper is measured photometrically.	0.05-0.3 on absorbance	-	Collection Coefficient 0.97-0.99	30 min.	Linear for absorbance of 0.05-0.3	-	-	-	-	-	WHO Method ASTM Method
Continuous Analysis	Beta-ray absorption system	The mass of SPM is obtained from the increase of the absorption amount of B-ray due to particles collected on filter paper	0-5000 μg/m3	-	within ±2%	60 sec.	within ±10%	within ±5%/10days	1-2 hr.	within ±2%	within ±2% for max. scale	within ±3% for max. scale	WHO Method JIS Method
	Light Scattering system	Sample is introduced into a dark chamber and is radiated by a light beam. The light is scattered by SPM. The intensity of the scattered light is measured and the mass concentration of SPM is obtained.	0-10000 μg/m3	-	within ±2%	-	within ±20%	within ±5%/day	3 hr.	within ±1% for AC 100V	within ±2% for max. scale	within ±2% for max. scale	JIS Method

3.2.3 Results of Measurement of Pollutants from Flue Gas and in Ambient Air

(1) Flue Gas Measurement

All results of measurement were summarized in from Appendix 10 showing these concentration of pollutants from flue gas to study and verify the relationship between the measurement value.

1) Difference of the measured value.

Regarding the differences of values measured between the analysers and chemical titration method, many issues will be caused from the target circumstances at such measurement. In such cases following issues shall be verified for each objectives of the problems;

(a) Proprietary errors caused by the said analytical method adopted as described in the Table 3-2-2 to 3-2-7, summarized error and precision for the analyser and supplementary explanation on the analysis method compiled in Appendix-3 shall be verified for the measured value.

(b) Regarding the process consideration on the fuel storage including analysis data of the fuel, fuel supply, combustion, including combustion condition like fuel-air ratio, workmanship of IDF or FDF the flue gas line and leakage volume of air in to the process etc shall be verified totally for the analysis of the difference between the two analysers.

(c) In general, automated continuous recording analysers shows rapid fluctuations of the detected value around ±20 - ±30% depending on the system of the flue gas line.

(d) However, it should be noted that there is no difference of the measured value for O_2, NOx, SO_2 etc in the radius direction of the duct and stacks, because a perfect mixing is achieved concerning to the flue gas stream when there is no air leakage is observed around the neibour. Regarding the concentration of dust, there are big differences of concentration of dust even in the radius direction of the duct. Therefore it is very important for a position of sampling to be installed in the duct where there is no obstacles to make a gas stream as uniform velocity distribution in the duct line.

(e) Therefore, difference between the various analyser measured shall be analysed individually taking into many causes in cordiderations.

Regarding the measured values in this study, only one sampling nozzle is installed against to our request to the power station due to the miscellaneous reasons, therefore it is very difficult to clarify the reason of the differences.

However, it is observed that measurement values in the almost consecutive time, as shown in the measurement data the difference between the value is almost equal in ±30%.

In addition to the above, some reason to the difference of the measured value are presented concerning to some procedure of the analysis;

2) Reduction ratio and quality of zinc in Zn-NEDA method

(a) Examination of reduction ratio and quality of zinc powder

The quality of zinc powder needs to be carefully examined, because the reduction of nitrate ion with zinc powder is a critical step in Zn-NEDA method. The particle size and reducing rate of zinc powders vary, as some of them are not manufactured for application to nitrate reduction. Therefore, it is important to measure reducing rate when a new zinc powder is used in the procedure.

(b) Reduction ratio in JIS standards

JIS K0104 (Analytical Method for Oxides of Nitrogen in Exhaust Gas) specifies that the reduction ratio of zinc powder used in Zn-NEDA method is not less than 90%. The annotations of the standards refers to considerable variation in the reduction ratio of various kinds of zinc powder as shown in Table 3-2-8.

Table 3-2-8 EXAMPLES OF REDUCTION RATIO

Zinc Powder	Addition of zinc powder (g)	Absorbance	Reduction ratio (%)
A	0.5	0.150	39.9
	1.5	0.297	79.0
B	0.5	0.116	61.1
	1.5	0.068	36.2
C	0.5	0.283	100.3
	1.5	0.281	99.6

Table 3-2-9 shows how the particle and type of zinc powder affects absorbance. Judged from the result, it is recommendable to use a zinc powder to be specified for use of nirogen oxide analysis and containing particles not greater than 5 μm in particle size about 50% by weight.

Table 3-2-9 DIFFERENCE IN ABSORBANCE BY PARTICLE SIZE OF ZINC POWDER

Zinc type	weight less than 5μm	Absorbance
Special grade, min 90%	59.0	0.379
General grade, min 85%	30.0	0.353
Reagent general grade	51.0	0.385
Special grade, min 99%	45.3	0.371

(c) Zinc powder used in the field survey

Two kinds of zinc powder, one procured in the Argentina and the other manufactured in Japan, were used in the field survey. Their influence on absorbance is compared in the following Table 3-2-10.

Table 3-2-10 COMPARISON BETWEEN ARGENTINE AND JAPANESE ZINC POWDERS

Zinc powder	Absorbance	
	NO_2 concentration	NO_2 concentration
	20 μl	40 μl
Argentine	0.025	0.054
Japanese	0.277	0.572

The zinc powder procured in the Argentina exhibited lower absorbance (reduction ratio) than that manufactured in Japan. The Japanese zinc powder is made specifically for application to the measurement of nitrogen oxides. The Argentine zinc powder is for general, analytical purposes. Zinc powders for general analysis are not uniform in particle size and unsuitable for nitrate reduction. A zinc powder made for the measurement of nitrogen oxides needs to be obtained for future assessment work in the Argentina.

3) NO_2 absorption ratio by JIS standars

(a) Absorption Ratio

JIS B7953 (Continuous Analysers for Oxides of Nitrogen in Ambient Air) specifies that the NO_2 absorption ratio by Saltzman method is not less than 97% under the following conditions:

condition 1) NO_2 concentration: 152-181 $\mu g/m^3$ (standard gas)
2) flow velocity: 0.4 l/min
3) sampling time: 60 minutes
4) the nozzle of an absorption bottle is a glass filter the pore diameter of which is not more than 60 μm.

According to Annotations of Analytical Methods for Environmental Assesment (edited by Japan Association for Environmental Assesment and Analysis), the test result of NO_2 absorption ratio under the above conditions showed a high average value of 99.2% as given in Table 3-2-11. No problem is expected in collecting NO_2, if flow velocity and the efficiency of glass filter is standardized.

Table 3-2-11 NO_2 ABSORPTION RATIO

Target Sample	A	B	C	D	E	Average
Absorption RAtio	99.8	99.0	99.6	98.7	98.7	99.2

(b) NO_2 absorption ratio by WHO standards

Selected Methods of Measuring Air Pollutants of WHO prescribes the conditions for measurement by Saltzman method as following:

condition: 1) NO_2 concentration: not more than 9400 μg/m^3
2) flow velocity: 0.3-0.6 l/min
3) sampling time: not more than 2 hours
4) the nozzle of an absorption bottle is a glass filter the pore diameter of which is not more than 60 μm.

The WHO standards do not contain NO_2 absorption ratio. But, the original literature, Saltzman, Anal. Chem. 26(1954), gave NO_2 absorption ratios of 94-99%, which are as high as those in the JIS strandards.

(c) Absorption ratio obtained in this experiment

Followings are the conditions for measurement by Saltzman method in this field survey:

condition: 1) NO_2 concentration: 0.6-14 μg/Nm^3 (measured values of ambient air)
2) flow velocity: 1.5-2.0 l/min
3) sampling time: 18-24 hours
4) the nozzle of an aborption bottle is a glass filter the pore diameter of which is about 1 mm.

The test result of NO_2 absorption ratio obtained under the above conditions in Mendoza are shown in Table 3-2-12.

Table 3-2-12 NO_2 ABSORPTION RATION IN MENDOZA

Date	Place	NO_2(μg) A Sample	 B Sample	Ratio(%) A Sample	 B Sample
July,23	CNEA	5.19	3.14	62.3	37.7
July,23	Municipalidad	5.79	4.58	55.8	44.2
July,27	CNEA	9.65	4.10	70.2	29.8
July,27	Polideportivo	3.86	2.90	57.1	42.9
July,27	Municipalidad	3.74	1.69	68.9	31.1
Average				63	37

The result shows that the absorption ratios are considerably worse than those in the test by the JIS standards. The comparison between the conditions for testing the efficiency of the JIS standards and those of this field survey follows.

(a) NO_2 concentration

JIS adopts a standard gas with 152-181 μg/m^3, but this field survey dealt with ambient air with 0.6-14 μg/m^3. Low NO_2 concetrations mean excess N-1-naphthylethylenediamine, which reacts with NO_2, in terms of equivalent. Therefore, they would not contribute to lowering the absorption ratio. Rather, the problem is rooted in the fact that the initial value of NO_2 concetration was unknown because a standard gas was not used in the test. The calculated values of NO_2 concentration are obtained by dividing measured values by Saltzman coefficient (the ratio of the amount of NO_2^- formed by the reaction of NO_2 with Saltzman reagent to that of initially present NO_2). The calculated values vary by the value of Saltzman coefficient. JIS adopts 0.84 and WHO uses 0.74.

(b) Flow velocity

Flow velocity in this field survey was 1.5-2.0 l/min, adjusted by flow rate control cock, which is about four times as great as those specified in JIS or WHO; it is

0.4 l/min for JIS and 0.3-0.6 l/min for WHO. Faster flow is generally believed to lower the absorption ratio. Consideration for the prevention of clogging, the accuracy of suction pumps, and the accuracy as well as turn-down ratio of flow meters led to the minimum flow velocity setting at 1.5-2.0 l/min in this field survey.

(c) Sampling time

It was set at 18-24 hours in this field survey, which is longer than 60 minutes for JIS or no more than 2 hours for WHO. Although sampling time does not directly affect the absorption ratio generally, sampling for a long time could lower the absorption ratio, if it allows contamination with foreign materials or colorization by sunlight. Sampling time was set around 24 hours in this field survey in order to obtain values for one full day.

(d) Pore diameter of nozzle

It is not more than 60 µm in either JIS or WHO. However, because a midget impinger was adopted as an absorption bottle, a nozzle with the pore diameter of about 1 mm was chosen in this field survey. Generally speaking, pore diameter is very important in a gas-liquid reaction; a larger pore diameter reduces the contact area between gas and liquid, and the absorption ratio. An easy-to-operate midget impinger was chosen as an absorption bottle in this field survey in order to facilitate a swift transfer of technology.

These factors led to the judgement that the absorption ratio needs to be corrected in this field survey.
The survey team performed a test of the absorption ratio under the same conditions as those of this field survey before setting out for the second field survey, because the team did not believe that the test performed in the Argentine was sufficient for determining the absorption ratio. The test result gave an average absorption ratio of

65% as shown in Table 3-2-13. This is believed to be appropriate as the absorption ratio under the conditions, because it is close to the absoption ratio of 63% obtained in the field test in the Argentine.
Therefore, it has been decided to divide by the absorption ratio of 0.65 all measured values of NO_2 concentration of ambient air under the aforementioned conditions (all the values of NO_2 concentration of ambient air in this report are those after divided by 0.65).

Table3-2-13 RESULT OF EXAMINATION OF NO_2 ABSORPTION RATIO

Item Run	NO_2 (μg) A Sample	 B Sample	Collection Ratio(%) A Sample	 B Sample
1	14.1	7.2	66.2	33.8
2	12.6	5.4	70.0	30.0
3	11.8	7.2	62.1	37.9
4	10.7	6.3	62.9	37.1
5	12.8	7.3	63.7	36.3
Average			65	35

(e) Future issues

It is believed that there is room for further examination of the absorption ratio by Saltzman method, because the transfer of techonology was done in a limited period of time in this field survey; it is desirable to test the collection ratio of a target component in advance and select the equipement and conditions for test that best suit the local environment, when monitering ambient air in the Argentine in future.

(2) Ambient Air Measurement

All results of measurement were summarized in Table 3-2-14, Table 3-2-15(1)-(3), and Table 3-2-15(4)&(5).

1) Measurement of atmospheric concentrations in Buenos Aires

Using a meteorological data already obtained and computation data on a short-term simulation, and assuming a northerly wind, the following three measurement sites were designated, and they are:

- Boca located 6.0 km south of the power plants
- CNEA in San Martin, 11.1 km west of the power plants where an R&D Institute of the Atomic Power Authority is located, and
- Morón, 16.1 km west of the power plants

Measurement results, indicated lower values than informations collected before for both NOx and SOx as shown in Table 3-2-14. To be specific, Boca had the highest value of 28.9 $\mu g/Nm^3$ for SOx, but other sites (8.5 km away from the power plants) gave lower values than the maximum landing concentration, i.e. 6.3 $\mu g/Nm^3$, calculated on the simulation. This result appears to have been caused by frequent changes in the direction of wind.

Eighty to ninety percent of a total of 5,600 thousands of automobiles of Argentina is driven in Buenos Aires and, therefore, the NOx value was suspected to run high, but its highest value was 25.8 $\mu g/Nm^3$ in Moron and 17.3 $\mu g/Nm^3$ on average. As regards SPM, the highest value was 90 $\mu g/Nm^3$ in Moron and 60 $\mu g/Nm^3$ on average, and both NOx and SPM meet the regulatory standards of the state and the country.

2) Measurement of atmospheric concentrations in the city of Mendoza

Selection of atmospheric measurement sites in the city of Mendoza was assisted by the Environmental Bureau of the city, which led to selection of the following five measurement sites:(refer to Figure 3-2-2).

a. CNEA, 19.1 km NNE of the Power Plants
b. Municipalidad, 20.3 km NNE of the Power Plants
c. Park, 21.0 km NNE of the Power Plants
d. Polideportivo, 20.3 km NE of the Power Plants
e. Escuela, 9.9 km ES of the Power Plants

With regard to SOx data, a branch office of CNEA located 19.1 km NNE of the station had the highest value of 13.0 $\mu g/Nm^3$, though the average was 3.4 $\mu g/Nm^3$, which is far below the country's and Mendoza's standards. It should be kept in mind, however, that temperatures ran low in Mendoza when measurement was done and that the low temperature have contributed to the lower value, particularly, when the absorption ratio, which was described before, is taken into consideration.

Concerning NOx, the highest value is observed, as expected, at the city office, 20.3 km NNE of the power plants where traffic is very heavy with average being 3.6 $\mu g/Nm^3$. These values, nevertheless, meet the standards of the country as well as the city.

As regards SPM, 24-hour measurement at the three sites, i.e. CNEA, the city office and the park, showed 240, 250 and 190 $\mu g/Nm^3$ respectively, which are considered to be on the high side.

In view of the fact that the country's standard is 150 $\mu g/m^3$ and that Mendoza's standards are 100 $\mu g/Nm^3$ for a monthly average and is 260 $\mu g/Nm^3$ for the daily average SPM is the most serious problem in the city of Mendoza.

3) Measurement of atmospheric concentrations in the city of San Nicolas

Through the cooperation of San Nicolas power plants, the following six sites were choosen near the power plants for measurement of atmospheric concentrations:(refer to Figure 3-2-3).

- Acero Parana premises, 0.7 km E of the San Nicolas power plants
- Flying Club premises, 4.2 km SSW of the power plants
- C&P Club, 6.6 km S of the power plants
- Camping Site, 5.1 km SSW of the power plants
- Escuela, 4.9 km W of the power plants
- City Office, 4.7 km NW of the power plants

This particular measurement of atmospheric concentration was meant for the impact of SOx only and, therefore, the only SOx value was measured, which produced a value of 11.2 ppb at its highest level at a point 4.2 km south-south-west of the power plants. The average concentration there is equally on the high side as proven at the Flying Club and the C&P both located 6.6 km south of the power plants. All these data can be taken to prove the impact of the power plants when the direction of wind during the measurement activity is considered.

However, both the highest and average measurement results well meet the standards of the country. The city of San Nicolas has a lower SOx concentration than the above three cities and the situation in the city is not bad at all.

When the environmental capacities of the three cities are studied, however, a good governmental administrative guidance needs to be in place so the current status will not aggravate any further. Comparisons in atmospheric concentrations with a global level will be described in section 3.3. To put it another way, the status is being maintained at the level of the outcome of atmospheric preservation efforts that ecologically advanced countries have made by working on environmental pollution prevention for many years.

