5.2.2 Control Measures for Vehicles in Circulation

(1) Regulation of Idling

1) Emission Standards

The emission standards for idling have been introduced through the ordinance of SEDUE (June 1988) for CO and HC for vehicles in circulation and new vehicles as shown in Table 5.2.3.

Table 5.2.3 Emission Standards for Idling

Model Year	CO (%vol)		HC (ppm)	
	High Altitude	Low Altitude	High Altitude	Low Altitude
-1979	6.0	5.5	700	650
1980-1986	4.0	4.0	500	500
1987-	3.0	3.0	400	400

Idling is a state at which the vehicle is stopped and the engine is under no load. In urban districts with the large traffic volumes, idling time occupies 30 - 40% of total driving time. Consequently, pollutants discharged during idling contribute to air pollution in a considerable degree, particularly at roadside and crossing.

As shown in Figure 5.2.1, a major factor influencing the CO concentration is the air-fuel ratio, and control of this ratio by the carburetor is important. The concentration of HC, on the other hand, is highest when the intake negative pressure is high during deceleration, followed by the idling state. To control concentration of CO and HC during idling, the air-fuel ratio is generally shifted to the leaner side.

Table 5.2.4 shows a comparison of the idling emission standards of Mexico with those of other countries. Considering the high altitude of Mexico City, the idling emission standards of Mexico are rather severe for both CO and HC.

Table 5.2.4 Idling Emission Standards in Some Countries

Country	CO (%vol)	HC (ppm)	Remark
MEXICO	3.0 - 6.0	400 - 700	depending on model year
CANADA	1.5 - 2.5		depending on number of cylinder
JAPAN	4.5	1200	
AUSTRALIA	4.5		
ECEC	4.5		

2) Effect of Regulation

Maintaining pollutant emissions at the minimum levels during idling may prove effective at crossings and roads where traffic congestion is frequent. However, it is difficult to estimate the effect of the regulation for the actual driving conditions. In this study, calculation of the regulation effect was attempted under various assumptions. Table 5.2.5 shows the state of idling concentration for vehicles currently operating in the of Mexico Valley according to the DDF survey.

Table 5.2.5 Pollutant Emission During Idling Tested for Used Cars in Mexico City

Manufacturer	Sample	CO (%)		HC (ppm)	
		Average	Deviation	Average	Deviation
CHRYSLER	428	3.98	2.70	682	731
FORD	241	4.02	2.60	735	814
G.M.	152	4.00	2.70	722	770
NISSAN	279	4.03	2.64	631	635
RENAULT	113	4.65	2.89	743	697
V.A.M.	114	4.80	2.30	687	643
V.W.	929	3.30	2.29	718	715
Others	9	3.74	2.79	925	686
Average	2265	3.78	-	703	-

Tables 5.2.6 through 5.2.8 show some example for the effect of changing idling CO concentration on the emission levels at driving mode.

Table 5.2.6 The Effects of Changing Idling CO Concentration on the Emission Levels at 4 Mode Driving

Idling CO (%vol)	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5
CO (% vol)	1.0	1.1	1.5	2.0	2.0	1.9	2.1	2.4
HC (ppm)	530	570	590	590	650	650	700	720

Source: "Report of Study on Smog Mechanism and Plant Damage in Tokyo," Pollution Research Institute, Tokyo Metropolitan Gov., 1973.

Table 5.2.7 The Effects of Changing Idling CO Concentration on the Emission Levels at 10 Mode Driving

Unit: g/km

Idling CO	3.0 (% vol)			4.0 (% vol)			4.5 (% vol)		
Test Car	CO	HC		CO	HC		CO	HC	
		CH_4	C_6H_{14}		CH_4	C_6H_{14}		CH_4	C_6H_{14}
A	25.7	6.3	5.7	28.9	6.6	5.9	32.0	6.6	5.9
B	26.4	4.5	4.0	29.1	4.1	3.6	33.0	4.6	4.2
C	6.9	2.8	2.5	10.8	2.8	2.5	12.7	2.8	2.5
D	14.6	3.0	2.7	18.6	3.1	2.8	21.2	3.4	3.0
E	11.7	2.5	2.2	13.9	2.4	2.1	15.4	2.5	2.3
F	12.0	3.5	3.2	13.7	3.7	3.3	14.8	3.4	3.1
G	27.2	6.8	6.1	31.1	6.8	6.1	33.5	7.2	6.4
H	13.7	4.4	4.0	15.2	4.3	3.9	18.2	4.5	4.0
I	11.9	2.1	1.9	13.7	2.3	2.1	19.1	2.8	2.5
J	12.8	4.0	3.6	13.9	3.8	3.4	14.1	4.3	3.9
Average	16.3	4.0	3.6	18.9	4.0	3.6	21.4	4.2	3.8

Source: "Report of Survey on Estimation of Air Pollutant Emission Factors (Mobile Source)," Pollution Bureau, Tokyo Metropolitan Gov., 1972.

Table 5.2.8 The Effects of Idling CO Concentration on the Real Mode CO Emission

Unit: g/km

Mode Category \ Idling CO concentration	0.5 (% vol)	4.8 (% vol)
No.5 mode (Average speed 15 km/h)	5.28	11.53
No.10 mode (Average speed 44 km/h)	4.42	5.69

Source: Present study

As shown in Table 5.2.8, by reducing the idling CO concentration from 4.8% to 0.5%, the CO emission was reduced by 50% at the No.5 mode with an average speed of 15 km/h, and by about 20% at the No.10 mode with an average speed of 44 km/h.

A cause of this difference may be that the No.5 mode (low speed) experiences more frequent idling and deceleration than the No.10 mode. This indicates that reduction of the idling concentration is effective in the low-speed range, but less effective in the high-speed range. The reduction of emission level (about 50%) in the No.5 mode as noted in Table 5.2.8 approximately equals to the reduction rate in the 4 mode obtained by changing idling CO from 4.5% to 0.5% as noted in Table 5.2.6. The idling control effects shown in Table 5.2.7 and that in Table 5.2.6 are also similar. Therefore, Table 5.2.6 may be used without introducing much error when effects of idling control on actual driving is to be evaluated. Since the Government of Mexico is planning to decrease the idling CO levels of vehicles that are above the average of about 4.5% vol, the actual effect is expected to be a reduction of about 20% from 2.4 ppm to 2.0 ppm when the idling CO concentration is decreased from 7.5% vol to 4.5% vol as noted in Table 5.2.6.

(2) Control of Exhaust Gas Using a Secondary Air Supply System

The previous section described the finding that emission of pollutants can be reduced to a certain extent by controlling idling of used cars. However, unless additional appropriate measures are to be taken, improvement of ambient air quality may require considerable time.

1) Secondary Air System

Of the exhaust gas control measures shown in Table 5.2.1, the secondary air system can be installed with a relatively low cost in vehicles using leaded gasoline. This system supplies air necessary for promotion of flameless oxidation of CO and HC in the exhaust system. The system is of two types: a secondary air injection system (AI) which uses an air pump to supply air, and a secondary air suction system (AS) which utilizes pulsation of the exhaust pressure as shown in Figure 5.2.2.

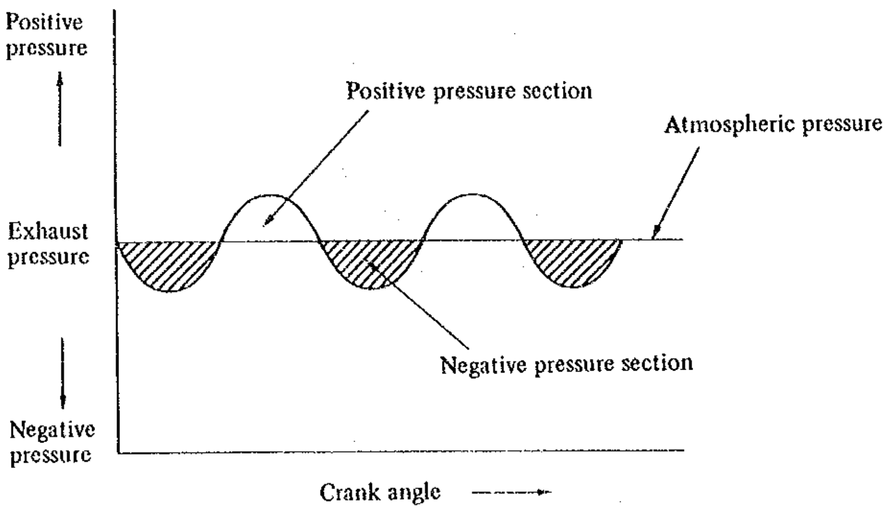


Figure 5.2.2 Pulsation of Exhaust Pressure

Comparison of these types indicates that "AS" is more favorable in terms of cost (including labor cost). The AS type successfully works for used cars, while the AI type inevitably suffers from interference with other engine parts. Note however that the AS type is less effective in the high-speed range as shown in Figure 5.2.3. Table 5.2.9 shows the necessary parts for the AS system, and Figure 5.2.4 shows structure. A total cost for the AS system including parts, installation, and adjustment amounts to about 20,000 to 30,000 in Japanese yen.

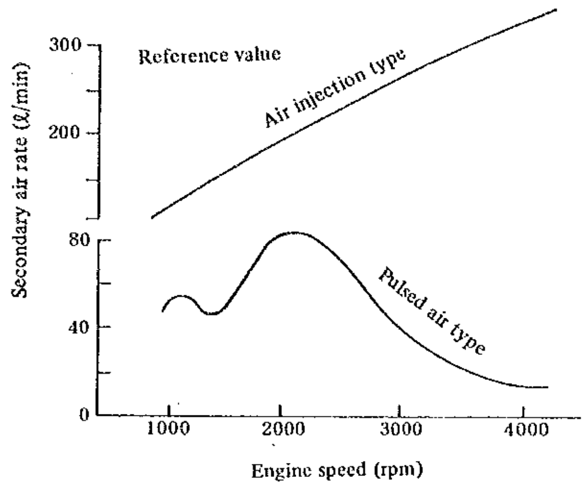


Figure 5.2.3 Comparison of Secondary Air Rate (Air injection type and pulsed air type)

Table 5.2.9 Necessary Parts for Secondary Air Suction (AS) System

Parts	Remark
Exhaust manifold	
Reed valve and its cover	
Fitting parts of reed valve	
Secondary air pipe	
Air injection pipe	heat-resistant materials

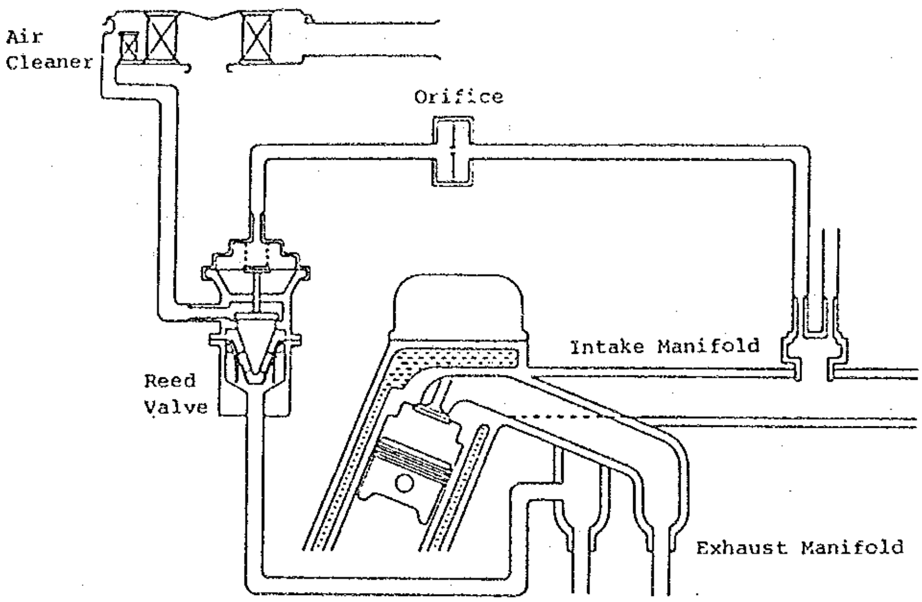


Figure 5.2.4 Secondary Air Suction System (AS)

2) Effect of the Secondary Air System

The system is designed to reduce the pollutant concentration in exhaust gas through flameless oxidation reaction. Theoretical concentration change is expressed as follows:

$$\ln \frac{C_1}{C_2} = D \cdot e^{(-B/T)} \cdot \frac{P^2 \cdot O \cdot V}{WT^2}$$

where, C_1, C_2: Concentration of a combustible at inlet and outlet of the combustion zone

D, B : Constant

T : Absolute temperature

P : Absolute pressure

O : Oxygen concentration

V : Volume of the combustion zone

W : Mass flowrate

ln : natural logarithm

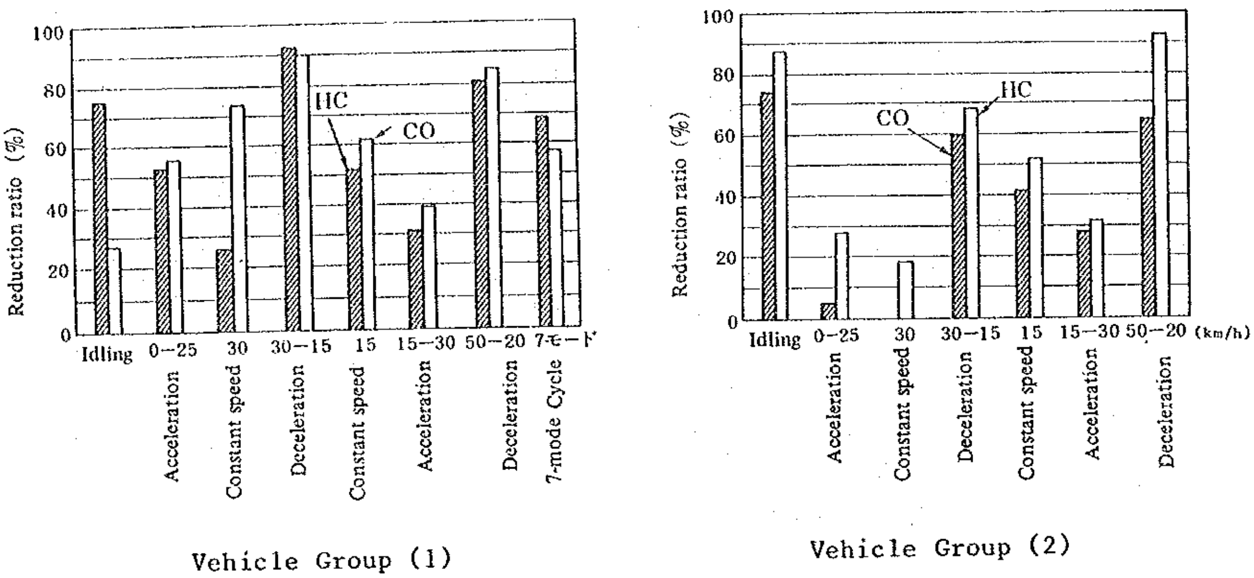
The reaction rate may be considerably decreased at a temperature above 700 - 750°C, and the presence of O_2 is the key to the reaction.

The experimental result with and without secondary air is shown in Table 5.2.10 and Figure 5.2.5. Because Mexico City is located in the highland where the air pressure is low, the air-fuel ratio tends to shift toward the rich side. Therefore, in urban areas where low-speed driving is frequent, a reduction of the CO emission by 30 -35% can be expected.
However, this secondary air system is considered less effective when idling control is made comprehensively and the air-fuel ratio is set to the leaner side.

Table 5.2.10 Example for Effect of Secondary Air

Constant car speed (mile/h)	Air fuel ratio	Without secondary air				With secondary air		
		HC (ppm)	CO (%)	CO_2 (%)	NO_x (ppm)	HC (ppm)	CO (%)	NO_x (ppm)
10	Rich	1000	2.4	14.7	0	154	0.6	0
	Lean	200	0	14.1	105	183	0	113
20	Rich	1000	1.9	14.0	725	91	0.3	143
	Lean	160	0.2	13.6	145	124	0	205
30	Rich	1050	2.5	13.9	455	100	0.5	675
	Lean	180	0.1	13.8	500	153	0.1	412
40	Rich	1900	1.5	14.7	975	162	1.3	1080
	Lean	250	0.3	14.0	1390	139	0.2	1490
50	Rich	1050	1.5	13.4	1025	158	1.4	1573
	Lean	160	0.3	14.4	1900	88	0.3	1870

Source: Automobile Engineering (Japanese), Vol. 27, No. 10.



Source: Yanagihara, S., Automabile Pollution and Control Technology (in Japanese)

Figure 5.2.5 Pollutant Reduction by Secondary Air Injection in Each Mode

5.2.3 Control Measures for New Vehicles

Regulation of exhaust gas from automobiles was first employed in California, USA in 1962 to prevent photochemical smog. Since then, various states of the USA, Japan, European countries, and other countries in the world have adopted emission standards for automobile exhaust gas.

