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THE REPUBLIC OF TURKEY

THE STUDY ON ANKARA AIR POLLUTION CONTROL PROJECT

FINAL REPORT

APPENDICES

JANUARY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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Part I

SUPPLEMENTARY STUDIES

1 Air Quality Simulation Model

1-1 Selection of Simulation Models

The main objective of the air quality simulation analysis is to predict the effects of pollution control measures in reducing the ambient concentration of pollutants. It is intended to present useful information to decision makers in the process of selecting appropriate control measures among various alternatives. Therefore, it is important for the simulation model to have ability to predict, with the adequate accuracy, the concentration of ambient air quality taking various factors such as meteorology, topography, and pollutant distribution into account.

In the case of air pollution in Ankara it is clear that drastic control measures are necessary. At the same time, since the implementation of drastic measures takes generally a long period of time, temporary shorter-term measures such as the restriction of fuel use at the time of occurrence of high pollutant concentration may also be necessary.

Selection of simulation model, therefore, must be made considering the two cases in time scale, i.e., seasonal time scale for the evaluation of mid-term drastic measures and hourly time scale for the evaluation of emergency measures.

Various mathematical models commonly used are shown in Table 1-1-1 for reference.

Model to be used for the evaluation of mid-term measures must be able to simulate the local distribution of pollutant concentration for a wide area. Among this type of models, a time-averaged plume-puff model was selected because it is internationally recognized as a reliable and practical model. From the seasonal average concentration computed using this model, one-hour mean concentration distributions at the time of high pollutant level can also be obtained by applying statistical factors.

Table 1-1-1 Mathematical Aiir Quality Models

Category	Name	Characteristics
Dispersion Model	Plume model	Smoke plume represents smoke shape emitted continuously from source. Calculation of concentration is very simple. This model can be applied for stationary conditions over relatively flat terrain.
	Puff model	Puff is one smoke mass emitted instantaneously. Continuous smoke is represented by a procession of puffs. This model can either be applied for non-stationary or calm conditions.
	Box model	Exchange of pollutants between neighboring boxes is calculated. This model is suitable for photochemical smog.
	Difference equation model	Differential equation of diffusion is solved numerically under complex boundary condition expressing real topography.
Statistical Model	Regression model	Relationship between concentration of pollutant and meteorological and other factors is correlated based on the past data by means of multiple regression analysis or control theory to predict the concentration. This model can not be applied when emission source conditions change in the future.
	Grouping model	Past data of concentration and meteorology are classified statistically into groups. Prediction of concentration is made stocastically. This model can not be used under the conditions that are different from those being grouped.

Model to be used for the evaluation of emergency measures needs to be able to describe the time variation of pollutant concentration within a period of one or two days. For this purpose, convective puff model, box model, or difference equation model can be used. Taking model performance and the available time into account, the convective puff model was selected and modified so that it can be used in conjunction with the locally varying wind field computed numerically by the finite difference method.

1-2 Time-Averaged Model

In the computation of winter-average concentration of pollutant, a plume equation and a puff equation are used, the former under the windy conditions and the latter under the calm conditions. Computations are made dividing one day into 6 time zones applying conditions of wind direction, wind speed, atmospheric stability, mixing height, and amount of emission averaged over each time zone. Computation is made on all the emission sources (virtually all the mesh points and some points outside the mesh). Concentration values thus computed for the winter period are then added up and averaged out for each mesh point to obtain the winter average concentration distribution. Equations used in this model are explained below.

(1) Plume Equation

The following plume equation is used when wind speed (U) is greater than or equal to 1 m/s.

$$C(R,z) = \sqrt{\frac{1}{2x}} \cdot \frac{Qp}{\frac{\pi}{8} R \sigma z U} \left[\exp\left\{ - \frac{(Z-He)^2}{2\sigma z^2} \right\} + \exp\left\{ - \frac{(z+He)^2}{2\sigma z^2} \right\} \right]$$

when $U \geq 1.0$ m/s

where,

C (R,z)	:	concentration at the location (R,z)
R	:	horizontal distance between emission source and computation point, $R^2 = x^2 + y^2$
x,y,z	:	coordinates of the computation point
Qp	:	emission rate of the source point
σz	:	dispersion coefficient in the vertical direction (see Figure 1-2-1)
U	:	wind speed
He	:	effective height of the source

Values of vertical dispersion coefficient can be obtained from the pasquill-Gifford diagram shown in Figure 1-2-1.

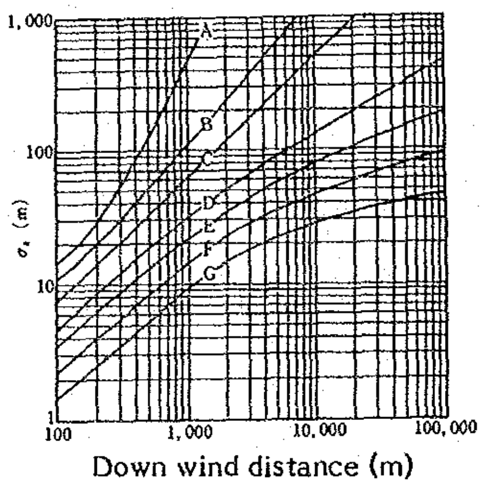


Figure 1-2-1 Pasquill-Gifford's Vertical Dispersion Coefficient

(2) Puff Equation

The following puff equation is used in the case when wind speed is less than 1.0 m/s.

$$C(R,z) = \sqrt{\frac{1}{2x}} \cdot \frac{Qp}{\frac{\pi}{8}\gamma} \cdot \left[\frac{1}{\eta_-^2} \cdot \exp\left\{ -\frac{U^2(z-He)^2}{2\gamma^2\eta_-^2} \right\} + \frac{1}{\eta_+^2} \cdot \exp\left\{ -\frac{U^2(z+He)^2}{2\gamma^2\eta_+^2} \right\} \right] \quad \text{when } U < 1.0 \text{ m/s}$$

where,

α: horizontal dispersion coefficient (from Table 1-2-1)

γ: vertical dispersion coefficient (from Table 1-2-1)

$$\eta_-^2 = R^2 + \frac{\alpha^2}{\gamma^2}(Z - He)^2$$

$$\eta_+^2 = R^2 + \frac{\alpha^2}{\gamma^2}(z + He)^2$$

and meaning of other symbols are same as that in the plume equation.

Table 1-2-1 Dispersion Coefficients for Calm and Low-Wind Conditions

Stability Class	$U \leq 0.4$ m/s		$0.5 < U < 0.9$ m/s	
	α	γ	α	γ
A	0.948	1.569	0.748	1.569
A-B	0.859	0.862	0.659	0.862
B	0.781	0.474	0.581	0.474
B-C	0.702	0.314	0.502	0.314
C	0.635	0.208	0.435	0.208
C-D	0.542	0.153	0.342	0.153
D	0.470	0.113	0.270	0.113
E	0.439	0.067	0.239	0.067
F	0.439	0.048	0.239	0.048
G	0.439	0.029	0.239	0.029

(3) Estimation of 24-Hour Mean and One-Hour Mean Concentration at High Pollutant Levels

When the variation of concentration values at a particular point is assumed to fit the logarithmic-normal distribution, the relationship between the arithmetic mean concentration and a concentration to be occurred in the probability P(%) is expressed as follows:

$$\bar{C} = Cp \cdot Sg^{(\frac{1}{2} \ln Sg - z)}$$

in which, $\bar{C}$: arithmetic mean concentration

Cp : concentration at probability P

Sg : geometric standard deviation

z : variable in the standard normal distribution

$$\int_{\infty}^{z} \frac{1}{\sqrt{2\pi}} \cdot \exp - \left(\frac{t^2}{2}\right) \cdot dt = \frac{P}{100}$$

(z = 2.05, when P = 98%)

Therefore, Cp can be obtained as follows:

$$Cp = \bar{C}/Sg^{\left(\frac{1}{2} \ln Sg - z\right)}$$

From the P-C curves for SO_2 presented in Section 2.2.3, values of Sg for 24-hour mean (Sg·D) and for one-hour mean (Sg·H) are obtained as follows:

Sg·D = 1.71, and Sg·H = 2.25

When the 90% value[1] (z = 1.28) and the 99% value[2] (z = 2.33) are chosen as the typically high values of 24-hour mean and one-hour mean concentration, respectively, the following relationships are obtained:

$C_D = 1.72\,\bar{C}$

$C_H = 4.75\,\bar{C}$

in which, C_D represents the typically high 24-hour mean concentration, and C_H represents the typically high one-hour mean concentration.

Notes:

1) Typically High 24-Hour Mean Concentration

A concept of "2% exclusion of values" is employed in Japan in order to assess daily mean SO_2 levels during a year. The highest 2% of data (7 data) are excluded from the 365 data. The remaining 98% of the data are checked against a designated level (environmental standard value). In other words, the daily mean values should not exceed the standard value for more than 98% of days of the year. For the present study, ambient air quality monitoring was conducted in Ankara for 86 days in the winter. Since the SO_2 levels are supposed to be lower in other seasons, the 98% value of the daily mean SO_2 concentration in the year corresponds approximately to the 90% value of those 86 data. For this reason, the 90% values of those monitored during the 86-day period are adopted here as the typically high daily mean levels.

2) Typically High One-Hour Mean Concentration

From the P-C curve for one-hour mean levels, the upper limit of the range that can be assumed to be logarithmic-normal distribution roughly corresponds to 99% in probability. This 99% value was adopted here as the typically high hourly level.

1-3 Time-Dependent Model

Dispersion equation used in the time-dependent model is a puff equation which describes the local and temporal variation of pollutant concentration corresponding to the instantaneous emission of a smoke puff from a point source. The equation is as follows:

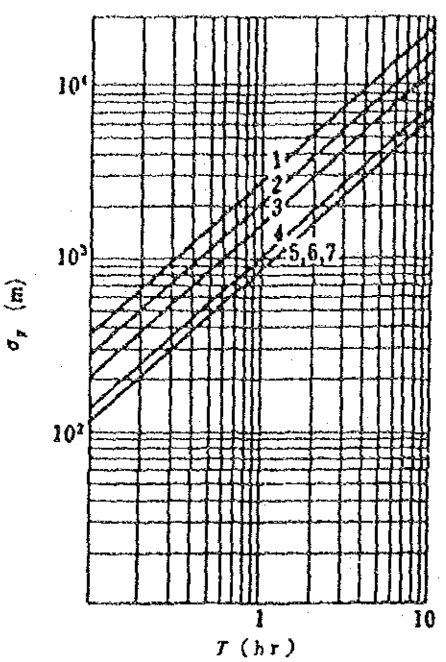
$$C(R,z,t) = \frac{Qp(t)}{(2\pi)^{3/2} \cdot \sigma y(t)^2 \sigma z(t)^2} \cdot \exp\left(-\frac{R^2}{2\sigma y(t)^2}\right) \times \left[\exp\left\{-\frac{(z-He)^2}{2\sigma z(t)^2}\right\} + \exp\left\{-\frac{(z+He)}{2\sigma z(t)^2}\right\}\right]$$

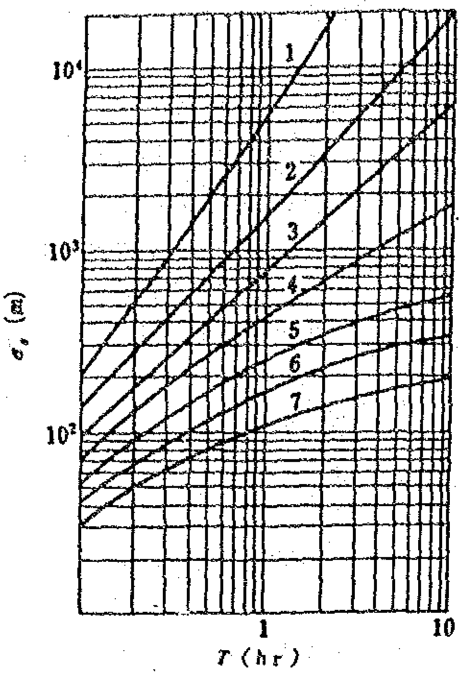
in which,

t : elapsed time
$Qp(t)$: pollutant emission rate at time t
$\sigma y(t)$: horizontal dispersion coefficient for time t
$\sigma z(t)$: vertical dispersion coefficient for time t
$C(R,z,t)$: concentration of the pollutant at a point at time t

and definitions of the other notations are the same as those given previously.

Values of horizontal and vertical dispersion coefficients can be obtained from the Turner's diagram shown in Figure 1-3-1.





Horizontal dispersion coefficient | Vertical dispersion coefficient

Figure 1-3-1 Dispersion Coefficients as the Function of Time Given by Turner

1-4 Topographic Condition

Topographic data used in the simulation were prepared using the topographic map of Ankara, specifying the height at each point on the 500 m grid system as shown in Table 1-4-1.