Table 3-2-14 RESULT OF MEASUREMENT ON POLLUTANT CONCENTRATION

(1993)

	Item	Suspended Perticulate Matter (mg/Nm3)			Silfer di Oxide (μg/Nm3)			Nitrogen di Oxide (μg/Nm3)		
AREA	Station	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
BUENOS AIRES		0.06	0.09	0.01	6.0	12	3.3	9.4	14	4.8
MENDOZA		0.14	0.25	0.03	1.4	5.4	0.2	1.8	5.3	0.6
SAN NICOLAS		—	—	—	0.8	4.4	<0.2	—	—	—
ALL AREA		0.12	0.25	0.01	1.4	12	<0.2	3.9	14	0.6
BUENOS AIRES	CNEA	0.07	0.07	0.07	4.3	5.3	3.3	8.3	11	4.8
	Boca	0.01	0.01	0.01	12	12	12	8.1	8.1	8.1
	Moron	0.09	0.09	0.09	5.0	5.0	5.0	14	14	14
MENDOZA	CNEA Cuyo	0.17	0.24	0.08	3.3	5.4	0.6	1.2	—	—
	Munici. LH	0.17	0.25	0.12	1.6	2.7	0.4	3.2	5.3	1.5
	Parque	0.10	0.19	0.03	1.1	2.0	0.4	1.2	1.6	0.6
	Polideport	0.16	0.21	0.08	0.6	0.8	0.5	1.8	2.9	0.7
	EscuelaNo.1-237	0.10	0.15	0.04	0.6	1.1	0.2	1.4	1.8	0.9
SAN NICOLAS	Club Somisa	—	—	—	1.0	2.7	<0.2	—	—	—
	Aero Club	—	—	—	1.4	4.3	<0.2	—	—	—
	Club C y P	—	—	—	0.3	0.5	<0.2	—	—	—
	Camping L y F	—	—	—	0.9	4.4	<0.2	—	—	—
	Escuela No.35	—	—	—	0.3	0.6	<0.2	—	—	—
	Munici. SN	—	—	—	0.9	2.5	<0.2	—	—	—
Note		Measurement Date:								
	BUENOS AIRES	13〜16／July								
	MENDOZA	22〜28／July								
	SAN NICOLAS	3〜12／August								

Table 3-2-15 (1) RESULT OF MEASUREMENTS ON POLLUTANT CONCENTRATION IN MENDOZA (1993)

	Item	Suspended Perticulate Matter	Sulfer di Oxide	Nitrogen di Oxide
Station	Date	(mg/Nm3)	(μg/Nm3)	(μg/Nm3)
CNEA Cuyo	22～23/JULY	0.19	3.8	–
	26～27/JULY	0.24	5.4	–
	27～28/JULY	0.08	0.6	1.2
Munici.LH	22～23/JULY	0.14	1.6	5.3
	26～27/JULY	0.25	2.7	2.9
	27～28/JULY	0.12	0.4	1.5
Parque	22～23/JULY	0.09	0.8	1.6
	26～27/JULY	0.19	2.0	1.3
	27～28/JULY	0.03	0.4	0.6
Polideport	22～23/JULY	0.19	0.5	1.7
	26～27/JULY	0.21	0.8	2.9
	27～28/JULY	0.08	0.6	0.7
Escuela№1-237	22～23/JULY	0.11	0.2	1.8
	26～27/JULY	0.15	0.5	1.6
	27～28/JULY	0.04	1.1	0.9
Average		0.14	1.4	1.8

Table 3-2-15 (2) RESULT OF MEASUREMENTS ON POLLUTANT CONCENTRATION IN BUENOS AIRES (1993)

Station	Item Date	Suspended Perticulate Matter (mg/Nm3)	Sulfer di Oxide (μg/Nm3)	Nitrogen di Oxide (μg/Nm3)
CNEA	13～14/JULY	0.07	5.3	4.8
	14～15/JULY	0.07	3.3	11
	15～16/JULY	0.07	4.3	9.0
Boca	15～16/JULY	0.01	12	8.1
Moron	15～16/JULY	0.09	5.0	14
Average		0.06	6.0	9.4

Table 3-2-15 (3) RESULT OF MEASUREMENTS ON POLLUTANT CONCENTRATION IN SAN NICOLAS (1993)

Item / Date / Station	Sulfer di Oxide (μg/Nm3)							
	3～4 /AUGUST	4～5 /AUGUST	5～6 /AUGUST	6～7 /AUGUST	9～10 /AUGUST	10～11 /AUGUST	11～12 /AUGUST	Average
Club Somisa	—	2.7	0.4	< 0.2	0.4	1.9	< 0.2	1.0
Aero Club	3.0	1.6	< 0.2	< 0.2	4.3	0.6	< 0.2	1.4
Club C y P	< 0.2	< 0.2	0.4	< 0.2	0.3	0.5	< 0.2	0.3
Camping L y F	< 0.2	4.4	< 0.2	< 0.2	0.7	0.6	< 0.2	0.9
Escuela №35	< 0.2	< 0.2	< 0.2	—	0.5	0.6	< 0.2	0.3
Munici. SN	< 0.2	< 0.2	1.1	2.5	0.4	1.1	0.7	0.9
Average	0.8	1.6	0.4	0.7	1.1	0.9	0.3	0.8

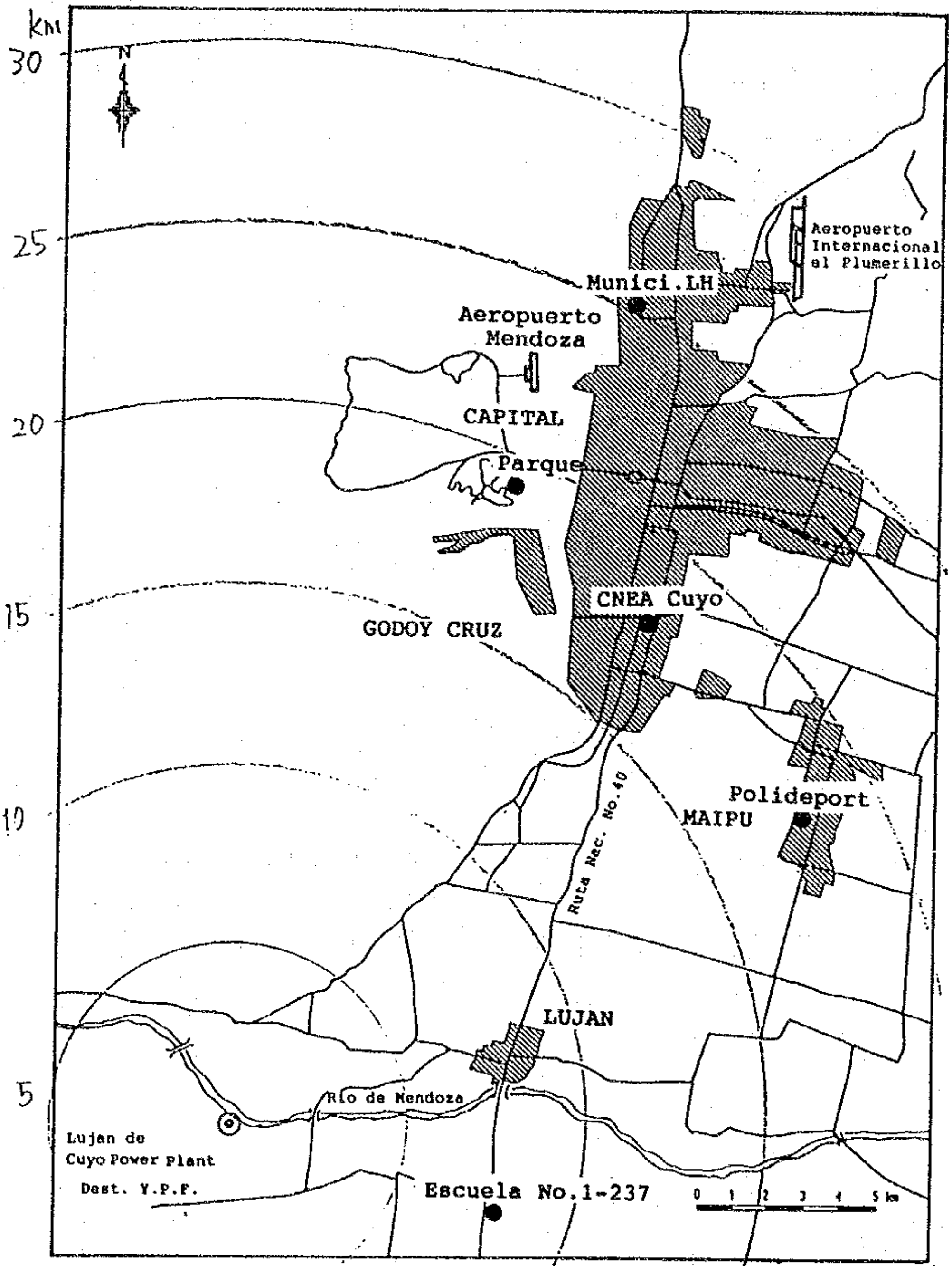
Table 3-2-15 (4) SUMMARY OF WIND DIRECTION AND VELOCITY (LUJAN DE CUYO PLANT)

Divection	Frequency	max. Velocity (m/sec)	ave. Velocity (m/sec)
N	12	2.4	1.2
NNE	1	1.7	1.7
NE	2	1.4	1.2
ENE	1	3.7	3.7
E	0	–	–
ESE	0	–	–
SE	0	–	–
SSE	1	0.8	0.8
S	10	2.0	1.1
SSW	0	–	–
SW	4	4.2	3.0
WSW	15	3.7	2.4
W	13	3.2	1.4
WNW	7	2.9	1.5
NW	1	1.5	1.5
NNW	1	0.5	0.5
		4.2	1.7

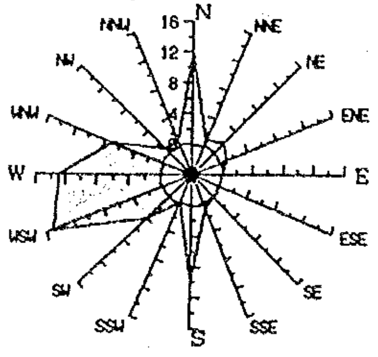
Table 3-2-15 (5) SUMMARY OF WIND DIRECTION AND VELOCITY (SAN NICOLAS POWER PLANT)

Divection	Frequency	max. Velocity (m/sec)	ave. Velocity (m/sec)
N	0	–	–
NNE	19	6.1	4.1
NE	8	5.6	4.4
ENE	15	7.2	4.3
E	16	4.3	1.9
ESE	9	4.3	3.2
SE	6	3.5	2.5
SSE	6	2.6	2.1
S	24	8.0	4.7
SSW	31	8.8	5.3
SW	10	3.1	2.3
WSW	35	8.8	4.3
W	9	3.8	2.7
WNW	23	5.0	2.7
NW	8	3.3	2.3
NNW	1	2.4	2.4
		8.8	3.7

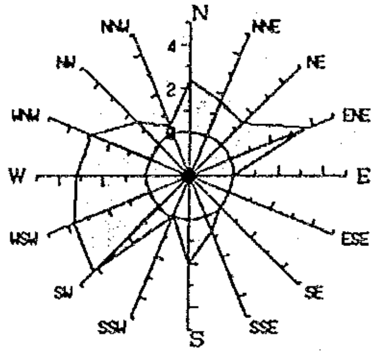
Figure 3-2-2 MEASUREMENT OF ATMOSPHERIC CONCENTRATIONS IN MENDOZA



Observation results of Wind direction and velocity -Appearance Frequency by 16-wind direction- (Lujan de Cuyo Power Plant) July 26-29,1993



Observation results of Wind direction and velocity -Maximum wind velocity by wind direction- (Lujan de Cuyo Power Plant) July 26-29,1993



Observation results of Wind direction and velocity -Average wind velocity by wind direction- (Lujan de Cuyo Power Plant) July 26-29,1993

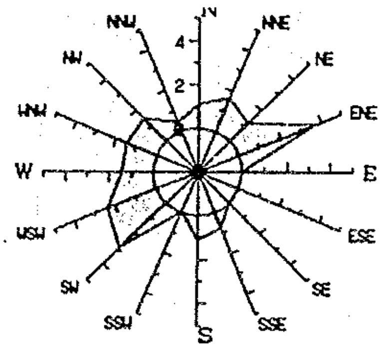
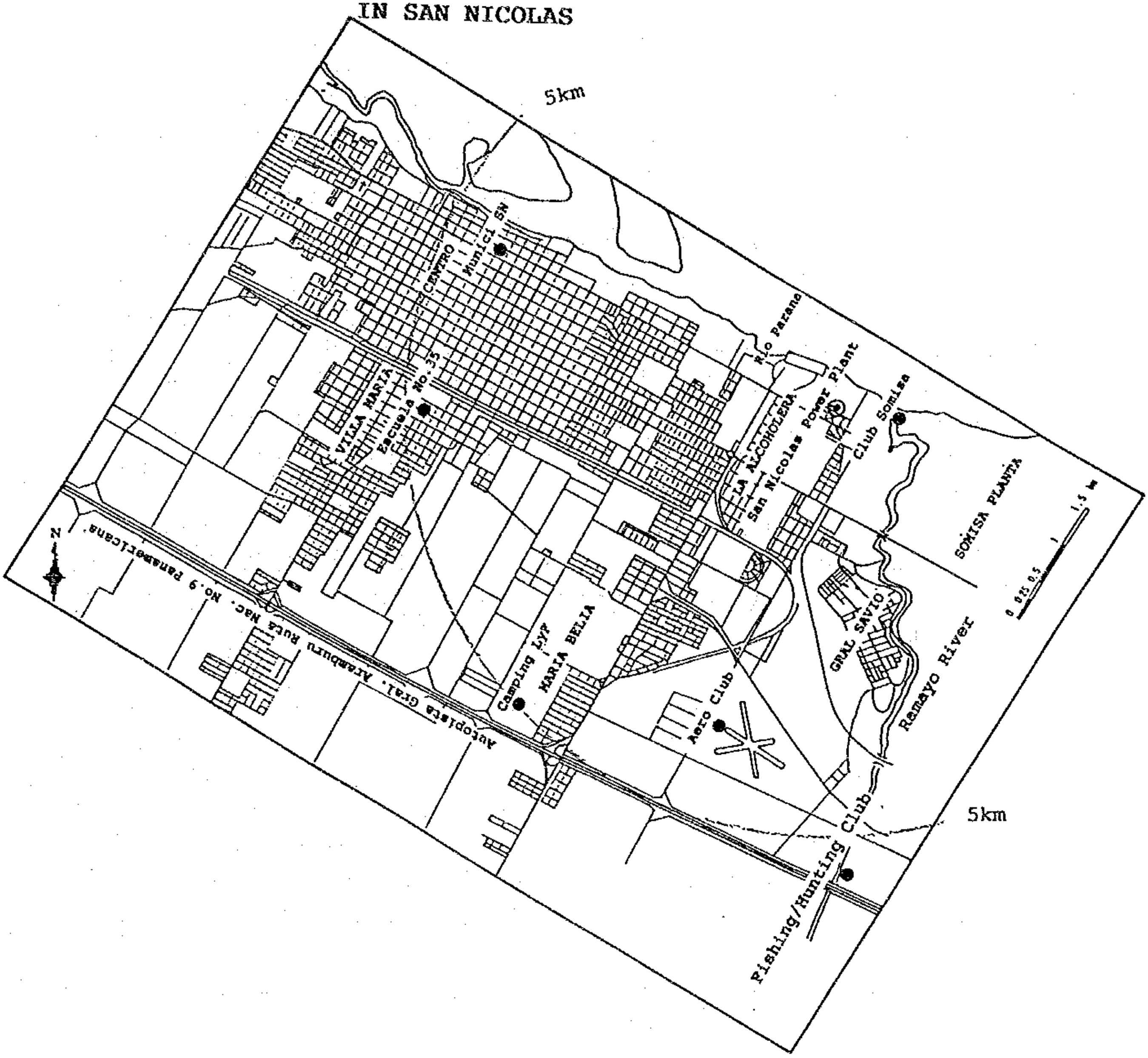
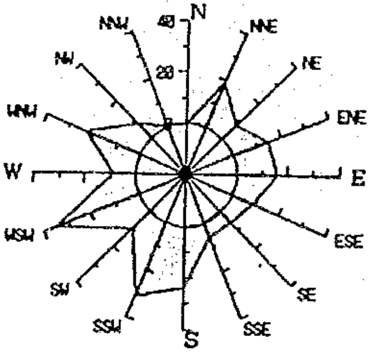


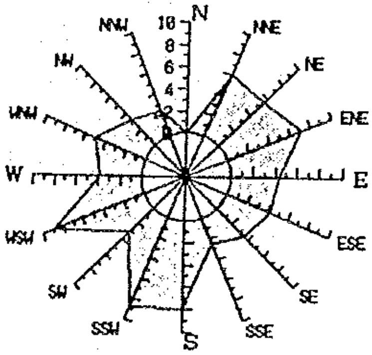
Figure 3-2-3 MEASUREMENT OF ATMOSPHERIC CONCENTRATIONS IN SAN NICOLAS



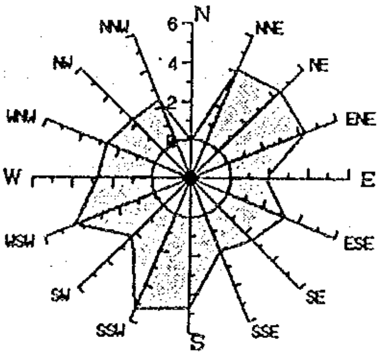
Observation results of Wind direction and velocity -Appearance Frequency by wind direction- (San Nicolas Power Plant) Aug 3-12, 1993



Observation results of Wind direction and velocity -Maximum wind velocity by wind direction- (San Nicolas Power Plant) Aug 3-12, 1993



Observation results of Wind direction and velocity -Average wind velocity by wind directions- (San Nicolas Power Plant) Aug 3-12, 1993



Followings are short comments by the Survey team on results of the measurement itself and instructional recommendations for further utilization of these by the government of Argentina.

2) In consideration of abundant analyzers provided to the government of Argentina, i.e. five kinds of analyzers for flue gas measurement, six kinds of monitors for measurement of ambient air together with various supporting instrument and analyzers, it is considered that monitoring of the emission from the thermal power plant will be easily commenced from now on.

3) However, it may be reviewed that a screening test and/or in-depth preparation of the measurement prior to the start-up of actual measurement might be more considered and prepared for this survey.

4) Therefore, it is recommended that all information on the analyzers such as, instruction manual, maintenance manual including list of spare parts, list of analyzer, standard manuals for chemical analysis, EPA standard, etc. shall be systematically compiled and further a receipy for analysis shall be prepared by the CNEA by itself, for an important analyzers and analytical method in español.

5) Regarding the individual analyzers, following comments shall be presented at this moment:

   -MSI-2000;

   This instrument was provided because many power plants are interested in and many were introduced already. However, there are many issues to be clarified, i.e. reproducibility, performance of gas cooler, maintenance, calibration etc. It can be said that these instrument shall be located as a handy and screening monitor prior to the detail measurement of chemical analysis and/or other instruments.

-NOA-7000;

Among many instrument analyzers, this chemiluminescence analyzer was selected because of its high performance, high functioning, easiness of maintenance and for necessities of measurement of wide range of concentration of NO for emission from flue gas.

-IRA-107;

There are four type of auto-mated analyzer i.e. a) infrared b) conductmetric c) ultraviolet fluorescence d)constant potential electrolysis. Among these, infrared absorption system has been developed as a automated analyzer due to its high performance reliability for elimination of disturbing components. This instrument also, is applicable for measurement of pollutants from flue gas for incinerators.

-Dust Monitor;

In the measurement of dust concentration in the flue gas, it is very important to measure the concentration of dust to cover the whole area of duct or stack due to the difference of gas Velocity.
At this moment, there is no instrument analyzer to meet the objective of these.

Therefore, determination of location of sampling point and measurement of flow rate, temperature, flow speed and flow rate of wet/dry basis are essential information in the measurement of dust.
Also this analyzer enable to take a sample for NOx and SOx, therefore, it can be said that this analyzer shall be a basic analyzer for measurement of pollutants from flue gas.

-AP-710N;

This analyzer is based on light scattering method and does not provide data for mass quantity of dust in flue gas, therefore, it is necessary to make a comparison data to

direct measurement of weight of dust from dust monitor mentioned as above.
These co-relation between the aboves was presented in the Appendix-3.

-Zn-NEDA;

At first, chemical analysis method was determined as Saltzman method because similar method was approved by EPA for the determination of NO_2 in ambient air.
However, in order to cover wide range of NO concentration in flue gas, there was a fear that conversion of NO to NO_2 will be decreased depending on the concentration of NO.
(conversion rate:60 to 70% for 80ppm of NO, and 50% for 200ppm of NO).
Therefore, Zn-NEDA method was finally adopted for chemical analysis method because it can apply to a wide range of NO concentration and sensitivity is more excellent than PDS method especially, analysis can be completed within two and half hours.

However, most important point in this analysis is a quality of zinc powder of which reduction rate shall be higher than 90%.
More detailed comparison test using Japanese product and Argentine is needed and technical hearing with manufacturer of powder shall be held by the technical team of SE.

-High Volume Air Sampler;

Almost similar method of SPM measurement is stipulated in Appendix-B in Sub-Chapter-C of EPA and in Chapter 1 in "Selected Method of Measuring Air Pollutants" of WHO.
This apparatus is based in almost same principle.
Especially remarkable point on maintenance and operational view are filter, carbon brush and supervision of running time.

-Stand Sampler;

This sampler is to get sample for measurement of SOx and NOx for designated period.
In this sampler, important point of measurement are a) supervision of flow rate and b) determination of absorption liquid.
Under the given environmental conditions, screening test of flow rate and absorption liquid volume or settling of number of impingers are needed.