Control technologies adopted or planned to be adopted by various countries against automobile exhaust gas were summarized in Table 5.2.1.

(1) Emission Standards of the United Mexican States

Emission standards for gasoline-powered vehicles of which the Government of Mexico has been applying and plans to apply in 1988 and beyond are shown in Table 5.2.11 and Table 5.2.12, respectively. Table 5.2.13 shows change in emission standards in the USA for gasoline-powered passenger cars.

Table 5.2.11 Change in Emission Standards for Gasoline-powered Passenger Cars in Mexico

Unit: g/km

Item \ Model Year	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88
HC	4.1 g/mile	3.4 g/mile		3.0							2.9	2.8		2.0
CO	47 g/mile	39 g/mile		33						30	28	27		22
NOx	No regulation		3.6 g/mile	No regulation										2.3

Note: 1) Evap: Device installation obligation only
2) Test procedure: LA-4CH + CVS

Table 5.2.12 Emission Standards for 1988 and Beyond in Mexico

Unit: g/km

Item	Model year	88	89	90	91	92	93	94
HC	Passenger car	2.0		1.8	0.7		0.25	
	Commercial vehicle			2.0				0.625
	Light-duty truck			3.0		2.0		0.625
CO	Passenger car	22		18	7.0		2.125	
	Commercial vehicle			22.0				8.75
	Light-duty truck			35		22		8.75
NOx	Passenger car	2.3		2.0	1.4		0.625	
	Commercial vehicle			2.3				1.44
	Light-duty truck			3.5		2.3		1.44

Note: Commercial vehicle: GVW upto 2727 kg
Light-duty truck : GVW 2728 kg - 3000 kg

Table 5.2.13 Changes in Emission Standards for Gasoline-powered Passenger Cars in the USA (EPA)

Unit: g/mile

Item \ Model Year	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90
HC	1.5					0.41				0.41						
			(1.5)				(0.57)									
CO	15					7.0	3.4			3.4						
			(15)				(7.8)									
NOx	3.1		2.0				1.0			1.0						
			(2.0)				(1.0)									
EVAP.	2.0			6.0			2.0			2.0						
			(2.0)				(2.6)									

Note: 1) Test method Exhaust -'74 : LA - 4C '75- : LA-4CH
EVAP. -'77 : Carbontrap '78 : SHED

Note: 2) Figure in parentheses is the standard value for the highlands (4,000 feet or more). The values after 1984 are same as for the plains areas.

Comparison of Tables 5.2.11 and 5.2.12 with Table 5.2.13 shows that the standard values of Mexico prior to 1987 are less severe than those in the USA and that the values after 1993 are on the same level.

(2) Control Technologies

To meet the emission standards of Mexico for 1993 and beyond, employment of three-way catalytic converters are considered to be necessary. The three-way catalytic converter shown in Figure 5.2.6 is outlined below.

Combustion of a gasoline-air mixture slightly richer than the stoichiometric ratio (A/F : 14 -15) produces exhaust gas of the reducing state without containing O_2, and thus NO_x can be reduced by a catalyst such as rhodium (Rh), etc. In contrast, combustion on the slightly lean side produces exhaust gas of the oxidizing state containing residual O_2, allowing CO and HC to be oxidized by a catalyst such as platinum (Pt), etc.

Accordingly, by swinging the A/F ratio around the stoichiometry, one three-way catalytic converter can reduce the emissions of CO, HC, and NO_x simultaneously. To remove these components at the time, the range of swinging air-fuel ratio must be restricted to a narrow range of about ±0.5% around the stoichiometry. For this purpose, a high-precision electronic air-fuel ratio control system is generally introduced. This system measures the amount of the instantaneous suction air to determine the basic fuel injection rate while detecting the O_2 concentration in the exhaust gas for compensation of the injection rate.

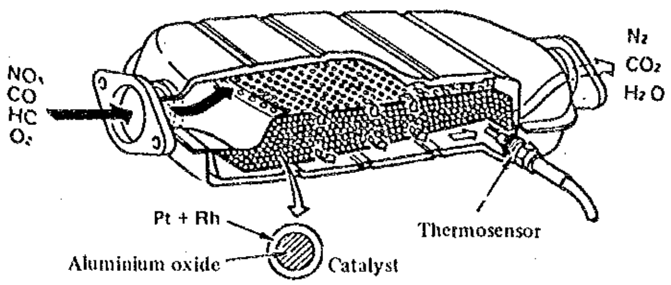


Figure 5.2.6 Three-way Catalytic Converter

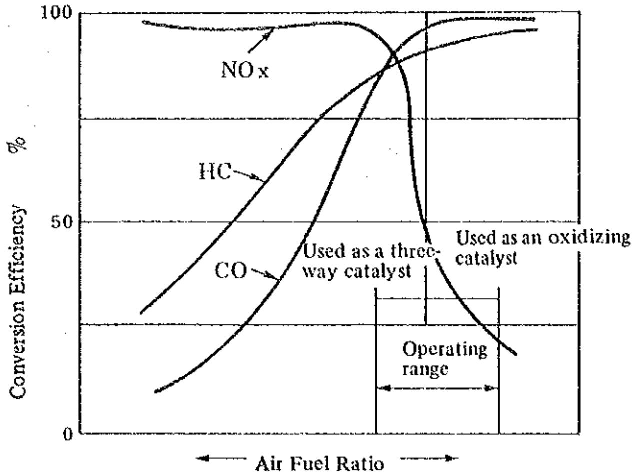


Figure 5.2.7 Air Fuel Ratio

(3) Effect of Emission Regulation

Estimation of the effect of the emisison standards for new vehicles poses two problems. One is the difference in the emission pattern between the measurement mode and actual operating modes. The other is the rate of renewal of vehicles. As to the first problem, the measurement in Mexico is made at the LA-4CH mode which is considered to be similar to the actual conditions. Accordingly, assuming that the reduction of the emission standard value stands for the actual reduction of pollutant emissions may not introduce much error. As regards the vehicle renewal rate, yearly registration of new vehicles in the three DELEGACIONES shown in Table 5.2.14 indicates that the renewal rate varys with year depending on the economic situation.

In the latest 5 years, the average renewal rate was 5.3% and the year 1987 marked the lowest at 2.6%.
The price of a three-way catalytic converter is expected to be 60,000 to 100,000 Japanese yen. Rate of price increase due to installation of this device is higher for economic cars, and this factor may possibly discourage purchasing of new vehicles meeting new standards. However, if the recent trend is to continue in the future, vehicles will be substituted by new vehicles at a rate of about 5% a year.

Table 5.2.14 Number of Automobile Registration by Year in Three DELEGACIONES

Year	Number of registered vehicle	Percentage	Year	Number of registered vehicle	Percentage
1987	12182	2.6	1976	22978	5.0
1986	26405	5.7	1975	23015	5.0
1985	33940	7.3	1974	19770	4.3
1984	27030	5.8	1973	15632	3.4
1983	24549	5.3	1972	12172	2.6
1982	42487	9.2	1971	9280	2.0
1981	44034	9.5	1970	8111	1.8
1980	36754	7.9	1969	6774	1.5
1979	26772	5.8	1968	5715	1.2
1978	21297	4.6	44-67	26736	5.8
1977	16905	3.7	Total	462538	100.0

Under this renewal rate, it takes about twenty years for replacing existing vehicles completely with new ones.

It is considered necessary for the Government to employ some measures to encourage purchase of new vehicles and to discourage extended use of old vehicles having no emission control devices.

Once marketed, new vehicles may suffer degradation of the emission control system. If it is assumed that such degradation is prevented by satisfactory maintenance with periodical automobile inspection and servicing, the pollutant emissions from vehicles will be decreased by 50% for CO and HC and by 35% for NOx from the present level in the year 2001.

(4) Control of HC Emission

As described in Chapter 3, HC is one of the pollutants whose ambient concentration exceeds the value specified by the ambient air quality standards in Mexico. Table 5.2.15 shows contribution of automobiles to the total of HC emissions investigated in some countries. The contribution of automobile is considerably high. Although it was not investigated in depth, the automobile contribution to HC emission in Mexico City is considered to be a similar level to that in Los Angles.

Table 5.2.15 Automobile Contribution in HC Emissions

Country or zone	Year of investigation	Automobile contribution (%)
Tokyo Bay area	1972 (Environment Agency)	57
Tokyo Metropolitan area	1975 (Tokyo Metropolitan Gov.)	32
USA (Nation wide)	1977 (EPA)	35
Los Angles	1970	66
UK	1973	18

There are three causes for the emission of HC from automobiles as mentioned in Section 5.2.1, and they are depicted in Figure 5.2.8. It is generally considered that percentage of HC emission at each source is: (1) exhaust gas 55%, (2) evaporation 20%, and (3) blow-by gas 25%. HC in the exhaust gas is to be controlled through the emission standards, and installation of anti-evaporation device is already obligated. For the remaining source, i.e., blow-by gas, obligation to install a blow-by gas control device is necessary. By doing so, the HC emissions from automobile will be decreased by 25%.

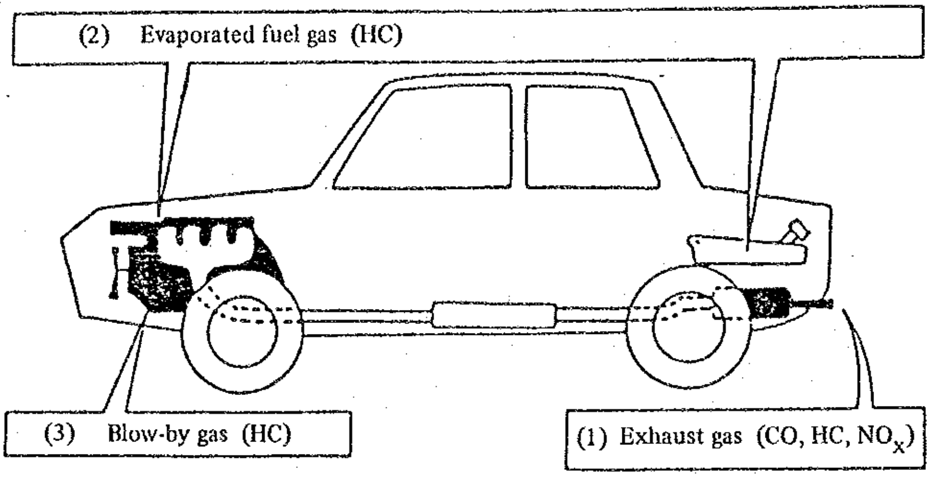


Figure 5.2.8 sources of Pollutant Emission

The function of a blow-by gas control device is to return the gas from the crankcase to the air intake system for combustion avoiding the release into atmosphere. The device is of two types: closed type and shield type. Removal efficiency is 100% for both types.

By the use of the blow-by gas control device and perfection of anti-evaporation device, it is possible to reduce emissions of HC by 30% to 40%.

5.2.4 Problems Associated with Gasoline Unleading and Introduction of Catalytic Converter

(1) Gasoline Unleading

The Government of Mexico intends to start supplying unleaded gasoline from 1988 for the full-scale enforcement of the emission standards planned for 1993.

Unleaded gasoline is favorable for human health and preservation of the performance of exhaust gas control systems. Yet, actual use of unleaded gasoline faces the following problems:

(a) Decrease in the octane rating of gasoline

(b) Valve recession

(c) Gasoline composition (particularly, increase in aromatic compounds)

(d) Increased costs due to lead elimination

(e) Problems met by vehicles in use that are designed for leaded gasoline

Unleaded gasoline causes knocking when used by the cars designed for gasoline with high octane rating. Therefore, it is necessary to prevent decrease in octane rating by operating high-octane gasoline production unit at oil refineries. Also, automobile manufactures need to make new cars which operate successfully with low-octane gasoline by lowering compression ratio.

Lead compounds in gasoline act as lubricant under high temperature. When unleaded gasoline is used, seat of the outlet valve is worn away in the case of cast iron seat. This causes fall-in of the valve which pushes the locker arm giving rise to valve recession. To counter this phenomenon, improvement of seat material is necessary.

Change in gasoline composition is closely related to the method of improving octane rating, i.e., increase in aromatic hydrocarbons is expected as a result of introducing octane improvement unit. Table 5.2.16 shows saturated, olefinic, and aromatic HC content in gasolines in Mexico and Chile.

Table 5.2.16 Content of Hydrocarbons in Gasoline

Unit: % by weight

Number of Carbon	Principal Compound	Chile	Mexico No.1	Mexico No.2
4			2.91	0.13
	n-Pentane		2.82	
5		4.62	23.01	9.32
	i-Pentane	2.62	9.99	3.54
	n-Pentane	2.0	13.02	5.72
6		11.47	19.46	19.21
	2-Methylpentane	3.55	6.70	6.19
	3-Methylpentane	2.2	4.15	3.84
7		8.63	8.58	10.21
	Toluene	2.49		
8		35.20	24.05	31.63
	m, p-Xylene	9.97	6.39	8.77
	o-Xylene	3.72	1.95	2.67
9		13.63	9.24	12.79
10		8.24	4.5	6.31
Saturated HC		47.30	64.96	54.09
Olefinic HC		9.21	8.45	9.82
Aromatic HC		34.47	19.89	27.79
Unknown		16.45	7.77	8.16

In view of photochemical reaction, increase of aromatic hydrocarbons does not pose a problem since they are slower in reaction than olefinic hydrocarbons. But possibility of producing PAN (peroxy acetyle nitrate) is pointed out.

Lead elimination contributes to substantial improvement in performance of the emission control device leading to reduction of pollutant emissions. In this context, it is generally asserted that an increase in aromatic compounds due to lead elimination is not a serious problem. But, in the case of Mexico City where photochemical smog is often observed, indiscreet increase of aromatic hydrocarbons in gasoline should be refrained.

Increase in costs due to lead elimination includes: initial cost for installation of production unit, its operation and maintenance cost, and costs associated with the sale of gasoline such as tanks and pumps at service stations, storage tank and tank rolleys. Unleaded and leaded gasolines must be treated separately when supplied to the service stations and when pumped into individual cars, for example, putting a sticker to each car specifying need for leaded or unleaded gasoline, and preparing fuel guns for the both types of gasoline.

For the vehicles that have been already in the market, it is virtually not possible to install control devices to eliminate the problems of (a) and (b). Consequently, it is necessary to keep supplying leaded gasoline as long as those vehicles remain in use.

Introduction of unleaded gasoline should be realized swiftly and smoothly with the considerations sited above.

(2) Introduction of Catalytic Converter

As described in (1) and will be in the next section, introduction of catalytic converters poses various problems. These are listed below.

(a) Prevention of supplying leaded gasoline to the vehicles equipped with a catalytic converter
(b) Establishment of inspection and maintenance system to prevent degradation of catalytic functions
(c) Improvement in quality of gasoline and lubricant and establishment of quality monitoring system

(d) Cost increase due to installation of the catalytic converter and use of unleaded gasoline

(a) above is necessary because when leaded gasoline is used, the catalytic function of the converter is destroyed by the lead film enviloping the catalyst. Therefore, means to eliminate accidental use of leaded gasoline by the vehicles equipped with a catalytic converter are necessary.

(b) is necessary since life time of a car is supposed to be considerably long in Mexico and prolonged performance of catalytic converters is required.

(c) is necessary because high-quality gasoline and lubricant are required for the converters to function satisfactorily.

The problem of (d) may suppress the rate of vehicle substitution by new models. Therefore, some means such as giving tax incentives may be necessary to encourage the purchase of new models equipped with a catalytic converter.

(3) Sulfur Content of Gasoline

The Government of Mexico intends to supply special diesel oil with a sulfur content of 0.5% for diesel vehicles. According to the JICA survey, the sulfur content of gasoline currently used in Mexico City was about 0.13% by weight, which is nearly equal to the quality standard set forth in ASTM D430-84 at 0.15% (maximum) for leaded gasoline. The air quality simulation based on this content shows a noticeable contribution of automobiles to the ambient SO_2 concentration, as noted in Table 3.5.12. This fact indicates that reduction of sulfur content is necessary also for gasoline.

5.2.5 Establishment of Vehicle Certification System and Inspection and Maintenance System

It is important to establish a certification system for new vehicles to ensure the compliance with the emission standards, as well as to establish an inspection and maintenance system for marketed vehicles to preserve performance of the emission control devices.

Table 5.2.17 shows the certification system employed in various countries.