Table 1-4-1 Altitude Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
38	20	70	40	20	0	960	0	0	20	30	20	19	30	40	60	110	70	50	20	87	40	38	990	80	118	85	90	70	50	0	940	0
37	0	30	990	10	980	955	969	996	10	8	8	14	20	70	80	195	50	10	15	40	20	10	10	15	10	40	10	30	0	900	900	60
36	0	990	990	20	990	964	970	10	10	0	10	19	24	100	115	70	20	20	990	960	990	980	10	970	950	20	10	35	840	950	0	0
35	990	980	0	60	10	20	33	10	50	10	10	50	80	115	70	50	0	960	980	980	930	930	960	890	950	980	910	990	900	950	970	20
34	950	960	960	100	80	20	54	49	30	10	10	10	80	110	20	0	980	950	960	960	950	950	970	20	975	920	910	900	900	880	0	0
33	893	899	932	132	110	140	110	100	65	10	30	30	40	40	10	980	965	940	950	960	950	950	910	930	900	900	900	840	940	10	0	995
32	889	897	930	50	109	80	110	100	90	90	50	30	0	50	985	970	950	930	940	960	950	970	930	930	880	880	10	0	50	35	40	990
31	860	890	950	50	60	70	20	20	10	70	0	0	70	960	970	960	830	910	920	950	950	920	940	840	0	0	50	40	80	70	50	990
30	870	910	990	10	40	55	30	960	990	975	970	955	[illegible]	940	940	920	920	890	900	930	940	930	950	950	0	50	90	140	170	150	74	40
29	875	895	970	990	990	40	0	950	850	945	940	940	9	Meteorological						930	940	960	960	950	950	990	90	125	130	130	100	80
28	870	905	940	960	950	980	15	920	930	940	910	935	8			Agency				900	920	960	960	940	980	40	50	80	120	120	105	105
27	876	904	892	900	900	905	930	910	898	890	890	890	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	900	900	930	950	960	0	0	30	40	90	82	120	80
26	879	897	870	870	870	Yenimahalle					880	874	872	870	870	850	860	880	870	870	900	930	950	940	980	995	0	20	48	80	100	108
25	870	887	850	850	860	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	865	860	850	860	860	860	850	860	870	880	890	910	930	950	980	990	0	30	50	90	115	130
24	866	879	870	841	820	850	850	840	840	842	840	850	850	860	850	850	860	870	870	900	900	910	930	940	950	970	980	11	55	85	150	265
23	850	866	870	850	840	835	840	840	840	840	840	840	850	850	860	860	870	880	880	900	900	890	910	930	940	960	0	50	72	130	160	270
22	856	854	830	840	840	840	840	840	840	[illegible]	[illegible]	[illegible]	960	860	880	880	880	900	900	920	900	910	920	930	940	955	10	40	60	77	130	190
21	840	830	830	840	830	850	840	840	840	[illegible]	Tandogan		350	860	880	880	890	900	920	920	910	930	940	960	950	960	0	30	50	66	120	160
20	849	830	830	840	850	850	850	850	850	860	860	850	840	840	860	Sıhhiye				Cebeci			980	990	980	980	0	30	20	40	50	159
19	830	830	840	840	860	870	870	850	860	870	860	860	840	840	850								[illegible]	960	990	980	990	0	0	40	100	140
18	840	840	852	830	850	880	880	860	870	880	870	900	880	880	870	870	890	910	920	920	940	930	920	950	910	930	940	990	0	60	140	20
17	888	854	836	830	860	876	890	Bahçelievler					[illegible]	870	880	880	900	930	950	960	970	950	950	950	920	930	910	940	20	0	0	30
16	870	852	842	852	848	850	870	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	930	970	960	940	960	950	960	980	960	910	930	980	980	20
15	860	856	850	856	860	862	870	890	890	890	890	920	910	91	Kavaklidere					900	900	900	930	970	10	20	980	980	920	920	940	940
14	860	870	860	862	880	882	872	890	910	910	910	910	920	900	910	940	940	930	920	890	900	920	960	975	25	20	15	850	890	10	930	940
13	868	880	874	870	878	900	876	900	900	910	910	928	920	910	920	960	960	950	920	910	880	890	980	20	60	50	20	970	890	25	950	0
12	872	880	880	883	878	889	900	910	920	920	930	920	930	920	940	980	Çankaya			[illegible]	940	890	940	0	10	60	10	5	30	30	0	0
11	872	880	900	908	889	906	914	930	930	940	950	930	960	940	950	970				[illegible]	980	950	925	940	0	25	20	40	58	20	30	20
10	885	892	900	918	920	910	940	960	950	960	960	970	980	980	980	980	20	35	45	950	20	20	930	930	890	20	48	58	40	30	40	40
9	910	908	920	930	940	940	970	960	970	980	986	0	0	10	40	40	60	60	70	0	50	80	35	910	930	0	55	69	40	35	20	0
8	940	923	940	960	970	980	10	970	10	0	0	30	40	45	60	78	94	78	40	70	93	50	950	910	970	985	50	40	30	25	50	150
7	965	950	950	972	990	999	10	980	30	20	22	30	50	0	70	98	94	50	70	84	70	950	910	990	935	10	10	80	40	0	110	160
6	995	990	970	8	24	15	50	0	60	45	50	80	60	990	60	74	86	90	80	90	30	925	930	40	0	0	980	100	35	40	70	80
5	38	31	991	20	55	60	76	20	80	110	120	180	150	50	70	100	114	198	80	20	20	30	950	980	0	965	10	100	80	50	60	50
4	30	15	14	66	94	70	100	65	120	160	200	210	130	90	120	132	138	110	20	20	20	50	0	0	50	0	10	104	123	70	80	65
3	40	80	70	120	130	120	90	90	180	220	280	170	80	130	170	160	100	990	970	970	0	70	0	50	50	70	70	100	110	100	50	10
2	110	165	135	190	224	175	120	140	240	290	220	164	110	150	175	90	990	960	970	0	120	110	70	100	50	100	120	85	114	120	110	30
1	195	218	210	235	242	170	150	190	230	244	210	140	140	178	178	120	0	960	950	90	130	90	50	130	130	100	162	124	114	130	110	30

Note: For the grids where altitude is above 1000 m, values after subtracting 1000 m are shown.

1-5 Meteorological Condition

(1) Meteorological Conditions for the Time-Averaged Model

i) Time Zones

Considering the hourly frequency of occurrence of wind direction and wind speed and the time-variation patterns in atmospheric stability and heating fuel consumption, one day was divided into six time zones as shown in Table 1-5-1.

Table 1-5-1 Time Zones

Time zone	Time of day
Mid-night	0:00 - 4:00
Early morning	5:00 - 7:00
Morning	8:00 - 10:00
Afternoon	11:00 - 14:00
Evening	15:00 - 17:00
Night	18:00 - 23:00

ii) Wind Direction Classification

Wind directions were classified into 16 directions and the calm condition ($U < 0.4$ m/s).

iii) Wind Speed Classification

Wind speeds are categorized into 6 classes as shown in Table 1-5-2.

Table 1-5-2 Wind Speed Classification

Condition	Actual speed (m/s)	Speed used (m/s)
Calm	0 - 0.4	0.0
Low wind	0.5 - 0.9	0.7
Windy	1.0 - 1.9	1.5
	2.0 - 2.9	2.5
	3.0 - 3.9	3.5
	4.0 -	5.0

iv) Atmospheric Stability Classification

Atmospheric stability was classified in accordance with the classification of Pasquill using insolation, net radiation, and wind speed observed.

v) Mixing Depth

Mixing depth (height of the lid) was specified for the time zones of morning and evening shown in Table 1-5-1 within the range of 100 m - 200 m.

vi) Area Blocks

In order to take the differences in topography and wind pattern into account, the whole simulation area was divided into three blocks, i.e., north, central, and south blocks where wind conditions were specified using the data obtained at Meteorological Agency, Tandogan, and Kavaklidere, respectively.

(2) Wind Condition in the Time-Dependent Model

For the air quality simulation with the time-dependent model, the simulation period was chosen to be the two-day period of December 20 and 21, 1984 when a characteristic high concentration peak appeared.

Wind field in the three-dimentional space during this period was computed by the wind simulation model using the variational optimization technique. Hourly wind data (direction and speed) at the three observation stations were used as the basis of the computation.

Wind vectors at 10 m above the ground are shown in Figures 1-5-1 and 1-5-2.

1-6 Emission Source Condition

(1) Effective Stack Height

For the windy and low-wind conditions the Concawe equation was used to obtain the effective height of the emission source:

$$He = Ho + \Delta H$$

where, He : effective height of the source, (m)

Ho : height of the source (stack), (m)

ΔH : $\Delta H = 0.175 \cdot Q_H^{1/2} \cdot U^{-3/4}$

Q_H : heat emission rate, (cal/s)

U : wind speed at the height of the source, (m/s)

From the building distribution data, height of the source (Ho) was categorized into small-height (10 m) and medium-height (30 m).

For the calm condition, the Briggs equation was used to obtain: ΔH:

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

where, $d\theta/dz$ denotes the lapse rate.

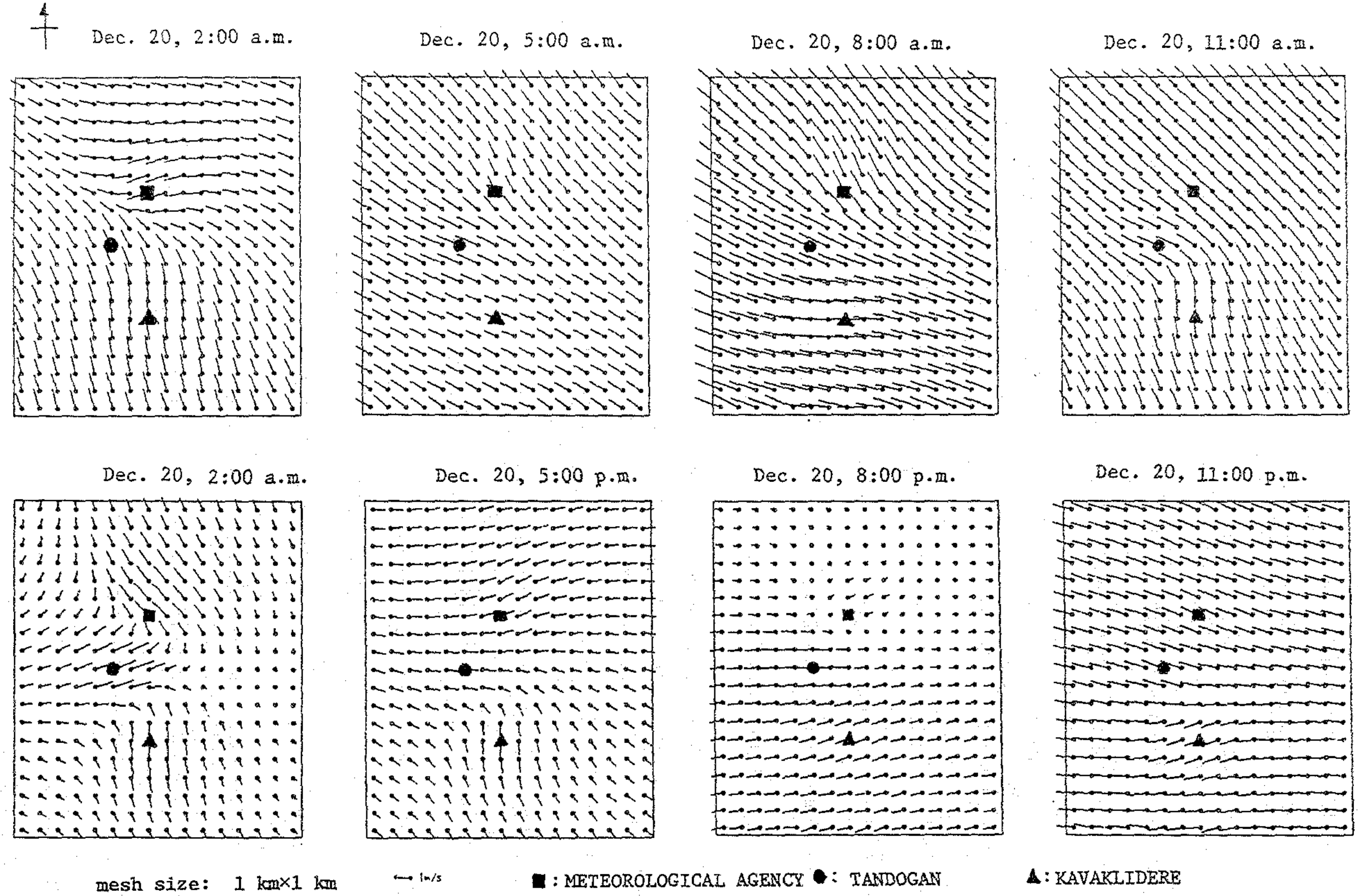


Figure 1-5-1 Simulated Wind Field (Dec. 20, 1984)

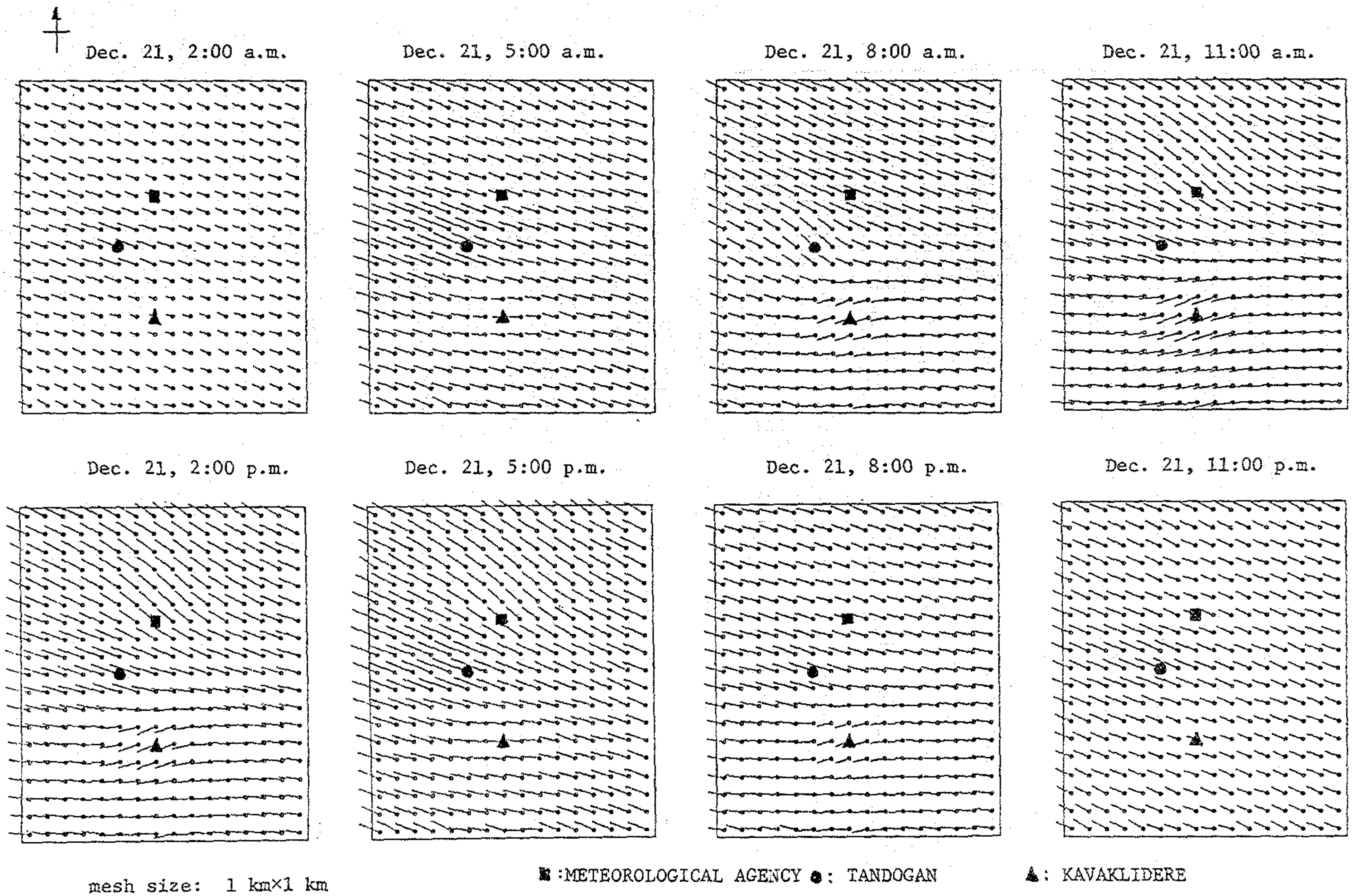


Figure 1-5-2 Simulated Wind Field (Dec. 21, 1984)

(2) Flue Gas Emission by Time Zone

Figure 1-6-1 shows the hourly variation of the flue gas emission obtained through the on-site questionnaire on the 100 boilers.