3.2.4 Comparison and review of atmospheric pollution in Argentina with a global level

The current ecological problems, which were one of the major issues at the "Ecology Summit" held in Brazil in 1992, have been recognized as an important element in discussions free trades as well as on issues surfacing in the relationships between the developed and developing countries. In this context, it is significant to understand where Argentina stands in terms of the level of atmospheric contamination on the global standard. This is needed from the standpoint of export promotion for the country's economic development that is currently considered as the most important issue.

While measurement of atmospheric concentrations performed in this particular survey is just an example, further consideration will be attempted based on the data so far obtained.

(1) Atmospheric standards in each country of the world

Atmospheric standards for SOx, NOx, SPM, etc. in each country of the world are given in Table 3-2-16(1),(2). Some countries have different ideas of setting standards, that is to say, different definition of data, and, therefore, simple comparisons cannot be easily made, but it is necessary to understand data even on a rule of thumb basis. Atmospheric concentrations for SO_2, NOx and SPM in OECD countries are given in Table 3-2-17(1)-(3).

Table 3-2-16 ENVIRONMENTAL STANDARDS OF VARIOUS COUNTRIES

(1/2)

	SO2(ppm)						NO2(ppm)			CO(ppm)						Photosynthetic Oxidant Ox (ppm)						Suspended particles material SPM(mg/m3)				Other Substances	Definitions
	Year	Month	24hr	1hr	30min	10min	Year	24hr	1hr	Month	24hr	8hr	1hr	30min	15min	Substance	Year	24hr	8hr	1hr	30min	10umCut	Year	24hr	1hr		
Argentine	-	0.0 *1	-	1 *2	-	-	-	-	0.5	-	-	10	50	-	-		-	-	-	0.1	-	-	-	-	-	NOx, TSP, Falling soot	Maximum allowable limit
Japan	(0.018)	-	0.04	0.1	-	-	(0.02-0.03)	0.04-0.06	(0.1-0.2)	-	10	20	-	-	-		-	-	-	0.1	-	100%	-	0.1	0.2		Standards desirable for protection of human health. Government's target. Annual assessment made on the basis of 2% elimination value or 98% value (for NOx only).
U.S.A. Primary standard	0.03	-	0.14	-	-	-	0.053	-	-	-	-	9	35	-	-	Ozone	-	-	-	0.1	-	50%	0.05	0.15	-	Pb	Standards that provide adequate protection of general public's health including on apropriate margin of allowance.
Secondary standard	-	-	(3hr value ↓)	0.5	-	-	0.053	-	-	-	-	-	-	-	-	Ozone	-	-	-	0.1	-	50%	0.05	0.15	-	Pb	Standards needed to protect general public's welfare from harmful impact construed to be related to atmospheric pollutants.
																											Except standards relating to annual average, the above standard should not be exceeded more than once a year.
Brazil Primary standard	0.028	-	0.13	-	-	-	0.053	-	0.2	-	-	9	35	-	-	Ozone	-	-	-	0.1	-	50%	0.05	0.15	-	TSP, Smoke	Except standards relative to annual average, the above standard should not be exceeded more than once.
Secondary standard	0.014	-	0.03	-	-	-	0.053	-	0.1	-	-	9	35	-	-		-	-	-	0.1	-	50%	0.05	0.15	-	TSP, Smoke	
Bulgaria	-	-	0.02	0.2	-	-	-	0.02	0.1	-	3	-	4	-	-	Ozone	-	0.0	-	0.1	-	-	-	-	-	TSP	
Peru	0.06	-	0.3	-	-	-	-	0.11	-	-	-	17	35	(2hr value ↓)	-		-	-	0.1	-	0.2	-	-	-	-	TSP, As, Pb, Smoke	24-hour limits for SO2 and TSP, and 30-min limits for Ox and As should not be exceeded more than once a year. limit is for reference.
Poland	0.011	-	0.07	-	0.2	-	0.027	0.08	0.3	0	1	-	-	4	-	Ozone	-	0.0	-	-	0.1	-	-	-	-	TSP	30-min limit for SO2 and annual average limit for CO have been set, which are given in 1-hour and monthly average columns respectivly.
Malaysia	-	-	0.04	0.1	-	0.2	-	-	0.2	-	-	9	30	-	-	Ozone	-	-	0.1	0.1	-	50%	0.05	0.15	-	TSP, Pb, Folling soot	
South Africa	0.028	-	0.09	0.3	-	-	0.144	0.29	0.6	-	-	-	-	-	-		-	0.1	0.1	-	-	-	-	-	-	Pb, TSP, Smoke	
Mexico	-	-	0.12	-	-	-	-	-	0.2	-	-	13	-	-	-		-	-	-	0.1	-	-	-	-	-	TSP	For Ox, the Mexico city standards are listed.
Rumania	0.021	-	0.09	-	0.3	-	0.021	0.05	0.2	-	2	-	-	5	-	Ozone	-	0.0	-	-	0.1	-	-	-	-	Smoke, TSP, and other 25 substances	30-min limit for SO2 has been set which is given in 1-hour column.
Russia	-	-	-0.1	-	-	-	-	-	-	-	1	-	-	-	-		-	-	-	-	-	-	-	-	-	TSP and other Totaliing 360	30-min limit for SO2 has been set which is given in 1-hour column.
South Korea	0.05	-	0.15	-	-	-	0.05	-	0.2	8	-	20	-	-	-		0.0	-	-	0.1	-	-	-	-	-	TSP, HC	Except annual and monthly limits these standards should not be exceeded more than three times a year.
Kuwait	0.03	-	0.06	0.2	-	-	-	0.05	-	-	8	10	35	-	-	Ozone	-	-	-	0.1	-	-	-	-	-	TSP, H2S, NH3, C12, NMHC, Pb	24-hour limits for SO2 and TSP should not be exceeded more than once a year, and 1-hour limit for SO2 should not be exceeded more than two times in 30 days under any circumstances.
Columbia	0.03	-	0.12	-	-	-	0.05	-	-	-	-	12	-	-	-		-	-	-	0.1	-	-	-	-	-	TSP	
Saudi Arabia	0.03	-	0.15	0.3	-	-	0.05	-	0.4	-	-	9	35	-	-	Ozone	-	-	-	0.2	-	-	-	-	-	TSP, F2	CO and O3 limits should not be exceeded more than once a year and 24hour for SO2 and H2S should not be exceeded more than two times a month.
Thailand	0.035	-	0.1	-	-	-	-	-	0.2	-	-	17	44	-	-		-	-	-	0.1	-	-	-	-	-	TSP	
Taiwan	0.03	-	0.1	0.3	-	-	0.05	-	0.3	-	-	9	35	-	-	Ozone	-	-	0.1	0.1	-	50%	0.07	0.13	-	TSP, Pb	
PR of China Class I	-	-	0.02	0.1	-	-	-	0.03	0.1	-	3	-	9	-	-	Ozone	-	-	-	0.1	-		-	-	-	NOx, TSP	Tourism, historical and preserved spots.
Class II	-	-	0.05	0.2	-	-	-	0.05	0.1	-	3	-	9	-	-	Ozone	-	-	-	0.1	-		-	-	-	NOx, TSP	Residential area.
Class III	-	-	0.09	0.2	-	-	-	0.08	0.2	-	5	-	17	-	-	Ozone	-	-	-	0.1	-		-	-	-	NOx, TSP	Industrial and heavy traffic areas.

(2/2)

SO2(ppm)						NO2(ppm)			CO(ppm)						Photosynthetic Oxidant						Suspended particles material SPM(mg/m3)				Other Substances	Definitions
															Subs-tance	Ox (ppm)										
Year	Month	24hr	1hr	30min	10min	Year	24hr	1hr	Month	24hr	8hr	1hr	30min	15min		Year	24hr	8hr	1hr	30min	10umCut	Year	24hr	1hr		
0.05	-	-	-	0.2	-	0.04	(30mi value ↓)	0.1	-	-	9	26	-	-	Ozone	-	-	-	-	-	50%	0.1	(30mi value ↓)	0.2	TSP, NO, Pb	Given as one of the conditions for approving installation and operation of certain facilities No suspension of operation is to be requested by neighboring people on account of environmental destruction, once formal approval is granted.
0.021	-	0.05	0.2	-	-	-	-	-	-	9	-	-	-	-	Ozone	-	-	-	0.1	-	-	-	-	-	Smoke	
(Smo value ↓)	0.0	0.04	-	-	-	-	0.05	-	-	-	9	35	-	-		-	-	0.0	0.1	-	-	-	-	-	Smoke, TSP, inorganic Pb F2, NMHC, H2S	
0.024	-	0.05	-	0.2	-	0.037	0.05	0.1	2	4	-	-	9	-	Ozone	-	0.1	-	-	0.1	-	-	-	-	TSP, Smoke	30-min limit for NO2 and annual average limit for CO have been set, which are given in columns of 1-hour and monthly average respectively.
-	-	0.13	0.3	-	-	-	-	0.1	-	-	9	74	-	-		-	-	-	0.1	-	-	-	-	-	TSP	
0.014	-	0.07	0.2	-	-	-	0.08	0.2	-	-	9	26	-	-		-	-	-	-	-	-	-	-	-	TSP, All Hydrogen sulfates, Falling substances	24-hour data are assessed on 98% of annual data, and 1-hour data except CO on 98% of data of 30 days. Separate standard is set for SO2 for areas other than towns and large villages.
0.017	-	0.04	0.1	-	0.2	-	0.08	0.2	-	-	9	26	52	87	Ozone	-	-	0.05-0.1	0.075-0	-	50%	-	0.07	-	24 substances including Cd trichloroethylene	The standards are to be used as background information and guidance for tisk management decisions, particularly when administrators set up standards. They are limits below which human health will not be hurt. Most of them are set up by WHO's European regional office.
0.014-0.021	-	0.035-0.05	-	-	-	0.027	0.07	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	SP due to black smoke process	Standards used as a guide value. The limits refer to a median value of 1-hour data and a 98% value for NO2. The former is given in the column of annual average and the latter in daily average respectively.
0.021	-	0.1	-	0.3	-	-	-	-	-	-	10	52	-	-	Ozone	-	0.0	-	-	0.1	-	-	-	-	H2S, NOx, TSP, Pb, Falling soot	24-hour value of Ox is scheduled to be replaced with 4-6 hour value.
-	-	-	0.1	-	-	-	-	-	-	-	20	-	-	-		-	-	-	0.1	-	-	-	-	-	TSP, NOx, HC, NH3, H2S, Pb	
-	-	0.07	-	-	-	-	0.1	-	-	3	-	-	-	-		-	-	-	-	-	-	-	-	-		
0.02	-	-	-	-	-	-	-	0.2	-	-	9	-	-	-		-	-	-	0.1	-	-	-	-	-	Pb, TSP	Long-range target for maximum allowable concentration. 1-hour limit should not be exceeded more than once a month and 8-hour limit should not be exceeded more than once a year.
-	-	0.03	-	-	-	-	-	0.0	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	Benzene	Standards used as a guide value. 50%, 95% and 98% values of 24-hour data are set for SO2, and 98% and 50% values of 1-hour data set for NO2. Both data given in the table are 98% values.
0.01	-	0.05	0.2	-	-	0.032	-		-	-	5	13	-	-		-	0.0	-	0.1	-	-	-	-	-	TSP	This is a long-range target and is to be a concentration level that should serve as Congress protection policies for unpolluted areas.
0.021	-	0.1	0.3	-	-	0.053	0.11	0.2	-	-	13	31	-	-		0.015	0.025	-	0.1	-	-	-	-	-	TSP	This is a concentration level intended to properly protect soil, water, plants, materials, animals, landscape individual comforts and welfare against harmful impact.
-	-	0.28	-	-	-	-	0.16	0.5	-	-	17	-	-	-		-	-	-	0.2	-	-	-	-	-	TSP	This is a concentration level to which pollutants are to be reduced without delay so as to avoid atmospheric deterioration that damages general life patterns and ultimately cause serious risks of public health.

As the principles of setting values are different from country to country, simple comparison of values is in appropriate.
Number in ( ) are not specified as environmental standards in Japan, but constitute bases of standards.
Suspended particles of dust by high-volume air samplers are expressed as Total Suspended Partifulate (TSP).
When the standards are expressed in unit other than those applied for Japan's standards, numbers have been converted in terms of Japan's units.

*1 : Monthly Average *2 : 8 hrs value

Table 3-2-17(1) CONCENTRATION OF SO2

Selected Cities, 1975 - 1990

	Cat (a)	City or Area	Measurement Method	No. Stations	1980 base reference (ug/m3)	Relative Concentration (%)											
						1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Canada b)	N	National	Coulometric c.	58	23.7	-	100	89	89	67	78	67	68	55	68	68	-
	A	MONTREAL	Coulometric c.	5	40.8	-	100	92	66	44	42	49	44	37	37	44	-
	B	HAMILTON	Coulometric c.	1	35.5	-	100	89	89	96	110	68	59	51	68	87	-
	C	VANCOUVER	Coulometric c.	3	19.2	-	100	72	87	73	73	89	82	78	83	83	-
	B.G.	DORSET	Coulometric c.	1	13.1(1983)	-	-	-	-	100	40	20	20	20	20	-	-
USA o)	N	National	Pulsed fluor. cont	374	28.8	136	100	91	91	82	91	82	82	76	76	-	-
	A	NEW YORK	Pulsed fluor. cont	17	37.5	115	100	104	113	105	107	98	93	89	87	-	-
	B	LOS ANGELES	Pulsed fluor. cont	14	21.8	-	100	78	74	65	71	57	51	46	48	-	-
	C	DENVER	Pulsed fluor. cont	2	23.0	-	100	111	96	107	87	65	72	75	74	-	-
	B.G.	-	-	1	2.9	-	100	100	100	100	100	100	-	-	-	-	-
Japan c, d)	N	National	Conduct. cont	38	38.0	134	100	92	89	68	66	61	55	55	50	-	-
	A	TOKYO	Conduct. cont	20	48.0	125	100	90	88	63	56	52	48	48	40	-	-
	B	KAWASAKI	Conduct. cont	7	38.0	158	100	97	87	79	76	68	63	68	68	-	-
	C	KANAZAWA	Conduct. cont	11	20.0	100	100	95	90	90	95	90	80	75	65	-	-
	B.G.	-	Conduct. cont	7	13.0	162	100	100	108	92	85	85	92	92	100	-	-
Austria	A	VEINNA	Pulsed fluor.	16	69.0	-	100	83	75	61	57	67	57	54	33	32	-
	B	LINZ	Pulsed fluor.	9	32.0	-	100	100	81	75	-	-	88	-	-	-	-
	B.G.	MOSCHENDORF	Pulsed fluor.	1	19.0(1983)	-	-	-	-	100	68	-	-	-	-	-	-
Belgium c)	N	National	-	5	50.0	-	100	106	86	94	112	92	86	60	56	-	-
	A	BRUXELLES	Acid. Titr. cont.	8	43.0	-	100	107	74	81	105	91	86	60	63	-	-
	B	ANTWERPEN	Acid. Titr. cont.	12	63.0	-	100	105	81	89	83	67	67	49	49	-	-
	C	LIEGE	Acid. Titr. cont.	7	56.0	-	100	82	64	61	82	77	66	43	39	-	-
	B.G.	SIG. D. ROT. LIEGE	Acid. Titr. cont.	1	8.0	-	100	225	188	138	238	250	225	150	125	-	-
Denmark	A	COPENHAGEN	KOM imp. Filter	3	31.0	-	100	58	74	81	84	84	61	-	68	58	-
	B.G.	TANGE	KOM imp. Filter	1	11.0	-	100	69	82	56	73	56	55	48	40	23	-
Finland l)	A	HELSINKI	Flourescence UV	5	26.0	-	100	92	-	-	-	-	88	73	81	54	48
	B	TAMPERE	Flourescence UV	1	59.0	175	100	98	102	68	56	69	29	31	19	12	12
	C	LAHTI	Flourescence UV	2	30.0(1984)	-	-	-	-	-	100	100	67	63	-	-	-
	B.G.	SODANKYLA	Clorimetry	1	6.0	33	100	83	50	50	62	72	67	67	50	33	43
France	N	National	-	-	54.0(1982)	-	-	-	100	-	-	94	83	81	59	63	57
	A	PARIS	Acidimetry	13	89.0	129	100	80	76	69	64	61	56	53	40	49	43
	B	ROUEN	Acidimetry	19	70.0	90	100	70	69	59	56	53	53	56	53	50	41
	C	NANTES	Acidimetry	20	30.0	113	100	70	87	73	53	50	47	37	33	40	40
Germany m)	A	BERLIN (West)	-	15	90.0	106	100	86	91	74	73	74	72	84	57	68	-
	B	FRANKFURT	-	1	71.0	156	100	106	101	80	72	86	77	89	48	38	-
	C	GELSENKIRCHEN	-	1	95.0	105	100	87	82	77	78	92	77	68	41	38	-
	B.G.	DEUSELBACK	-	1	18.0	78	100	94	94	83	94	100	89	78	33	56	-
Ireland	A	DUBLIN	-	13	42.0	198	100	162	105	119	-	79	112	83	67	-	-
	B	CORK	-	6	31.0	110	100	-	-	-	-	52	113	77	61	-	-
	C	GALWAY	-	4	14.0	-	100	-	-	-	-	43	64	71	57	-	-
	B.G.	AGHADA, CORK	-	1	15.0	-	100	-	-	-	-	-	-	47	53	-	-
Italy g, h)	A	ROMA	Conduct/Fluor. c.	2	93.0	-	100	93	95	-	-	-	-	-	-	-	-
	B	MILANO	Conduct. cont.	8	201.0	121	100	89	63	-	55	43	42	28	-	-	-
	C	PESCARA	Conduct. cont.	1	31.0	-	100	-	-	-	294	-	-	-	-	-	-
Luxembourg	N	National	Acidimetry	12	37.0	165	100	100	89	57	59	51	46	59	42	41	38
Netherl. i)	N	National	Fluorescence UV	8	32.3	-	100	112	86	85	-	-	91	64	53	52	-
	A	AMSTERDAM	Fluorescence UV	10	25.0	136	100	103	85	78	78	63	54	54	56	44	-
	B	RIJNMOND	Fluorescence UV	10	44.1	-	100	101	89	84	86	76	-	66	66	55	-
	C	UTRECHT	Fluorescence UV	4	24.0	-	100	125	88	92	-	-	-	-	-	-	-
	B.G.	-	Fluorescence UV	8	19.0	-	100	119	83	91	102	86	95	60	56	48	-
Norway c, m)	N	National	Colorimetry n.c.	23	20.9	119	100	90	73	71	74	72	67	56	47	44	-
	A	OSLO	Colorimetry n.c.	2	35.5	134	100	89	57	44	46	42	35	36	-	-	20
	B	PORSGRUNN	Colorimetry n.c.	1	11.5	-	100	130	61	78	117	109	83	104	61	87	43
	C	KRISTIANSAND	Colorimetry n.c.	1	11.5	-	100	91	104	126	109	83	91	87	61	57	52
	B.G.	-	KOM Imp. Filter	6	1.2	-	100	137	59	100	125	96	133	107	62	65	-
Portugal n)	A	LISBOA	Acid. titr. n.c.	11	44.0	82	100	77	77	80	73	70	61	70	98	-	-
	B	BARREIRO/SEIXAL	Acid. titr. n.c.	5	225.0	44	100	79	45	48	45	37	39	40	55	-	-
	C	PORTO	Acid. titr. n.c.	8	47.2	50	100	127	102	79	55	6	64	83	136	182	-
	B.G.	BRAGANCA	-	-	1.9	-	100	95	105	58	58	89	111	137	-	-	-
Sweden e, j)	A	GOTEBORG	Fluorescence UV	2	24.0	171	100	138	79	76	104	92	71	79	54	46	-
	B	STOCKHOLM	Fluorescence UV	5	42.0	140	100	102	71	64	64	50	55	43	33	19	-
	C	SUNDSVALL	Fluorescence UV	1	36.0	200	100	83	58	78	56	-	61	67	36	36	-
	B.G.	RORVIK	Colorimetry	1	9.2	-	100	72	91	61	70	83	76	63	49	59	-
Switzerl	A	ZURICH	Fluor. UV cont.	1	43.0(1981)	-	-	100	114	112	107	116	88	70	63	53	42
	B	BASEL	Fluor. UV cont.	1	36.0	-	100	79	100	95	82	95	87	-	45	47	37
	C	DUEBENDORF	Fluor. UV cont.	1	31.0	94	100	87	100	81	84	113	81	90	58	55	36
	B.G.	PAYERNE	Fluor. UV cont.	1	11.0	73	100	109	82	73	55	91	82	73	55	5	36
Turkey p)	A	ANKARA	Gas Bubbler	3	208.0	-	100	105	123	74	64	63	59	75	125	75	-
	B	KOCAELI	Gas Bubbler	2	47.0(1985)	-	-	-	-	-	245	100	183	277	360	353	-
	C	ESKISEHIR	Gas Bubbler	1	137.0(1985)	-	-	-	-	-	-	100	69	86	81	97	-
UK c, k, m)	N	National	Acid. Titr. cont.	175	48.0	141	100	104	84	82	79	76	74	73	68	68	-
	A	LONDON	Acid. Titr. cont.	23	70.0	166	100	97	87	70	71	60	64	56	56	53	-
	B	NEWCASTLE	Acid. Titr. cont.	1	69.0	162	100	96	109	58	58	58	55	86	52	-	-
	C	BRISTOL	Acid. Titr. cont.	1	64.0	119	100	103	66	81	93	95	61	45	27	-	-
	B.G.	LITTLE HORKESLE	-	1	28.0	214	100	79	64	71	96	114	61	39	36	29	-
Yugosl m)	A	BEOGRAD	Colorimetry n.c.	1	128.0	-	100	73	76	77	77	78	96	114	84	96	113
	B	ZENICA	Acid. Titr. cont.	1	154.0	-	100	120	109	137	125	121	113	105	107	77	110
	C	CELJE	Acid. Titr. cont.	1	143.0	-	100	92	80	87	76	72	58	57	35	41	35
	B.G.	PUNTIJARKA	-	-	16.0(1985)	-	-	-	-	-	-	100	75	75	75	50	-