As described in 4.5.1, DDF plans inspection at the twelve centers in the city for vehicle verification and diagnosis. For the maintenance, the manufacturers need to administer their dealers to expand their equipment and to improve workmanship of mechanics. Establishment of a solid system for maintenance should be pushed forward through coordination of official and private sectors, with due attention to the following points:

(a) Training for technical improvement of mechanics

(b) Funding or tax incentives for installation of exhaust gas measuring systems in repair shops

(c) Preparation of technical manuals on the exhaust gas control systems by each manufacturer

Table 5.2.17 Certification System in Various Countries

Country	Pre-Production		Assembly-Line	In Use
	Testing	Certificate		
JAPAN	Official Lab.	Issued by Government	Emission sampling and testing by manufacturer	Periodic inspection and maintenance by Government or Authorized service shop
U.S.A.	Official Lab. and/or Manufacturer	Issued by Government	Selective audit testing under the order of Government	Emission testing of privately owned vehicle by Government
SWEDEN & SWITZERLAND	Official Lab.	Issued by Government	—	Emission testing of stabilized vehicle by Government
AUSTRALIA	Official Lab.	Issued by Government	—	Emission Testing of new vehicle by some state governments
CANADA	Manufacturer	Self-certificate	—	Emission testing of stabilized vehicle by Government
GREAT BRITAIN & F.R. GERMANY	Official Lab.	Issued by Government	—	—
SAUDI ARABIA	Manufacturer	Self-certificate	—	—

5.3 Traffic Control Measures

5.3.1 General Considerations

An effective means of reducing the gross quantity of exhaust gas from automobiles is to lower the traffic volume itself. Features and problematic factors of the automobile traffic volume control measures, which are generally considered, are summarized in Table 5.3.1. These measures can be categorized as follows:

(1) Reduction of the gross traffic volume of passenger cars through enhancement of the public mass transport systems

(2) Regulation of driving of automobiles to reduce the number of running cars and running distance, and smoothing of traffic to reduce the running time

(3) Rationalization of parking to facilitate the smooth automobile traffic

(4) Regulation of automobile production and ownership

(5) Rational layout of urban facilities to reduce the running distance and frequency

The authority of the Mexico City is promoting these measures on the basis of the urban development plan and the integrated traffic/road program. The plan for AMCM is outlined hereafter while referring mainly to (1) through (3) above.

Table 5.3.1 Automobile Traffic Control Measures in View of Air Pollution Control

Measure	Characteristics	Impact or Problems	
		Technical	Socio-economic
Car entry control	• Control of car entry into certain areas by time-zone, car type and car usage	• difficulty in usage control	• unequality between in and out of the subjected area
Installation of exclusive bus lane	• assurance of driving speed and time table • stimulates bus utilization	• exhaust gas control for buses • selection of lanes • necessity for strict traffic control	• traffic increase in nearby roads • increase in the number of buses required
Adjustment of traffic signals	• application of area-wide synclonized traffic light system to smooth traffic flows		• large cost
Lifting of one-way traffic	• to reduce driving distance by reducing one-way traffic	• selection of roads	• possibility of increased traffic accidents
Construction of by-passes	• to reduce concentrated traffics in particular areas	• selection of roads	• large cost • air pollution along the by-pass
Prohibition of road parking	• prohibition of road parking in particular areas	• strict control required • provision of alternative traffic means	• stagnated commercial activities
Parking price hike	• hike of parking fee in certain areas		• convenience in commercial activity decreased
Taxation or tax rate increase for car ownership	• to reduce car ownership due to the increased cost	• difficulty in setting tax rate	• objection by users • objection from car industry

(to be continued)

Measure	Characteristics	Impact or Problems	
		Technical	Socio-economic
Tax increase for un-suitable cars	• tax increase for the cars not meeting emission standards		•objection by users
Increased utilization of mass transit systems	• pollution free systems such as subways, trolleys, and trains • decrease in use of private cars		• large cost
Living in close vicinity to working area	• decrease in utilization of automobiles • decrease in driving distance	• promotion of urban reorganiza-tion	
Organic linkage of related facilities	• decrease in utilization of automobiles	• difficult in existing urban areas	• large cost
Construction of cargo distribution center	• rational use of cargo vehicles		• concensus among industries
Introduction of collabo-rated collec-tion and distribution system	• reduction of number of trips by the increased efficiency		• concensus among industries
Enforcement of providing parking lot	• to enforce buildings to install parking lot	• problem of land	
Limitation of automobile production in number	• to control number of automobiles	• not directly reflected to traffic volume	• objection by industry
Limitation of automobile production in types	• encouragement of production of cars with low emission rate, and control of those with large emission rate	• not directly reflected to traffic volume	• objection by industry

5.3.2 Enhancement of Public Transport Systems

Enhancement of the mass transport systems (subway, bus, and other services) is an effective means not only for improving urban functions, but for control of the gross emission of pollutants from automobiles as well through reduction of passenger car traffic.

The integrated program of traffic and road drafted by the General Coordination for Transportation (COORDINACION GENERAL DE TRANSPORTE: CGT), DDF, involves short-term (1988), medium-term (1989-1994), and long-term (1995-2000) enhancement and improvement plans for various public transport means. These are outlined below.

(1) Subway

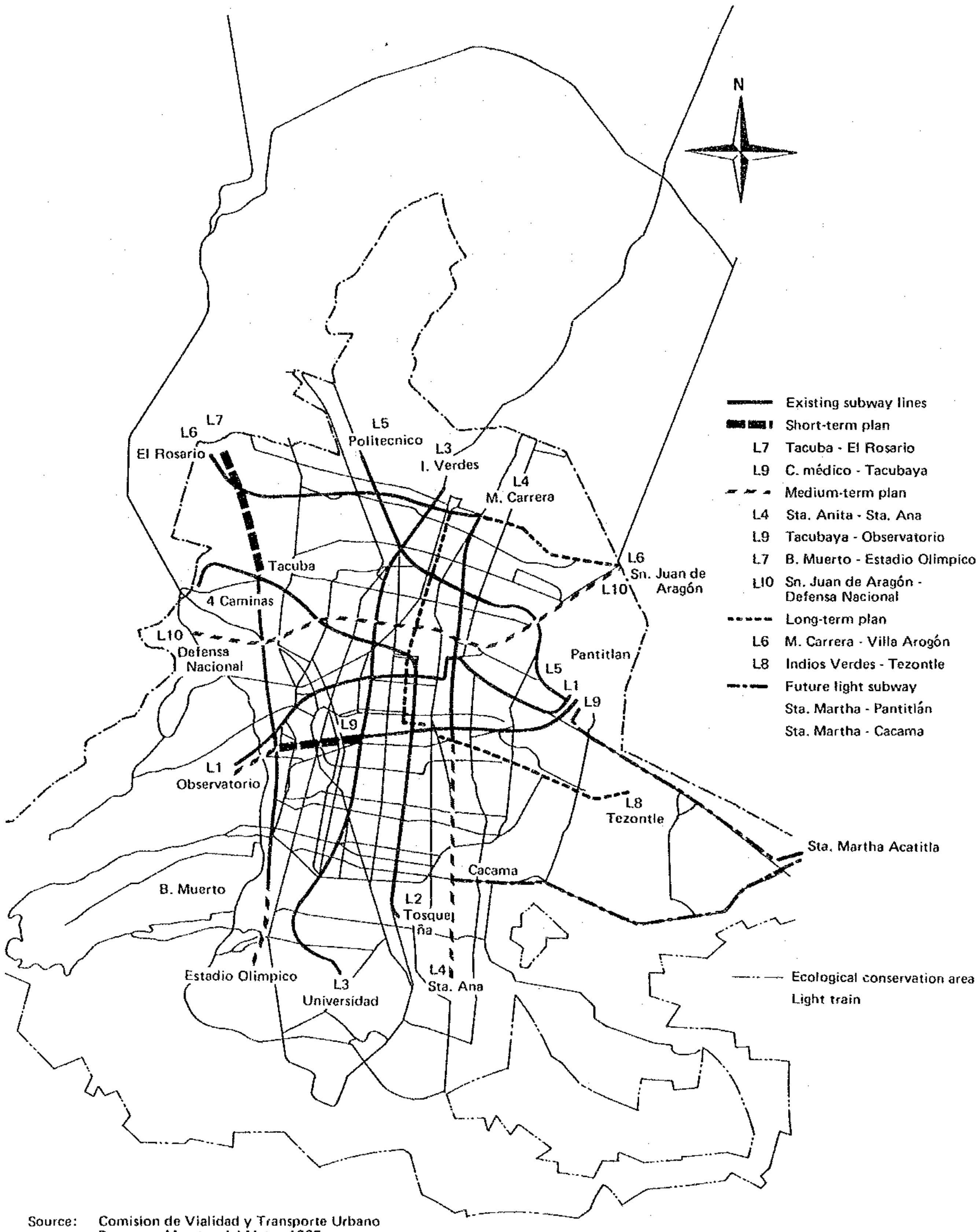
Figure 5.3.1 shows the subway route improvement plan up to the year 2000. The short-term plan for 1988 includes extension of No.7 line by 5.7 km and No.9 line by 3.8 km. In the medium-term plan up to 1994, the following improvements will be made:

- Expansion of TASQUENA station of No.2 line to include three tracks
- Extension of No.4 South line by 9.22 km, with addition of seven stations
- Extension of No.7 South line by 3.3 km, with addition of three stations
- Extension of No.9 line by 1.2 km
- New construction of No.10 line which covers 20.73 km with 19 stations
- Construction of short-distance subways: 13 km between PANTITLAN and MARTHA, and 17.1 km between MARTHA and CAMACA

Improvements planned up to the year 2000 are as follows:

- Extension of No.6 line by 7.10 km, with addition of six stations
- Extension of No.8 line by 22.2 km, with addition of 8 stations

In this way, annual average extension of about 10 km up to 1994 and about 5 km subsequently up to 2000 are planned. Consequently, the passengers expected for 1994 are 7.4 million person-trips per day which occupy 22.9% of the entire traffic means and those for 2000 are 8.56 million person-trips per day occupying 21%.



Source: Comision de Vialidad y Transporte Urbano Programa Maestro del Metro 1985

Figure 5.3.1 Existing and Projected Subway Network

(2) Trolley Bus and Light Train

For trolley bus, the stress is placed on renewal and reconstruction of vehicles to expand the traffic capacity through maximum utilization of the existing network. Also planned is the extension of the route principally into the areas with steep road slopes not favorable for the diesel bus service. For light trains, improvement will be made with due consideration of the effect of the TASQUENA line operated since 1986.

Trolley bus and light train routes whose improvement is planned by 2000 are shown in Figure 5.3.2. The new trolley bus routes of totaling about 90 km and light train route of 7 km will be constructed in 1988. In this way, the trolley bus route will be extended by 200 km by 1994 and further 200 km by 2000. One or two routes will also be added for the light trains. These expansions are expected to increase the passenger distribution ratio for trolley bus and light trains from present 3.1% to 6.7% in 2000.

(3) Urban Bus Service (Ruta-100)

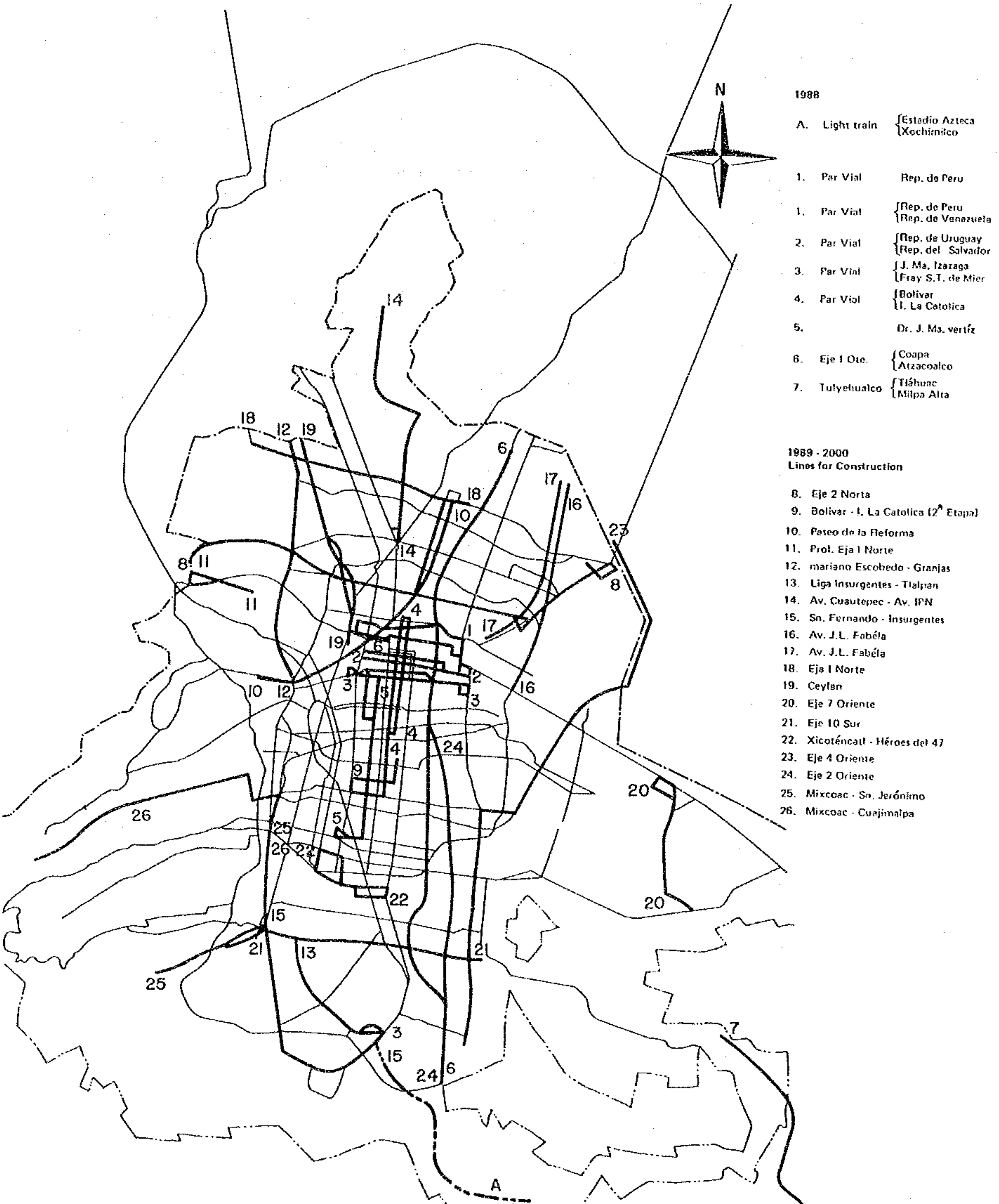
The passenger distribution of the urban bus service is said to be on a downward trend these days. To stop this trend, strengthening of the service is intended by increasing the number of operable buses until the demand along the existing network is met.

The principal short-term measures are as follows:

- Assessment of vehicles owned. The number of operable buses will be increased to 4840 by reparing 500 units (In 1987, 4340 units were operating.)
- Continuation of remodeling of diesel engine to the capsuled diesel/gas type
- Review of the routes overlapping with trolley bus routes, and transfer of buses to other routes.
- Strengthening of various maintenances

The principal measures in the medium-term program are as follows:

- Retaining 4,400 units of single vehicle and 410 units of coupled vehicle (a total of 5,220 units as converted to single vehicles) by means of repair of vehicles and procurement of single and



Source: Coordinacion General de Transporte
Direccion General de Estudios y Proyectos

—·—·— Ecological conservation area

Figure 5.3.2 Projected Trolley Bus and Light Train Network coupled vehicles. The expected number of passengers per single vehicle per day is 1500.

- Continuation of remodeling of diesel vehicles
- Increase in the operating factor of owned vehicles to 80%.
- Construction of the exclusive bus lane on 15 major roads.
- Strengthening of various maintenances

The long-term program is aimed at increasing the number of vehicles owned to 4630 units of single vehicles and 1735 units of coupled vehicles (a total of 8100 units as converted to single vehicles). This is expected to result in the number of passengers per unit per day of 1200.

When the above programs are put into practice, the number of passengers in 1994 will be 7.8 million person-trips per day (24.1% of all) and that in 2000 will be 9.7 million (24.0%).

(4) Taxi, Collective Taxi, and High-grade Transport

The number of certification for taxis and collective taxi (COMBI) is maintained at the present level to improve the service quality. At the same time, present drivers of passenger cars will be advised to transfer to the high-grade transport by mini-buses.

The short-term program includes:

- Switching present vehicles (large vans) for collective taxi to mini-buses with larger capacity, which will be continued in the medium and the long-term programs.
- Introduction of high-grade routes with mini-bus for users of passenger cars. The right of offering this service may be assigned to individuals through bidding.

The medium- and the long-term programs include:

- Introduction of 13 experimental routes using mini-buses for collective taxi. As a result, 2290 large vans will be replaced by 809 mini-buses.
- Regional traffic sub-network in the MILPA ALTA area totaling 38 km with three routes and 52 mini-buses
- Expansion of the service to other areas on the basis of result of operation of the high-grade route included in the short-term program

These programs place a stress on the quality of service. Due to improvement of services of other mass transport means, the transport ratio of taxi, collective taxi, and high-grade transport will be reduced to 12.3% in the year 2000.

5.3.3 Roads, Vehicle Parks, and Regional Transportation

(1) Road Infrastructures

DDF-CGT plans to resort to the low-cost road operation through effective utilization of existing road infrastructures. For newly constructed roads, public transport will be given priority over private passenger cars.