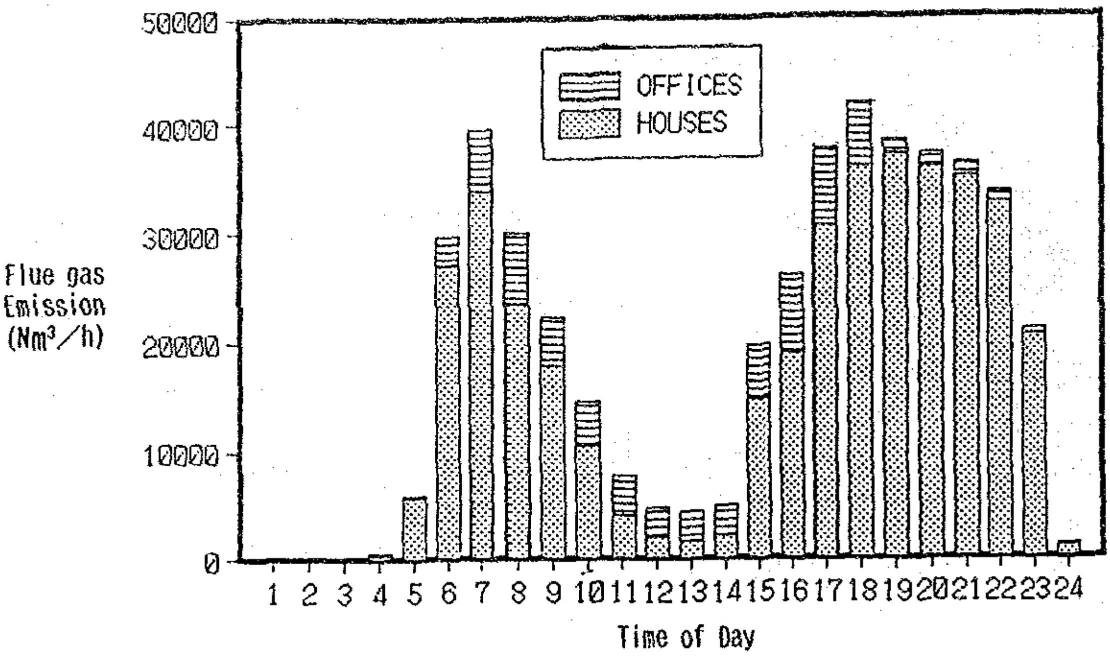


Figure 1-6-1 Hourly Variation of Flue Gas Emission

For the time-averaged model, pollutant emission rate was specified for each of the 6 time zones described in 1-5, (1), i) averaging the hourly rate over each time zone.

For the time-dependent model, the hourly variation pattern as shown in Figure 1-6-1 was used.

2 Air Quality Monitoring System and Emergency Forecasting System

2-1 Necessity of Monitoring System and Emergency Forecasting

At the present in Ankara City, air quality is monitored on the basis of 24-hour mean concentration. Sampling for a 24-hour period is made from 11:00 a.m. to 11:00 a.m. the next day. Concentration of air pollutants, however, varies from time to time depending on the changes in weather conditions and the pollutant source conditions. Even if drastic source control measures are enforced, it generally takes a considerable length of time for them to take effects. Therefore, it is considered to be necessary to take emergency control measures at the time of high pollutant concentration that may occur until the drastic measures are widely implemented. In order to take emergency actions promptly, it is necessary to seize the ever changing pollutant concentration and weather conditions on the hourly basis and to develop the system of forecasting air pollution and judging the necessity of the emergency actions. The steps leading to the execution of the emergency actions are shown below.

Hourly Measurement of Weather Conditions and Pollutant Concentration

↓

Transmission of Data from Measuring Stations

↓

Batch Processing of Data Transmitted

↓

Forecast of Air Pollution and Judgement of Actions to be Taken

↓

Emergency Actions

2-2 A Plan for Air Quality Monitoring System

(1) Air Quality Monitoring System

With the air quality monitoring system, the real time situation of air quality at each monitoring station is measured and the measured data are accumulated. This system is divided into tow parts, the monitoring stations and the control station as shown in Figure 2-2-1. The monitoring stations are equipped with automatic air and weather measuring devices, and telemeter terminals. The control station is equipped with a signal transmitter (wire or wireless system), a host telemeter, and a data processor. Installation of on-the-street displays is also desirable to let the public know the situation of air pollution.

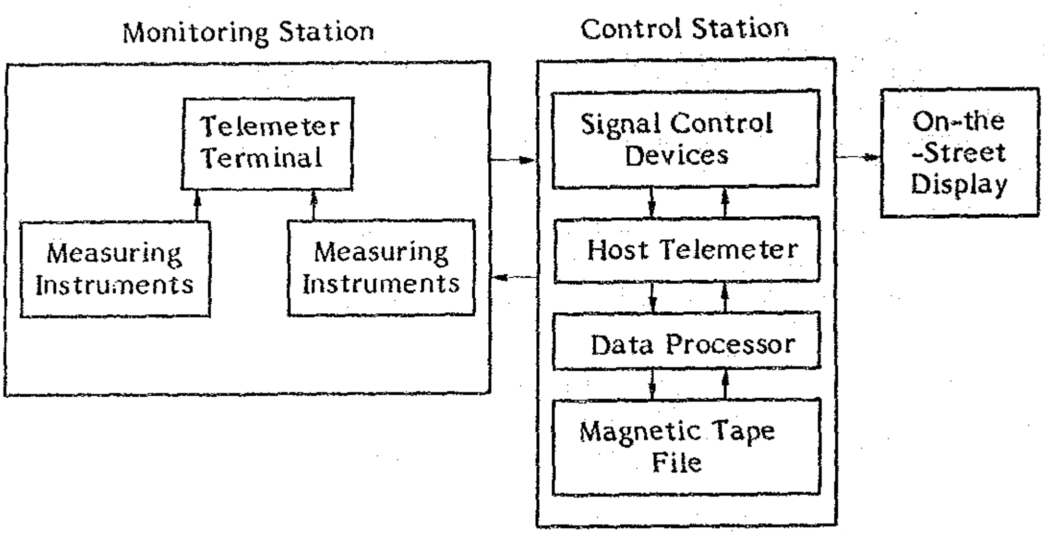


Figure 2-2-1 Air Quality Monitoring System

Various kinds of data measured at each monitoring station is temporarily filed in the telemeter terminal of the station and transmitted to the control station when instructed. After checking the transmitted data, the host telemeter transmits the data to the data processor where the transmitted signals are digitally processed, and the data are displayed on the auxiliary devices such as display screens, printers, and data memorizers. Based on the digital data, judgement whether emergency actions should be taken is made and the air quality levels are shown on the on-the-street displays for the public.

(2) Maintenance of Monitoring System

While this system features real time data, detailed planning is required for the maintenance of the total system. Not only the maintenance of the mechanical system (measurement-transmission-processing), but also the improvement on the personnel management of the staff members operating this monitoring system is essential.

Before the monitoring system is actuated, planning and preparations should be made with care and in detail.

(3) Budget Required for Seven Full-Time Monitoring Stations

The following estimate was made on the assumption that 7 monitoring stations, 2 transit stations, and one on-the-street display are to be set up.

1.	Equipment and Materials	95,520,000
	1) Supervisor/Control Center	36,100,000
	2) Repeater Station x 2	16,400,000
	3) Gauging Station x 7	41,020,000
	4) On-the-Street Display Equipment	2,000,000
2.	Freight/Insurance/Inland Transportation	11,050,000
3.	Installation/Adjustment/Testing	77,860,000
4.	Radio Wave Propagation Test and Site Survey	10,120,000
	Total	¥367,120,000 (770,952,000 T/L)

Notes:

1. Sensors, station housing, testing instruments, spare parts/units, air-conditioners are not included.
2. On-the-job training, operation, and maintenance services are not included.
3. Data transmission speed is 200 BPS.
4. Cost of electricity (AC220V, 1ϕ, 50Hz) is not included.

2-3 Tentative Plan for the Emergency Forecasting System

(1) Steps for the Development of Emergency Forecasting System

In order to ask the public for their cooperation in taking necessary measures at the time of high concentration, it is necessary and effective to predict the pollutant concentration approaching the emergency level as soon as possible and to make forecasting.

It should be noted that even if an emergency action plan is made public, good effects can not be expected without cooperation and understanding of the public and the businees firms in concern.

As shown in Figure 2-3-1, it is desirable that the forecasting system be introduced step by step by gaining understanding and cooperation of the public and the business firms.

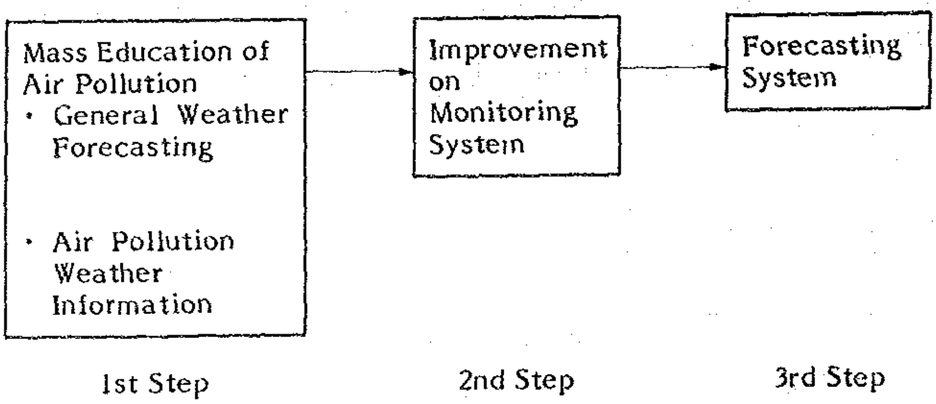


Figure 2-3-1 Steps of Introduction of Forecasting System

(2) Mass Education of Air Pollution

In order to arouse interest and understanding of the public, information about weather conditions related to air pollution should be added to daily weather forecasting by the weather station. In this case such technical terms as values of SO_2 concentration should not be used. Instead, explanation should be made about levels of pollution using such terms as low concentration, high concentration, and extremely high concentration.

Such mass media as television, radio, and newspaper should be used in informing general weather and air pollution forecasts.

(3) Improvement of Monitoring System

As air pollution is largely dependent on the weather condition from time to time, hourly concentration should be constantly monitored. And introduction of telemeters is necessary to transmit concentration data.

Maintenance of the measuring instruments at 7 monitoring sites should be improved so that better accuracy be obtained.

In order to arouse interest of the residents, mean and highest concentration levels of the previous day should be added to air pollution information through mass media.

Conventionally, Ankara City has employed 24 hour mean value and analysis has been manually made. Due to this, the analysis has been delayed to some extent after Saturdays and Sundays. The staff should be reinforced during the heating season so that daily analysis can be conducted.

(4) Introduction of Forecasting System

After technical and organizational procedures stated above, the forecasting system shown in Figure 2-3-2 can be introduced.

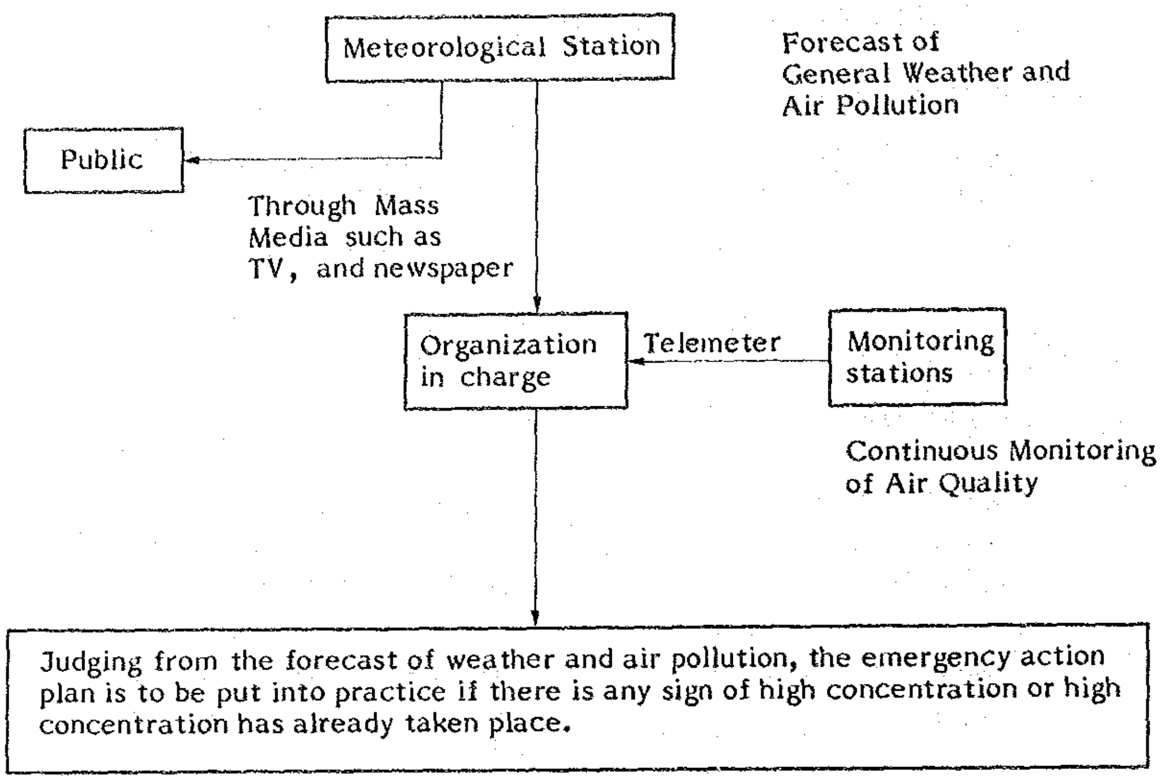


Figure 2-3-2 Example of Forecasting System

2-4 Tentative Method for the Forecast of High SO_2 Concentration

The method presented here for the forecast of SO_2 concentration has been schemed out based on the statistical analysis of meteorological data of 3 months as from Dec. 18, 1984 through Mar. 9, 1985. Due to the lack of data, there is room for improving reliability. However, it is expected that this method can be utilized if data is supplemented and adjustment is made during the preparatory stages of introducing the emergency forecasting system.

The tentative method for forecasting SO_2 concentration is described as follows.

(1) Classification of Weather Conditions at the Times of High Pollutant Concentration

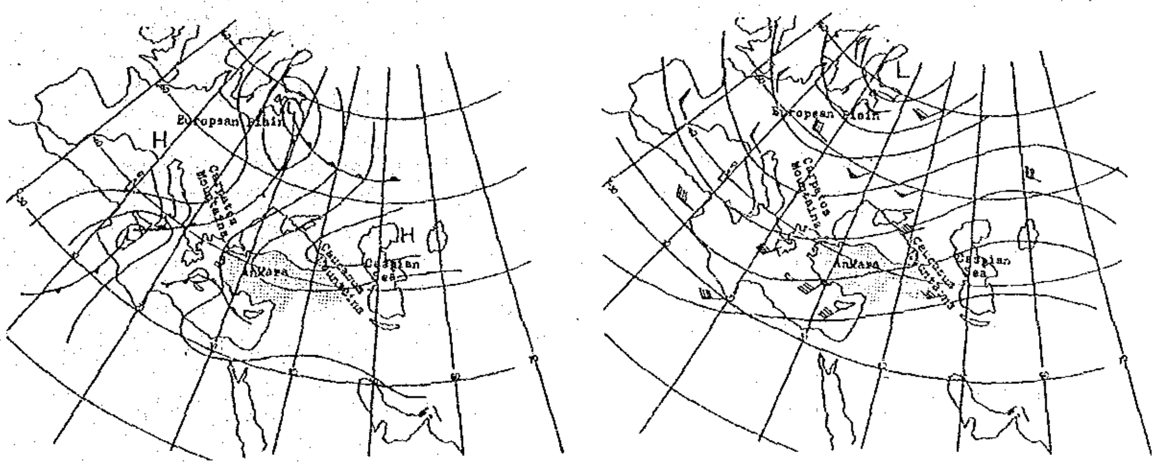
On the basis of all the weather charts made by the Ankara Meteorological Station at ground level and upper layers (altitude:

5,000m) as from Dec. 18, 1984 through Mar. 9, 1985, the distributions of atmospheric pressure at the time of high SO_2 concentration were classified into the typical patterns. A summary of the classification was presented in Table 7.3.1 in the Main Report. A more detailed description is given below.

i) Pattern of High Concentration under High Temperatures (cf. Figure 2-4-1)

On the Ground level weather chart, there is a cyclone or a front over the Eastern European Plains, Lesistyje Karparty, and Mediterranean, and an anti-cyclone in Caspian Sea spreads out to Turkey. In this case, strong southwest (SW) wind blows in the upper layers (5,000 m), introducing warm air. Thus the ground level temperature tends to be higher than 0°C, and the weather is mostly fine. The wind speed is low during night through early morning. Under these condition, an inversion layer and radiation fog are apt to form.