NOTES:

a) Categories: N - country network, national trend; A - city in which a notable portion (5-10%) of the national population is concentrated; B - city in which a significant number of inhabitants are considered to be exposed to the highest level of pollutants in 1980; C - city with residential and service function and with intermediate level of pollutants; B.G. - selected station representing the background concentration.
b) Measurement under the temperature of 15.6 degrees below zero.
c) Fiscal year, commencing 1st April.
d) Operating temperature 20 degrees Celsius.
e) Data for Sundsvall refer to city centre.
f) 1989 data for Tange refer to April 1988 - April 1989.
g) Country did not give the means for whole region: data represent weighted averages of specific monitoring stations.
h) Pescara: operating term of stations is one sixth of a whole year. Milano, Roma: 1981 and 1982 data are Secretariat estimates based upon national report data.
i) Amsterdam 1975: year commencing January; otherwise year commencing April.
j) Monitoring period from October to March, except for B.G.
k) Measurement method follows the British Standard 1747 Part.3.
l) Tampere 1979 and 1980: some data were obtained by automatic analyzer; Sodankyla: number of measurements per year ranges from 34 to 54.
m) Data for cities that refer to one station only, represent intermediate pollution level.
n) Break in time series between 1975 and 1980.
o) For New York, Los Angeles and Denver: break in time series between 1981 and 1982.
p) Instrumental conductory method since 1987.

Table 3-2-17(2) CONCENTRATION OF NO2

Selected Cities, 1975 - 1990

	Cat (a)	City or Area	Measurement Method	No. Stations	1980 base reference (ug/m3)	Relative Concentration (%)											
						1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Canada	N	National	Chemiluminesc.	34	47.2	-	100	92	92	88	96	88	87	83	83	83	-
	A	MONTREAL	Chemiluminesc.	5	54.7	-	100	83	86	83	82	79	75	86	91	93	-
	B	HAMILTON	Chemiluminesc.	2	51.9	-	100	102	102	100	94	87	91	83	91	89	-
	C	VANCOUVER	Chemiluminesc.	3	50.0(1979)	-	-	94	86	94	78	86	86	86	100	96	-
USA	N	National	Chemiluminesc.	116	52.6	-	100	97	93	89	93	89	89	91	91	-	-
j)	A	NEW YORK	Chemiluminesc.	3	66.2	104	100	92	100	101	98	96	93	101	101	-	-
	B	LOS ANGELES	Chemiluminesc.	14	96.1	96	100	107	98	92	91	93	93	78	83	-	-
	C	DENVER	Chemiluminesc.	2	54.3	-	100	92	92	110	102	103	108	123	122	-	-
	B.G.	-	Sodium Arsenite	1	5.0	-	100	100	100	100	100	100	100	100	100	-	-
Japan	N	National	Saltzmann	31	58.0	107	100	93	93	98	95	91	94	102	102	-	-
b, c)	A	TOKYO	Saltzmann	20	66.0	105	100	94	95	94	89	86	88	95	97	-	-
	B	KAWASAKI	Saltzmann	7	51.0	112	100	100	94	118	125	116	122	125	124	-	-
	C	KANAZAWA	Saltzmann	4	27.0	93	100	93	93	93	89	89	85	93	93	-	-
	B.G.	-	Saltzmann	6	12.0	92	100	108	100	100	108	117	117	125	108	-	-
Austria	A	VEINNA	Chemiluminesc.	16	50.9	-	100	122	148	104	67	122	-	-	83	88	-
	B	LINZ	Chemiluminesc.	9	42.0	-	100	110	126	126	-	-	138	-	-	-	-
	B.G.	MOSCHENDORF	Chemiluminesc.	1	24.5(1982)	-	-	-	100	77	-	-	-	-	-	-	-
Belgium	N	National	Chemilum. cont.	5	53.0	-	100	98	102	100	113	102	91	91	100	-	-
b)	A	BRUXELLES	Chemilum. cont.	4	63.0	-	100	83	79	98	83	83	81	73	78	-	-
	B	ANTWERPEN	Chemilum. cont.	3	48.0	-	100	104	100	96	113	96	92	85	104	-	-
	C	LIEGE	Chemilum. cont.	1	42.0	-	100	98	119	112	136	21	117	102	119	-	-
	B.G.	-	Chemilum. cont.	1	85.0	-	100	53	39	72	54	53	53	45	45	-	-
Denmark g)	A	COPENHAGEN	Chemilum. cont.	3	80.0(1982)	-	-	-	100	89	70	80	74	-	73	66	-
Finland	A	HELSINKI	Chemilum. cont.	2	42.0(1988)	-	-	-	-	-	-	-	-	-	100	100	108
France	N	National	Chemiluminesc.	4	70.0(1982)	-	-	-	100	-	-	86	81	77	70	76	76
	A	DUNKERQUE	Chemiluminesc.	1	42.0	-	100	74	129	124	83	86	71	90	98	105	112
	B	CAEN	Chemiluminesc.	1	34.0	-	100	88	97	100	97	103	109	97	109	126	132
	C	NANTES	Chemiluminesc.	1	17.0(1986)	-	-	-	-	-	-	-	100	171	232	294	294
	B.G.	DONON	Chemiluminesc.		12.0(1985)	-	-	-	-	-	-	100	58	25	42	-	-
Germany	A	BERLIN (West)	-	1	35.0	-	100	94	114	103	109	120	109	131	129	123	-
k)	B	FRANKFURT	-	1	54.0	131	100	87	91	105	87	80	83	94	98	102	-
	C	GELSENKIRCHEN	-	1	87.0	60	100	-	70	59	56	64	74	80	74	60	-
	B.G.	DEUSELBACK	-	1	13.0	77	100	100	92	92	100	108	92	100	85	123	-
Netherl.	N	National	Chemilum. cont.	5	42.6	-	100	105	96	107	109	98	106	106	110	107	-
e)	A	AMSTERDAM	Chemilum. cont.	5	39.8	105	100	110	114	108	102	114	129	142	142	46	-
	B	RIJNMOND	Chemilum. cont.	3	40.3	108	100	118	114	127	110	106	126	115	136	115	-
	C	UTRECHT	Chemilum. cont.	3	45.0	-	100	102	98	113	127	-	-	-	-	-	-
	B.G.	-	Chemilum. cont.	4	22.3	-	100	125	104	110	120	110	110	100	106	99	-
Norway	N	National	Colorimetry n.c.	9	55.5(1986)	-	-	-	-	-	-	-	100	95	99	84	-
h, d)	A	OSLO	Colorimetry n.c.	2	70.0(1982)	-	-	-	100	-	-	116	121	129	84	87	71
	B	DRAMMEN	Colorimetry n.c.	1	73.0(1986)	-	-	-	-	-	-	-	100	92	101	88	-
	C	STRAVANGER	Colorimetry n.c.	1	80.0(1986)	-	-	-	-	-	-	-	100	101	100	59	-
	B.G.	-	Colorimetry n.c.	5	3.8(1986)	-	-	-	-	-	-	-	-	129	126	105	100
Portugal	A	LISBOA	Sodium Arsenite	-	28.0	408	100	107	107	121	100	-	96	43	93	118	-
i)	B	BARREIRO/SEIX	-	-	18.0(1982)	494	-	-	100	67	78	94	-	-	-	-	-
Sweden	A	GOTEBORG	Chemilum. cont.	1	28.0(1982)	221	179	246	100	96	121	154	146	104	129	-	-
h, f)	B	STOCKHOLM	Chemilum. cont.	2	43.0(1982)	-	-	79	100	95	102	105	93	86	100	-	-
	C	SUNDSVALL	Chemilum. cont.	1	52.0(1982)	-	-	-	100	85	-	-	73	71	73	-	-
	B.G.	RORVIK	Chemil/Saltzm.c.	1	6.9(1982)	-	-	48	100	86	81	81	77	77	96	104	-
Switzerl	A	ZURICH	Chemilum. cont.	1	59.0(1981)	-	-	100	102	98	93	102	98	100	98	98	83
	B	BASEL	Chemilum. cont.	1	32.0(1981)	-	-	100	166	169	138	147	-	-	128	140	128
	C	DUEBENDORF	Chemilum. cont.	1	51.0	-	100	100	102	106	98	100	92	78	76	88	82
	B.G.	PAYERNE	Chemilum. cont.	1	21.0(1985)	-	-	-	-	-	-	100	110	105	95	105	86
UK	A	LONDON	Chemiluminesc.	1	64.1	167	100	103	127	115	127	98	108	117	105	111	-
	C	STEVENAGE	Chemiluminesc.	1	33.9	-	100	100	111	11	124	118	118	153	136	142	-
	B.G.	-	Chemiluminesc.	1	13.0(1977)	-	-	-	-	-	-	-	-	-	-	-	-

NOTES:

a) Categories: N - country network, national trend; A - city in which a notable portion (5-10%) of the national population is concentrated; B - city in which a significant number of inhabitants are considered to be exposed to the highest level of pollutants in 1980; C - city with residential and service function and with intermediate level of pollutants; B.G. - selected station representing the background concentration.

b) Fiscal year, commencing 1st April.

c) Operating temperature 20 degrees Celsius.

d) Data for Drammen and Stravanger refer to heavy traffic area.

e) Monitoring period from April to March.

f) Data for Sundsvall refer to city centre.

g) Monitoring period from February to December.

h) Monitoring period from October to March, except for B.G.

i) Break in time series between 1980 and 1981. 1981-85 data for Lisboa refer to 1 station only which represents medium concentration level. 1981-85 data for Barreiro refer to 3 stations respectively representing the highest, medium and lowest concentration level.

j) New York, Los Angeles and Denver: break in time series between 1981 and 1982.

k) Data for cities that refer to one station only represent intermediate pollution level.

Table 3-2-17(3) CONCENTRATION OF PATICULATES

Selected Cities, 1975 - 1990

	Cat (a)	City or Area	Measurement Method	No. Stations	1980 base reference (ug/m3)	Relative Concentration (%)											
						1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Canada b)	N	National	-	85	67.0	-	100	87	77	71	69	64	64	72	66	66	-
	A	MONTREAL	EPA Hi-Vol Sampler	8	82.0	-	100	88	77	74	65	59	62	65	55	55	-
	B	HAMILTON	EPA Hi-Vol Sampler	3	102.0	-	100	85	98	93	75	63	76	73	78	83	-
	C	VANCOUVER	EPA Hi-Vol Sampler	7	68.0	-	100	88	75	59	51	63	59	65	54	53	-
	B.G.	KENORA	EPA Hi-Vol Sampler	-	2.2	-	100	77	86	86	100	123	-	-	-	-	-
USA c, j)	N	National	Gravimetry	1750	64.2	-	100	94	78	77	80	76	76	77	79	-	-
	A	NEW YORK	Gravimetry	39	56.3	90	100	95	89	85	88	89	82	85	88	-	-
	B	LOS ANGELES	Gravimetry	18	90.4	-	100	105	77	77	94	93	66	90	93	-	-
	C	DENVER	Gravimetry	11	102.4	-	100	89	76	78	87	80	70	69	70	-	-
	B.G.	MESA VERDE	Gravimetry	1	15.0	87	100	100	87	60	73	73	53	60	53	-	-
Japan d, e)	N	National	B-ray absorption	17	47.0(1982)	-	-	-	100	94	98	94	104	104	100	-	-
	A	TOKYO	L.Scatt/B-ray abs.	7	48.0	169	100	108	106	98	108	110	121	123	110	-	-
	B	KAWASAKI	L.Scatt/B-ray abs.	8	48.0(1982)	-	-	-	100	96	96	88	98	106	98	-	-
	C	KANAZAWA	L.Scatt/B-ray abs.	2	25.0	108	100	92	104	92	84	80	100	108	104	-	-
	B.G.	-	B-ray absorption	7	31.0(1982)	-	-	-	100	74	84	77	77	81	94	-	-
Austria	A	VEINNA	B-ray absorption	12	52.0(1988)	-	-	-	-	-	-	-	-	-	100	90	-
	B	LINZ	B-ray absorption	9	77.0	-	100	87	106	99	-	-	73	-	-	-	-
Belgium d, g)	N	National	-	5	105.0	-	100	106	86	96	106	98	80	70	79	-	-
	A	BRUXELLES	OECD Filter-Soiling	4	156.0	-	100	107	61	66	71	59	60	50	56	-	-
	B	ANTWERPEN	OECD Filter-Soiling	2	103.0	-	100	104	97	92	127	95	86	69	76	-	-
	C	LIEGE	OECD Filter-Soiling	3	95.0	-	100	96	96	100	100	89	84	78	85	-	-
	B.G.	-	OECD Filter-Soiling	1	79.0	-	100	110	116	108	200	125	106	90	109	-	-
Denmark	A	COPENHAGEN	Gravimetry	3	57.0(1982)	-	-	-	100	91	109	112	100	-	139	-	-
Finland i)	A	HELSINKI	EPA Hi-Vol Sampler	5	63.0(1979)	-	-	95	103	113	-	-	119	113	124	111	102
	B	TAMPERE	Hi-Vol Sampler	1	126.0(1982)	31	100	118	100	-	-	-	-	100	96	89	72
	C	RAUMA	Low-Vol Sampler nc.	1	16.0(1975)	100	-	-	-	-	-	-	-	-	-	-	-
	B.G.	SODANKYLA	Low-Vol Sampler nc.	1	8.0	63	100	88	75	63	100	75	100	100	88	63	70
France h)	N	National	cont.	-	54.0(1985)	-	-	-	-	-	-	100	85	80	61	78	-
	A	PARIS	cont.	13	51.0	112	100	98	92	90	92	96	90	90	57	67	-
	B	ROUEN	cont.	6	25.0	-	100	108	108	84	68	100	72	120	108	116	-
	C	NANTES	cont.	8	14.0	257	100	107	79	114	100	136	129	129	-	-	-
Germany r)	A	BERLIN (West)	-	5	98.0	119	100	78	87	112	122	127	128	97	92	98	-
	B	FRANKFURT	-	1	73.0	84	100	36	37	67	47	93	79	97	83	69	-
	C	GELSENKIRCHEN	-	1	102.0(1982)	-	-	-	100	65	71	75	73	88	66	81	-
	B.G.	DEUSELBACK	-	1	41.0	100	100	93	115	98	95	93	93	85	63	76	-
Ireland h, t)	A	DUBLIN	OECD Black Smoke	13	43.0	102	100	-	-	-	-	105	137	123	119	-	-
	B	CORK	OECD Black Smoke	6	20.0	110	100	-	-	-	-	165	150	215	220	-	-
	C	GALWAY	OECD Black Smoke	4	16.0	-	100	-	-	-	-	75	63	75	69	-	-
	B.G.	AGHADA, CORK	OECD Black Smoke	1	3.0	-	100	-	-	-	-	-	-	333	167	-	-
Italy k, l)	A	ROMA	Gravimetry	1	139.4	105	100	-	-	-	-	-	-	-	-	-	-
	B	MILANO	Low-Vol Sampler c.	3	140.0	-	100	81	111	95	80	95	-	-	-	-	-
	C	PESCARA	EPA Hi-Vol Sampler	1	104.0	-	100	104	98	-	88	-	-	-	-	-	-
Luxembourg	N	National	Reflectometry	12	17.0	218	100	100	88	59	76	88	88	100	82	100	106
Netherl. m)	A	AMSTERDAM	EPA Hi-V.Sampler c.	5	66.0	106	100	101	95	96	98	96	80	68	66	62	-
	B	RIJNMOND-Rott	EPA Hi-V.Sampler c.	2	64.0	-	100	100	91	90	99	96	84	78	-	79	-
Norway n, r)	N	National	OECD Black Sm. n.c.	28	23.6	-	100	94	80	83	94	96	85	77	86	75	-
	A	OSLO	OECD Black Sm. n.c.	2	30.0	137	100	122	98	96	98	93	81	87	-	-	-
	B	PORSGRUNN	OECD Black Sm. n.c.	1	29.5	-	100	80	66	73	81	59	66	47	75	53	-
	C	KRISTIANSAND	OECD Black Sm. n.c.	1	18.5	-	100	89	78	92	92	86	89	95	76	78	-
Portugal v)	A	LISBOA	Smoke Shade	11	232.0	70	100	90	85	83	66	71	51	76	87	-	-
	B	BARREIRO/SEIXAL	Smoke Shade	5	27.1	76	100	-	-	-	-	-	694	624	631	-	-
	C	PORTO	Smoke Shade	8	48.2	74	100	112	106	107	47	47	50	46	-	27	-
	B.G.	BRAGANCA	-	-	28.7(1983)	-	-	-	-	100	87	-	-	-	-	-	-
Sweden p, q, u)	A	GOTEBORG	OECD Filter-Soiling	3	8.0	200	100	200	113	100	113	113	100	100	88	-	-
	B	STOCKHOLM	OECD Filter-Soiling	3	12.0	-	100	125	100	108	125	108	133	142	-	-	-
	C	SUNDSVALL	OECD Filter-Soiling	1	17.0	69	100	106	-	-	82	-	-	-	-	-	-
	B.G.	RORVIK	OECD Filter-Soiling	1	7.1	-	100	54	92	51	76	70	70	70	70	56	-
Switzerl o)	A	ZURICH	Grav. Hi-Vol Sampler	1	46.0(1981)	-	-	100	109	107	111	109	109	100	83	98	83
	B	BASEL	Grav. Hi-Vol Sampler	1	52.0(1982)	-	-	-	100	90	85	96	106	-	73	86	73
	C	DUEBENDORF	Grav. Hi-Vol Sampler	1	42.0(1981)	40	-	100	112	114	110	124	124	110	93	112	88
	B.G.	PAYERNE	Grav. Hi-Vol Sampler	1	33.0	100	100	106	112	121	118	136	136	121	97	112	103
Turkey f)	A	ANKARA	-	3	88.0	-	100	99	142	99	61	65	113	125	140	116	-
	B	KOCAELI	-	2	33.0(1985)	-	-	-	-	-	-	100	92	146	142	150	-
	C	ESKISEHIR	-	1	44.0(1985)	-	-	-	-	-	-	100	103	106	110	120	-
UK d, r, s)	N	National	OECD Black Smoke	175	19.1	169	100	120	89	94	81	81	80	77	71	69	-
	A	LONDON	OECD Black Smoke	23	21.0	171	100	114	95	85	86	71	71	76	90	71	-
	B	NEWCASTLE	OECD Black Smoke	1	28.0	214	100	107	89	89	75	79	68	86	71	-	-
	C	BRISTOL	OECD Black Smoke	1	16.0	172	100	100	83	122	122	100	78	67	61	-	-
	B.G.	LITTLE HORKESLEY	OECD Black Smoke	-	9.0	111	100	111	89	100	100	89	78	89	100	75	-
Yugosl r)	A	BEOGRAD	OECD Filter-Soiling	1	62.0	-	100	85	84	81	81	81	74	100	102	106	106
	B	ZENICA	OECD Filter-Soiling	1	64.0	-	100	95	86	88	78	73	53	42	63	88	55
	C	CELJE	OECD Filter-Soiling	2	48.0	-	100	68	71	90	79	75	54	92	63	56	60