The principal items of the short-term (1988), the medium-term (1989-1994), and the long-term (1995-2000) programs are as follows:

1) Short-term Program

- Installation of a crossing gate at dangerous railway crossings
- Improvement at 23 level crossing and installation of signals at 54 crossings
- Review of traffic regulations and fostering of patrol policemen specialized in road traffic
- Completion of interchange between PICACHO and ANILLO PERIFERICO (completed)
- Construction of a bypass between PASEO DE LA REFORMA and CHIVATITO (completed)

2) Medium-term Program

- Preparation of an implementation program for improvement of the existing road network for enhancement of the public transport system
- Implementation of a system similar to the new road traffic system currently under way in the historical center area in other five areas.
- Implementation of the improvement program for eleven principal roads
- Preparation and implementation of the maintenance program for optimum running conditions of the road network
- Change of the lane width in principal roads to meet the existing standard for the purpose of improving the transport efficiency

- Long-term campaign on traffic safety education
- Pavement of newly-constructed road in the areas of low-income earners to ensure satisfactory public transport service
- Construction or improvement of the roads in the Federal District connecting to the roads in the Mexico State
- Improvement of crossings of primary roads
- Construction of pertinent road infrastructures to eliminate closing of road thus providing continuity
- Progress with grade separation of 21 planned crossings
- Progress with construction of 21 planned road stretches

3) Long-term Program
- Progress in the continual works and construction of road infrastructures to advance toward the ideal road network

(2) Vehicle Parks

For the purpose of recovering the road transport capacity hindered by on-street parking and regulating incoming private passenger cars into the congested recreational district, DDF is preparing a specific implementation plan under following policies:

- Prohibition of construction of any buildings having no vehicle park required by the DF's construction regulation
- Promotion of the use of vehicle parks other than those in the public roads and transfer areas to subway
- Strict observance of the no-parking rule on main roads
- Transfer of vehicles parking in main roads, if possible, to neighboring secondary roads
- Implementation of the subsidy system to motivate construction of vehicle parks by private enterprises in the places other than public roads

(3) Transfer Areas

There are 29 transfer areas ("Paradero" in Spanish) at present to change the traffic means from one to another, of which 25 are located at subway stations. DDF plans to improve infrastructures to help improve functions of these areas and also to construct new ones. For the time being, emphasis of improvement will be placed on the areas of transfer between the municipal bus or the trolley bus and the subway, and subsequently shifted to the areas of transfer between transport means of medium to small capacities.

Operation and management of transfer areas will be under the unified control of SERVIMET.

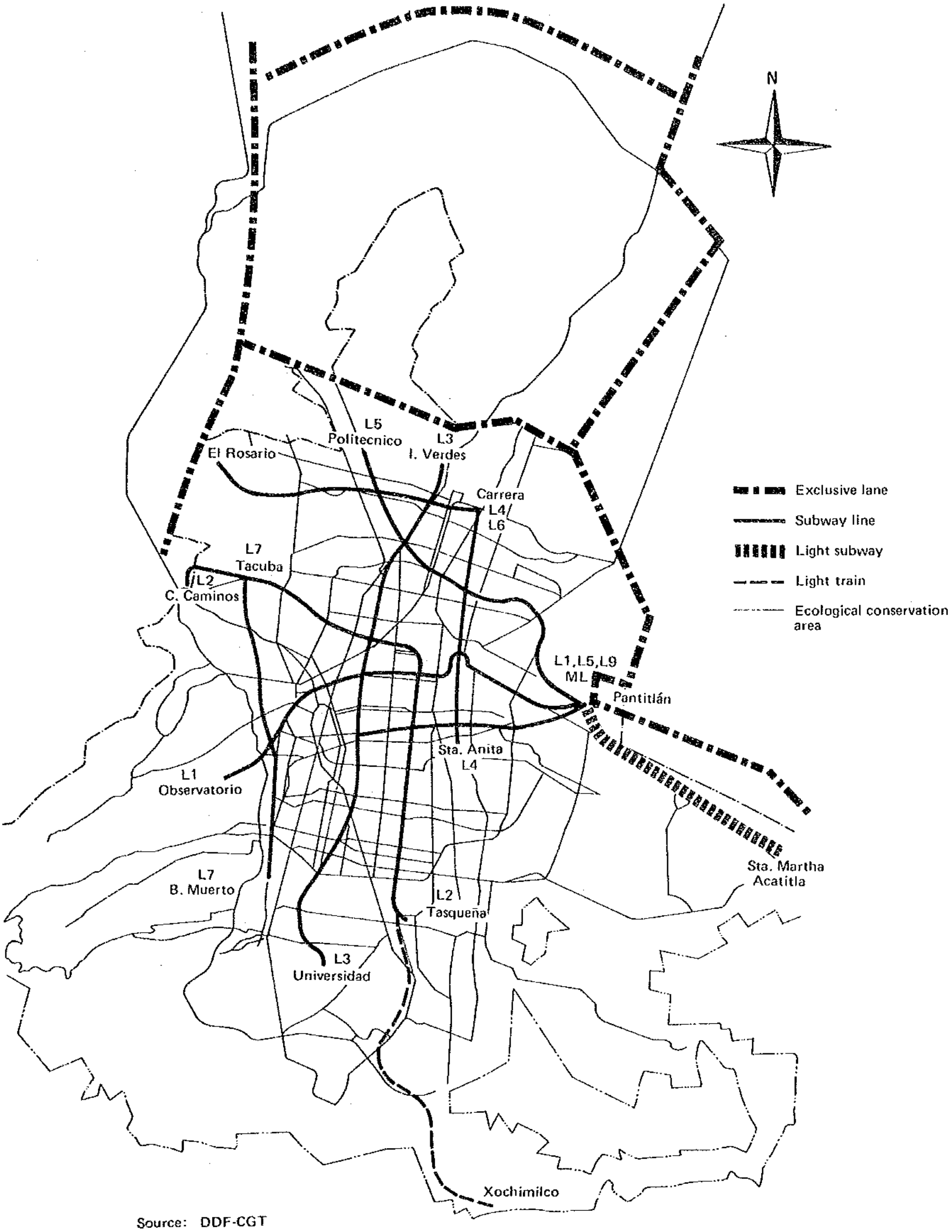
(4) Freight Transport

A rational freight transport system contributes to smooth road traffic. DDF has various rationalization plans concerning freight transport. In particular, these plans include relocation of those freight distribution centers that have been causing traffic congestion, and setting of the distribution time for each major route and area.

(5) Regional Transport

A cooperation agreement will be concluded among DDF and the authorities in the Mexico State and the Federal Government to establish an organic linkage of traffic infrastructures in DF and urban areas of Mexico State, and to connect these systems to regional transport services.

DF and Mexico State are jointly preparing various programs including a mass transport road integration program with exclusive bus lanes as shown in Figure 5.3.3. Mexico State will start the road integration work with funds provided by international financial institutions and proceed with the work step by step to make up the network of specialized bus lanes (called "double-H"). If possible financially, Mexico State will continue developing the double-H by using the regional train system.



Source: DDF-CGT

Figure 5.3.3 Integration of Mass Transportation in DF and the State of Mexico

5.3.4 Control of Use of Private Passenger Cars

At present, the number of private passenger cars in AMCM is 2.35 million, which is about 80% of all road traffic vehicles (see Table 2.6.1). Since the transport capacity of these private passenger cars averages 1.7 persons per car, they account for only about 18% of the total traffic passengers as shown in Table 2.6.2.

Congestion of road traffic occurs when the number of running vehicles exceeds a certain level. Whether or not congestion occurs at a certain point is determined by a small difference in the number of running vehicles. Accordingly, it is expected that reduction of only 10% in the number of private passenger cars will produce a considerable effect eliminating traffic congestion at many points. Though the resultant reduction of air pollutants is difficult to quantity, a 10% reduction in private cars plus a reduction of fuel consumption due to curtailed congestion will present a substantial advantage.

SEDUE and DDF are studying measures which will lead to the above effects, but are not yet implemented. The measures propose that private passenger cars not be used in any one day of the weekdays (Monday to Friday), which may lead to reduction of private cars by 20% on weekdays when such days are distributed evenly over a week. In spite of various problems assosiated with this measure, practical application may be considered possible if appropriate exceptions are provided.

5.4 Estimation of Quantity of Air Pollutant Emissions Corresponding to Implementation of Control Measures

5.4.1 Implementation Schedule and Conditions for the Estimation of Pollutant Emissions

Among various air pollution control measures discussed in the previous sections, measures whose effect in pollutant emission reduction is quantifiable are selected. Time schedule for the implementation of these measures are presumed, and corresponding amounts of pollutant emissions estimated. Specific years for which estimation is made are set to be 1993 and 2001. Groups of control measures to be implemented by the years 1993 and 2001 are referred to as "short-term measures" and "long-term measures", respectively.

(1) Stationary Source Control Measures

Control measures for stationary sources currently executed or planned by the Mexican Government were outlined in the section 5.1.2. However, the time schedule for implementation of some of these measures are not definitely known because of the uncertainty concerning amount of natural gas available for supply and the varying situations at the sources. In the case of VALLE DE MEXICO power generation plant, for example, it is not yet determined whether to adopt flue gas desulfurization or to increase utilization of natural gas. Accordingly, in selecting control measures for the short-term and long-term programs and in estimating corresponding reduction of pollutant emissions, the following assumptions were made.

1) Priority in supplying natural gas is given to the 10 major factories and 18 DE MARZO refinery.

2) Consequently, the supply of natural gas to the two thermoelectric power plants is not increased from the present level, and other measures have to be taken at these power plants.

3) Implementation of control measures is completed by 2001, and the progress by 1993 is assumed to be about 40%.

4) Pollutant reduction rate for each control measure is assumed as follows:

Use of natural gas .... 100% for SO_x and smoke and soot
Flue gas desulfurization .... 85% for SO_x
Low-NO_x burner .... 30% for NO_x
Use of low-sulfur fuel ...... SO_x reduction proportional to the reduction in sulfur content

Table 5.4.1 shows the short-term and the long-term pollution control measures for each stationary source, and Table 5.4.2 shows the corresponding reduction rate of SO_x, NO_x, and smoke and soot postulated under the above assumptions.

Table 5.4.1 Tentative Schedule for Stationary Source Control Measures

Pollutant Source	Short term Control Measures (by 1993)	Long-term Control Measures (by 2001)
VALLE DE MEXICO Power Plant	a. 40% of currently used heavy oil (3.5%-S) changed to 1.0%-S heavy oil b. Flue gas desulfurization applied to 40% of heavy oil combustion facilities C. Low-NO_x burner installed in 40% of heavy oil combustion facilities	a. 100% use of 1.0%-S heavy oil b. Flue gas desulfurization for all the heavy oil combustion facilities c. 100% use of low-NO_x burner
JORGE LUQUE Power Plant	a. Same as a. of VALLE DE MEXICO b. Shut-down of operation during winter (Nov-Jan) c. Same as c. of VALLE DE MEXICO	a. Same as a. of VALLE DE MEXICO b. Shut-down of operation during winter c. Same as c. of VALLE DE MEXICO
18 DE MARZO Oil Refinery	a. 40% of heavy oil (3.5%-S) changed to natural gas b. Low-NO_x burner used by 40% of combustion facilities	a. 100% use of natural gas b. 100% use of low-NO_x burner
10 major Factories	a. 40% of heavy oil (3.5%-S) changed to natural gas b. 30% curtailment of operation in winter (Nov-Jan) c. Low-NO_x burner used by 40% of combustion facilities	a. 100% use of natural gas b. 30% curtailment of operation in winter c. 100% use of low-NOx burner
Other Factories	a. 40% of 3.5%-S heavy oil changed to 1.0%-S heavy oil	a. 100% use of 1.0%-S heavy oil
Service and Commercial Establishments	a. 3.5%-S heavy oil changed to 0.5%-S diesel	a. Use of 0.3%-S diesel

Table 5.4.2 Rates of Pollutant Reduction at Stationary Sources

Unit : %

Pollutant Source	Control Measure	Short-term (1993)			Long-term (2001)		
		SOx	NOx	Smoke and soot	SOx	NOx	Smoke and soot
VALLE DE MEXICO Power Plant	a. Use of low-sulphur heavy oil	29	---	---	71	---	---
	b. Flue gas desulphurization	24	---	---	25	---	---
	c. Use of low-NOx burner	---	12	---	---	30	---
	Total	53	12	---	96	30	---
JORGE LUQUÉ Power Plant	a. Use of low-sulphur heavy oil	29	---	---	71	---	---
	b. Cut of operation in winter	12	15	17	13	30	43
	c. Use of low-NOx burner	---	12	---	---	30	---
	Total (winter)	41	27	17	84	60	43
	Total (other seasons)	29	12	---	71	30	---
18 DE MARZO Oil Refinery	a. Use of natural gas	40	---	40	100	---	100
	c. Use of low-NOx burner	---	12	---	---	30	---
	Total	40	12	40	100	30	100
10 Major Factories	a. Use of natural gas	40	---	40	100	---	100
	b. 30% cut of operation in winter	3	5	3	---	9	---
	c. Use of low-NOx burner	---	12	---	---	30	---
	Total (winter)	43	17	43	100	39	100
	Total (other seasons)	40	12	40	100	30	100
Other Factories	a. Use of low-sulphur heavy oil	29	---	---	71	---	---
Service & Commercial Establishments	a. Use of low-sulphur diesel	34	---	---	91	---	---

(2) Automobile Source Control Measures

As describe earlier, the Government of Mexico is planning various measures to control automobile exhaust gas. These include emission control measures to be applied to each vehicle and measures concerning traffic volume and flow. In this study, primary attention is given to the evaluation of the effect of implementing new emission control regulations proposed by the Government. To clarify this effect, traffic volume, traffic flow, and number of automobiles with their type distribution are assumed to be the same as present.

In estimating pollutant emission quantity from automobiles in the future years, further assumptions are made as follows.

1) Automobile emission standards shown in Table 5.2.12 are implemented as scheduled.

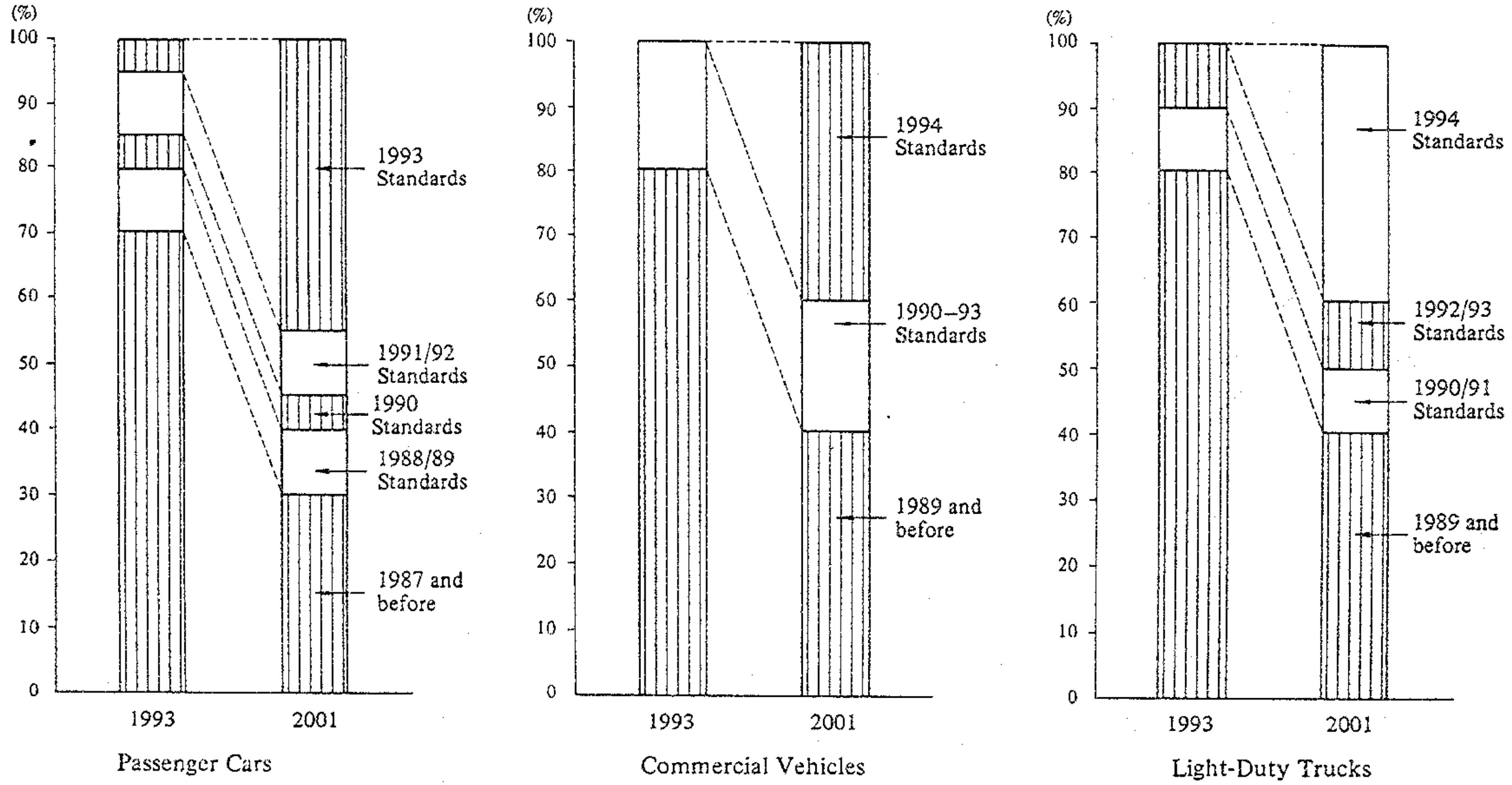
2) Annual rate for vehicle renewal is assumed to be 5%. In other words, the number of new vehicles complying with new emission standards increases by 5% among the total annually, and the number of oldest model vehciles decreases by 5%.