In case the anti-cyclone weakens, or it moves toward east leaving Turkey behind, a cyclone is apt to appear in Aegean Sea resulting the formation of frontal fog. With this type of weather pattern, high SO_2 concentration occurs when the ground level temperature is as high as above 0°C. (This is the case which belongs to A or B rank shown in Tables 2-4-1 through 2-4-4.)



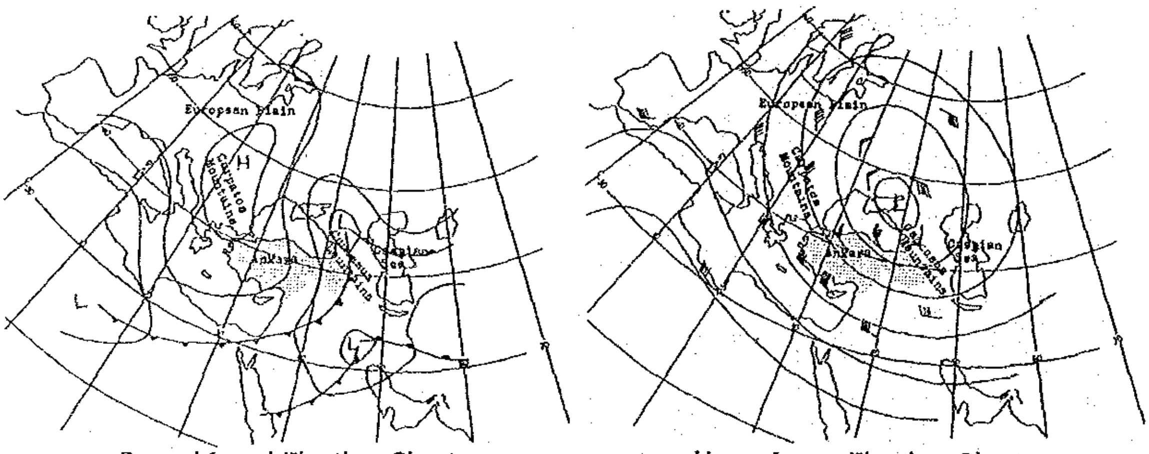
Ground Level Weather Chart　　　Upper Layer (5,000 m) Weather Chart

Figure 2-4-1　Pattern of Occurrence of High SO_2 Concentration under High Temperature

ii) Pattern of High Concentration under Low Temperature (cf. Figure 2-4-2)

On the weather chart at ground level, there is a cyclone or a front over Bol'shoy Kavkas through Tigris River, and an anti-cyclone spreads out over Eastern Europe plains or Lesistyje Karpaty through Turkey. And strong NW wind keeps on blowing in upper layers (5,000 m). In case when the wind speed exceeds 20 m/s, the ground level temperature tends to fall below -10°C, and with the wind speed of over 25 m/s, the ground level temperature is likely to fall below -15°C; extremely low temperatures.

Concentration of SO_2 largely depends on the wind speed at the ground level. High SO_2 concentration is apt to occur at low temperatures below -10°C. (This is the case which belongs to C or D rank shown in Tables 2-4-1 through 2-4-4.)



Ground Level Weather Chart   Upper Layer Weather Chart

Figure 2-4-2 Pattern of Occurrence of High SO_2 Concentration under Low Temperature

(2) Forecast of SO_2 Concentration in the Peak Time-Zones by Use of Classification Table and Estimation Chart

High concentration of SO_2 in Ankara City is characterized by the tow-peak type. The peaks generally appears in the morning (8:00 a.m.) and in the evening (8:00 p.m.).

By forecasting the weather conditions at these two time-zones, SO_2 concentration may be estimated.

As a means of estimating SO_2 concentration from weather forecast, estimation charts have been made for the areas of Kavaklidere and Bahcelievler.

Estimated correlation between temperature and SO_2 concentration is illustrated in Figures 2-4-3 through 2-4-6 according to the four ranks of meteorological condition denoted by A through D as shown in Tables 2-4-1 through 2-4-4.

These charts were statistically mapped out, taking temperature, wind speed, weather, and conditions of upper layers as from Dec. 18, 1984 through Mar. 9, 1985 into consideration.

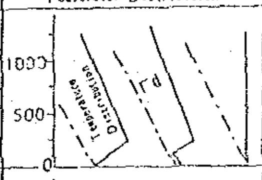
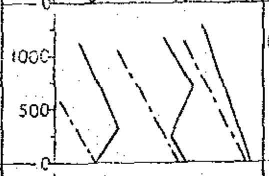
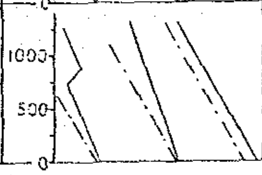
The axis of abscissas of the charts shows the mean temperature during the two time zones (morning: 7 - 9 a.m., evening: 7 - 9 p.m.). The axis of ordinates shows SO_2 concentration in Kavaklidere or Bahcelievler area during the time zones. The classification of meteorological condition (A - D) was made taking wind speed at ground level, weather, and upper layer meteorological conditions (wind speed, inversion layer, etc.) into consideration.

Since the SO_2 concentration at a place is dependent on changes in wind speed, not only the wind speed forecasted for the peak time-zones but also the one before them should be taken into account. Wind speed during the peak time-zones is divided into two ranks; windless (wind speed below 1.0 m/s) and windly (wind speed over 1.1 m/s). Wind speed before the peak time-zones is devided into four ranks. Time-zones before the peaks were taken as 3 - 6 a.m. for the morning and 3 - 6 p.m. for the evening.

If the rank of wind speed at ground level and the upper layer meteorological condition can be predicted, a proper SO_2 estimation curve can be selected out of A-D, and SO_2 concentration can be estimated from the predicted temperature at each peak time-zone.

Table 2-4-1 Ranking Table by Weather Conditions

When forcasted wind speed is less than 1.0 m/sec.
for the forcasting time zone (morning 7,8,9, night 19,20,21) Kavaklidere Area

RANK	Ground Level Wind Speed (m/s) Morning Measurement (Mean Value: 3~6 a.m.) Night Measurement (Mean Value: 15~18 p.m.)	Wind Speed (Altitude: 5,000 m) 500 mb Upper Layer Weather Chart (00Z, 12Z) Indication of High and Low Temperature	Temperature Distribution in Upper Layers Oct by Rawin Sonde (00Z, 12Z) Typical Pattern of Vertical Temperature Distribution	Weather
Ⓐ	Below 0.4	High Temperature Type. Morning and Night Time Temperature: Above 0℃ Low Temperature Type. Morning and Night Time Temperature: Below -10℃		○ ⦶ ◎ ● ≡ Radiation Fog, Rain Front Fog
Ⓑ	0.5 ~1.0	High Temperature Type. Morning and Night Time Temperature: Above 0℃ Low Temperature Type. Morning and Night Time Temperature: Below -10℃		○ ⦶ ◎ ● ⊗ ≡ Radiation Fog, Rain Front Fog
Ⓒ	1.1 ~1.5	Low Temperature Type. Morning and Night Time Temperature: Below -10℃ Extraordinarily Low Temperature Type. Morning and Night Time Temperature: Below -15℃		○ ⦶ ◎ ● ⊗
Ⓓ	Above 1.6	Low Temperature Type. Morning and Night Time Temperature: Below -10℃ Extraordinarily Low Temperature Type. Morning and Night Time Temperature: Below -15℃		○ ⦶ ◎ ● ⊗

Note :

1) In predicting SO_2 concentration from this chart, ground level wind velocity is give priority, as concentration is largely dependent on ground level wind speed.
2) Wind speed in upper layers (altitude: 5,000 m, 500 mb weather chart) serves as a good indication of extremely high or low temperature occurence.
3) In the explanation in the above chart. Morning stands for 5 a.m., and Night, 18 p.m.
4) Weather Mark
   ○ Very Fine ⦶ Fine ◎ Cloudy
   ● Rain ⊗ Snow ≡ Fog
5) Wind Direction Mark
   SW Above 20 m/s NW Above 20 m/s
   NW Above 25 m/s
6) In the vertical temperature distribution chart, Γd stands for dry adiabatic lapse rate (1℃/100 m)

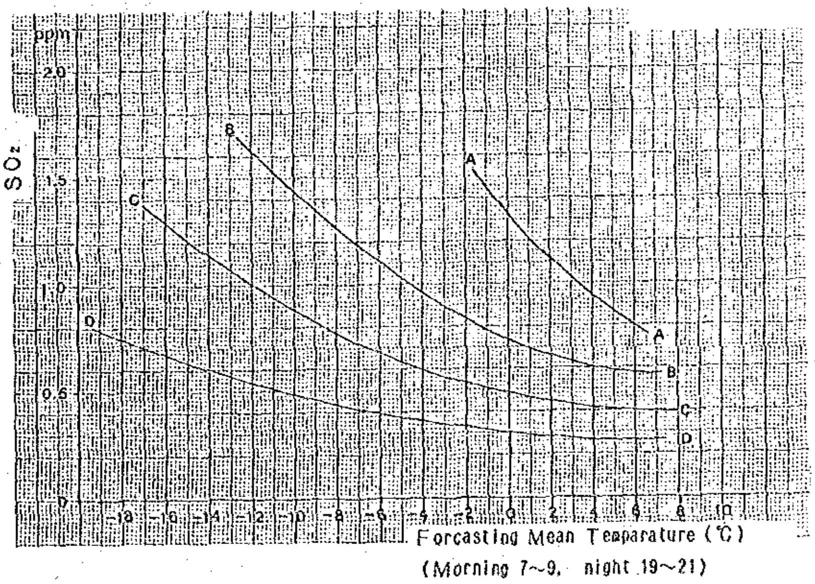
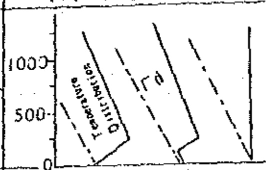
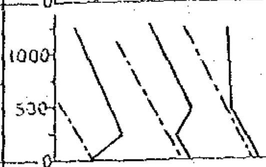


Figure 2-4-3 SO_2 Concentration Estimation Chart (Kavaklidere, windless condition)

Table 2-4-2 Ranking Table by Weather Conditions

When forcasted wind speed is over 1.1 m/sec,
for the forcasting time zone(morning 7,8,9, night 19,20,21)

Kavaklidere Area.

RANK	Ground Level Wind Speed (m/s) Morning Measurement (Mean Value: 3~5 a.m.) Night Measurement (Mean Value: 15~19 p.m.)	Wind Speed (Altitude: 5,000 m) 500 mb Upper Layer Weather Chart (00Z, 12Z) / Indication of High and Low Temperature		Temperature Distribution in Upper Layers Data by Rawin Sonde (00Z, 12Z) / Typical Pattern of Vertical Temperatur Distribution	Weather
(A)	Below 1.0		High Temperature Type. Morning and Night Time Temperature: Above 0℃		○ ⦶ ◎ ● ≡ Radiation Fog, Rain Front Fog
			Low Temperature Type. Morning and Night Time Temperature: Below -10℃		
(B)	1.1 ~1.5		High Temperature Type. Morning and Night Time Temperature: Above 0℃		○ ⦶ ◎ ● ⊛ ≡ Radiation Fog, Rain Front Fog
			Low Temperature Type. Morning and Night Time Temperature: Below -10℃		
(C)	1.6 ~2.0		Low Temperature Type. Morning and Night Time Temperature: Below -10℃		○ ⦶ ◎ ● ⊛
			Extraordinarily Low Temperature Type. Morning and Night Time Temperature: Below -15℃		
(D)	Above 2.1		Low Temperature Type. Morning and Night Time Temperature: Below -10℃		○ ⦶ ◎ ● ⊛
			Extraordinarily Low Temperature Type. Morning and Night Time Temperature: Below -15℃		

Note ;

1) In predicting SO_2 concentration from this chart, ground level wind velocity is give priority, as concentration is largely dependent on ground level wind speed.
2) Wind speed in upper layers (altitude: 5,000 m, 500 mb weather chart) serves as a good indication of extremely high or low temperature occurence.
3) In the explanation in the above chart. Morning stands for 5 a.m., and Night, 18 p.m.
4) Weather Mark
   ○ Very Fine ⦶ Fine ◎ Cloudy
   ● Rain ⊛ Snow ≡ Fog
5) Wind Direction Mark
   SW Above 20 m/s NW Above 20 m/s
   NW Above 25 m/s
6) In the vertical temperature distribution chart, Γd stands for dry adiabatic lapse rate (1℃/100 m)

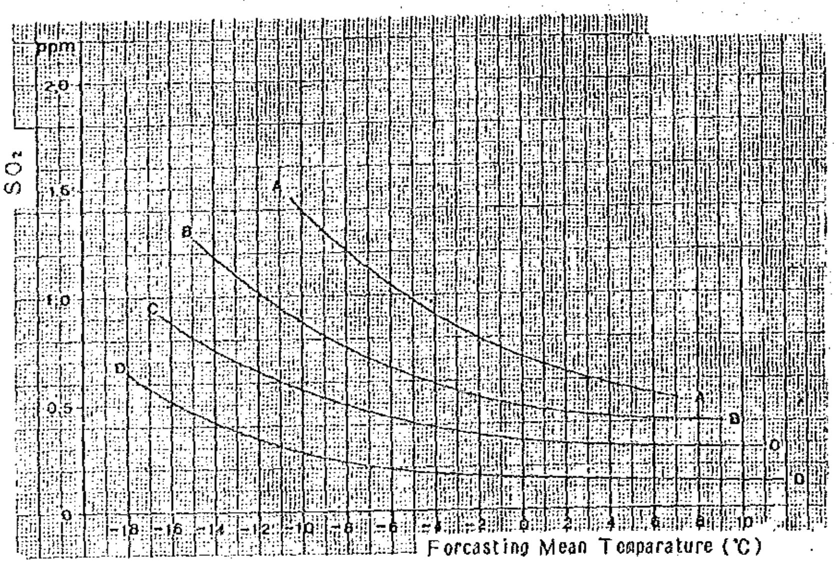
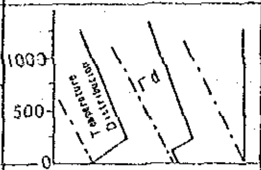
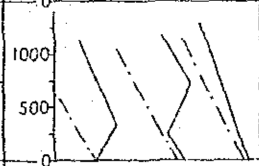
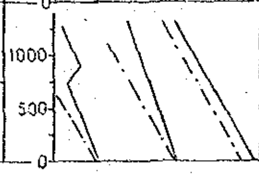