NOTES:

a) Categories: N - country network, national trend; A - city in which a notable portion (5-10%) of the national population is concentrated; B - city in which a significant number of inhabitants are considered to be exposed to the highest level of pollutants in 1980; C - city with residential and service function and with intermediate level of pollutants: B.G. - selected station representing the background concentration.
b) Sampling protocol changed in 1983.
c) Annual geometric means. Site of background station for 1981-83 differs from earlier years. Particulates smaller than 60 um.
d) Fiscal year commencing 1st April.
e) Particulates smaller than 10 um.
f) Beta-ray absorption method since 1987.
g) Paticulates smaller than 7 um.
h) Black smoke.
i) Total suspended matter.
j) New York, Los Angeles and Denver: break in time series between 1981 and 1982.
k) Pescara 1981 and 1982: Secretariat estimates based on national report.
l) Rome: year commencing October; particulates smaller than 20 um. Milano: particulates smaller than 60 um.
m) Amsterdam 1975: year commencing January; otherwise, year commencing April. Amsterdam: sampling is 24 hours every 3 days.
n) National, Porsgrunn and Kristiansand; measurement months are February, May, August, and November; particulates smaller than 20 um.
o) Data for Duebendorf (Zuerich) follow British standard 1747, Part 2.
p) Except for B.G. monitoring period: October to March (winter season).
q) Particulates smaller than 2 um.
r) Data for cities that refer to one station only represent intemediate pollution levels.
s) Measurement method follows the British Standard 1747.
t) Particulates greater then 20 um.
u) Data for Sundsvall refer to city centre.
v) Lisboa and Porto: break in time series between 1975 and 1980.

Given below are the status of major countries:

(2) U.S.A.

In the U.S.A., the Clean Air Act (CAA) revised in 1977 dictated that the National Ambient Air Quality Standard (NAAQS) be reviewed at least once every five years, and that additionally all the NAAQS's put in effect to date be reviewed by end-December, 1980, but the task was delayed to a great degree, and even currently no division has been given.

The NAAQS for SOx is given in the following Table, which must be legally met by end-1995.

NAAQS FOR SO_2

	Primary atmospheric standard	Secondary atmospheric standard
three hours average *1	-	0.5 ppm (1300 $\mu g/m^3$)
24 hours average *1	0.14 ppm (365 $\mu g/m^3$)	-
annual average (Arithmetic)	0.03 ppm (80 $\mu g/m^3$)	-

Note : *1 not to be exceeded more than once per year

The primary atmospheric standard stipulated in the NAAQS of the U.S.A. is a standard that allows human health to be protected and maintained, and the standard, in principle, must be attained within three years. The secondary atmospheric standard is a standard that needs to be in place in order to protect public welfare (like animals, plants, damages to properties, etc.). The standard for NO_2 has been left untouched to date since it was reviewed in 1985. Therefore, a proposal was made that a short-term standard be set up, but its set-up was postponed until new research results are made available.

For SPM, the TSP (Total Suspended Particulate) had been in use in the past, but its revisions on July 1, 1987 were incorporated into the TSP so that particles with a diameter of less than 10 μm (D_{50})(PM_{10}) should be regulated because adverse effects on health was observed in the deep part of lungs which were caused by particles with a short diameter.

At the same time, the 24-hour average value and the annual average value of the primary atmospheric standard have been revised from 260 $\mu g/m^3$ and 75 $\mu g/m^3$ to 150 $\mu g/m^3$ and 50 $\mu g/m^3$ respectively, but the secondary atmospheric standard has remained unchanged. Reasons for the revision include the following:

- In the 140 - 250 $\mu g/m^3$ range, statistically significant reversible impact is observed on children's lung functions.
- No impact is observed on children's lung functions at 125 $\mu g/m^3$
- There is a possibility for impact on health even when PM_{10} is lower than 250 $\mu g/m^3$, etc.

The final version of the CAA submitted in 1990 stipulates a two-tier implementation of the CAA, i.e. the primary version in 1997 and the secondary version in the year 2000 in order to restrict an annual emission at 8,900 thousand tons of SO_2 or below out of all thermal power stations by the year 2000. In other words, in the first stage of the reduced emission policy for SO_2 to be implemented beginning in 1995, an emission standard of 4.5 kg $SO_2/10^6$ kcal is scheduled to be applied at 110 thermal power stations in operation in 21 states in the east and mid-west region of the country where SO_2 discharge is relatively low.

In the second stage to be running by the year 2000, the total annual emission of SO_2 throughout the country shall be within 8,900 thousand tons by applying an emission standard of 2.16 kg $SO_2/10^6$ kcal to approximately 800 thermal power stations. The EPA regulations concerning the NOx emission standard at thermal power stations provide a definition of the Overfire Air method based on an NOx emission standard tentative plant for thermal power stations using coal, gas and oil. The definition says, "The Overfire Air method is a device equipped with an air intake at the top section of a burner so as to keep the amount of NOx generated in its burning process at a minimal level" and the facility mounted with this device is broken into two categories of:

a) both TFU (Tangentially Fired Unit) and WFU (Wall-Fired Unit), or
b) only TFU installed and WFU being excluded.

The EPA has announced the following NOx emission standard tentative plan regulating thermal power stations using coal, gas and oil:

a) 0.81 kg /10^6 kcal for CFT (Coal-Fired Tangential) Unit
b) 0.90 kg /10^6 kcal for CFDBW (Coal-Fired Dry Bottom Wall) Unit
c) 1.26 kg /10^6 kcal for a coal burnt boiler except a) and b) above
d) 0.36 kg /10^6 kcal for GOT (Gas/Oil Tangential) Unit
e) 0.54 kg /10^6 kcal for GOW (Gas/Oil Wall) Unit
f) 0.99 kg /10^6 kcal for a gas/oil burnt boiler except d) and e) above

Currently, however, no consensus has been reached by power stations with regard to the above EPA proposals, because the Over Fire method is thought to be four to eight time more expensive than the low NOx burner.

(3) Japan

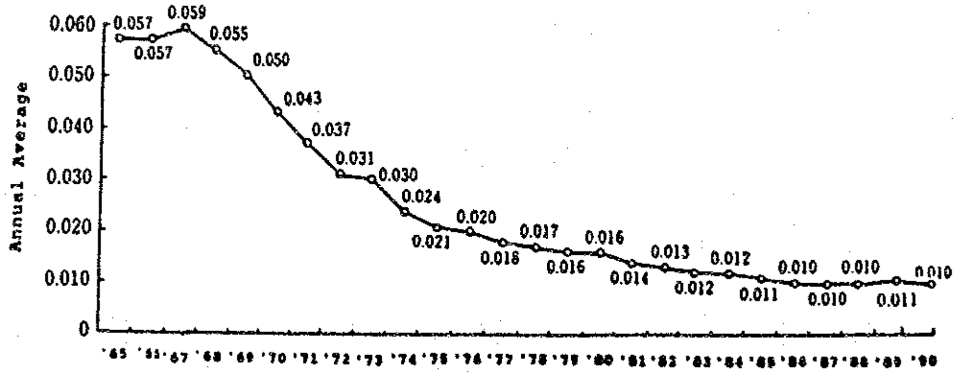
In Japan, progress has been made year after year in meeting the general atmospheric measurement standards that pertain to the standards given in Table 3-2-16(1), and the performance progress is shown in Table 3-2-18(1) through 3-2-18(3).

The current status of Japan's environmental pollution control policies are detailed in Appendix-7. The standards for SOx, NOx and SPM are being met due to installation of de-SOx, de-and de-facilities necessitated by more rigorous restrictions on stationary sources. NOx discharge is increasing, however, mainly out of mobile sources like cars, consequently, regulations concerning types of automobiles are being institutionalized leading to prohibition of use of automobiles other than low-NOx cars.

Table 3-2-18(1) HISTORICAL RECORD OF SOX FOR ENVIRONMENTAL QUALITY STANDARD (EQS) (At Standard Environmental Ambient Air Monitoring Station)

Items/Year	1984	1985	1986	1987	1988	1989	1990
Number of stations	1623	1609	1608	1603	1601	1599	1602
Number of stations cleared of EQS	1614	1603	1600	1596	1596	1591	1598
Achievement (%)	99.4	99.6	99.5	99.6	99.7	99.5	99.8

Remarks: Excluded of Stations of which effective measure time is less than 6000 hrs/y



Remarks: "Annual average" means value of simulation of hourly measurements over one year divided by total hours of measurement
Same meaning for the Figure herein after in Figure 1.1 - 1.4

Figure 3-2-4(1) HISTORICAL ANNUAL ARITHMETIC AVERAGE OF ANNUAL AVERAGE OF SO_2 AT CONTINUING 15 MONITORING STATIONS

Table 3-2-18(2) HISTORICAL RECORD OF NOX FOR ENVIRONMENTAL QUALITY STANDARD (EQS) OF STANDARD ENVIRONMENTAL AMBIENT AIR MONITORING STATION

Year	1986		1987		1988		1989		1990	
Average value of daily average covering 98% of the measurement	Numbers of Stations	%	Numbers of Stations	%	Numbers of Stations	%	Numbers of Stations	%	Numbers of Stations	%
Higher than 0.06ppm	34	2.6	80	6.0	55	4.1	65	4.8	87	6.4
0.04ppm and higher-0.06ppm and lower	307	23.2	342	25.8	370	27.7	350	25.8	359	26.2
Lower than 0.04ppm	980	74.2	902	68.2	912	68.2	942	69.4	921	67.4

Remarks: Excluded by the criteria same as Table 1.1

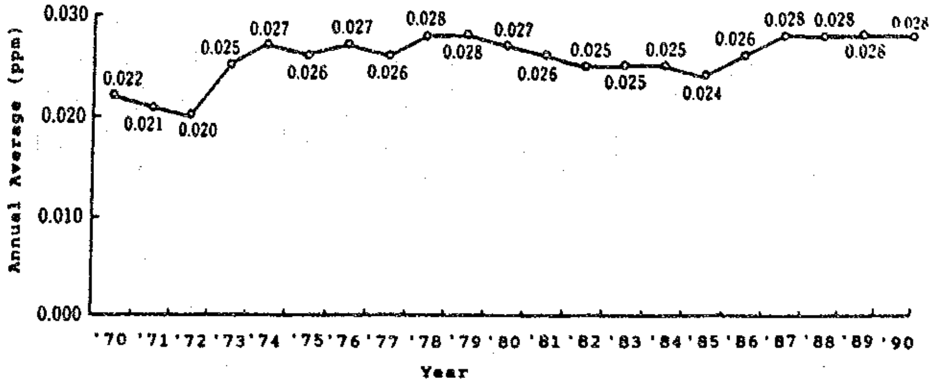


Figure 3-2-4(2) HISTORICAL RECORD OF ARITHMETIC AVERAGE OF ANNUAL AVERAGE OF NO2 AT CONTINUING 15 MONITORING STATIONS (Standard Environmental Ambient Air Monitoring Stations)

Table 3-2-18(3) ACHIEVEMENT OF ENVIRONMENTAL QUALITY STANDARD SPM BASED ON LONG-TERM EVALUATION

Items/Year	1982	1983	1984	1985	1986	1987	1988	1989	1990
Number of stations	353	465	607	755	855	958	1095	1203	1282
Number of stations cleared of EQS	173	293	304	393	486	504	515	784	552
Achievement (%)	49.0	63.0	50.1	52.1	56.8	52.6	47.0	65.2	43.1

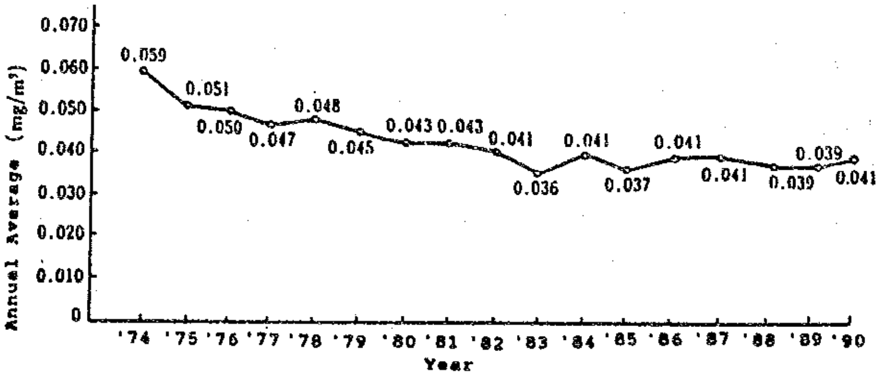


Figure 3-2-4(3) HISTORICAL RECORD OF SIMPLE AVERAGE OF ANNUAL AVERAGE VALUE OF SPM AT CONTINUING 40 MONITORING STATIONS (Standard Environmental Ambient Air Monitoring Stations)

3.3 Evaluation of Impact of Air Pollutants from the Thermal Power Plants in the Country

3.3.1 Estimation of Pollutants Emitted from the Thermal Power Plant in the Country

(1) Methodology of Evaluation of Impact of Air Pollution from the Thermal Power Plant

Flowchart for explanation of methodology of evaluation of impact of air pollution from the thermal power plant are shown in Figure 3-3-1 and detail parameters in the flowchart required for the evaluation were explained followings:

1) Data on major sub-sectors(No.(2) and No.(9) in the Figure 3-3-1)

In order to estimate total quantity of pollutants emitted from the sub-sectors, it is necessary to obtain these, emission from combustion facility and from main process, if there are any.
Therefore, emission from sub-sector will be calculated by (a) SOx and NOx emission factor for energy used by eliminating of process use energy and (b) emission from target process.(Table 3-3-1,3-3-2)

If energy consumption data are not available, these shall be estimated from the energy consumption ratio per unit production.

For these data sources, Steel Industrial Center, ADEFA, Consejo Tecnico de Inversions, Argentine Petrochemical Institute, Association of Cellulose and Paper Manufactures(AFCP), etc. shall be utilized in the estimation.

2) Data on emission from transportation Vehicles (No.(3) and No.(10) in Figure 3-3-1)

Meanwhile, emission from vehicle sector is very complicated, and it seems difficult to estimate these in the area where there is no data base on vehicles like in Argentina.

However, in order to evaluate an impact of emission from thermal power plant, order of magnitude of estimation of emission from vehicle be considered inevitable because apparently there are huge emission from vehicle especially in Federal Buenos Aires, Rozario, and so on.

Therefore, at least, annual fuel consumption classified by passenger car, track, bus, light ban and their traffic volume and also annual fuel consumption classified by gasoline, LPG, diesel oil shall be deemed necessary including parameters on performance of vehicle prevailing in urban area.

3) Rated capacity and fuel consumption of power plants (No.(4) in Figure 3-3-1)

List of all power plants in the country was shown in Figure 3-3-1.
From this table, total emission of SOx, NOx, Dust was estimated on the assumption that generation efficiency, sulfur contents are 33%, 1.0% respectively.

4) Investigation of Meteorological Data (No.(7) in Figure 3-3-1)

Meteorological data required for calculation of short term, especially for long term dispersion model are wind speed, wind direction, temperature gradient, atmospheric stability etc.
Among these, latter two parameters are still not found in our project, therefore, method of estimation of these parameters and further necessary activity of CNEA regarding collection of meteorological data for long term shall be requested.