   The vehicle model distributions in 1993 and 2001 obtained under this assumption are shown in Figure 5.4.1.

As to sulfur content of fuels, which affects the amount of SO_x emission, it is assumed as follows:

Gasoline 0.13%
Diesel for bus 0.5%

As noted in the various assumptioned stated above, effects of the measures proposed by the JICA Study team are not accounted for in the estimation of amount of pollutant emissions in the future years.



Note 1) The emission standards for each type of vehicle are shown in Tables 4.4.2, 4.4.3 and 4.4.4, respectively.

2) In addition to the new model's standards, the idling standards shown in Table 4.4.1 are applied to all the gasoline-powered vehicles.

Figure 5.4.1 Vehicle Model Composition in Terms of Progressive Emission Standards

5.4.2 Quantity of Air Pollutant Emissions Corresonding to Implementation of Control Measures

(1) Quantity Corresponding to Short-term Control Measures (1993)

The pollutant emission quantity for each type of source as estimated on the basis of the short-term measures is shown in Table 5.4.3. The pollutant emission quantity of each source can be reduced by 35.2% for SOx, 18.1% for CO, 6.6% for NOx, and 18.7% for smoke and soot from the present level. The HC emission quantity from automobiles as estimated for reference is 73,015 ton/year, which is 18.1% down from the present level.

Figure 5.4.2 shows SOx and NOx emission quantities for stationary and mobile sources after implementation of the short-term measure according to the five-region classification as shown in Figure 3.4.14.

The SOx emissions from the stationary sources can be reduced by nearly one half, yet account for a high percentage in the total. The NOx emissions can be reduced slightly for both stationary and mobile sources.

Geographical distribution of the pollutant emissions is shown in the Appendices.

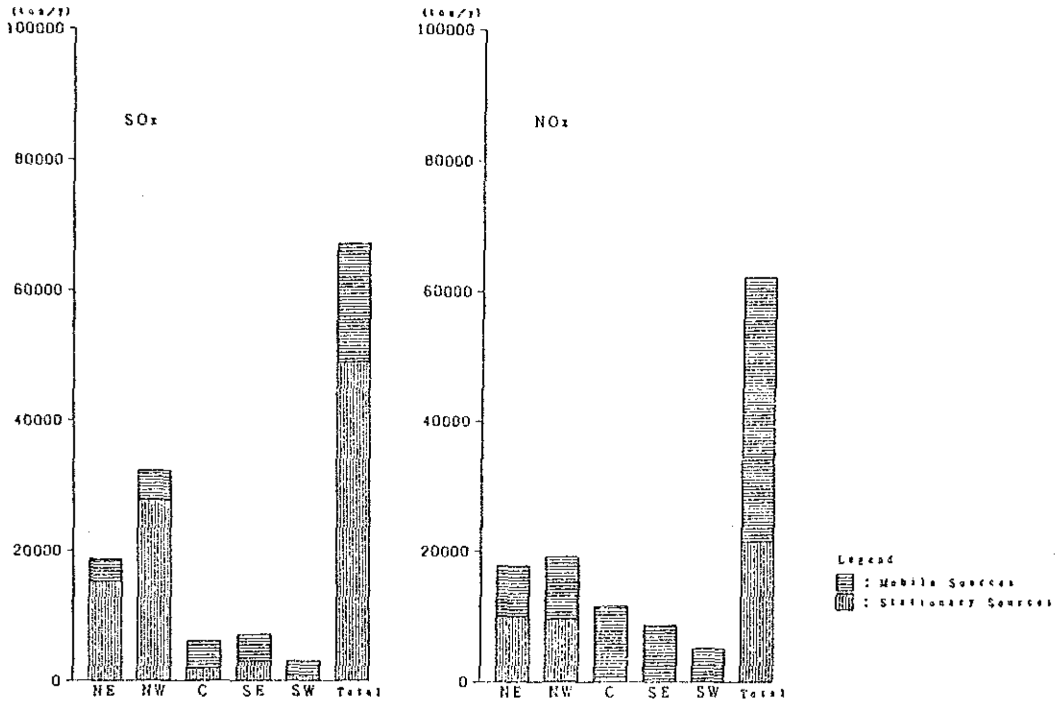


Figure 5.4.2 Pollutant Emission Quantity by Region
(1993: after implementation of the short-term measures)

Table 5.4.3 Pollutant Emission Quantity by Source
(1993: with short-term measures)

Classification	Pollutant Sources		SO_x	CO	NO_x	Smoke and Soot
				(Nm^3/h) (ton/y)		(kg/h) (ton/y)
Stationary Sources	Factories	Power Plant	258.2(23.6) 6463.4	-(-) -	517.9(18.8) 9316.4	90.9(32.3) 796.3
		18 De Marzo Refinery	0.(0.0) 0.	-(-) -	150.4(5.5) 2705.3	0.(0.0) 0.
		Large 10 Factories	0.(0.0) 0.	-(-) -	53.2(1.9) 957.3	0.(0.0) 0.
		Other Factories	94.5(8.7) 2364.5	-(-) -	202.0(7.3) 3633.5	151.0(53.6) 1322.3
		Factories Total	352.7(32.3) 8827.9 (10.6)	-(-) - (-)	923.5(33.6) 16612.5 (71.0)	241.9(85.8) 2118.7 (53.6)
	Service and Commercial Establishments		14.8(1.4) 370.9	-(-) -	50.9(1.9) 916.3	39.9(14.2) 349.8
	Stationary Sources Total		367.5(33.6) 9198.8 (10.6)	-(-) - (-)	974.4(35.4) 17528.8 (72.1)	281.8(100.) 2468.5 (57.4)
Mobile Sources	Automobiles	Major Roads	320.7(29.4) 8025.3	27518(47.9) 301325	852.1(31.0) 15329.0	-(-) -
		Narrower Roads	402.9(36.9) 10083.7	29918(52.1) 327062	913.5(33.2) 16433.3	-(-) -
		Automobiles Total	723.6(66.3) 18109.0 (100.)	57435(100.) 628917 (59.9)	1765.5(64.2) 31760.5 (77.0)	-(-) - (-)
	Airplanes	Climb Approach/Landing	0.3(0.0) 8.5	-(-) -	3.2(0.1) 57.2	-(-) -
		Idling/Taxing Take-off	0.8(0.1) 19.3	-(-) -	7.3(0.3) 132.2	-(-) -
		Airplane Total	1.1(0.1) 27.8 (100.)	-(-) - (-)	10.5(0.4) 189.4 (100.)	-(-) - (100.)
	Moble Sources Total		724.7(66.4) 18136.8 (100.)	57435(100.) 628917 (59.9)	1776.0(64.6) 31949.9 (77.1)	-(-) - (-)
Total			1092.2(100.) 27335.6 (26.0)	57435(100.) 628917 (59.9)	2750.4(100.) 49478.7 (75.3)	281.8(100.) 2468.5 (57.4)

Note: Figure within the parentheses on the right indicates the ratio (%) to the total, and that below indicates ratio (%) to the present quantity.

(2) Quantity Correspoonding to Long-term Control Measures (2001)

The pollutant emission quantity for each type of source as estimated on the basis of the long-term measures is shown in Table 5.4.4. The pollutant emission quantity of each source can be reduced by 74% for SOx, 40.1% for CO, 25.0% for NOx, and 42.6% for smoke and soot from the present level. The HC emission quantity from automobiles as estimated for reference is 54,344 ton/year, which is a drop of 39.1% from the present level.

Figure 5.4.3 shows SOx and NOx emission quantities for stationary and mobile sources after implementation of the measures according to the five-region classification.

The SOx emissions from the stationary sources can be substantially reduced and will be less than that of the mobile source in the regions other than NW.

The NOx emissions from both stationary and mobile sources can be reduced further from the levels of the short-term measures.

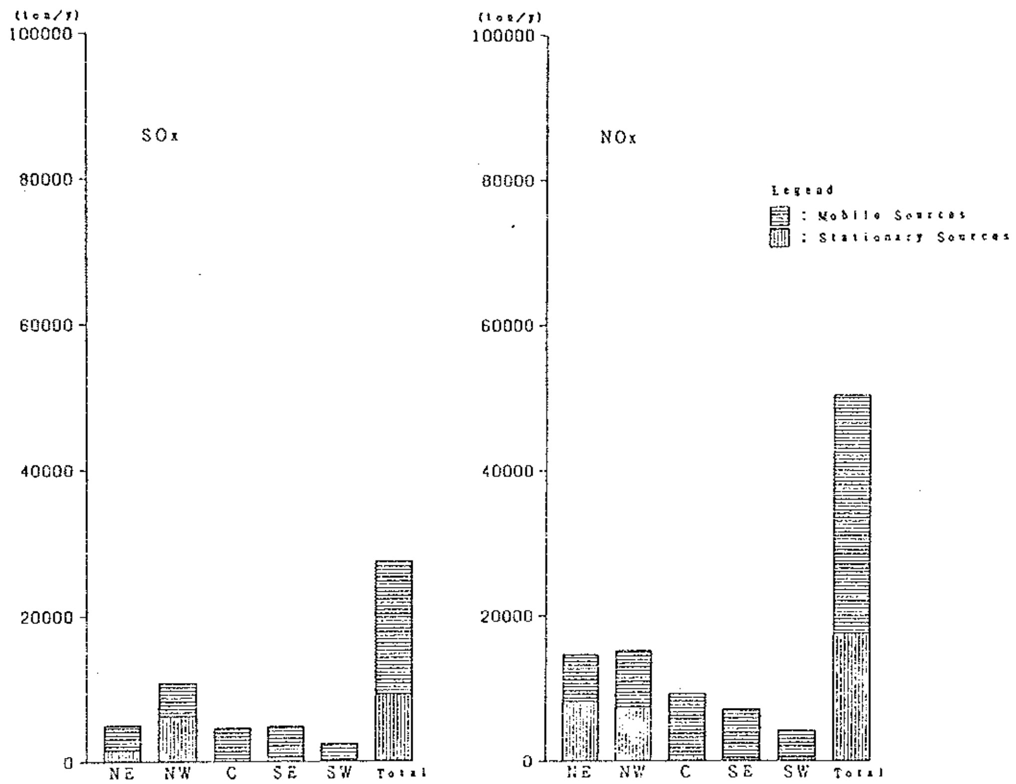


Figure 5.4.3 Pollutant Emission Quantity by Region
(2001: after implementation of long-term measures)

Table 5.4.4 Pollutant Emission Quantity by Source (2001: with long-term measures)

Classification	Pollutant Sources		SOx	CO	NOx	Smoke and Soot
			(Nm³/h) (ton/y)			(kg/h) (ton/y)
Stationary Sources	Factories	Power Plant	1194.2(43.8) 29889.2	-(-) -	684.0(20.0) 12304.1	90.9(22.8) 796.3
		18 De Marzo Refinery	115.1(4.2) 2880.5	- -(-)	189.0(5.5) 3400.1	77.8(19.5) 681.9
		10 Major Factories	350.4(12.9) 8769.9	- -	69.9(2.0) 1257.6	39.9(10.0) 349.2
		Other Factories	231.3(8.5) 5789.0	-(-) -	202.0(5.9) 3633.5	151.0(37.8) 1322.3
		Factries Total	1891.0(69.4) 47328.6 (57.0)	-(-) - (-)	1144.9(33.5) 20595.3 (88.0)	359.6(90.0) 3149.7 (79.7)
	Service and Commercial Establishments		108.6(4.0) 2719.6	-(-) -	50.9(1.5) 916.3	39.9(10.0) 349.8
	Stationary Sources Total		1999.6(73.4) 50048.2 (57.4)	-(-) - (-)	1195.8(35.0) 21511.6 (88.5)	399.5(100.) 3499.5 (81.3)
Mobile Sources	Automobiles	Major Roads	320.7(11.8) 8025.3	37978(48.3) 415859	1071.5(31.4) 19274.6	-(-) -
		Narrower Roads	402.9(14.8) 10083.7	40609(51.7) 444292	1137.1(33.3) 20454.6	-(-) -
		Automobiles Total	723.6(26.6) 18109.0 (100.)	78553(100.) 860151 (81.9)	2208.4(64.7) 39727.9 (96.3)	-(-) - (-)
	Airplanes	Climb Approach/Landing	0.3(0.0) 8.5	-(-) -	3.2(0.1) 57.2	-(-) -
		Idling/Taxing Take-off	0.8(0.0) 19.3	-(-) -	7.3(0.2) 132.2	-(-) -
		Airplanes Total	1.1(0.0) 27.8 (100.)	-(-) - (-)	10.5(0.3) 189.4 (100.)	-(-) - (-)
	Mobile sources Total		724.7(26.6) 18136.8 (100.)	78553(100.) 860151 (81.9)	2218.9(65.0) 39917.3 (96.3)	-(-) - (-)
Total			2724.3(100.) 68185.0 (64.8)	78553(100.) 860151 (81.9)	3414.7(100.) 61428.9 (93.4)	399.5(100.) 3499.5 (81.3)

Note: Figure within the parentheses on the right indicates the ratio (%) to the total, and that below indicates ratio (%) to the present quantity.

(3) Summary

The change in pollutant emission quantity by year is shown in Figure 5.4.4. Reduction of the SOx emission from the stationary sources is remarkable.

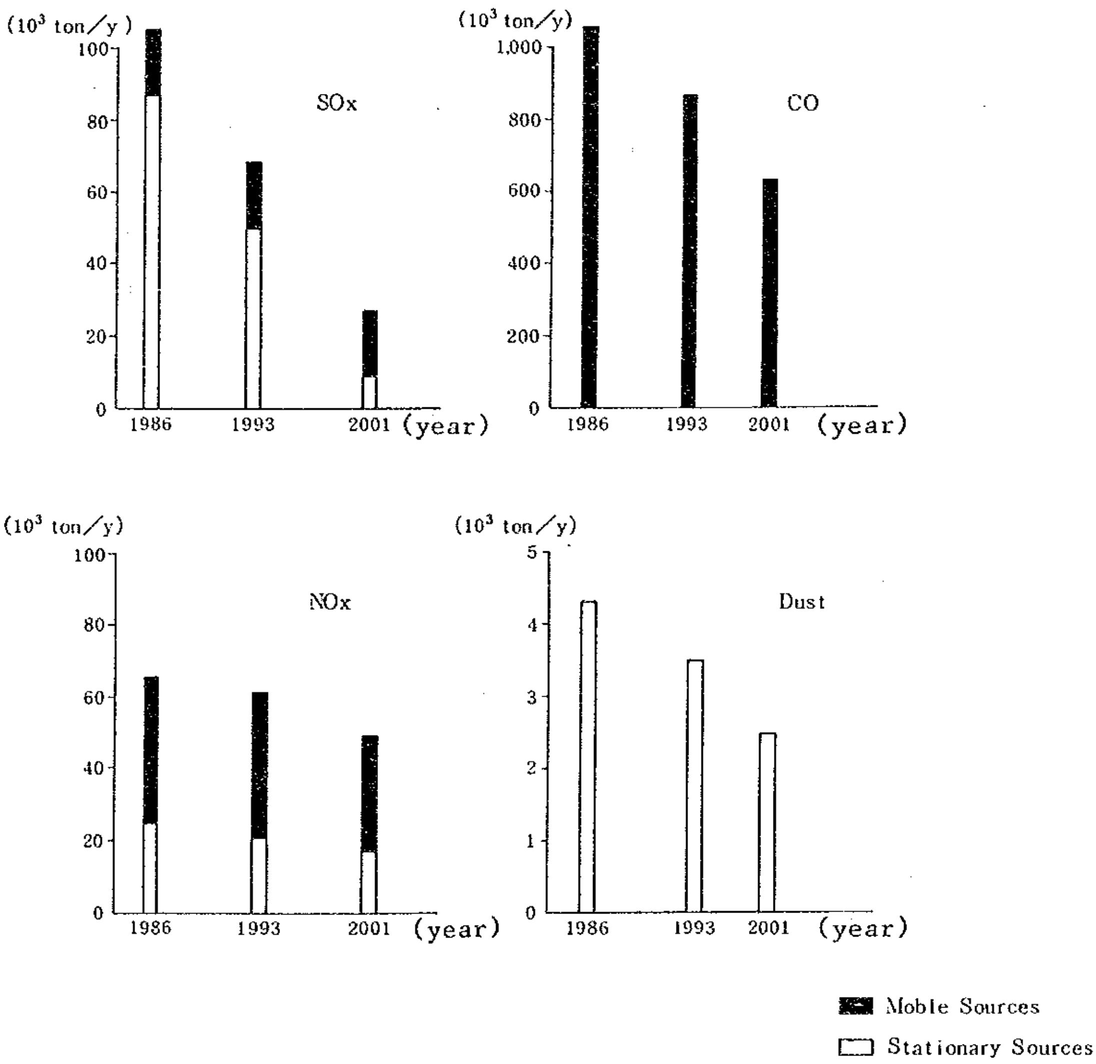


Figure 5.4.4 Pollutant Emission Quantity by Year

5.5 Computation and Evaluation of Ambient Air Quality Corresponding to Implementation of Control Measures

5.5.1 Targets in Ambient Air Quality

(1) Determination of Target Concentration

The annual average concentration of pollutants which corresponds to the ambient air quality standard was determined on the basis of the measurement data of the SEDUE stations for SOx and CO. This annual average concentration was regarded as the target concentration.