Figure 2-4-4 SO_2 Concentration Estimation Chart (Kavaklidere, windy condition)

Table 2-4-3 Ranking Table by Weather Conditions

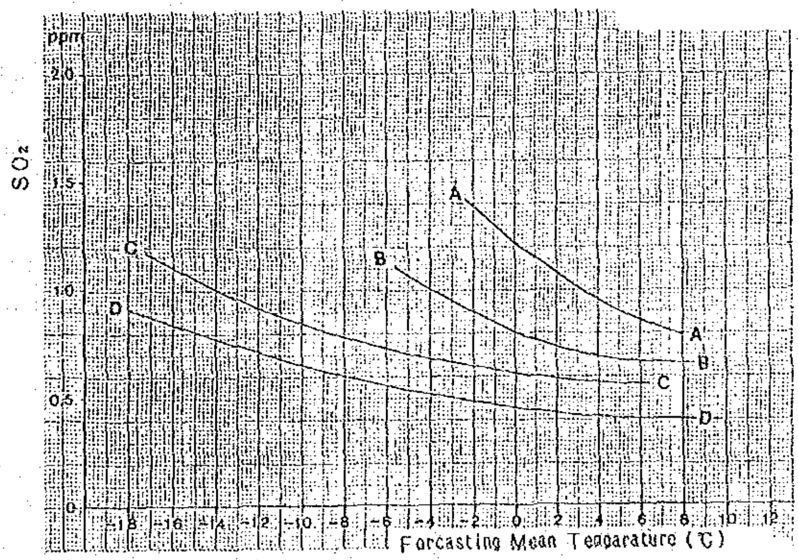
When forcasted wind speed is less than 1.0 m/sec,
for the forcasting time zone (morning 7,8,9, night 19,20,21)

Barchelievlor Area

RANK	Ground Level Wind Speed (m/s) Morning Measurement (Mean Value: 3~6 a.m.) Night Measurement (Mean Value: 15~19 p.m.)	Wind Speed (Altitude: 5,000 m) 500 mb Upper Layer Weather Chart (00Z, 12Z)		Temperature Distribution in Upper Layers Data by Rawin Sonde (00Z, 12Z)	Weather
		Indication of High and Low Temperature		Typical Pattern of Vertical Temperatur Distribution	
Ⓐ	Below 0.4		High Temperature Type. Morning and Night Time Temperature: Above 0℃		○ ⦶ ◎ ● ≡ Radiation Fog, Rain Front Fog
			Low Temperature Type. Morning and Night Time Temperature: Below -10℃		
Ⓑ	0.5 ~1.0		High Temperature Type. Morning and Night Time Temperature: Above 0℃		○ ⦶ ◎ ● ⊗ ≡ Radiation Fog, Rain Front Fog
			Low Temperature Type. Morning and Night Time Temperature: Below -10℃		
Ⓒ	1.1 ~1.5		Low Temperature Type. Morning and Night Time Temperature: Below -10℃		○ ⦶ ◎ ● ⊗
			Extraordinarily Low Temperature Type. Morning and Night Time Temperature: Below -15℃		
Ⓓ	Above 1.6		Low Temperature Type. Morning and Night Time Temperature: Below -10℃		○ ⦶ ◎ ● ⊗
			Extraordinarily Low Temperature Type. Morning and Night Time Temperature: Below -15℃		

Note :

1) In predicting SO_2 concentration from this chart, ground level wind velocity is give priority. as concentration is largely dependent on ground level wind speed.
2) Wind speed in upper layers (altitude: 5,000 m. 500 mb weather chart) serves as a good indication of extremely high or low temperature occurence.
3) In the explanation in the above chart. Morning stands for 5 a.m., and Night, 18 p.m.
4) Weather Mark
   ○ Very Fine ⦶ Fine ◎ Cloudy
   ● Rain ⊗ Snow ≡ Fog
5) Wind Direction Mark
   SW Above 20 m/s, NW Above 20 m/s
   NW Above 25 m/s
6) In the vertical temperature distribution chart, Γd stands for dry adiabatic lapse rate (1℃/100 m)



(Morning 7~9, night 19~21)

Figure 2-4-5 SO_2 Concentration Estimation Chart (Bahcelievler, windless condition)

Table 2-4-4 Ranking Table by Weather Conditions

When forcasted wind speed is over 1.1 m/sec.
for the forcasting time zone(morning 7,8,9, night 19,20,21)

Barchellevler Area

RANK	Ground Level Wind Speed (m/s) Morning Measurement (Mean Value : 3~6 a.m.) Night Measurement (Mean Value : 15~18 p.m.)	Wind Speed (Altitude : 5,000 m) 500 mb Upper Layer Weather Chart (00Z, 12Z) — Indication of High and Low Temperature	Temperature Distribution in Upper Layers Data by Rawin Sonde (00Z, 12Z) — Typical Pattern of Vertical Temperatur Distribution	Weather
Ⓐ	Below 1.0	High Temperature Type. Morning and Night Time Temperature : Above 0℃	1000 / 500 / 0; Temperature Distribution; Γd	○ ⦶ ◎ ●
		Low Temperature Type. Morning and Night Time Temperature : Below -10℃		≡ Radiation Fog / Rain Front Fog
Ⓑ	1.1 ~1.5	High Temperature Type. Morning and Night Time Temperature : Above 0℃	1000 / 500 / 0	○ ⦶ ◎ ● ⊗
		Low Temperature Type. Morning and Night Time Temperature : Below -10℃		≡ Radiation Fog / Rain Front Fog
Ⓒ	1.6 ~2.0	Low Temperature Type. Morning and Night Time Temperature : Below -10℃	1000 / 500 / 0	○ ⦶ ◎ ● ⊗
		Extraordinarily Low Temperature Type. Morning and Night Time Temperature : Below -15℃		
Ⓓ	Above 2.1	Low Temperature Type. Morning and Night Time Temperature : Below -10℃	1000 / 500 / 0	○ ⦶ ◎ ● ⊗
		Extraordinarily Low Temperature Type. Morning and Night Time Temperature : Below -15℃		

Note ;

1) In predicting SO_2 concentration from this chart, ground level wind velocity is give priority. as concentration is largely dependent on ground level wind speed.
2) Wind speed in upper layers (altitude : 5,000 m. 500 mb weather chart) serves as a good indication of extremely high or low temperature occurence.
3) In the explanation in the above chart. Morning stands for 5 a.m., and Night, 18 p.m.
4) Weather Mark
   ○ Very Fine ⦶ Fine ◎ Cloudy
   ● Rain ⊗ Snow ≡ Fog
5) Wind Direction Mark
   SW Above 20 m/s NW Above 20 m/s
   NW Above 25 m/s
6) In the vertical temperature distribution chart, Γd stands for dry adiabatic lapse rate (1℃/100 m)

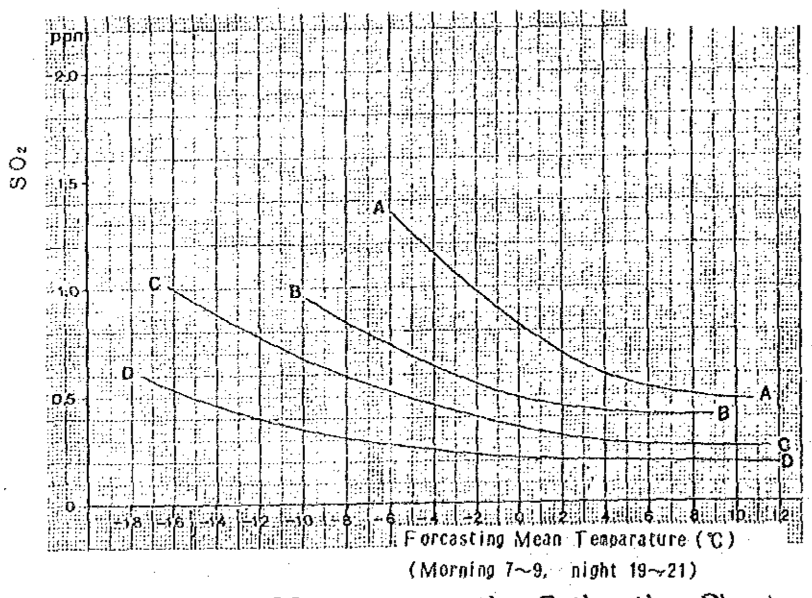


Figure 2-4-6 SO_2 Concentration Estimation Chart (Bahcelievler, windy condition)

Part II

RESULTS OF INVESTIGATION ON POLLUTANT SOURCES AND THEIR CONTROL

3 Boiler Flue Gas Analysis

3-1 Methodology

(1) Object of measurement

Houses (Apartment) 8 Boilers for heating
Government office 2 Boilers for heating

(2) Measurement period and time

Feb. 20, 1985 -- Feb. 27, 1985
09:00 - 12:00 / 14:00 - 17:00

(3) Measuring items and methods

Measuring items and methods are shown in Table 3-1-1.

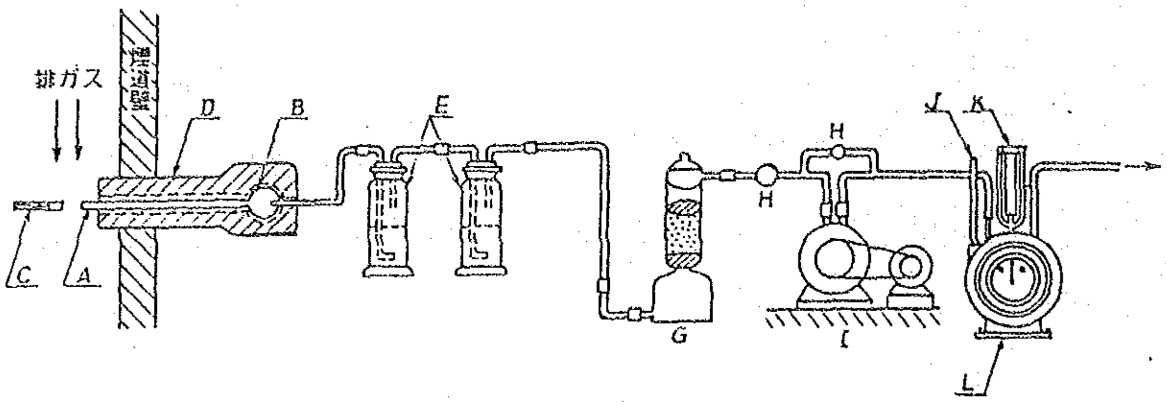
Table 3-1-1 Measuring Items and Methods

Measuring item	Analytical method
Sulfur oxides	Manual analysis (neutralizing titration method)
Particulate matter	Manual analysis (gravimetric methods)
Oxygen Carbon monoxide Carbon dioxide	Manual analysis (Orsat method)

The apparatus used for sampling flue gas are shown in Figure 3-1-1.

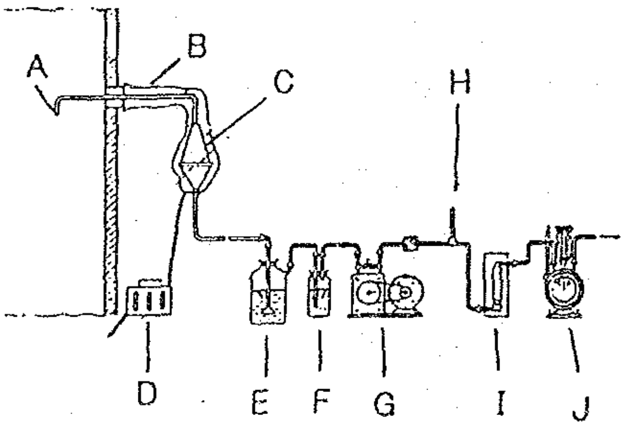
3-2 Results

The results are shown in Tables 3-2-1 through 3-2-3.



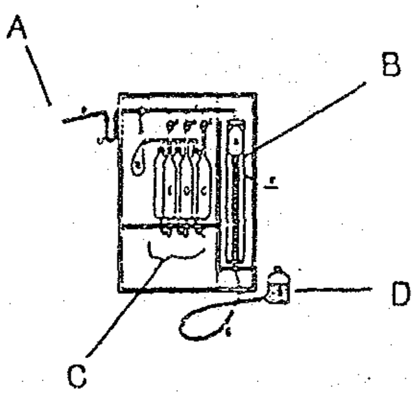
A : Sampling nozzle
B : Adapter
C : Filter
D : Keeping warmth or heating
E : SO_2 absorption bottle
F : Dryer
G : Flow control
H : Vacuum pump
I : Thermometer
J : Manometer
K : Gas meter

SO2 Sampler



A Sampling nozzle
B heater
C filter holder
D Slidac
E H_2O_2 solusion
F mist arrestor
G vacuum pump
H thermometer
I flow meter
J gas meter

Dust Sampler



A Sampling nozzle
B Gas buret
C absorption tubes
D water leveler

Orsat Sampler

Figure 3-1-1 Sampling Apparatus for Flue Gas Analysis

Table 3-2-1 Results of Boiler Flue Gas Analysis

No.	Date mon./day	Time	Kind of Fuel	Flue Gas					Composition of Flue Gas				Air Ratio	Dust		SO_x	
				Velocity (m/s)	Temp. (°C)	Static Pressure (mmAg)	Flow Rate (Wet) (m^3N/h)	Flow Rate (Dry) (m^3N/h)	CO_2	O_2	CO	N_2		Concent-ration (g/m^3N)	Emis-sion (kg/h)	Concent-ration (ppm)	Emis-sion (m^3N/h)
1	2/20	09:00 11:30	Lig	2.16	143	-5	1200	1169	4.7	15.3	0.0	80.0	3.56	0.251	0.293	330	0.386
2	2/21	09:00 - 10:00 14:00 - 15:00	Oil	4.02	398	-8	288	263	9.6	7.7	0.0	82.7	1.54	0.184	0.048	270	0.070
3	2/22	09:30 11:40	Lig	0.70	173	-4	388	373	5.7	14.1	0.0	80.2	2.95	1.290	0.481	790	0.295
4	2/23	09:00 11:30	Lig	4.16	200	-37	1823	1757	3.8	16.2	0.0	80.0	4.19	1.107	1.945	680	1.195
5	2/25	09:00 12:00	Lig	2.09	120	-5	1014	966	4.4	15.6	0.1	79.9	3.73	0.435	0.420	1270	1.227
6	2/25	14:00 16:30	Lig	1.00	148	-3	622	605	4.0	16.2	0.0	79.8	4.22	1.564	0.946	750	0.454
7	2/26	10:00 12:00	Oil	1.56	169	-35	850	802	5.8	12.8	0.0	81.4	2.45	0.058	0.047	250	0.201
8	2/26	14:00 16:30	Oil	5.44	106	-10	3520	3400	3.2	16.4	0.0	80.4	4.29	0.012	0.040	140	0.476
9	2/27	08:50 11:30	Lig	1.10	123	-3	682	664	5.3	14.6	0.0	80.1	3.18	0.169	0.112	1150	0.764
10	2/27	14:00 16:00	Lig	2.74	200	-14	913	869	6.6	12.5	0.0	80.9	2.39	0.217	0.189	1170	1.017