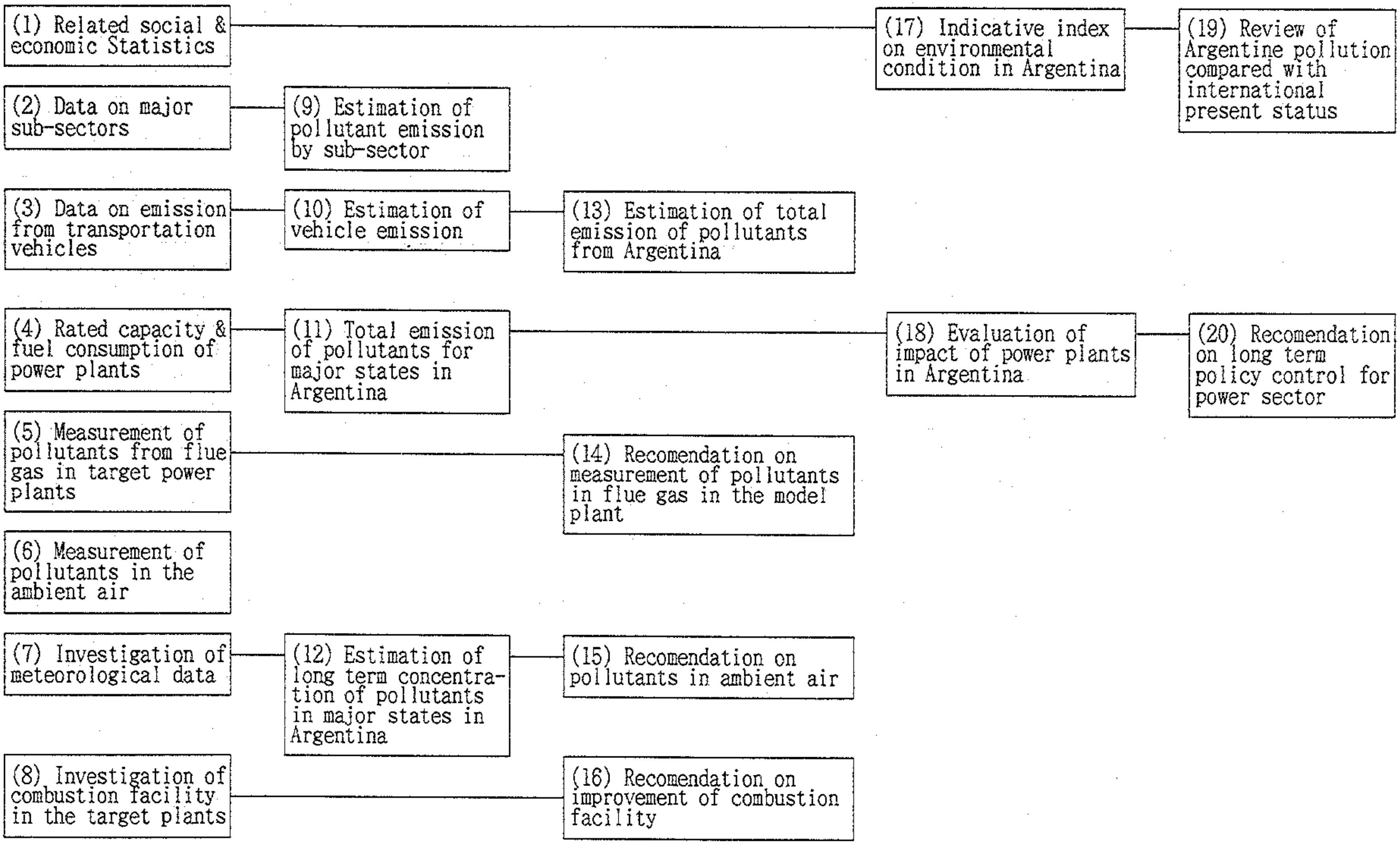


Figure 3-3-1 MAJOR EVALUATION FLOW DIAGRAM FOR IMPACT OF AIR POLLUTION OF POWER PLANTS IN ARGENTINA

Table 3-3-1 SULFUR OXIDES EMISSION FACTOR (SOxEF)

		CONVERSION SECTOR							MANUFACTURING SECTOR				TRANSPORTATION			
		Briquet	Cokes	Gas Fac.	Petroleum Refinery	Power Plant	Others	Sefl-Consumer	Steel Plant	Chemical & Petroleum	Non-Metal Processing	Others	Aerial	Road	Rail Way	Shipping
Coal	kg/ton		1.37	1.55		19.5	15.5	15.5	15.5	15.5	15.5	15.5			15.5	
Lignite	kg/ton					19.5				15.5	15.5	15.5				
Cokes	kg/ton			1.77				1.77		17.7	17.7	17.7			17.7	17.7
Briquet	kg/ton											10				
BKB	kg/ton															
Cupola Gas	kg/10*10cal			0.001		0.01		0.01	0.01							
Cokes Gas	kg/10*10cal			3.8		38	38	38	38	38	38	38				
Gas Fac.	kg/10*10cal					0.01	0.01	0.01	0.01	0.01	0.01	0.01				
Natural Gas	kg/10*10cal			0.000092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092				0.0092
Crude Oil	kg/ton			2	0.46	20	20	20	20	20	20	20				20
NGL	kg/ton				0.013	0.013				0.013						
Refinery Oil	kg/ton				0.46											
Refinery Gas	kg/ton			0.0013		0.013	0.013	0.013		0.013	0.013	0.013				
LPG	kg/ton			0.00136		0.0136	0.0136	0.0136	0.0136	0.0136	0.0136	0.0136		0.0136		
Aerial Gasoline	kg/ton												0.8			
Automobile Gasoline	kg/ton					20		20	20	20	20	20	20	20	20	20
Jet Fuel	kg/ton												3.2			
Kerosine	kg/ton					20		20	20	20	20	20		20		20
Light Oil	kg/ton			20		20	20	20	20	20	20	20	20	20	20	20
Fuel Oil	kg/ton			20		20	20	20	20	20	20	20	20	20	20	20
Naphtha	kg/ton			0.1		1		1	1	1	1	1				
Others	kg/ton				1	1	1	1		1	1	1				

Remarks : SOxEF. means Emission factor of SOx

Table 3-3-2 NITROGEN OXIDES EMISSION FACTOR (NOxEF)

		CONVERSION SECTOR							MANUFACTURING SECTOR				TRANSPORTATION			
		Briquet	Cokes	Gas Fac.	Petroleum Refinery	Power Plant	Others	Sefl-Consumer	Steel Plant	Chemical & Petroleum	Non-Metal Processing	Others	Aerial	Road	Rail Way	Shipping
Coal	kg/ton		1	0.75		9.95	9.95	7.5	7.5	7.5	7.5	7.5			7.5	
Lignite	kg/ton					8.46				6.38	6.38	6.38				
Cokes	kg/ton			0.9				9	2.5	9	9	9			9	9
Briquet	kg/ton											7.5				
BKB	kg/ton															
Cupola Gas	kg/10*10cal			0.031		0.44		0.31	3.18							
Cokes Gas	kg/10*10cal			0.229		3.26	3.26	2.29	5.89	2.29	2.29	2.29				
Gas Fac.	kg/10*10cal					0.44	0.44	0.31	3.18	0.31	0.31	0.31				
Natural Gas	kg/10*10cal			0.0224		4.4	4.4	2.24	2.24	2.24	2.24	2.24				2.24
Crude Oil	kg/ton			2.19	0.24	7.24	7.24	5.09	5.09	5.09	5.09	5.09				5.09
NGL	kg/ton					6.2				2.52						
Refinery Oil	kg/ton				0.24											
Refinery Gas	kg/ton			0.063		0.75	0.75	0.53		0.53	0.53	0.53				
LPG	kg/ton			0.263		3.74	3.74	2.63	2.63	2.63	2.63	2.63		20.3		
Aerial Gasoline	kg/ton												10.5			
Automobile Gasoline	kg/ton					16.71		16.71	16.71	16.71	16.71	16.71	16.71	31.7	16.71	16.71
Jet Fuel	kg/ton												10.5			
Kerosine	kg/ton					21.23		7.46	7.46	7.46	7.46	7.46		27.4		54.13
Light Oil	kg/ton			9.62		27.37	27.37	9.62	9.62	9.62	9.62	9.62	54.13	27.4	54.13	54.13
Fuel Oil	kg/ton			5.84		10	10	5.84	5.84	5.84	5.84	5.84	54.13	27.4	54.13	54.13
Naphtha	kg/ton			1.46		16		7.34	7.34			7.34				
Others	kg/ton					10	10	5.84		5.84	5.84	5.84				

Remarks: NOxEF means Emission factor of NOx

3.3.2 Calculation of Short and Long Term Concentration of Pollutants by the Thermal Power Plant in the Targeted Area

(1) General Characteristics of Flue Gas Dispersion

Plume is emitted from a stack into the air with its stack exit velocity. Hot gas emitted from a stack without wet type de-SO_x facilities continues to rise up due to buoyance caused by the density difference between flue gas and the ambient air is drifted by wind horizontally and gradually is dispersed (Figure 3-3-2).

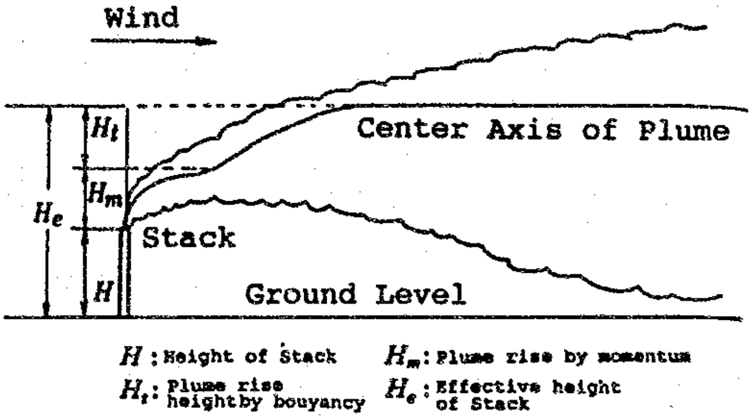


Figure 3-3-2 **PLUME RISE AND DISPERSION PATTERN OF BENT-OVER PLUME**

As indicated in the figure, the effective stack height is defined as the sum of the actual stack height and the height of rising up of the emitted gas.

As shown in Figure 3-3-3, the pollutants in flue gas does not fall down on the ground near the stack on the leeward. The concentration of pollutants becomes gradually higher as the distance from the stack increases and then gradually lower because of dispersion of the pollutants.

As shown in Figure 3-3-3, the concentration of pollutants reaches the maximum at some distance from the stack on the leeward. This distance is called the maximum concentration distance (Xmax) and the concentration at that distance is called the maximum concentration of pollutants (Cmax).

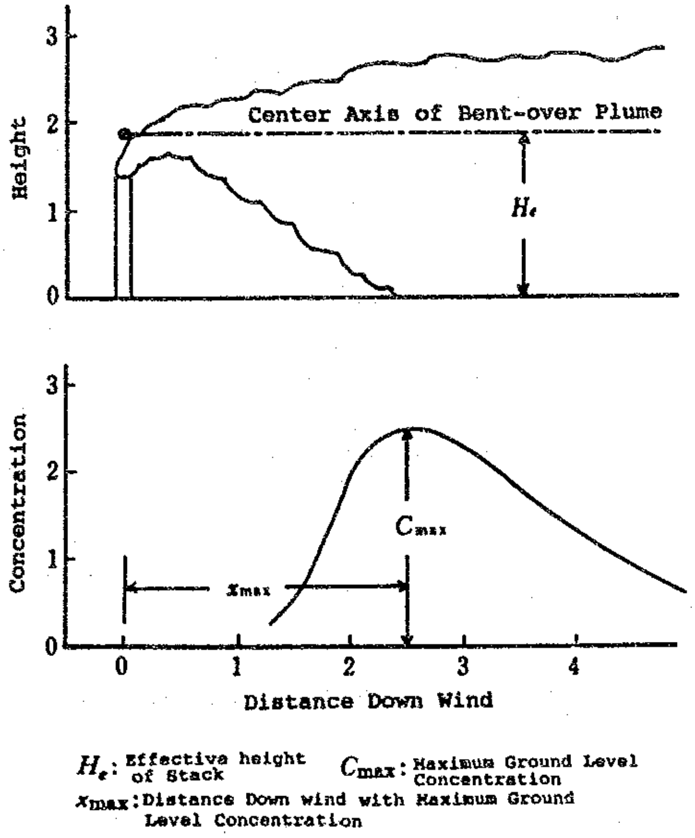


Figure 3-3-3 DISPERSION PETTERN OF BENT-OVER PLUME AND GROUND LEVEL CONCENTRATION

The dispersion of flue gas depends on the atmospheric conditions, i.e. wind velocities, changes of wind directions, vertical gradients of atmospheric temperatures and condition of atmospheric stabilities etc. Figure 3-3-4 shows types of dispersion and the characteristic features of these types are shown in Table 3-3-3.

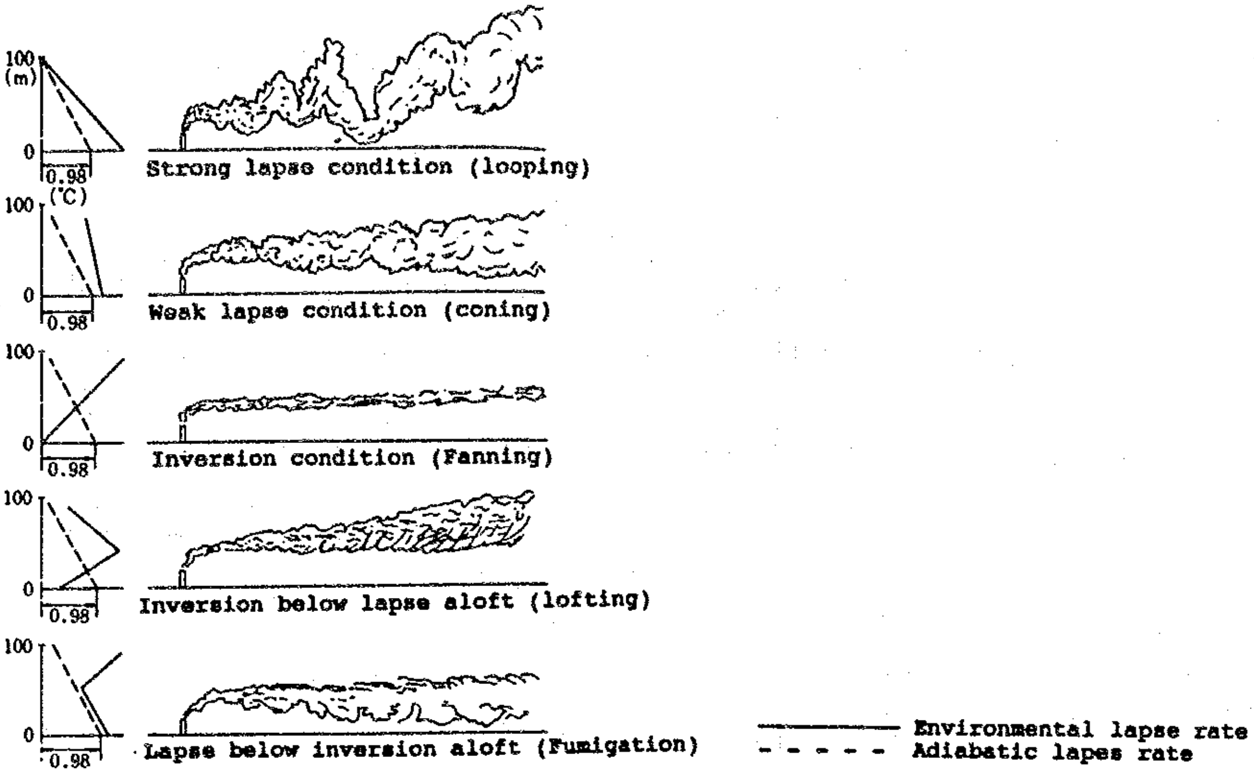


Figure 3-3-4 TYPES OF PLUME BEHAVIOR DEPENDING ON LOCALIZED AIR STABILITY

Table 3-3-3 RELATIONSHIP BETWEEN ATMOSPHERIC STABILITY AND PLUME BEHAVIOR

Plume Shape	Atmospheric stability	Plume Behavior and Characteristics
Looping	Strong lapse condition	Looping: It is a type of plume which has a wavy character. It occurs in a highly unstable atmosphere because of rapid mixing. The high degree of turbulence helps in dispersing the plume rapidly but high concentrations may occur close to the stack if the plume touches the ground.
Coning	Weak lapse condition	Coning: It is a type of plume which is shaped like a cone. This takes place in a near neutral atmosphere (adiabatic condition) when the wind velocity is greater than 32 km/h. However, the plume reaches the ground at greater distances than with looping.
Fanning	Inversion condition	Fanning: It is a type of plume emitted under extreme inversion conditions. The plume, under these conditions will spread horizontally, but

		little, if at all vertically. Therefore, the prediction of ground level concentrations is difficult here.
Lofting	Inversion below lapse aloft	Lofting: Lofting occurs when there is a strong lapse rate above a surface inversion. Under this condition, diffusion is rapid upward, but downward diffusion does not penetrate the inversion layer. Under these conditions, emissions will not reach the surface.
Fumigation	Lapse below inversion aloft	Fumigation: It is a phenomenon in which pollutants that are aloft in the air are brought rapidly to ground level when the air destabilizes.

(1) Empirical Formula of Plume Rise

The height of rise of plume is calculated as mentioned in the previous section. The concentration of pollutants in flue gas from a stack is calculated on the assumption that pollutants are emitted from a point at the effective stack height. Various formulae have been proposed to calculate the plume rise. The following are most widely used.

1) Bosanquet, Carey and Halton's Equation

$$Hm = \frac{4.77}{1 + \frac{0.43u}{Vg}} \cdot \frac{\sqrt{Qvl \cdot Vg}}{u}$$

$$Ht = 6.37g \cdot \frac{Qvl \cdot \alpha T}{u^3 T_1} \left(\log \cdot J^2 + \frac{2}{J} - 2\right)$$

$$J = \frac{u^2}{\sqrt{Qvl \cdot Vg}} \left(0.43\sqrt{\frac{T_1}{g(d\theta/dz)}} - 0.28\frac{Vg}{g} \cdot \frac{T_1}{\alpha T}\right) + 1$$

Hm : Plume rise by stack exit velocity (m)
Ht : Plume rise by buoyancy (m)
u : Mean wind velocity (m/sec)
Vq : Exit velocity (m/sec)
Qvl: Effluent gas volume at temperature T_1 (m^3/sec)

T_1 : Temperature at which density of flue gas is equal to atmospheric density (k)
αT : Temperature difference between flue gas and T_1 (°C)
g : Local acceleration due to gravity (=9.81 m/sec^2)
$d\theta/dz$: Gradient of potential temperature in atmosphere (°C/m)

$$(0°C/m,\ \tau d + \frac{dt}{dz})$$

*1 In case of calculation of Effective stack height for SO_2 total emission control, the formulae above shall be as follows;

$Ht = Ho + 0.65\ (Hm + Ht)$
Ho : Actual Stack Height (m)

2) Moses and Carson

$$\alpha H = (C_1 vgD + C_2 Q_H{}^{1/2})/u$$

Atmospheric Stability	C_1	C_2
Stable	-1.04	0.145
Neutral	0.35	0.171
Unstable	3.47	0.33

3) Briggs's formulae (No wind)

$$\alpha H = 1.4 Q_H{}^{1/4}\ (d\theta/dz)^{-3/8}$$

4) CONCAWE and Brummage's formulae

$$\alpha H = 0.175\ Q_H{}^{1/2}/u^{3/4}$$

αH : Plume rise (m)
vq : Exit velocity (m/sec)
D : Stack outlet diameter (m)
u : Average wind velocity at stack outlet height (m/sec)
$d\theta/dz$: Temperature Gradient (°C/m)

Q_H :Exhaust Heat Capacity (cal/sec, J/sec)

(2) Estimation of Dispersion Parameters

1) Pasquill's method

Pasquill classified atmospheric stability into 5 classes from A to F by the combination of a ground wind velocity, a solar radiation and a cloud amount. He estimated dispersion parameters αy and αz theoretically from many results of tracer experiments (Table 3-3-4, Figure 3-3-5, 3-3-6).