The method to determine the target value consists of two steps, i.e., 1) determination of the correlation between the 98% value of daily averge (98% value of the 8-hour average for CO) and the annual average by linear regression equation, and 2) determination of the target value in the annual average corresponding to the ambient air quality standard value using the regression line. Namely, it was assumed that the probability of achieving the standard value is high if the annual average is less than the target value.

Table 5.5.1 summarizes the result of above regression line for SO_2 and CO and the target concentration values thus obtained. Figure 5.5.1 shows the scatter diagram and the regression line for the 98%-values of daily average and the annual average values for SO_2. And Figure 5.5.2 shows similarly for CO.

The number of measuring stations considered in this analysis were 14 for SO_2 excluding ENEP ACATLAN, and all the 15 stations for CO .

Table 5.5.1 Regression Line and Target Concentration Value

Item	Regression equation	No. of points	Correlation coefficient	Air quality standard	Target concentration
SO_2	Y = 0.017 + 0.283X	14	0.828	0.13 ppm Daily average	0.054 ppm Annual average
CO	Y = 0.891 + 0.319X	15	0.888	13 ppm 8-hour average	5.0 ppm Annual average

Note: Y: annual average concentration (ppm)
X: 98% value of daily average concentration for SO_2 (ppm)
A 98% value means, for example, the 98th value among 100 values when aligned from the lowest to the highest.

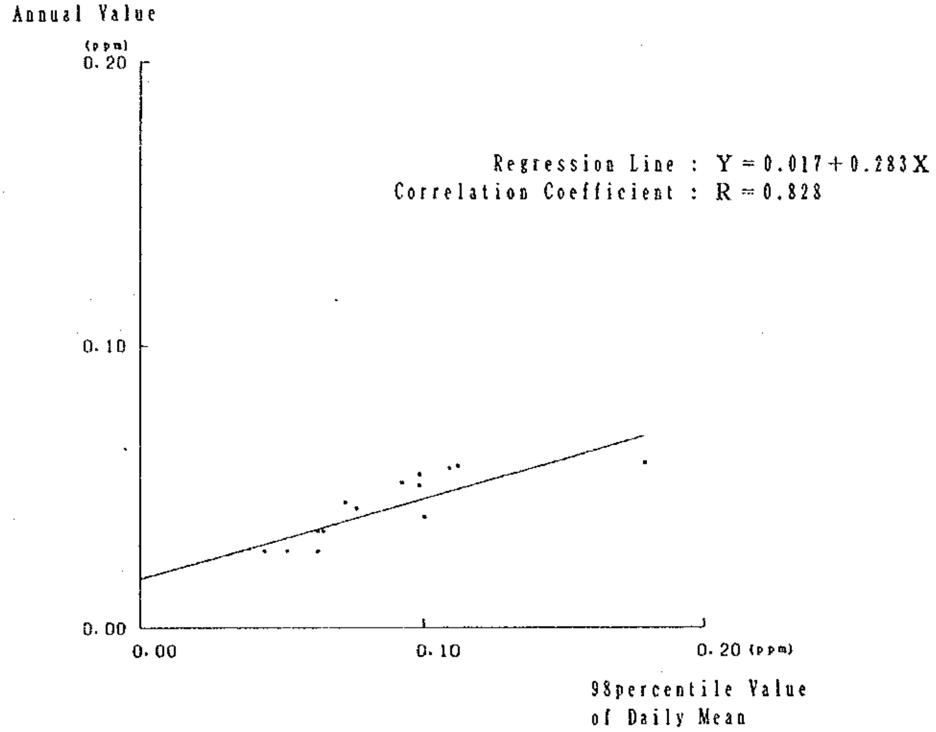


Figure 5.5.1 Scatter Diagram of SO_2 98%-Value of Daily Average and the Annual Average

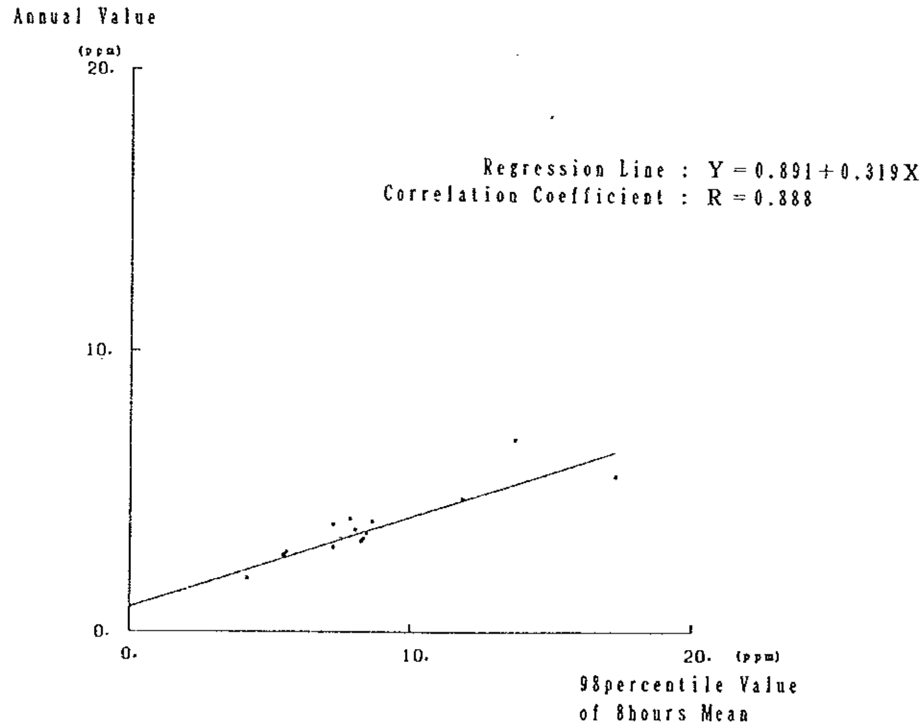


Figure 5.5.2 Scatter Diagram of CO 98%-Value of 8-hour Average and Annual Average

(2) Areas Exceeding Target Concentration

1) SO_2

Areas where the target value of 0.054 ppm (54 ppb) for SO_2 is exceeded at the present are shown with concentration isopleths in Figure 5.5.3. The area around DELEGACION CUAUHTEMOC, the area to the east of DELEGACION IZTACALCO and to the north of IZTAPALAPA, and the area from TLALNEPANTLA to TULTITLAN failed to achieve the target concentration.

2) CO

Figure 5.5.4 shows the unit areas where the target concentration of 5.0 ppm for CO is exceeded at certain points.

The areas exceeding the target CO concentration are distributed inside DF.

Unit: ppb

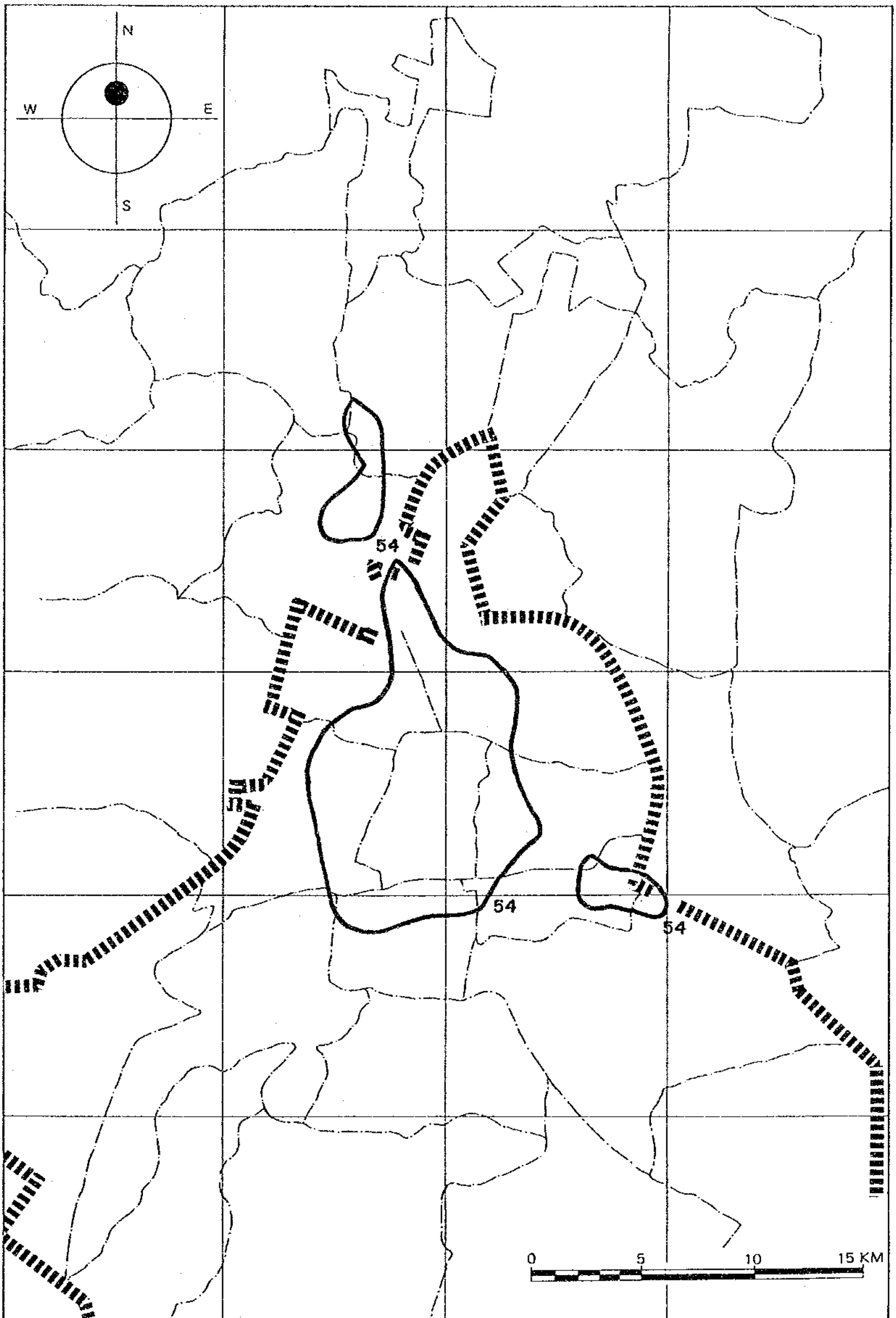


Figure 5.5.3 Area Exceeding Target SO_2 Concentration (54ppb in Annual Average)

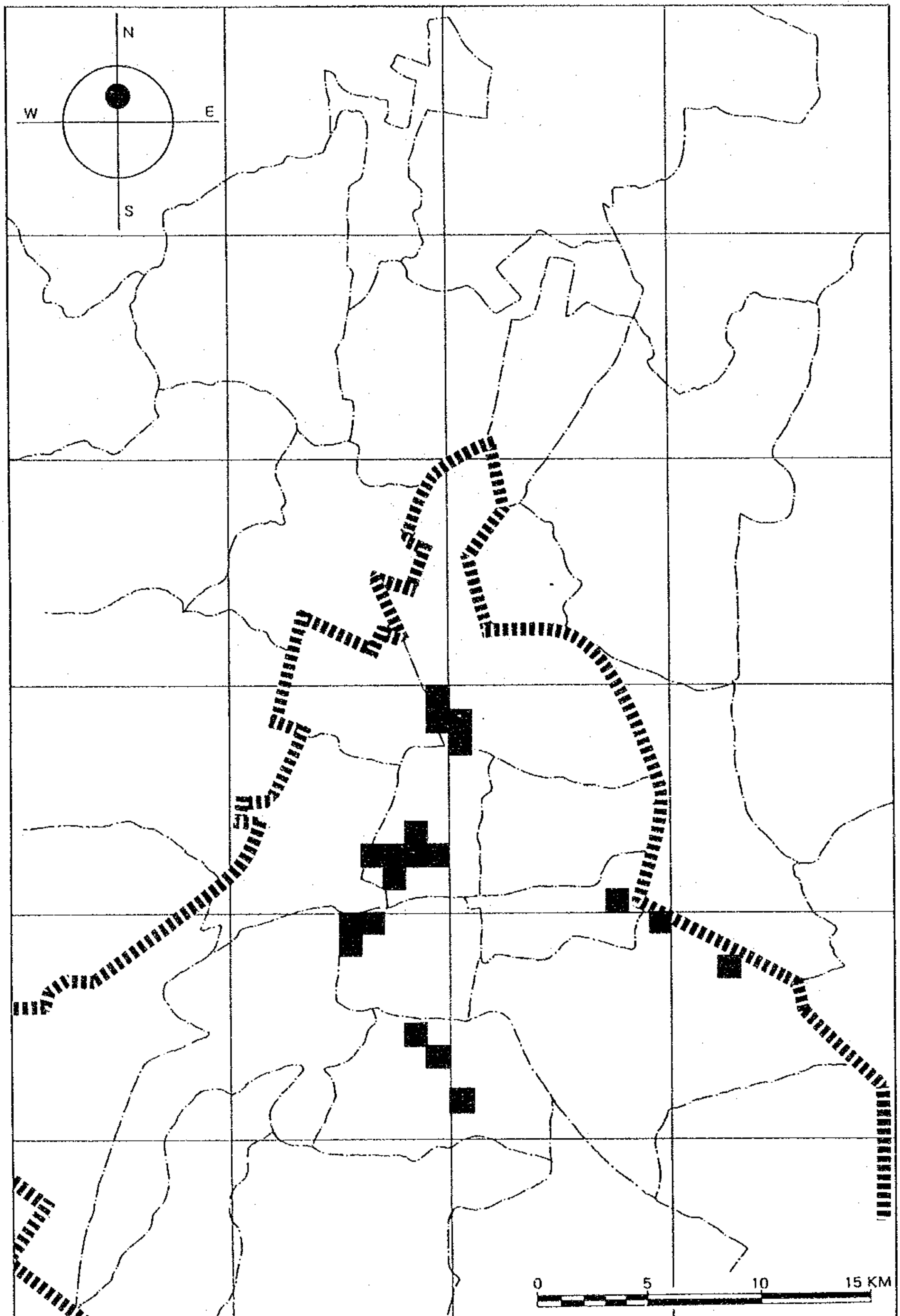


Figure 5.5.4 Areas Exceeding Target CO Concentration (5.0ppm in Annual Average)

5.5.2 Ambient Air Quality Corresponding to Implementation of Control Measures

(1) Short-term Measures

1) SO_2

Distribution of the annual average concentration of SO_2 after implementation of the short-term measures is shown in Figure 5.5.5. It was assumed in the computation that the background concentration remains unchanged from the present.

The concentration distribution shows that the areas with the 54 ppb concentration isopleth, though limited, exist in DELEGACION CUAUHTEMOC and to the east of DELEGACION IZTACALCO. The C_{max} point with the concentration of 90.9 ppb appears at the same location as the present.

Unit areas with concentration exceeding 54 ppb, though not shown by concentration isopleth, are found in the south-eastern region.

The contribution to SO_2 concentration by source for the receptors and the C_{max} point is as shown in Figure 5.5.6 and Table 5.5.2. The annual average concentration at all receptors excluding the C_{max} point is less than the target value of 54 ppb, and thus the air quality standard can be achieved.

Contribution of stationary sources to the annual average concentration of SO_2 is shown in Figure 5.5.7. The C_{max} point with the concentration of 44.7 ppb appears at the east end of CUAUTITLAN of the State of Mexico.