Table 3-2-2 Combustible Sulfer Content in Fuels

No.	Kind of Fuel	Fuel consumption	SO_2 emission (kg/h)	Combustible sulfer content (%)
1	Laved lignite	70 kg/h	1.10	0.79
2	Oil	20 l/h	0.20	0.50
3	Ungraded lignite	30 kg/h	0.84	1.40
4	Ungraded lignite	60 kg/h	3.41	2.84
5	Ungraded lignite	40 kg/h	3.51	4.39
6	Ungraded lignite	30 kg/h	1.30	2.16
7	Oil	30 l/h	0.57	0.96
8	Oil	70 k/h	1.36	0.97
9	Ungraded lignite	40 kg/h	2.18	2.73
10	Ungraded lignite	75 kg/h	2.91	1.94

Table 3-2-3 Emission of Dust and SO_X per Unit Fuel Consumption and Unit Heating Surface

No.	Kind of Fuel	Fuel consump-tion	Heating surface (m^2)	Emission per 1 kg/h or one l/h of Fuel			Emission per 1 m^2 of Heating Surface		
				Flue gas (wet)	Dust	SO_X	Flue gas (wet)	Dust	SO_X
				m^3/kg,l	g/kg,l	m^3N/kg,l	m^3/m^2	g/m^3	m^3N/kg
1	Lig	70 kg/h	70	17.1	4.19	0.0055	17.1	4.19	0.0055
2	Oil	20 l/h	30	14.4	2.40	0.0035	9.6	1.60	0.0023
3	Lig	30 kg/h	35	12.9	16.00	0.0098	11.1	13.70	0.0084
4	Lig	60 kg/h	55	30.4	32.40	0.0199	33.1	35.70	0.0217
5	Lig	40 kg/h	40	25.4	10.50	0.0307	25.4	10.50	0.0307
6	Lig	30 kg/h	60	20.7	31.50	0.0151	10.4	15.80	0.0076
7	Oil	30 l/h	45	28.3	1.57	0.0067	18.9	1.04	0.0045
8	Oil	70 l/h	125	50.3	0.57	0.0068	28.2	0.32	0.0038
9	Lig	40 kg/h	50	17.1	2.80	0.0191	13.6	2.24	0.0153
10	Lig	75 kg/h	65	12.2	2.52	0.0136	14.0	2.91	0.0156

4 Automobile Exhaust Gas Analysis

4-1 Methodology

In the investigation of emission factors from mobile sources, sulfur dioxide and particulate matter in automobile exhaust gases were measured by simple methods for the typical types of cars prepared by the Turkish side.

Methods of sampling and analysis are as follows.

Sulfur dioxide ………… Sampled directly from car exhaust pipe, and measured manually by the SO_2 detector tube method.

Particulate matter ………… Exhaust gas during idling was sampled directly from the car exhaust pipe, and measured by combined use of filtration and light scattering methods.

4-2 Results

The results are shown in Table 4-2-1.

Table 4-2-1 Results of Automobile Exhaust Gas Analysis

Pollutant		PM				SO_2
Method of measurement		Filtration method			Light scattering method	Detector tube method
Kind of car	Item and unit	Mass (g)	Volume of gas (m^3)	Mass concentration (mg/m^3)	Mass concentration (mg/m^3)	Concentration (ppm)
Large-sized car (Diesel)	MAN-590	0.0158	0.3	52.7	-	(0.3)
	BMC-140	0.0178	0.3	59.3	-	1
	BMC-140	0.0101	0.2	50.5	-	(0.8)
Bus (Diesel)	Mercedes	0.0098	0.15	65.3	-	Not detected
	Ikarus	0.0198	0.15	132.0	-	1.7
	Dodge	0.0102	0.1	102.0	-	(0.7)
Small-sized freight car (gasoline)	Chrysler Fargo	0.0002	0.3	0.67	0.36	Not detected
	Chrysler Fargo	0.0003	0.3	1.0	0.33	Not detected
Passenger car (gasoline)	Renault 12	0.0011	0.3	3.7	-	Not detected
	Chevrolet	0.0011	0.3	3.7	-	Not detected

Note: The values of concentration shown are the averages of several measurements.
Since the detector tube method for SO_2 has the detection limit of 1ppm, the average values less than 1ppm are shown with the parentheses.

5 Traffic Volume Survey

5-1 Methodology

The traffic volume survey was conducted at 5 stations on the major roads in Ankara City in the following manner.

i) Time of the Survey: 6:00 a.m. - 10:00 p.m. (16 hours)
March 14, 1985

ii) Locations of the survey stations are shown in Figure 2.1.1 of the main report. Station number and station name are as follows:

Station No.	Station Name
1	Dormitory
2	EGO
3	MENR
4	Opera House
5	GDE

iii) Types of automobiles counted are categorized as follows:

- Large vehicle : large buses and trucks
- Small cargo vehicles : small trucks and minibuses
- Passenger car : taxies and passenger cars

iv) Traffic count was made for two directions.

5-2 Results

The results are shown in Tables 5-2-1 through 5-2-5. Numbers in three rows for each time zone indicate as follows:

- Upper row : direction toward the central part of the City (Ulus)
- Middle row : direction from the central part of the City (Ulus)
- Bottom row : total of the above two

The two-way totaled traffic counts by stations are also shown in Figure 5-2-1.

Table 5-2-1 Traffic Count at Station 1

Vehicle Type / Time	Large Vehicle	Small Cargo Vehicle	Passenger Car	Total
	67	178	108	353
6:00 - 7:00	58	98	88	244
	125	276	196	597
	136	395	454	985
7:00 - 8:00	120	306	220	646
	256	701	674	1631
	123	386	910	1419
8:00 - 9:00	100	322	410	832
	223	708	1320	2251
	91	268	494	853
9:00 - 10:00	98	239	371	708
	189	507	865	1561
	75	245	441	761
10:00 - 11:00	87	263	457	807
	162	508	898	1568
	88	247	468	803
11:00 - 12:00	91	228	445	764
	179	475	913	1567
	82	211	342	635
12:00 - 13:00	101	231	392	724
	183	442	734	1359
	77	238	487	802
13:00 - 14:00	98	246	546	890
	175	484	1033	1692
	75	243	567	885
14:00 - 15:00	99	303	575	977
	174	546	1142	1862
	74	222	557	853
15:00 - 16:00	71	264	465	800
	145	486	1022	1653
	85	233	529	847
16:00 - 17:00	82	225	458	765
	167	458	987	1612
	101	260	459	820
17:00 - 18:00	110	295	522	927
	211	555	981	1747
	99	338	433	870
18:00 - 19:00	105	320	668	1093
	204	658	1101	1963
	77	199	351	627
19:00 - 20:00	92	290	587	969
	169	489	938	1596
	51	122	215	388
21:00 - 22:00	69	180	373	622
	120	302	588	1010
	25	77	147	249
21:00 - 22:00	42	77	247	366
	67	154	394	615

Table 5-2-2 Traffic Count at Station 2

Vehicle Type / Time	Large Vehicle	Small Cargo Vehicle	Passenger Car	Total
6:00 - 7:00	270	95	832	1197
	174	99	739	1012
	444	194	1571	2209
7:00 - 8:00	249	192	1075	1516
	249	244	863	1356
	498	436	1938	2872
8:00 - 9:00	286	242	1519	2047
	298	221	1005	1524
	584	463	2524	3571
9:00 - 10:00	226	336	975	1537
	294	298	939	1531
	520	634	1914	3068
10:00 - 11:00	237	275	981	1493
	291	258	822	1371
	528	533	1803	2864
11:00 - 12:00	234	213	836	1283
	235	249	788	1272
	469	462	1624	2555
12:00 - 13:00	198	177	837	1212
	223	172	755	1150
	421	349	1592	2362
13:00 - 14:00	197	203	882	1282
	214	161	783	1158
	411	364	1665	2440
14:00 - 15:00	236	277	994	1507
	270	236	1000	1506
	506	513	1994	3013
15:00 - 16:00	241	236	1027	1504
	269	203	1013	1485
	510	439	2040	2989
16:00 - 17:00	222	209	950	1381
	224	190	933	1347
	446	399	1883	2728
17:00 - 18:00	280	219	1048	1547
	240	159	1045	1444
	520	378	2093	2991
18:00 - 19:00	267	188	903	1358
	233	164	1042	1439
	500	352	1945	2797
19:00 - 20:00	147	132	757	1036
	211	124	990	1325
	358	256	1747	2361
20:00 - 21:00	139	108	674	921
	183	104	698	985
	322	212	1372	1906
21:00 - 22:00	95	68	469	632
	97	52	526	675
	192	120	995	1307

Table 5-2-3 Traffic Count at Station 3

Time \ Vehicle Type	Large Vehicle	Small Cargo Vehicle	Passenger Car	Total
6:00 - 7:00	186 113 299	78 76 154	64 48 112	328 237 565
7:00 - 8:00	268 179 447	231 200 431	219 159 378	718 538 1256
8:00 - 9:00	282 292 574	272 237 509	327 420 747	881 949 1830
9:00 - 10:00	259 232 491	189 217 406	317 244 561	765 693 1458
10:00 - 11:00	187 247 434	174 175 349	322 323 645	683 745 1428
11:00 - 12:00	181 257 438	174 191 365	299 321 620	654 769 1423
12:00 - 13:00	214 253 467	162 154 316	304 291 595	680 698 1378
13:00 - 14:00	220 268 488	150 197 347	328 342 670	698 807 1505
14:00 - 15:00	180 234 414	153 204 357	289 303 592	622 741 1363
15:00 - 16:00	217 203 420	160 223 383	260 293 553	637 719 1356
16:00 - 17:00	218 225 443	156 218 374	240 272 512	614 715 1329
17:00 - 18:00	269 252 521	188 240 428	320 281 601	777 773 1550
18:00 - 19:00	252 273 525	184 182 366	267 268 535	703 723 1426
19:00 - 20:00	148 172 320	113 136 249	174 165 339	435 473 908
20:00 - 21:00	110 111 221	66 76 142	140 131 271	316 318 634
21:00 - 22:00	74 97 171	51 69 120	103 84 187	228 250 478

Table 5-2-4 Traffic Count at Station 4

Time \ Vehicle Type	Large Vehicle	Small Cargo Vehicle	Passenger Car	Total
	118	51	142	311
6:00 - 7:00	233	81	146	460
	351	132	288	771
	313	130	489	932
7:00 - 8:00	406	161	652	1219
	719	291	1141	2151
	370	152	1873	2395
8:00 - 9:00	281	131	1491	1903
	651	283	3364	4298
	268	160	1598	2026
9:00 - 10:00	203	198	1160	1561
	471	358	2758	3587
	221	248	1593	2062
10:00 - 11:00	194	153	1144	1491
	415	401	2737	3553
	212	171	1227	1610
11:00 - 12:00	220	160	1151	1531
	432	331	2378	3141
	223	119	1139	1481
12:00 - 13:00	214	95	981	1290
	437	214	2120	2771
	206	149	1258	1613
13:00 - 14:00	212	125	1070	1407
	418	274	2128	3020
	224	214	1572	2010
14:00 - 15:00	211	152	1203	1566
	435	366	2775	3576
	202	198	1581	1981
15:00 - 16:00	221	167	1315	1703
	423	365	2896	3684
	214	158	1449	1821
16:00 - 17:00	251	132	1319	1702
	465	290	2768	3523
	230	139	1313	1682
17:00 - 18:00	266	130	1385	1781
	496	269	2698	3463
	217	142	1382	1741
18:00 - 19:00	234	103	1155	1492
	451	245	2537	3233
	221	84	1379	1684
19:00 - 20:00	189	63	922	1174
	410	147	2301	2858
	192	54	815	1061
20:00 - 21:00	146	44	542	732
	338	98	1357	1793
	87	40	535	662
21:00 - 22:00	73	41	354	468
	160	81	889	1130

Table 5-2-5 Traffic Count at Station 5

Time \ Vehicle Type	Large Vehicle	Small Cargo Vehicle	Passenger Car	Total
6:00 - 7:00	142 156 298	42 58 100	194 242 436	378 456 834
7:00 - 8:00	210 240 450	90 138 228	788 753 1541	1088 1131 2219
8:00 - 9:00	222 240 462	95 134 229	2340 2008 4348	2657 2382 5039
9:00 - 10:00	217 197 414	124 125 249	2237 1435 3672	2578 1757 4335
10:00 - 11:00	190 197 387	184 162 346	1887 1499 3386	2261 1858 4119
11:00 - 12:00	199 199 398	160 143 303	1678 1523 3201	2037 1865 3902
12:00 - 13:00	196 202 398	105 96 201	1582 1458 3040	1883 1756 3639
13:00 - 14:00	192 204 396	132 110 242	1746 1527 3273	2070 1841 3911
14:00 - 15:00	210 198 408	184 139 323	2056 1770 3826	2450 2107 4557
15:00 - 16:00	194 184 378	141 139 280	2088 1802 3890	2123 2125 4548
16:00 - 17:00	201 201 402	130 146 276	1885 1967 3852	2216 2314 4530
17:00 - 18:00	235 227 462	100 144 244	1995 2354 4349	2330 2725 5055
18:00 - 19:00	230 230 460	124 81 205	1912 2734 4646	2266 3045 5311
19:00 - 20:00	227 226 453	75 65 140	1947 2145 4092	2249 2435 4685
20:00 - 21:00	180 140 320	42 43 85	1270 1366 2636	1492 1549 3041
21:00 - 22:00	88 76 164	57 30 87	803 858 1661	948 964 1912