Table 3-3-4 PASQUILL'S STABILITY CLASSIFICATION

Surface Wind Speed (m/s)	Day time			Day&Night	Night	
	Insolation (cal/cm^2•h)			Thickly Cloudy	Upper Cloud (5-10) Middle&Low (5-7)	Cloud (0-4)
	>50	49-25	<24	(8-10)	0-5 Net Flux (cal/cm^2/2	>5
<2	A	A-B	B	D	-	-
2-3	A-B	B	C	D	E	F
3-4	B	B-C	C	D	D	E
4-6	C	C-D	D	D	D	D
>6	C	D	D	D	D	D

* 1 cal/cm^2• = 8.57×10^{-2} W/cm^2

Note; A: strongly unstable B: unstable
C: weakly unstable D: neutral
E: weakly stable F: stable

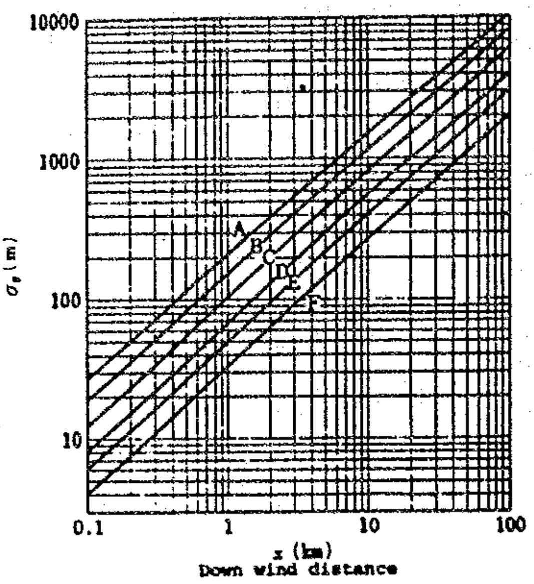


Figure 3-3-5 Pasquill's Horizontal Direction Width 6y

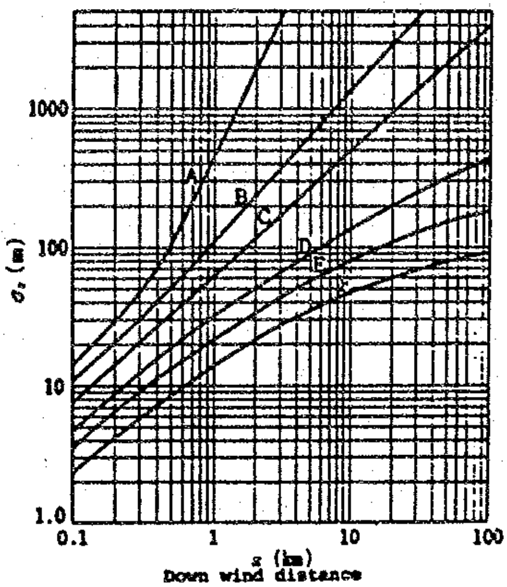


Figure 3-3-6 Pasquill's Vertical Direction Plume width 6x

2) Turner's Method

The Turner's method is similar to the Pasquill's method. He classified the atmospheric stability into 7 classes as shown in Table 3-3-5 by combining an altitude of the sun, a cloud amount and a ground wind velocity. The dispersion parameters for each class are obtained as functions of dispersion time as shown in Figure 3-3-7, 3-3-8, and 3-3-9.

Table 3-3-5 TURNER'S STABILITY CLASSIFICATION

Wind Speed (Knot)*1	Index of Total Insolation						
	4	3	2	1	0	-1	-2
0, 1	1	1	2	3	4	6	7
2, 3	1	2	2	3	4	6	7
4, 5	1	2	3	4	4	5	6
6	2	2	3	4	4	5	6
7	2	2	3	4	4	4	5
8, 9	2	3	3	4	4	4	5
10	3	3	4	4	4	4	5
11	3	3	4	4	4	4	4
≥12	3	4	4	4	4	4	4

*1 1 knot = 0.52m/sec

Note: 1. Stability rankage = 0 at cloud 10/10 and height of cloud bottom less than 7000 ft
2. Night time (from sunset to sunrise)
   (a) Cloud ≤ 4/10, -2
   (b) Cloud ≥ 4/10, -1
3. Day time
   (a) radiation index is calculated with following table
   (b) in case of cloud ≤ 5/10, be used of radiation index bellow
   (c) in case of cloud ≥ 5/10, radiation index shall be corrected as follows:
      i) Height of cloud bottom < 7000 ft; reduction 2 from radiation index
      ii) Height of cloud bottom ≥ 7000 ft; reduction 1 from radiation index
      iii) Cloud 10/10; rediation of 1
      iv) No correction of radiation value except above
      v) in case, corrected value is less than 1, it should be 1

Radiation index	Height of sun
4	a > 60°
3	60° ≥ a > 35°
2	35° ≥ a > 15°
1	15° ≥ a

$$Cm = \frac{2Q}{e\pi uHe^2}\left[\frac{Cz}{Cy}\right]$$

$$Xm = \left[\frac{He}{Cz}\right]^{2/(2-n)}$$

Cm : Maximum ground level concentration (m^3/m^3)
Q : Emission volume of plume (m^3/sec)
Cy, Cz, n: Dispursion parameter of sutton
u : Wind velocity (m/sec)
He : Effective height of stack (m)
Xm : Distance to Cm point (m)
π : Ratio of the circumference

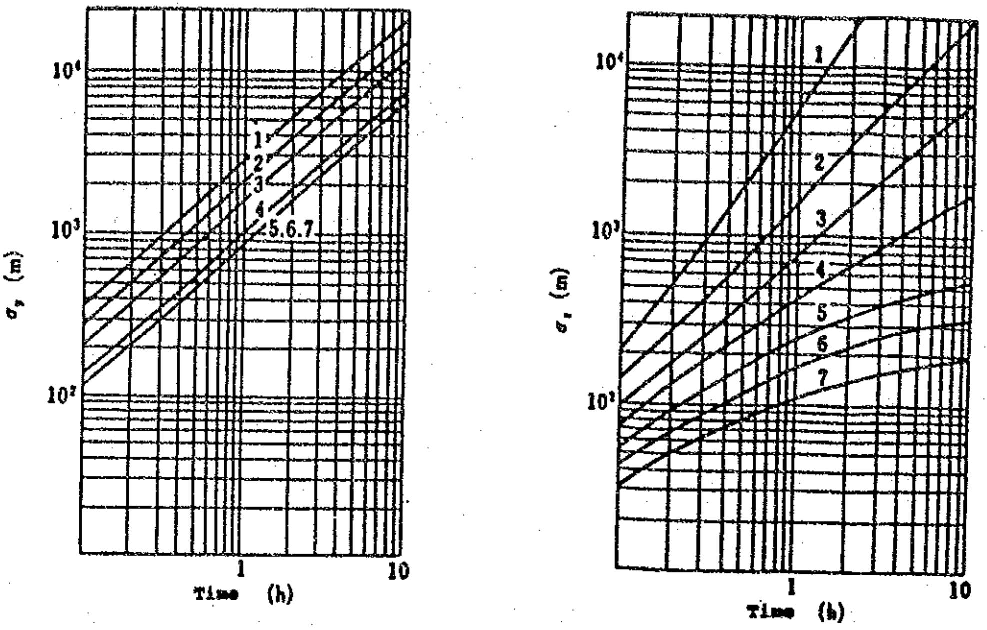
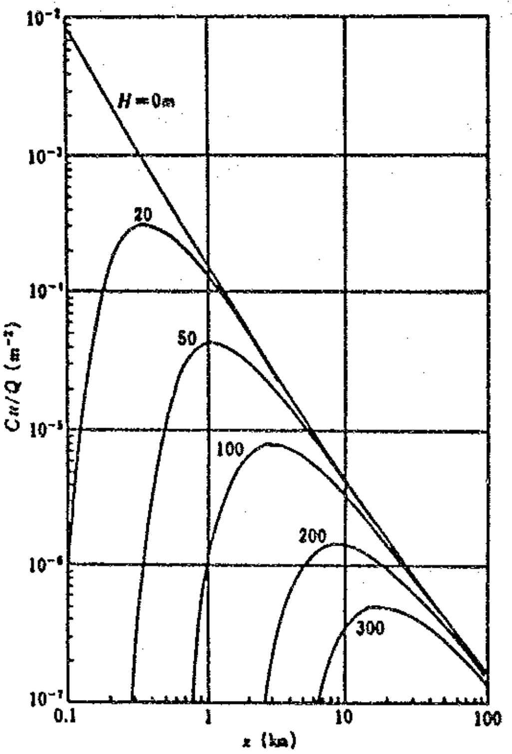


Figure 3-3-7 RELATIONSHIP OF DISPERSION PARAMETERS (6Y,6Z) CLASSIFIED BY TURNER'S STABILITY INDEX



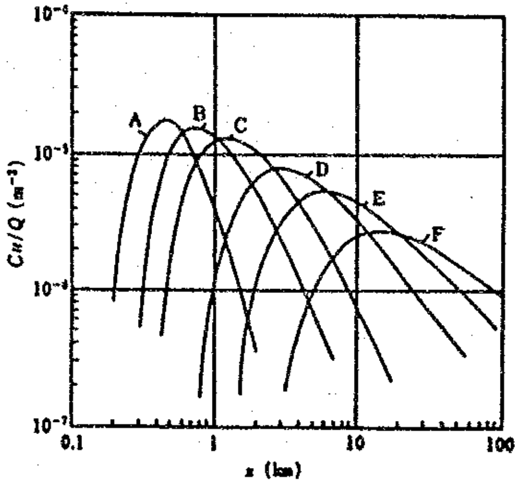


Figure 3-3-8 AXIAL GROUND LEVEL CONCENTRATION FOR DIFFERENT EFFECTIVE STACK HEIGHTS He (U: WIND SPEED, Q: EMISSION RATE)

Figure 3-3-9 RELATIVE DILUTION RATIO (CU/Q) ON THE CENTRAL AXIS PLUME BY STABILITY INDEX

3) Sutton's Method

Sutton assumed that the dispersion parameters are proportional to powers of x (distance on the leeward) and proposed the following formula.

$\sigma y = (Cy/\sqrt{2})x^{1-n/2}$ $\sigma z = (Cz/\sqrt{2})x^{1-n/2}$

Where Cy, Cx, n are Sutton's dispersion parameters which depend on atmospheric conditions such as atmospheric stability.

An Example of A Simulation Programme of Dispersion

There are two kinds of programmes for calculation of atmospheric dispersion: Programmes for short tern and programmes for long term such as half a year or one year.

(1) Range

Ranges (m) in east-west and north-south are input. The area is divided into 20 equal subareas.

(2) Source conditions

Position of flue gas source (X, Y). Actual stack height Ho (m). Diameter D (m). Amount of wet flue gas (Nm^3/hr). Temperature of flue gas (°C). Amount of emitted pollutants (Nm^3/hr)

(3) Position of measurement place

Beside coordinates of the mash points mentioned in (1), if you measure concentrations at other points, the coordinates of these points are also input.

(4) Meteorological conditions

Wind direction (North is taken as 0° and the direction is measured clockwise. For example, the north wind is 0° and the east, wind is 90°). Wind velocity (m/sec). Temperature gradient

(°C/m).

(5) Calculation of dispersion

1) Selection of plume rise formula

(a) Bosanquet - 1
(b) CONCAWE
(c) Moses - Carson
(d) Briggs (Caln)
(e) Briggs (Windy)

2) Selection of dispersion formula

(a) Sutton
(b) Pasquill - Gifford
(c) Sigma
(d) Puff (Linear)

3) Input of parameters of the plume rise formula

If the Moses - Carson or the briggs (Windy) is selected for the formula of plume rise, the parameters in the formula must be input.

4) Input of parameters of dispersion formula

(a) Pasquill or Puff formula

Select the class of atmospheric stability.
Input the time (in minute) to average the concentration (Pasquill formula).
Input the time duration (in minute) of calm state (Puff formula).

(b) Sutton or Sigma formula

Input the dispersion parameters.

The Puff formula (Linear) is applied when calm and other formulae when windy.

5) The maximum concentration of pollutants and the maximum concentration distance

When the parameters of the dispersion formula are input, the maximum concentration of pollutants and the maximum concentration distance are calculated and are displayed. Input data, concentrations from each stack, a simplified concentration distribution chart, a detailed concentration distribution chart etc. can be printed.

The above is an outline of the atmospheric dispersion calculation for a short term. Details of a long term model is not exploited here. However, it is necessary to pay attention to the following points.

(a) Frequencies of occurrence of each stability by wind velocity class during the observation period are input for 16 wind directions (N~S~NNW) and calm.

(b) Atmospheric stability is chosen from among 11 classes; A, A-B, B, B-C, C, C-D, D, D-E, E, F, G and is input.

A personal computer provided through this project is equipped with programs for the short term and long term models of EPA. These programs perform the same calculations as mentioned above.

Calculation for the 3 Candidate Plants

(1) Input data

Table 3-3-6 shows input data for the 3 candidates.

(2) Output data

Table 3-3-7 shows output data for the 3 candidates.

Table 3-3-6 PARAMETERS FOR CALCULATION OF SHORT TERM DISPERSION MODEL

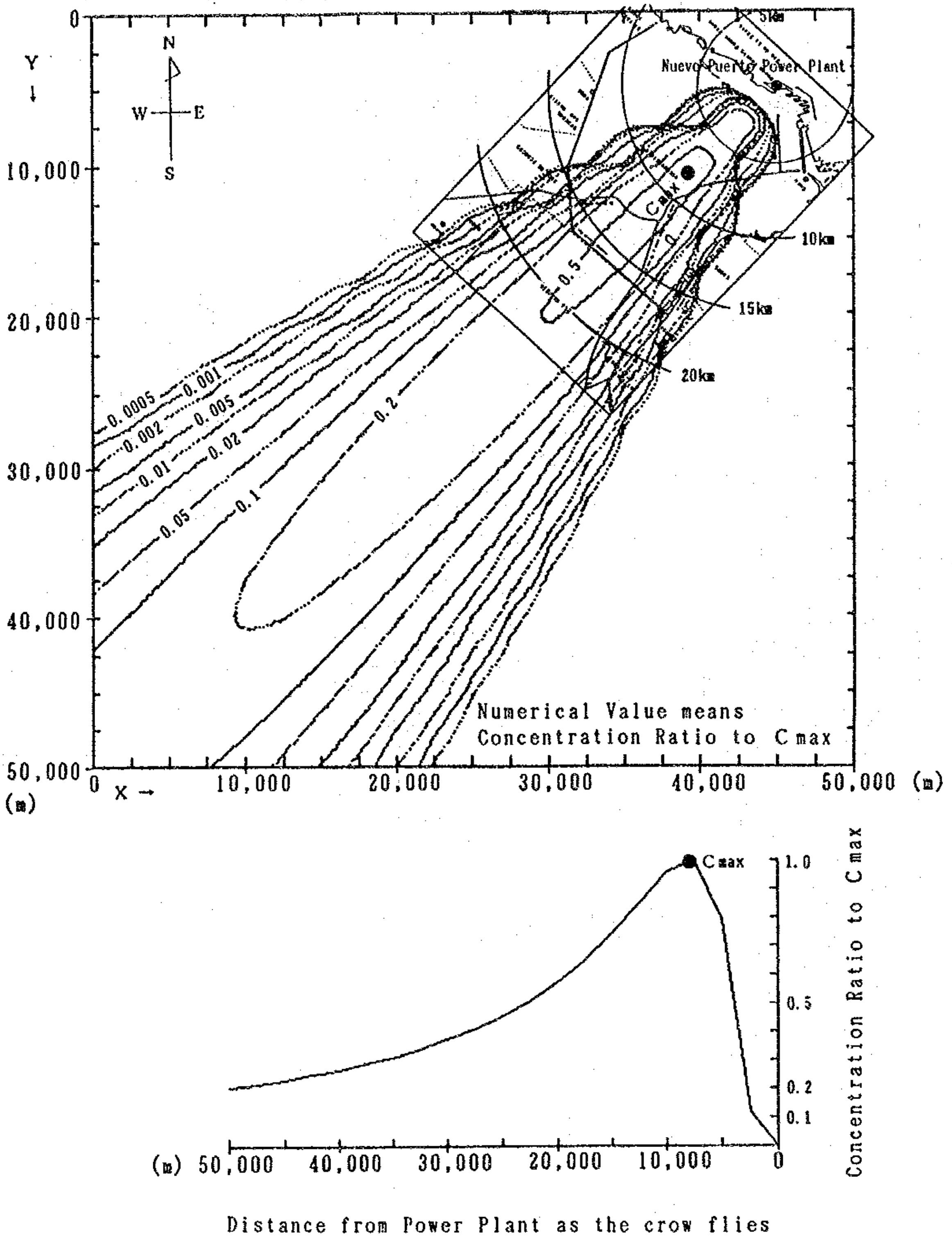
Power Plant Item	(Unit)	Nuevo Puerto	Lujan de Cuyo	San Nicolas
Boiler No.		13	12	5
Power Generation	(MW)	110	60	350
Ranges in East-West [X]	(m)	50,000	35,000	40,000
Ranges in North-South [Y]	(m)	50,000	35,000	40,000
Stack Height [H0]	(m)	47	50	120
Stack Diameter [D]	(m)	3	4.1	8.1
Amount of Flue Gas (Wet)	(Nm3/h)	468,000	271,000	1,410,000
Flue Gas Temperature	(℃)	136	116	134
Amount of Pollutants (SO2)	(Nm3/h)	94	72	630
Wind Direction	(°)	NE (45)	SW (225)	E (90)
Wind Speed	(m/s)	3.9	1.7	3.2
Potential Temperature Gradient	(℃/m)	0.0033		
Plume Rise Formula		CONCAWE		
Dispersion Formula		Pasquill-Gifford		
Atmospheric Stability		D (Neutral)		
Mean Diffusion Time	(min)	60		
Effective Stack Height	(m)	182.6	225.7	390.8
Smoke Rising Height	(m)	135.6	175.7	270.8
C max:Maximum Ground Concentration	(ppm)	0.006259	0.006527	0.007345
Distance from source to C max point	(m)	7,998.2	11,061.4	26,962.7