■ Area exceeding 54 ppb ✕ Cmax point Unit: ppb

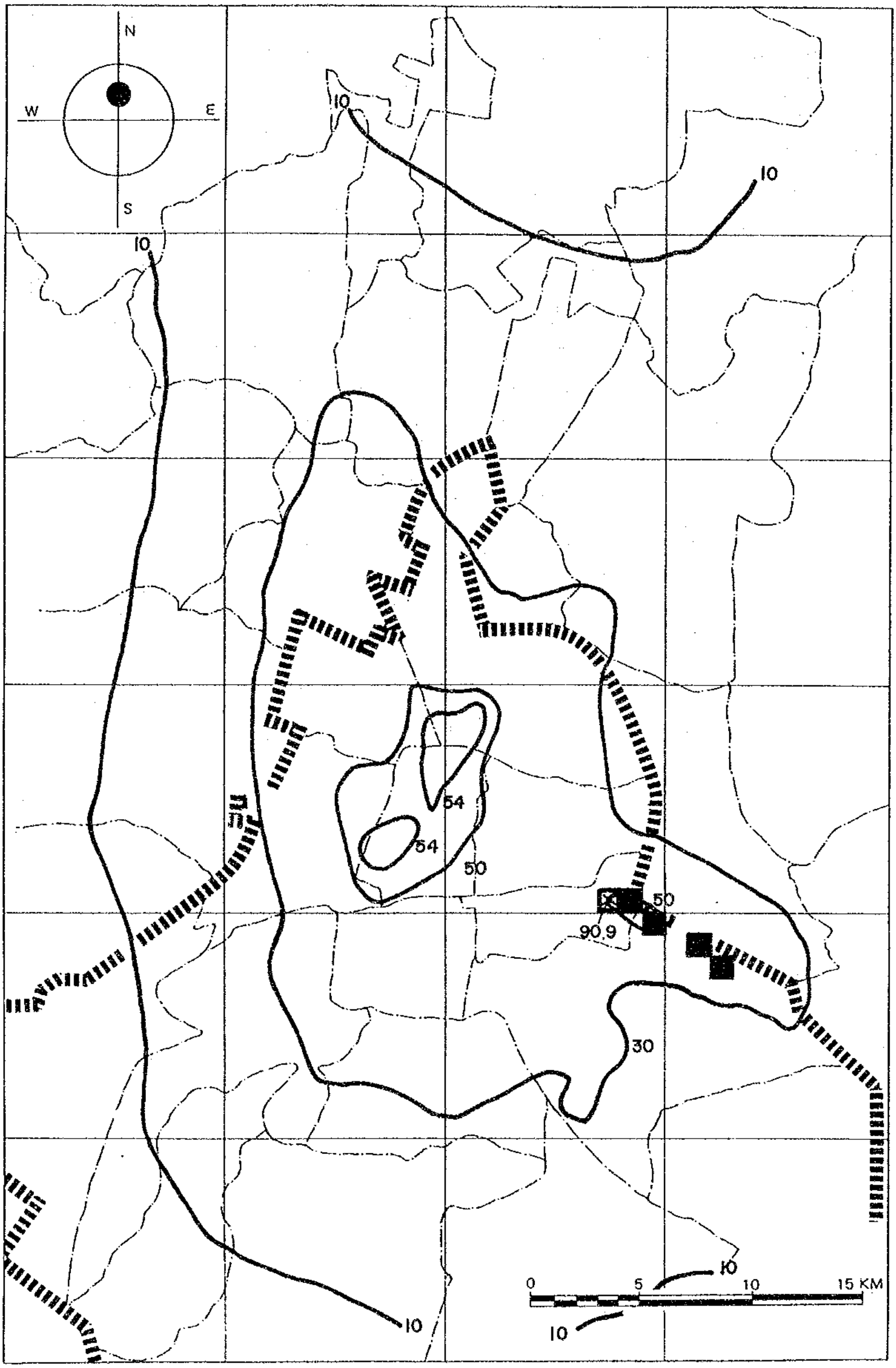


Figure 5.5.5. Annual Average Concentration Isopleths of SO_2
- 1993, With Short-term Control Measures -

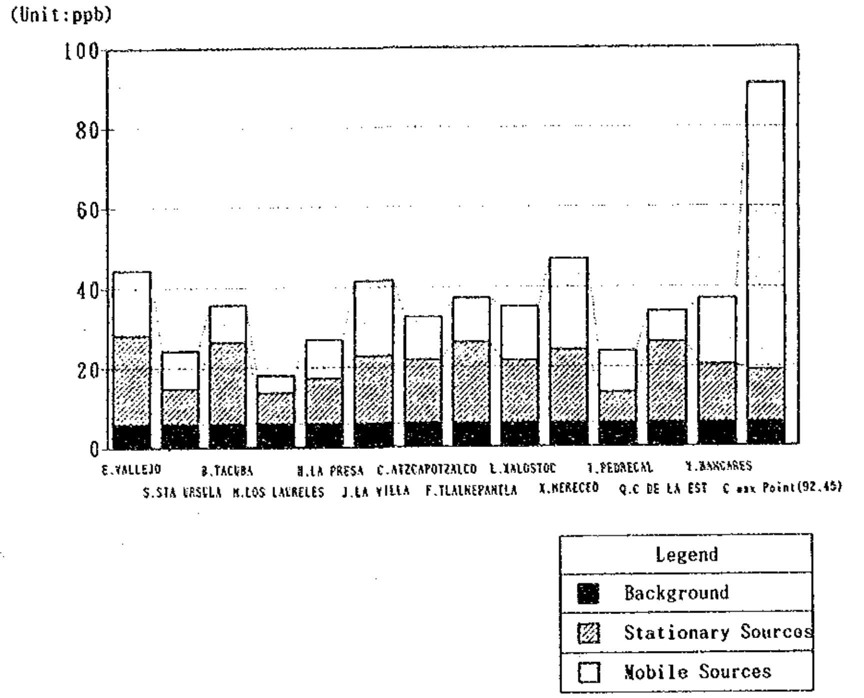


Figure 5.5.6 Contribution of Sources to SO_2 Concentration (1993: After the short-term measures)

Table 5.5.2 Contribution of Sources to SO_2 Concentration (1993: After the short-term measures)

Unit: ppb, (%)

Receptor	Total	Stationary Sources	Mobile Sources	Background
E. VALLEJO	44.46	22.28(50.1)	16.31(36.7)	5.87(13.2)
S. STA URSULA	24.27	8.88(36.6)	9.52(39.2)	5.87(24.2)
B. TACUBA	35.61	20.53(57.7)	9.21(25.9)	5.87(16.5)
M. LOS LAURELES	17.97	7.89(43.9)	4.21(23.4)	5.87(32.7)
H. LA PRESA	27.03	11.51(42.6)	9.65(35.7)	5.87(21.7)
J. LA VILLA	41.56	16.97(40.8)	18.72(45.0)	5.87(14.1)
C. ATZCAPOTZALCO	32.50	16.06(49.4)	10.58(32.6)	5.87(18.1)
F. TLALNEPANTLA	37.25	20.31(54.5)	11.07(29.7)	5.87(15.8)
L. XALOSTOC	35.15	15.75(44.8)	13.53(38.5)	5.87(16.7)
X. MERCED	47.05	18.47(39.3)	22.72(48.3)	5.87(12.5)
T. PEDREGAL	23.93	7.58(31.7)	10.48(43.8)	5.87(24.5)
Q. C DE LA EST	33.99	20.20(59.4)	7.93(23.3)	5.87(17.3)
Y. HANGARES	37.06	14.56(39.3)	16.62(44.8)	5.87(15.8)
C max Point(92, 45)	90.93	13.26(14.6)	71.80(79.0)	5.87(6.5)

× Cmax point Unit: ppb

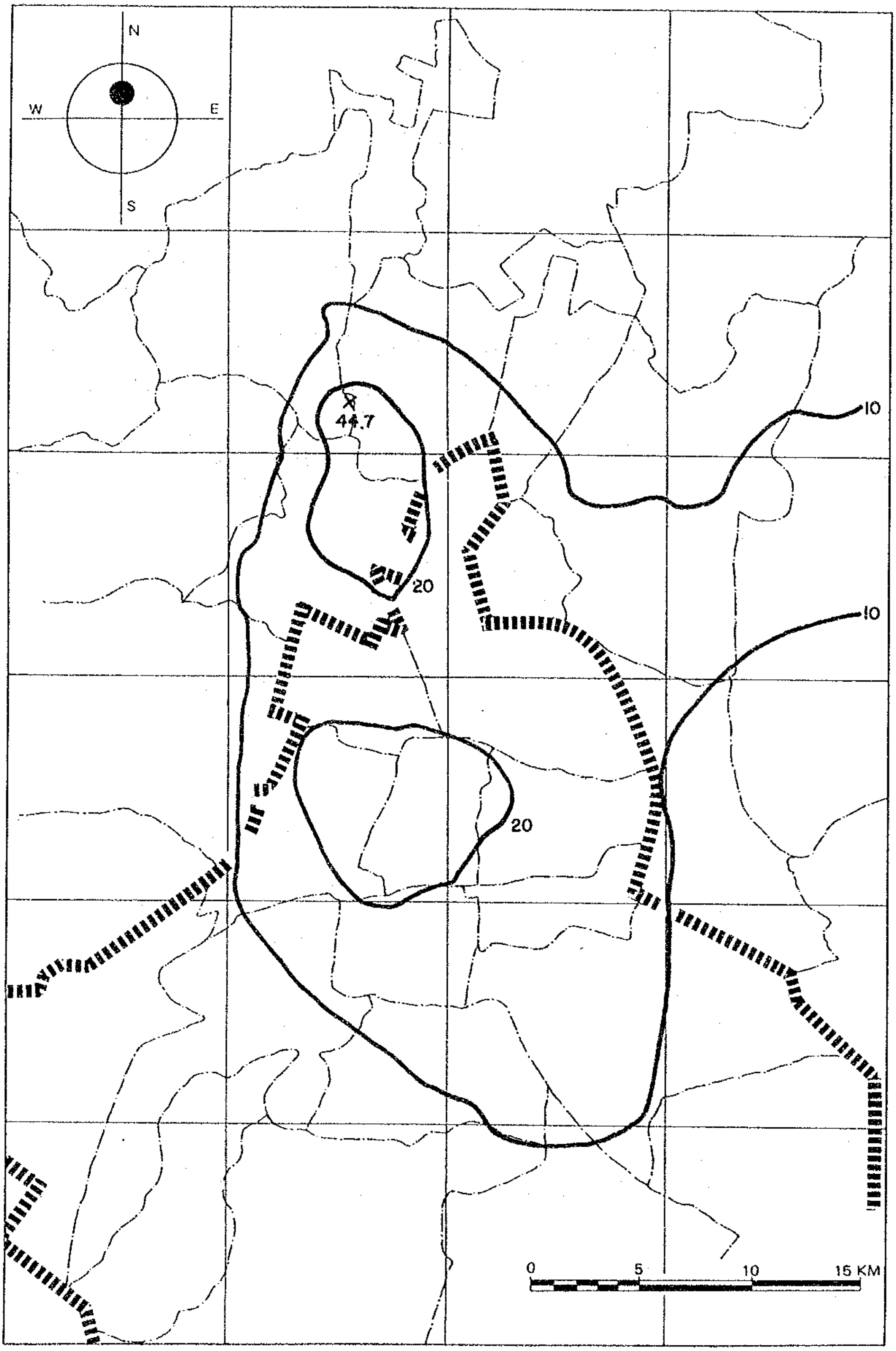


Figure 5.5.7 Contribution of Stationary Sources to Annual Average Concentration of SO_2 - 1993, With Short-term Control Measures -

2) CO

Distribution of the annual average concentration of CO after implementation of the short-term measures is shown in Figure 5.5.8. It was assumed as in the case of SO_2 that the background concentration remains unchanged from the present. Number of unit areas exceeding 5.0 ppm could be reduced by 17 from the present. Only two areas, to the east of DELEGACION IZTACALCO and to the north of IZTAPALAPA, remained.

The C_{max} point appears in the area to the east of IZTACALCO and its concentration is 5.31 ppm. The annual average concentration at the receptors and the C_{max} point is shown in Table 5.5.3. The annual average concentration is less than the target value of 5.0 ppm at the receptors excluding INSURGENTES and the C_{max} point, and thus the air quality standard can be mostly achieved.

Table 5.5.3 Annual Average Concentration of CO (1993: after the short-term measures) Unit: ppm

Receptor	Total	Automobile	Background
Z. LAGUNILLA	3.27	2.09	1.18
F. TLALNEPANTLA	2.21	1.03	
L. XALOSTOC	2.48	1.30	
X. MERCED	3.64	2.46	
T. PEDREGAL	2.06	0.88	
Q. C. DE LA EST.	2.32	1.14	
U. PLATEROS	3.10	1.92	
P. UAM-IZTAPALAPA	2.53	1.35	
K. ARAGON	2.29	1.11	
O. NEZAHUALCOYOTL	2.95	1.77	
D. IMP	2.96	1.78	
W. BENITO JUAREZ	3.77	2.59	
R. TASQUEÑA	3.81	2.63	
V. INSURGENTES	5.76	4.58	
A. CUITLAHUAC	4.40	3.22	
Cmax Point(94, 44)	5.31	4.13	

■ Area exceeding 5.0 ppm   ✕ Cmax point   Unit: ppm

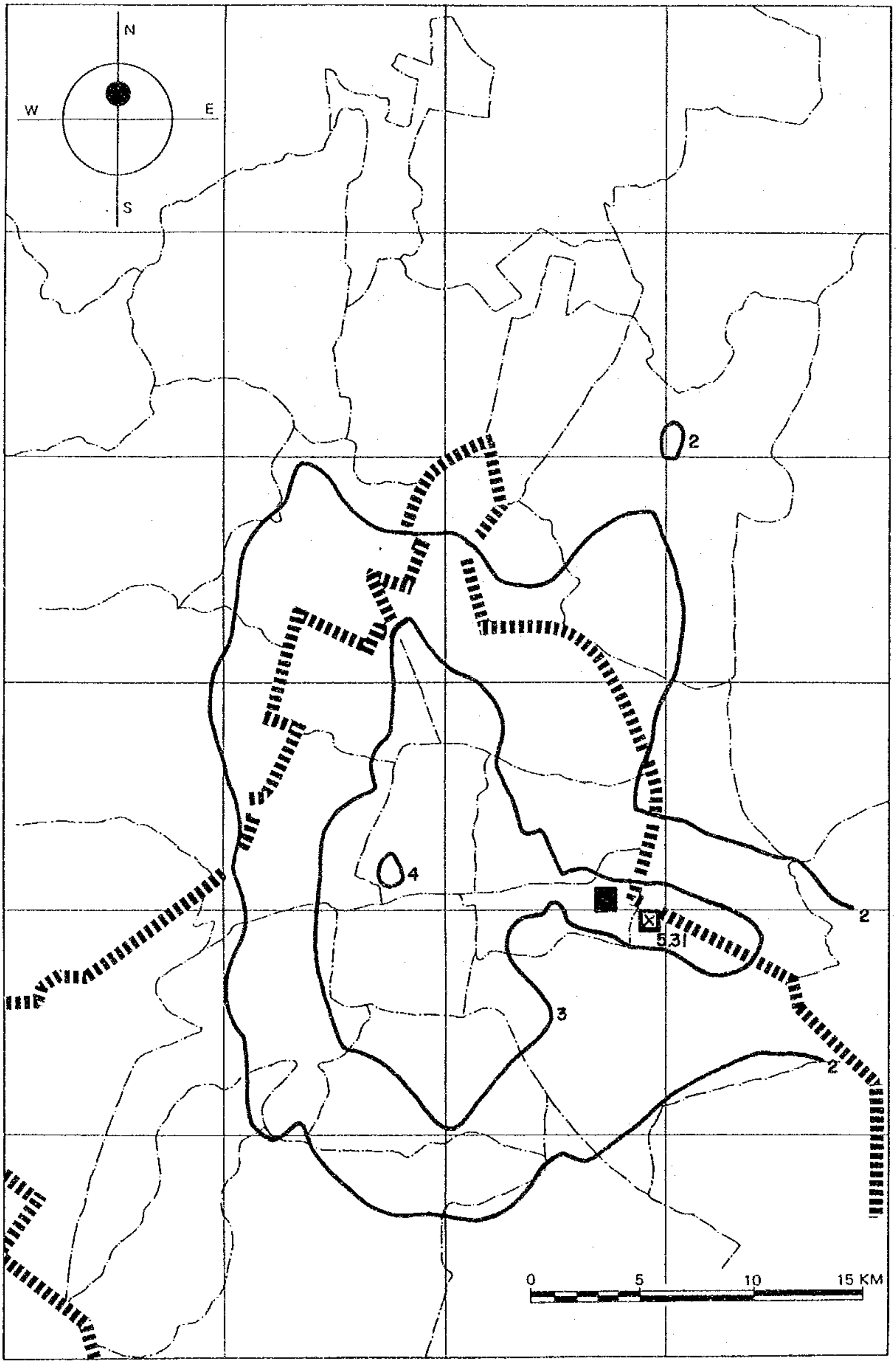


Figure 5.5.8 Annual Average Concentration Isopleths of CO
- 1993, With Short-term Control Measures -

3) NO_2

Computation for NO_2 was made only for reference. Distribution of the annual average concentration of NO_2 after the implementation of the short-term measures is shown in Figure 5.5.9.