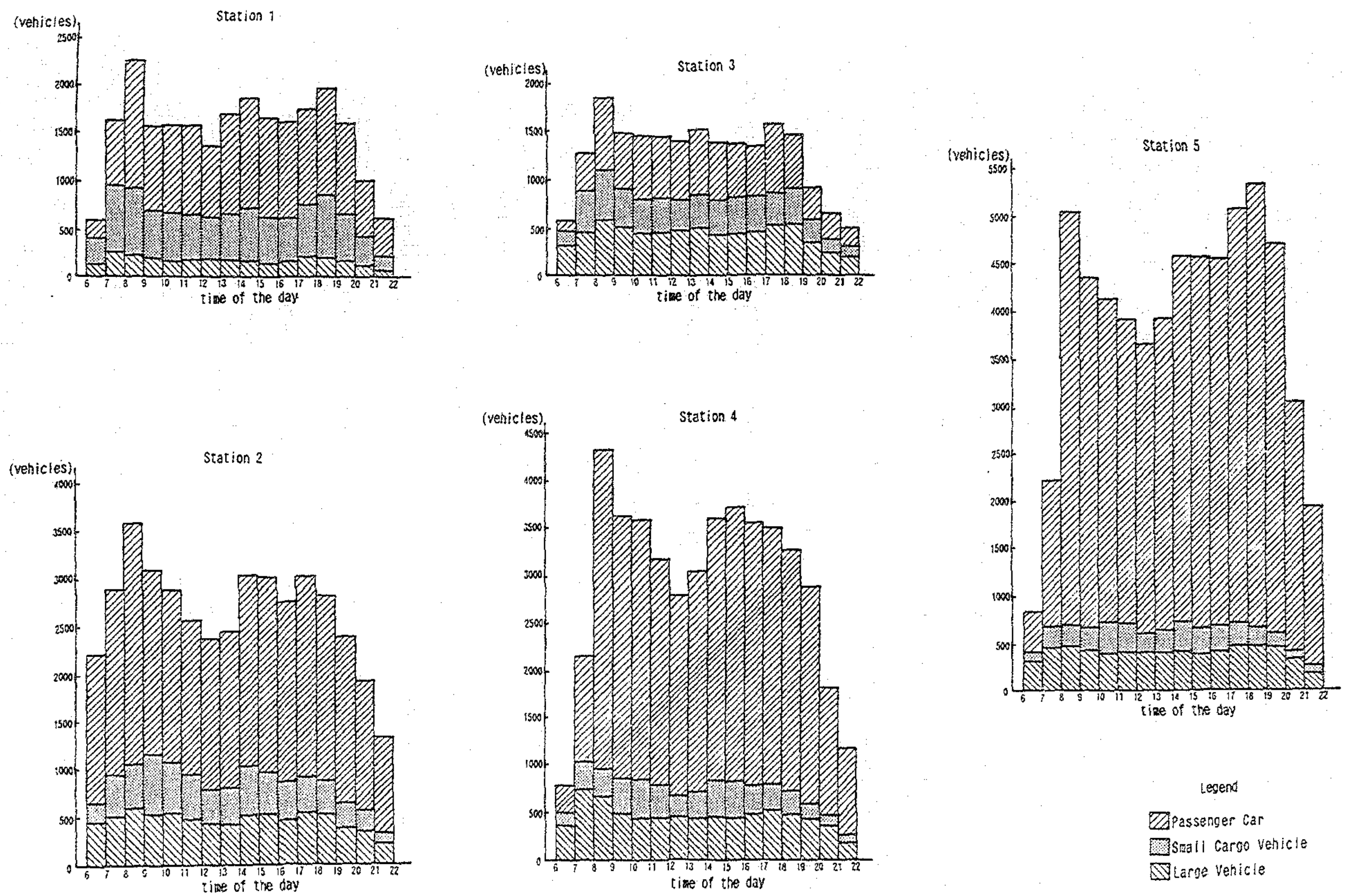


Figure 5-2-1 Summary of Traffic Counts (two-way total)

6 On-Site Questionnaire at Boiler Rooms

6-1 Methodology

In order to investigate the present state of heating buildings by boiler combustion, the on-site questionnaire was made at 100 boiler rooms.

Major items in the questionnaire are as follows:

1. Location of building
2. Usage of building
3. Height of building
4. Floor area of building
5. Kind of fuel
6. Combustion hours
7. Fuel consumption
8. Heating surface of boiler

6-2 Results

The results of the on-site questionnaire are shown in the subsequent Tables.

Figure 6-2-1 shows number of boilers according to building stories, floor areas, 1-day combustion hours, 1-day fuel consumption, 1-hour fuel consumption, and heating surface areas of boilers.

The daily heating hour distribution and the hourly distribution of flue gas emission obtained from the results given in the Tables are shown in Figures 6-2-2 and 6-2-3, respectively. Clear two peaks of the day are seen in the emission of flue gas.

More than 50% of buildings are used for both dwellings and shops.

Eight-story buildings are mostly governmental buildings and offices and oil-fueled. Majority of other buildings are lignite-fueled. Percent of Oil-fueled and lignite-fueled buildings are 35% and 65%, respectively. However, the total fuel consumption per day is 15.7 ton for oil-fueled and 45.3 ton for lignite-fueled, oil consumption being about 34% of the total.

Floors	Number of units	Floor area (m²)	Usage	Area of boiler room (m²)	Kind of fuel	Combustion hour	Total	Amount of fuel consumption	Number of boilers	Fuel consumption /hour(Nm³/h)	Amount of exhaust gas	Heating surface (m²)
8	32	120～180	offices		Oil	07：00～11：00, 14：00～17：30	7.30	7t/1.5month		31kg	322.4	
11	16	330	16houses, 4stores		Oil	06：00～12：00, 16：00～22：00	12.00	10t/month		28	291.2	
8	16	200	5houses, 2stores 11offices		Oil	06：00～10：00, 15：30～22：00	10.30	10t/month		32	332.8	
8	32	320	office(Dept.of Foreign Affairs)		Oil	07：00～17：00	10.00	8～10t/month		45	468.0	17
4	8	180	Houses		Lig	06：00～07：00, 14：00～23：00	10.00	60t/season		40	234.0	
6	27	625	Houses		Lig	05：00～07：00, 14：00～18：00	6.00	1t/day, 183t/season	2	167	976.95	30, 14
5	22		Houses		Lig	05：00～11：00, 14：00～23：00	15.00	1t/day, 150t/season	2	67	391.95	52, 15
5	19	500	Houses		Lig	06：00～07：00, 14：00～22：00	9.00	1t/day, 120t/season	2	110	643.5	35, 10
5	18	600	18houses, 4stores		Lig	05：00～07：00, 14：00～21：00	9.00	0.8t/day 150t/season	2	89	520.65	60, 15
12	130	700	offices		Lig	05：00～07：00, 14：00～18：00	6.00	1.25t/day	2	208	1216.8	50× 2
8	16	220	government office		Oil	06：30～16：30	10.00	5t/month	2	25	260.0	40, 10
7	14	600	houses		Lig	05：00～07：30, 14：00～18：00	6.30	1t/day, 130t/season	1	153	895.05	35
8	16	600	offices		Lig	05：00～08：00, 15：00～17：30	5.30	1～1.5t/day 150t/season	1	188	1099.8	50
8	32	600	28offices, 4houses 3stores		Oil	06：00～07：30, 14：00～17：30	5.00	12t/month	1	80	832.0	50
8		600	hotel		Lig	00：00～24：00 (20℃)	24.00	15t/month	1	21	122.85	
8	42	600	38houses, 4stores		Oil	07：00～10：30, 14：30～16：30	5.30	8t/month		48	499.2	
8	20	200	1house, 4stores 15offices		Oil	07：00～10：30, 15：30～17：30	5.30	5t/month		30	312.0	
5	22	300	2stores, 20offices		Oil	07：00～11：00, 14：00～17：00	7.00	4t/month	1	28	291.2	20
10	46	750	houses	250	Lig	04：00～05：30, 18：00～22：00	5.30	1.5t/day	3	270	1579.5	50, 70, 70
10	64	850	houses	200	Lig	04：00～05：30, 17：00～23：00	7.30	3.5～4t/day	3	470	2749.5	70, 70, 60
4	15	600	houses	50	Lig	06：00～07：00, 15：00～22：00	8.00	1t/day	1	125	731.25	60
4	17	600	houses	100	Lig	06：00～09：00, 14：00～21：00	10.00	0.6t/day	2	60	351.0	40, 15
9	14	400	houses	40	Oil	06：00～09：30, 16：00～23：00	10.30	8t/month	1	25	260.0	
8	46	900	houses	120	Oil	05：30～10：00, 16：00～23：00	11.30	1t/day	2	87	904.8	80, 80
6	16	400	houses	60	Lig	05：30～08：30, 17：00～22：00	8.00	0.85t/day	2	106	620.1	50, 10

Floors	Number of units	Floor area (m²)	Usage	Area of boiler room (m²)	Kind of fuel	Combustion hour	Total	Amount of fuel consumption	Number of boilers	Fuel consumption/hour	Amount of exhaust gas(Nm³/h)	Heating surface (m²)
5	24	400	20houses,4stores	60	Oil	06:00~09:00, 16:00~23:30	10.00	7~8t/month		27kg	280.8	
6	23	400	23houses,6offices	50	Oil	06:00~10:00, 18:00~22:00	8.00	6t/month	2	25	260.0	
5	9	450	houses	30	Oil	06:00~09:00, 16:00~23:00	10.00	4t/month		13	135.2	
5	10	500	houses	50	Oil	06:30~23:00	15.30	15t/month	2	32	332.8	40, 15
5	10	450	houses	70	Oil	05:00~10:00, 16:00~24:00	13.00	5t/month	2	13	135.2	32, 6
4	8	500	houses	50	Lig	05:00~07:00, 14:00~22:00	10.00	0.5t/day	1	38	222.3	35
4	14	700	14houses,5stores	40	Lig	05:00~11:00, 13:00~23:00	16.00	0.6t/day	1	38	222.3	35
4	8	250	houses	30	Lig	05:00~09:00, 14:00~23:00	13.00	0.5t/day	1	38	222.3	30
13	50	500	houses	100	Lig	05:00~07:00, 14:0υ~23:00	11.00	1.5~2t/day	3	160	936.0	50, 50, 50
11	25	250	houses	60	Lig	06:00~23:30	17.30	1t/day	2	57	333.45	55, 20
10	13	250	houses	60	Oil	06:00~23:00	17.00	0.6t/day,8t/month	2	18	187.2	50, 20
10	21	250	houses	60	Lig	06:00~23:00	17.00	1t/day		58	339.3	50, 20
10	22	250	houses	60	Lig	06:00~23:00	17.00		2			50, 20
13	30	250	houses	45	Lig	05:00~07:30, 14:00~23:00	11.30	1t/day	2	87	508.95	50, 25
10	31	600	houses,4stores	70	Lig	05:00~08:00, 16:00~23:00	10.00	1.7t/day	3	170	994.5	50, 35, 20
5	24	750	houses,3stores	40	Lig	05:30~07:00, 17:00~23:00	8.30	1t/day	2	118	690.3	50, 20
5	24	750	houses,4stores	35	Lig	05:00~11:00, 13:00~19:00	12.00	1t/day	2	83	485.55	60, 20
4	29	650	houses,3stores	35	Lig	04:00~07:00, 14:00~23:00	12.00	1t/day	2	83	485.55	60, 30
5	23	400	houses,4stores	30	Lig	06:30~10:00, 15:30~22:00	10.00	0.65t/day	1	65	380.25	65
4	24	600	houses,3stores	20	Lig	05:00~07:00, 14:30~23:00	9.30	0.8t/day	1	84	491.4	65
5	20	500	houses,1store	18	Lig	05:00~07:00, 14:00~19:00	7.00	1t/day	1	140	819.0	50
5	17	500	houses,3stores	40	Lig	05:00~07:00, 14:00~23:00	11.00	0.5t/day	1	45	263.25	55
5	23	600	houses,6stores	30	Lig	06:00~07:30, 16:00~22:00	7.30	0.7~0.8t/day	1	100	585.0	60
5	15	400	houses,3stores	25	Lig	05:00~09:00, 16:30~23:00	10.30	0.7t/day	2	67	391.95	40, 12
5	18	550	houses,4stores	36	Oil	06:00~10:00, 16:00~22:30	10.30	5~6t/month	1	17	176.8	

Floors	Number of units	Floor area (㎡)	Usage	Area of boiler room(㎡)	Kind of fuel	Combustion hour	Total	Amount of fuel consumption	Number of boilers	Fuel consumption /hour (Nm³/h)	Amount of exhaust gas	Heating surface (㎡)
4	13	300	stores	20	Lig	05 : 00～08 : 00, 15 : 00～23 : 00	11.00	0.3t/day	2	27kg	157.95	30, 5
4	20	400	18houses, 2stores	85	Oil	05 : 30～09 : 00, 18 : 00～22 : 00	7.30	5t/month	2	22	226.6	35, 10
5	21	500	houses	60	Lig	05 : 00～09 : 00, 15 : 00～22 : 00	11.00	0.8t/day	1	73	427.05	45
7	14	250	12house, 2stores	16	Oil	06 : 00～09 : 00, 16 : 00～21 : 00	8.00	4.5t/month	1	19	195.7	40
3	6	225	4houses, 2stores	77	Lig	04 : 00～08 : 00, 16 : 00～23 : 00	11.00	0.3t/day	1	27	157.95	30
7	13	225	11houses, 2stores	22	Lig	05 : 00～07 : 00, 14 : 30～22 : 00	9.30	0.7t/day	2	73.7	431.145	
3	13	300		41	Lig	05 : 30～13 : 00, 15 : 00～23 : 00	15.30	0.4t/day	1	26	152.1	25
3	8	200	5houses, 3stores	45	Lig	05 : 30～13 : 30, 15 : 00～23 : 00	16.00	0.3t/day	1	18.8	109.98	30
5	10	200	houses	17	Lig	06 : 00～09 : 00, 16 : 00～23 : 00	10.00	0.3t/day	1	30	175.5	20
5	10	200	houses	19.2	Lig	05 : 00～07 : 30, 14 : 00～23 : 00	11.30	0.5t/day	1	43.5	254.475	20
5	20	600	15houses, 5stores	20	Lig	05 : 00～07 : 00, 14 : 00～23 : 00	11.00	0.8t/day	2	72.7	425.295	30, 30
5	12	500	11houses, 1store	36	Lig	05 : 30～09 : 00, 16 : 00～23 : 00	10.30	0.4t/day	1	38.1	222.885	
5	20	500	15houses, 5stores	36	Oil	07 : 00～10 : 30, 14 : 30～23 : 00	12.00	7t/month	2	19.5	200.85	
5	17	300	houses	20	Oil	06 : 00～10 : 00, 16 : 00～21 : 00	9.00	6t/month	1	22	226.6	35
4	16	450	11houses, 5stores	30	Lig	06 : 00～08 : 00, 14 : 00～23 : 00	11.00	0.6t/day	1	54.5	318.825	40
5	12	250	houses	13	Lig	05 : 00～07 : 00, 16 : 00～23 : 00	9.00	0.4t/day	1	44.4	259.74	
5	10	200	houses	15	Lig	05 : 00～07 : 30, 16 : 00～23 : 00	9.30	0.4t/day	1	42	245.7	30
5	26	500	houses	40	Lig	05 : 30～07 : 00, 16 : 00～23 : 00	8.30	0.4t/day	2	47	274.95	50, 20
4	8	400	4houses, 4stores	33	Lig	05 : 30～07 : 00, 14 : 00～23 : 00	10.30	0.4t/day	2	38.1	222.885	
5	15	500	10houses, 5stores	18	Lig	05 : 00～09 : 00, 16 : 00～23 : 00	11.00	0.6t/day	1	54.5	318.825	30
12-4 Block	44 60 42 20	700	houses, stores		Oil	05 : 00～10 : 00, 16 : 00～22 : 00	11.00	3t/day	4	272	2801.6	
6	26	650	23houses, 3stores	35	Lig	05 : 00～07 : 00, 15 : 00～22 : 00	9.00	0.8t/day	2	88.9	520.065	40, 50
4	12	400	8houses, 4stores	27.5	Oil	06 : 00～09 : 00, 17 : 00～22 : 00	8.00	5t/month	2	20.8	214.24	30
4	15	300	houses	26	Lig	06 : 00～12 : 00, 14 : 00～23 : 00	15.00	0.5t/day	1	33.3	194.805	
4	7	200	5houses, 2stores	16.5	Lig	05 : 00～23 : 00	18.00	0.4t/day	1	22	128.7	