Table 3-3-7 OUTPUT DATA FOR THE 3 CANDIDATES

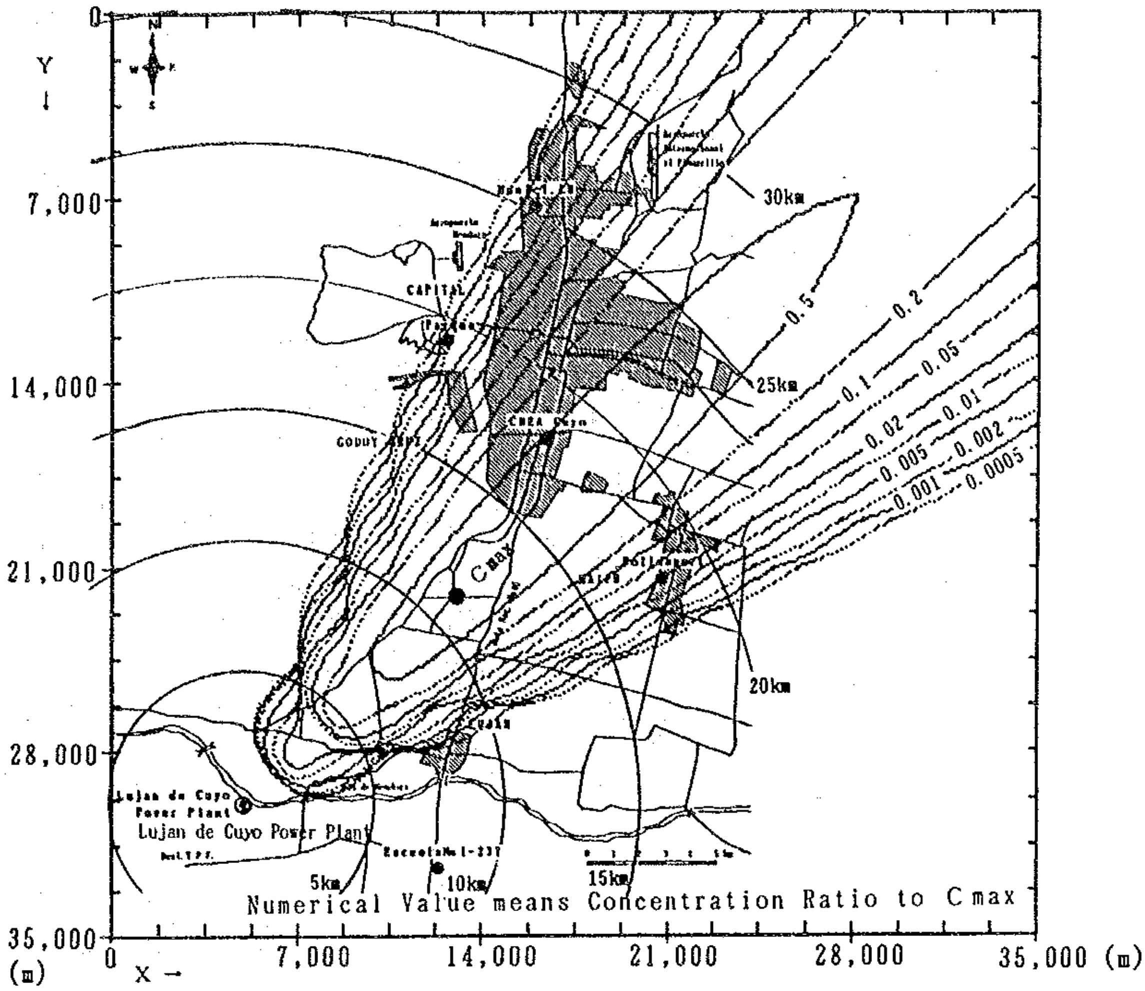
Place	Concentration of Superposition (ppm)	Location (m)	
		X: East-West	Y: North-South
Nuevo Puerto P.P	-	45,000	5,000
Boca	0.000E+00	48,530	13,530
CNEA-Tandar	0.000E+00	28,660	4,250
Moron	1.733E-05	25,000	15,000
Lujan de Cuyo P.P	-	5,000	30,000
CNEA-Cuyo	5.011E-03	16,650	17,140
Munici. LH	1.141E-05	16,050	7,090
Parque SM	4.048E-06	12,630	12,310
Polideportivo	1.299E-04	20,970	21,160
Escuela No.1-237	0.000E+00	12,430	32,110
San Nicolas P.P	-	38,000	20,000
Club Somisa	0.000E+00	38,560	20,200
Aero Club	0.000E+00	36,350	23,580
Club CyP	0.000E+00	37,640	25,420
Camping LyF	0.000E+00	34,070	23,210
Escuela No.35	0.000E+00	33,270	19,760
Munici. SN	0.000E+00	34,260	17,920

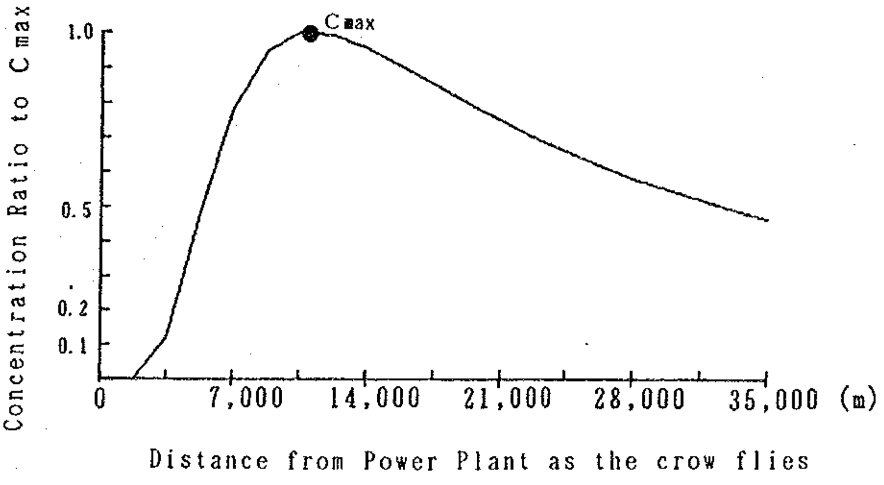
* Location [X=0, Y=0] Corresponds to NW Corner

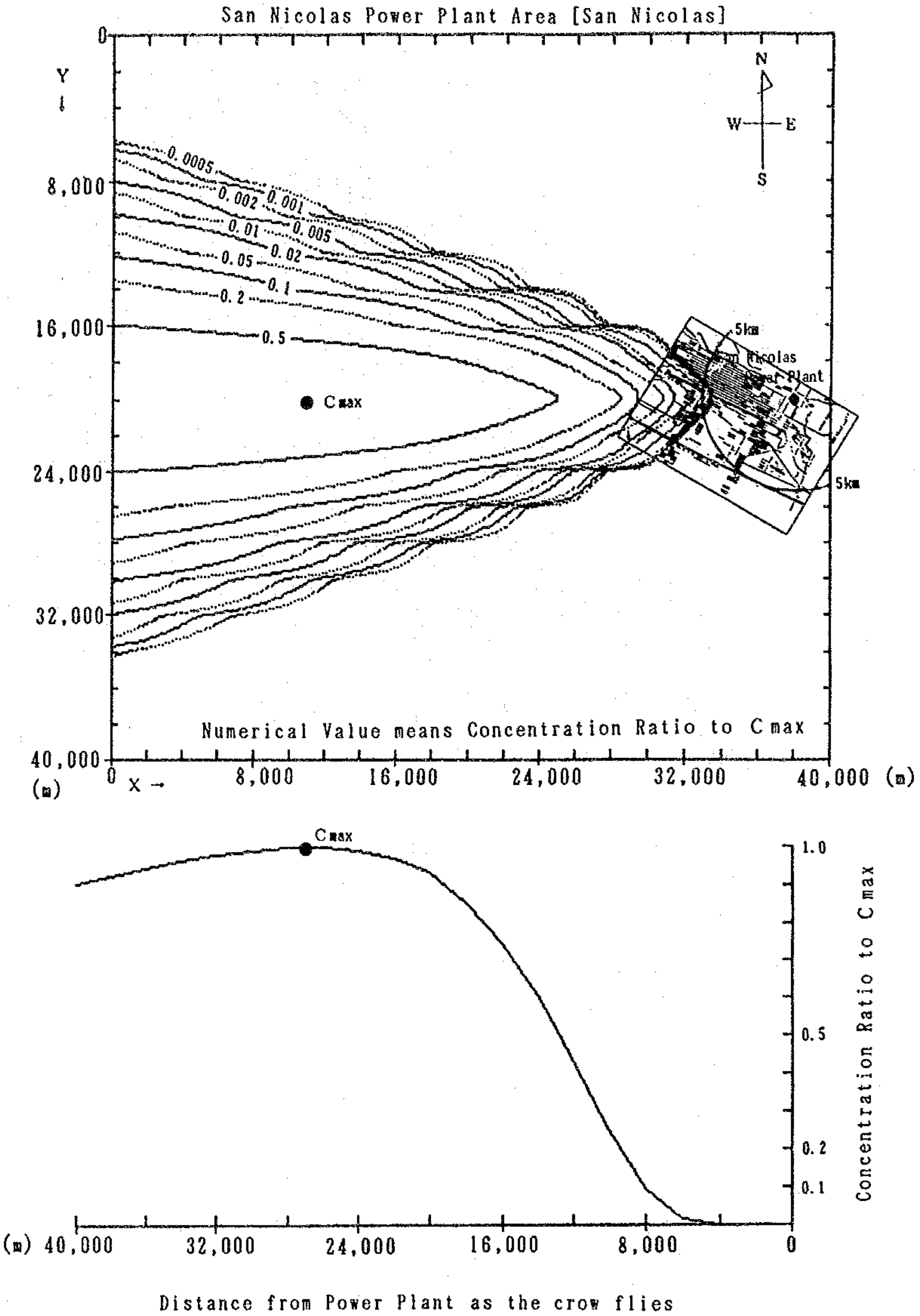
Nuevo Puerto Power Plant Area [Buenos Aires]



Lujan de Cuyo Power Plant Area [Mendoza]






San Nicolas Power Plant Area [San Nicolas]
Y
↓
0
8,000
16,000
24,000
32,000
40,000
(m)
X →
N
W
E
S
0.0005
0.001
0.002
0.005
0.01
0.02
0.05
0.1
0.2
0.5
● Cmax
5km
San Nicolas
Power Plant
5km
Numerical Value means Concentration Ratio to Cmax
0
8,000
16,000
24,000
32,000
40,000 (m)
Cmax
1.0
0.5
0.2
0.1
Concentration Ratio to Cmax
(m) 40,000
32,000
24,000
16,000
8,000
0
Distance from Power Plant as the crow flies

3.3.3 Estimates of pollutant emissions in major sub-sectors

While the data needed for estimating pollutant emissions in major sub-sectors were not made available systematically, the data are indispensable for consideration of impact of flue gas emission out of thermal power plants. Therefore, an attempt was made to estimate the pollutant discharge based on the data collected during the on-site survey.

(1) Steel and Nonferrous Metals Industries

The industrial sector producing basic metals generates altogether about 7.3% of the GDP in industrial manufacturing (at 1970 prices), occupying some 22,000 workers directly and another 80,000 indirectly. Steal production capacity by companies, potential plant capacity and operable capacity for hot-rolling plant and for cold-rolling plant by companies are shown in Table 3-3-8(1) to (3), respectively.

Table 3-3-8(1) STEEL PRODUCTION CAPACITY - BY COMPANIES

- Thousand tons yearly -

Sector and Companies	Potential Installed Capacity	Operating Capacity
Reduction	3,544	3,483
- Blast Furnace - Pig-iron	2,434	2,373
Zapla Blast Furnaces	184 (1)	123
ACEROS PARANA	2,250	1,870
TAMET S.A.	50	50
- Direct reduct. - sponge-iron	1,100	1,110
Acindar S.A.	700	700
SIDERCA	410	410
Steel Manufacture - solid crude	6,228	4,890
- Electric Furances	2,398	2,268
Aceros brabado S.A.C.I.F.	210	210
Acindar S.A.	1,338	1,338
SIDERCA	760	540
Establec. Altos Hornos Zapla	70	70
Molded foundry steel parts	110	110
- LD Oxygen Converters	3,600	2,500
ACEROS PARANA	3,600 (2)	2,500
- Thomas Conventional and Thomas OBM Oxygen Converters	270	122
Establec. Altos Hormos Zapla	270	122
Continuous Tapping - crude steel	3,985	3,470
Aceros Bragado S.A.C.I.F.	1,050	1,050
SIDERCA	600	415
ACEROS PARANA	2,250	1,870

(1) Depending on Metal Charge

(2) Non-aggregable maximum capacities. Joint use limited to availabilities of pig-iron and oxygen.

Source: Steel Industrial Center

Table 3-3-8(2) STEEL PRODUCTION CAPACITY - BY COMPANIES POTENTIAL PLANT CAPACITY AND OPERABLE CAPACITY

- Hot-Rolling Production -

Sector/Company	Potential Plan Capacity	Operable Capacity
Partly finished goods - rough-cast		
- Partly finished good - rough-cast	3,140	1,645
Aceros bragado S.A.C.I.F.	120	65
Acindar S.A.	240	240
Establecimiento Altos Hornos Zapla	180	150
ACEROS PARANA	2,600 (1)	1,190 (4)
- Finished goods	4,398	4,120
Non-flat	2,473	2,195
Aceros Bragado S.A.I.C.F.	138	120
Acindar S.A.	1,245	1,245
Establecimiento Altos Hornos Zapla	257	137
La Cantabrica S.A.	170	170
ACEROS PARANA	250	110
Acerias Coronel Pringless S.A.	2	2
Aceros Puesto Viejo S.A. (ex-Met.Palpala)	20	20
Arian Metal	3.5	3.5
Barreiro Roberto O.	1.5	1.5
Establecimiento Devoto	3	3
Establecimiento Metalurgico San Jose SAICF	20	20
Erviti Hnos. e Hijos S.A.C.I.	1	1
Fernandez y Geranio	3.5	3.5
Fortunato Bonelli & Cia. Ind. Met. SAICF	80	80
Laminacion Ferreyra S.A.	25	25
Laminacion S.R.L.	4.2	4.2
Lamitecnica S.A.	1.5	1.5
Laminacion Las Heras S.A.	2.5	2.5
Metalurgica Munso	3	3
Matini y Sinal SACIFIA	2	2
Navarro S.A.	70	70
Rosati y Cristofaro SAIC (San Nicolas)	55	55
Rauna S.A.(ex Planta Don Bosco Ros.& Cristofaro)	7	7
Sipar Laminacion de Aceros S.A.	75	75
Sociedad Industrial Argentina S.A.	15	15
Lamifal SAIC	9.4	9.4
Laminacio Gigante Hnos.	1.2	1.2
Pecoraro Antonio e Hijos SRL	1.4	1.4
Perfilam SRL	1.1	1.1
Raimundo Miguel C.e Hijo S.A.	1.2	1.2
Talleres Dos SAIC	4	4
Flat Products	1,500	1,500
Acindar S.A.(Flejes)(tapped steel)	100	100
ACEROS PARANA (Chapas - Sheet Steel)	1,400	1,400 (2)
Seamless steel tubing	525	525
SIDERCA	525	525

(1) Due to limited steel supply, 1,300,000 in steel bars and 1,300,000 billets
(2) Capacity subject to mixture of required thickeness and sizes
(3) Under normal operating at 18 shifts weekly and standard mix production
(4) Due to limited steel

Table 3-3-8(3) COLD-ROLLING PRODUCTION

- Thousand tons/yearly -

Cold-rolling Producion	Potential Plan Capacity	Operable Capacity
Cold-rolling Production	1585	1420
- Sheet Steel	1475	1310
Adabor S.A.	40	25
Propulsora Siderurgica S.A.I.C.	735	735
ACEROS PARANA	700	550 (1)
- Tape Steel		
Canerias Argentinas Metales y Afines CANAR S.A.	7	7
Fortuny Hnos. y Cia. S.A.	7	7
Hermac S.A.I.C.	12	12
Laminfer S.A.	24	24
Laminacion Basconia S.A.	14	14
ILFA Industrias Metalurgica S.A.	25	25
Sataz y Alcarez S.A.	7	7
Trafilam S.A.I.C.	12	12
Tinplate	110	110
ACEROS PARANA	110	110

(1) Capacity subject to real mix of required sizes and thickness and depending upon supply of base material

Source: Steel Industrial Center

Table 3-3-9 EMISSION FACTOR FOR STEEL PLANTS

Process	Production (ton/day)	Exhaust Gas Volume		Effluent SOx			Effluent NOx			Effluent Dust		
		(Nm3/ton-product)	(10K-N/hr)	Conc. (ppm)	Flow Rate (Nm3/hr)	Emission per unit product (ton) (Nm3/ton-product)	Conc. (ppm)	Flow Rate (Nm3/hr)	Emission per unit product (ton) (Nm3/ton-product)	Conc. (ppm)	Flow Rate (Nm3/hr)	Emission per unit product (ton) unit/ton-product
Cokes Plant	13600	650-750	366-425				(100-300ppm)	37-128	0.065-0.225-cokes	(case:coal to cokes)	567	1kg/ton-cokes
Incineration Plant	43200	3,000-3,400	540-610	400-650	2160-3960	1.2-2.2	200	1080-1244	0.60-0.68	50-100 0.08	432-488	15-34kg/ton
Cupula	28800	1,000-1,200	288-346				30-100	36-144	0.03-0.12	20-30	14.4-17.7 (=0.005g/Nm3)	26-30g/steel-ton
Mill	32800	120-steel-ton (furnace type) 55-steel-ton (non furnace type)	7.5							15-20 30-80	3.75 (=0.05g/Nm3)	0.15-0.24/steel-ton 0.15-0.44kg/steel-ton
Rolling												
	19680	182-350-Block-ton	15-29	-	0- 74	0-0.09-Block-ton	60-475	8-136	0.01-0.17-Block-ton			
	32800	280-700-Sheet-ton	38-96	-	0-239	0-1.75-Sheet-ton	60-400	27-384	0.02-0.28-Sheet-ton			
Total for Seel Plant	1.2 Mt	1,368.5-2,645Nm3/hr		13,890-16,000Nm3/ton			1,280-2,106Nm3/hr			1,147-1,076kg/hr		

(2) Chemical Industry

Given in Table 3-3-5 is a list of companies in Argentina producing major chemicals with their addresses, starting dates of operation and their nominal production capacity (tons/year).

Shown also are the data on steam consumption per unit of production (tons of steam/ton of product), power consumption per unit of production (KWH of power/ton of product) and fuel consumption per unit of production (MMBtu of fuel/ton of product). All of them are related to pollutants from utilities needed for production. These values of consumption per unit of production for each chemical industry process are in line with average values widely applicable to other countries and sourced from licenser catalogs, general publications, etc. that have been made public.

As a next step, Table 3-3-10 was used to obtain the total pollutant emission from the whole chemical industry, and in that effort table 3-3-10 was used for the amount of pollutant discharge per unit emitted from energy sources used for utilities.

The following assumptions were made for calculation of the discharge coefficient for this table:

* Heavy oil based energy : 10300 kcal/kg
* Natural gas based energy : 10500 kcal/kg
* Coal based energy : 6500 kcal/kg
* Sulfur content in heavy oil : 1%
* Boiler efficiency
    Heavy oil : 85%
    Natural gas : 83%
    Coal : 75%
* Power generation efficiency :-36%

A star mark denotes other assumed parameters, to which generally accepted values were applied.