Floors	Number of units	Floor area (m²)	Usage	Area of boiler room (m²)	Kind of fuel	Combustion hour	Total	Amount of fuel consumption	Number of boilers	Fuel consumption /hour	Amount of exhaust gas (Nm³/h)	Heating surface (m²)
4	14											
4	15	500		50	Oil	06:00~09:00, 16:30~22:00	8.30	17t/month	3	67kg	696.8	35, 40, 20
5	20											
5				40	Lig	05:00~07:00, 14:30~23:00	10.30	0.75t/day	2	71	415.35	50, 20
12	84	1500		150	Oil	06:00~10:00, 17:00~23:00	10.00	40t/month	5	130	1352.0	
7	28	900	houses,8stores	45	Oil	06:00~09:00, 18:00~21:00	6.00	20t/month	3	110	1144.0	
5	10	450	houses,3stores	30	Oil	06:00~08:00, 16:00~20:00	6.00	15t/month	3	83	863.2	40, 10, 10
6	24	450	7houses,10stores 7offices	30	Oil	07:30~22:30	15.00	8t/day	2	18	187.2	65, 10
4	9	300	department store	55	Oil	06:00~09:00, 10:00~14:00	5.00	5t/day	1	40	416.0	32
4	16	450	3houses,offices	75	Oil	07:00~19:00	12.00	2.5t/day	2			25, 15
4		500	offices	80	Oil	07:00~16:30	9.30	6t/day	2	32	332.8	30, 30
12	50	700	government office	170	Oil	06:30~17:30	11.00	20t/day	4	90	936.0	45× 3, 10
5	18	500	houses,3offices	40	Lig	05:00~09:00, 15:00~23:00	12.00	0.75t/day	2	62	362.7	45, 20
5	23	400	houses,2stores	27	Lig	05:00~09:00, 16:00~23:00	11.00	0.8t/day	2	72	421.2	25, 25
4	18	500	houses,3stores	40	Lig	05:00~08:00, 15:00~23:00	11.00	0.8t/day	2	72	421.2	
4	15	400	houses	40	Lig	06:00~09:30, 16:00~23:00	10.30	0.6t/day	1	57	333.45	40
5	20	500	houses,4stores	90	Lig	04:00~08:00, 15:00~24:00	13.00	0.8t/day	2	61	356.85	15, 40
5	16	450	houses,4stores	40	Lig	05:00~07:00, 15:00~22:00	9.00	1t/day	2	110	643.5	
5	20	600	7houses,13offices	40	Oil	07:00~10:00, 15:00~21:00	9.00	6.5t/month	2	24	249.6	35, 10

Floors	Number of units	Floor area (m²)	Usage	Area of boiler room(m²)	Kind of fuel	Combustion hour	Total	Amount of fuel consumption	Number of boilers	Fuel consumption /hour(Nm³/h)	Amount of exhaust gas	Heating surface (m²)
4	15	250	12houses,3stores	22	Lig	05:00~09:00, 14:00~22:00	12.00	0.5t/day	1	41.7	243.945	30
5	14	300	12houses,2stores	20	Lig	06:00~07:00, 14:00~22:00	9.00	0.5t/day	2	55.6	325.26	40
5	13	300	11houses,2stores	20	Lig	05:00~07:00, 15:00~23:00	10.00	0.4t/day	2	40	234.0	
5	31	600	26houses,5stores		Lig	06:00~07:00, 14:00~23:00	10.00	1t/day	2	100	585.0	
5	13	300	11houses,2stores	26	Lig	03:30~07:00, 17:00~22:30	9.00	0.6t/day	1	67	391.95	
4	12	250	9houses,3stores	35	Lig	05:00~09:00, 14:00~22:00	12.00	0.5t/day	2	41.7	243.945	25, 10
4	8	250	6houses,2stores	23.5	Lig	06:00~09:00, 16:00~23:00	10.00	0.4t/day	1	40	234.0	30
5	14	250	houses	18	Lig	06:00~09:00, 14:00~22:00	11.00	0.5t/day	1	45.5	266.175	40

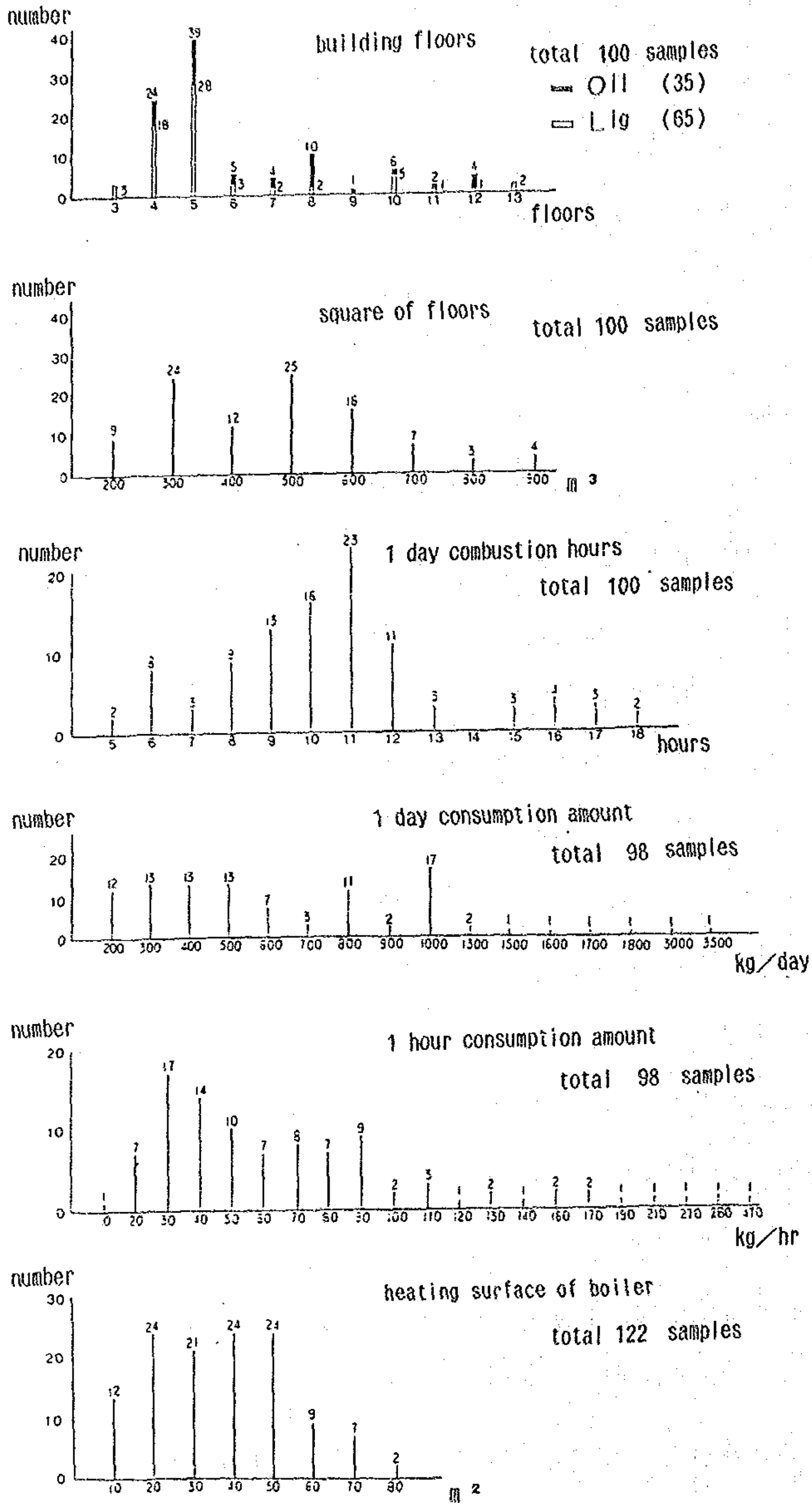


Figure 6-2-1 Some Results of the On-site Questionnaire

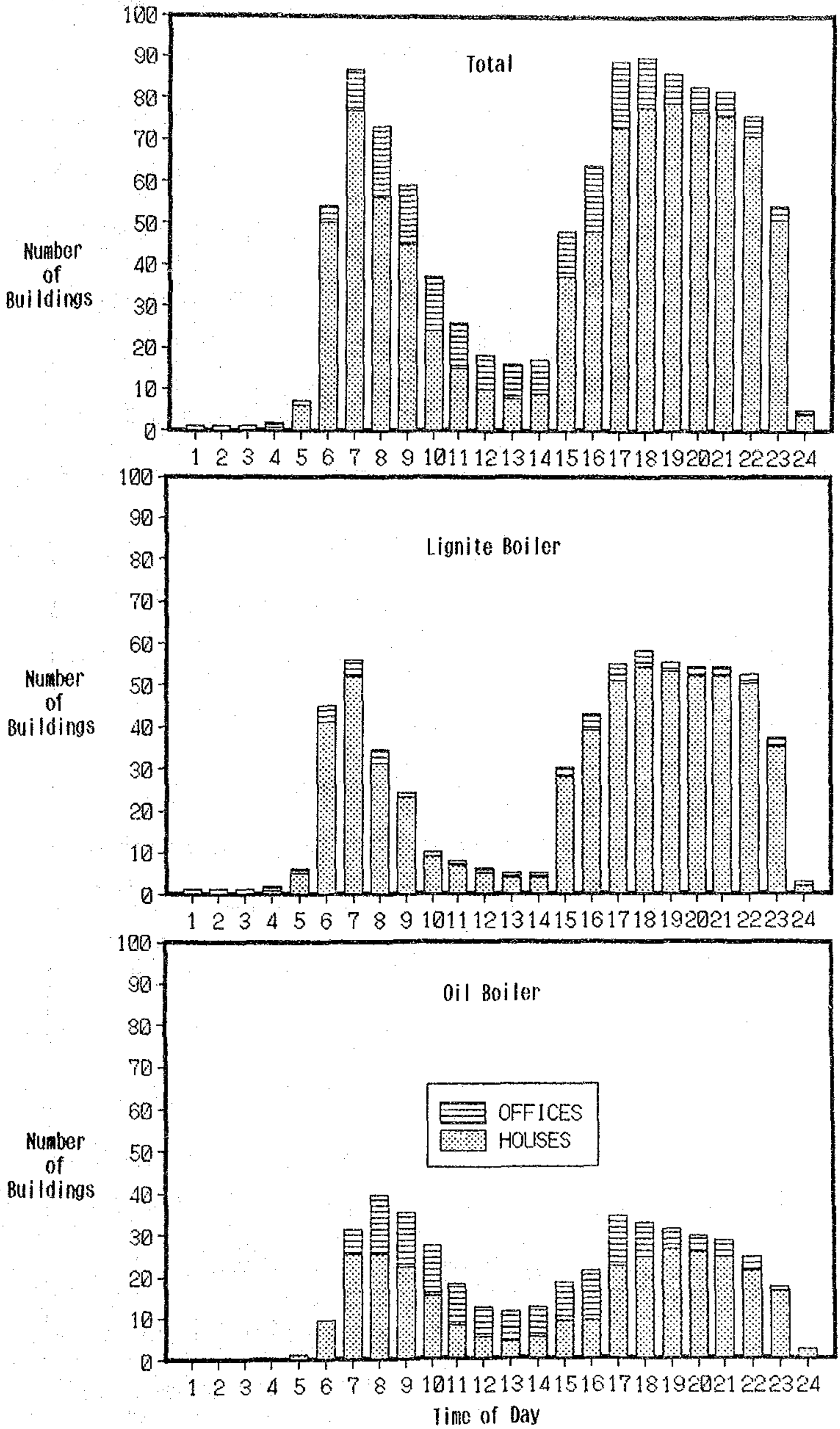


Figure 6-2-2 Heating Hour Distribution

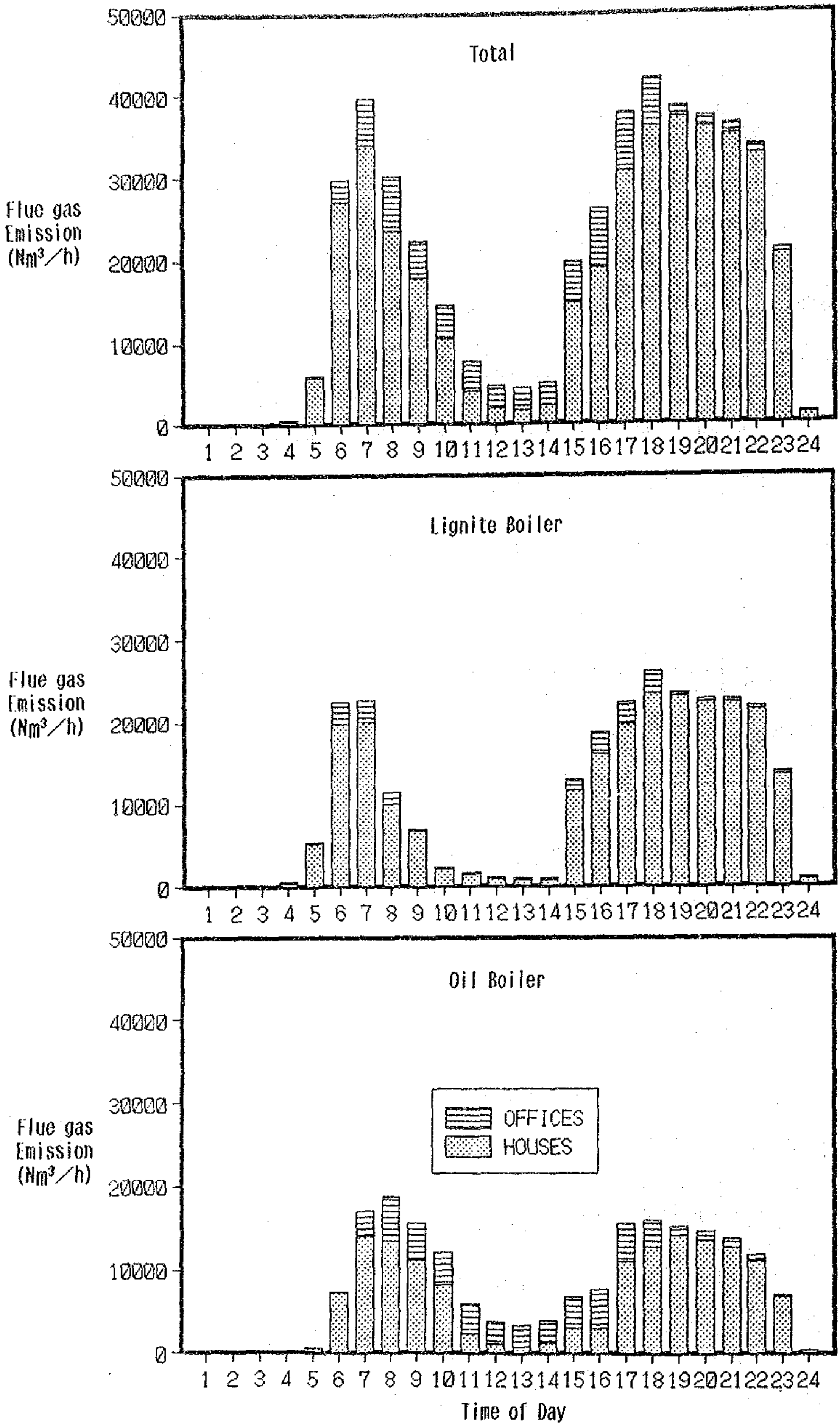


Figure 6-2-3 Hourly Distribution of Flue Gas Emission