Contribution of each type of source to the concentration at the receptors and the C_{max} point is shown in Figure 5.5.10 and Table 5.5.4.

Contribution of stationary sources to the annual average concentration distribution is shown in Figure 5.5.11, and that of mobile sources in Figure 5.5.12.

× Cmax Point Unit: ppb

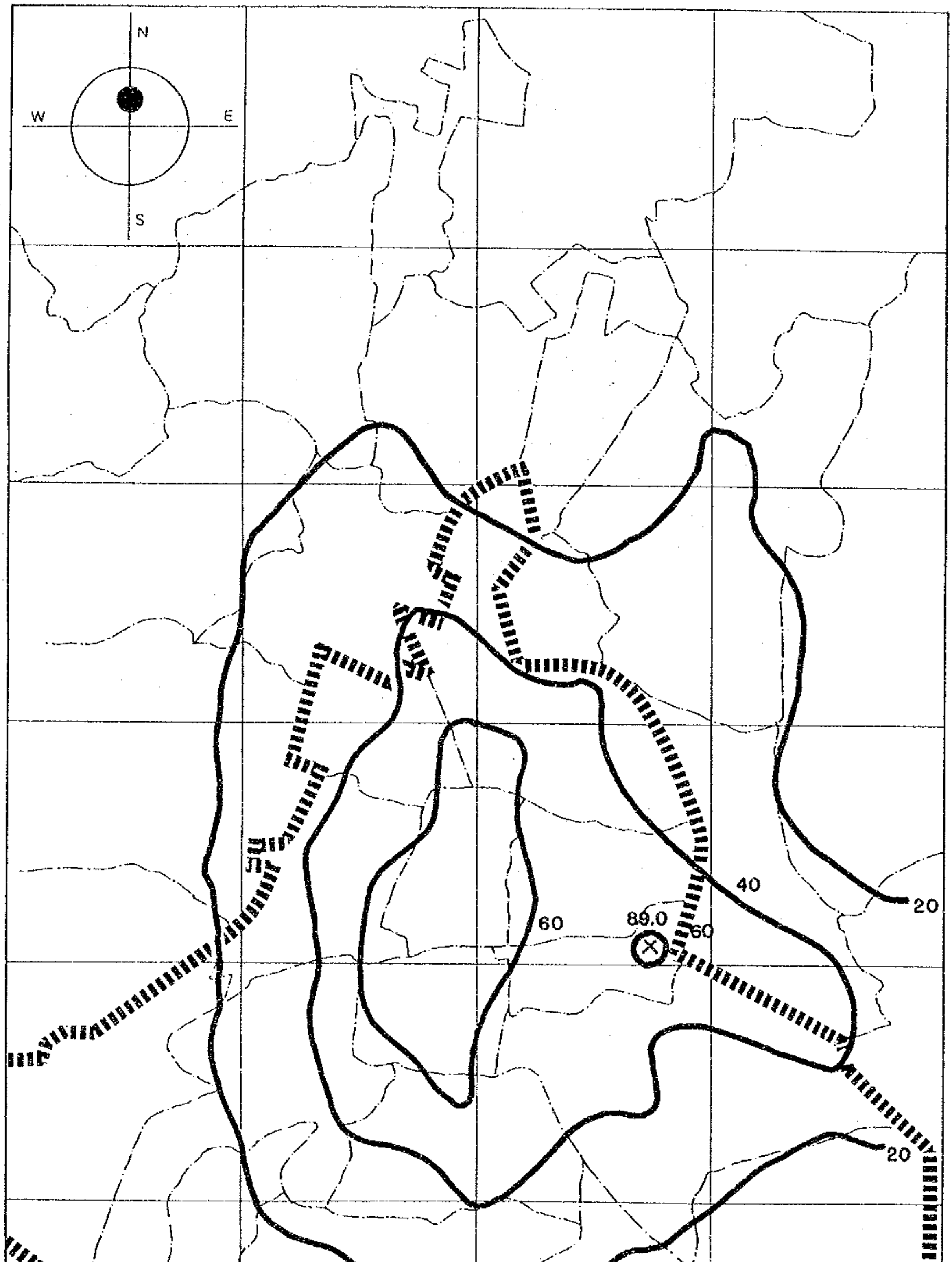


Figure 5.5.9 Annual Average Concentration Isopleth of NO_2
- 1993, With Short-term Control Measures -

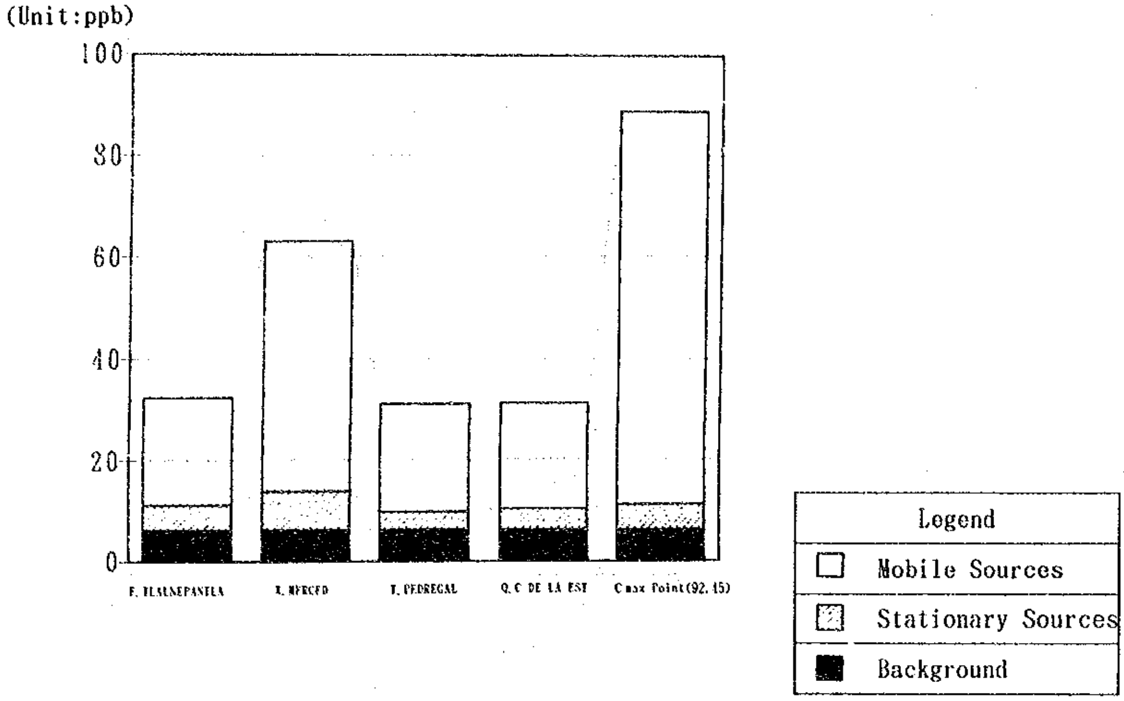


Figure 5.5.10 Contribution of Sources to NO_2 Concentration (1993: After the short-term measures)

Table 5.5.4 Contribution of Sources of NO_2 Concentration (1993: After the short-term measures)

Unit: ppb, (%)

Receptor	Total	Stationary Sources	Mobile Sources	Background
F. TLALNEPANTLA	32.15	5.18(16.1)	20.91(65.0)	6.06(18.8)
X. MERCED	63.08	7.61(12.1)	49.40(78.3)	6.06(9.6)
T. PEDREGAL	31.00	3.47(11.2)	21.47(69.3)	6.06(19.5)
Q.C DE LA EST	31.23	4.12(13.2)	21.06(67.4)	6.06(19.4)
Cmax Point(92,45)	89.04	5.07(5.7)	77.92(87.5)	6.06(6.8)

× Cmax Point Unit: ppb

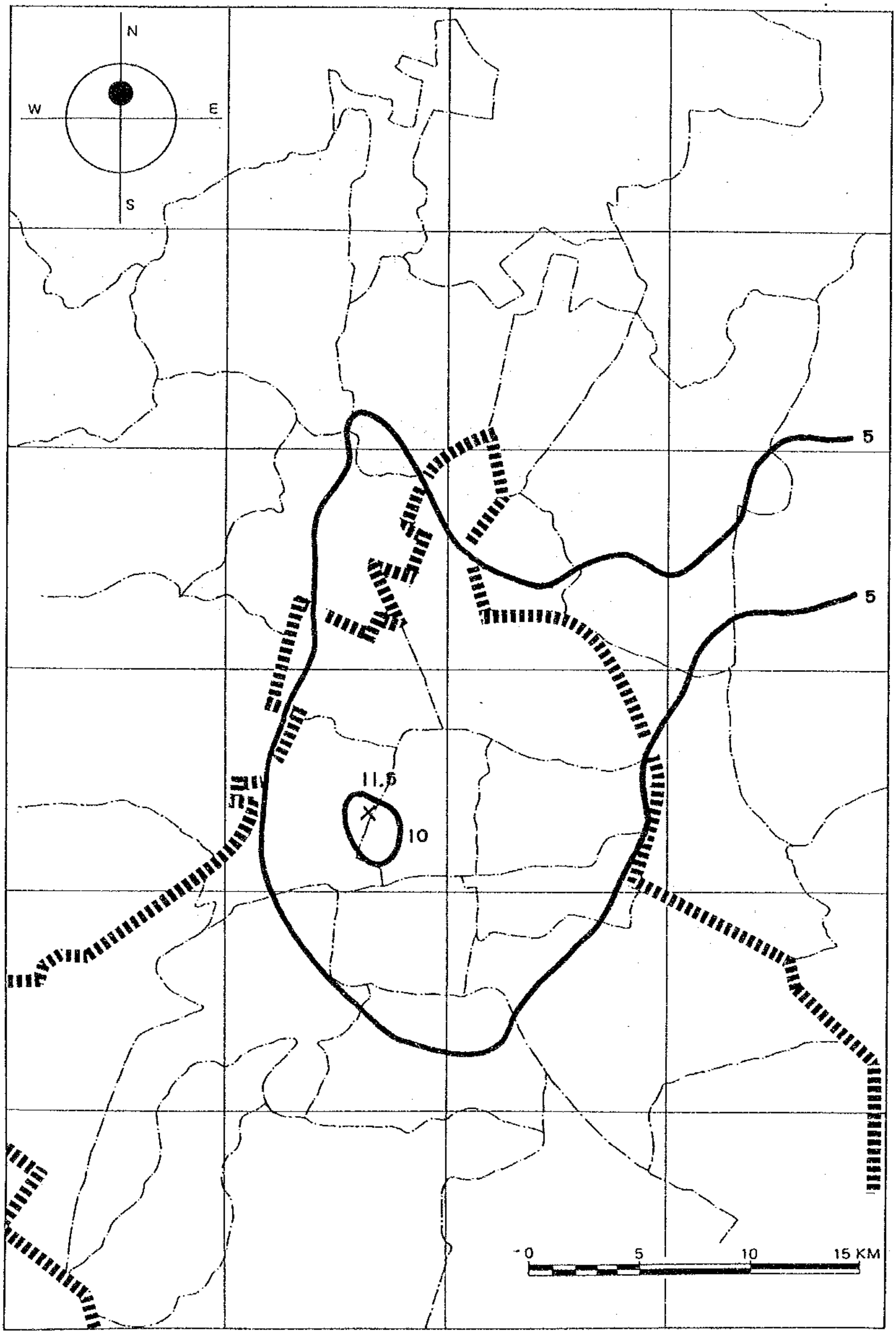


Figure 5.5.11 Contribution of Stationary Sources to Annual Average Concentration of NO_2
- 1993, With Short-term Control Measures -

X Cmax Point Unit: ppb

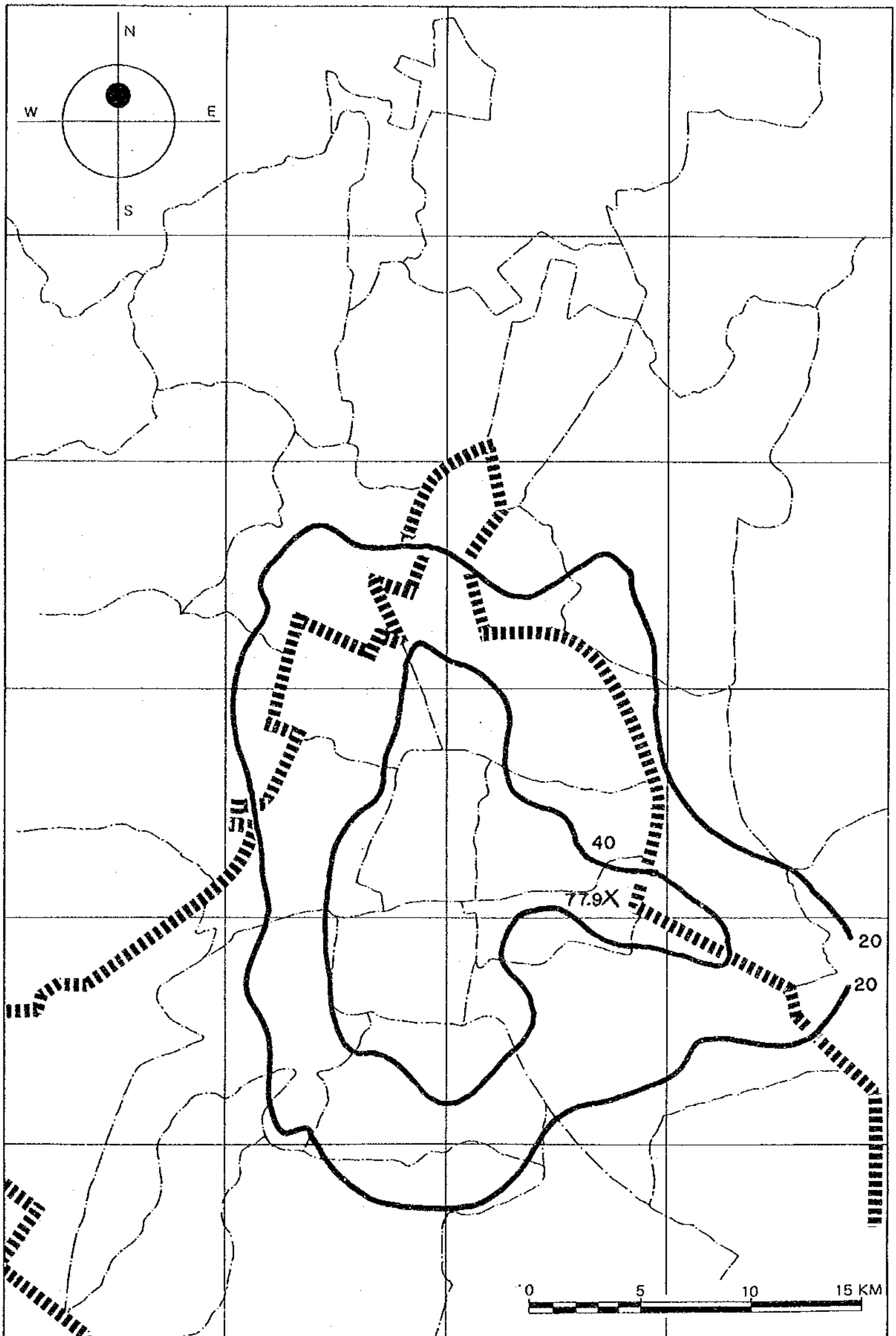


Figure 5.5.12 Contribution of Mobile Sources to Annual Average Concentration of NO_2
- 1993, With Short-term Control Measures -

(2) Long-term Measures

1) SO_2

Distribution of the annual average concentration of SO_2 after the implementation of the long-term measures is shown in Figure 5.5.13. The background concentration was assumed to be the same as the present.

This concentration distribution shows that the 54 ppb concentration isopleth disappears, but that three unit areas including the C_{max} point to the east of DELEGACION IZTACALCO and to the northeast of IZTAPALAPA exceed 54 ppb. The C_{max} point appears at the same point as the present and the concentration is 80.3 ppb.

The contribution of sources to the concentration at the receptors and the C_{max} point is shown in Figure 5.5.14 and Table 5.5.5, with the annual average concentration decreasing further at the receptors excluding C_{max} point. The contribution of mobile sources at C_{max} point is 71.8 ppb and cannot be reduced below the target concentration with the measures against stationary sources alone. Contribution of stationary sources to the annual average concentration distribution is shown in Figure 5.5.15. The C_{max} point appears in the same location as that with the short-term measures and the concentration is 14.8 ppb.

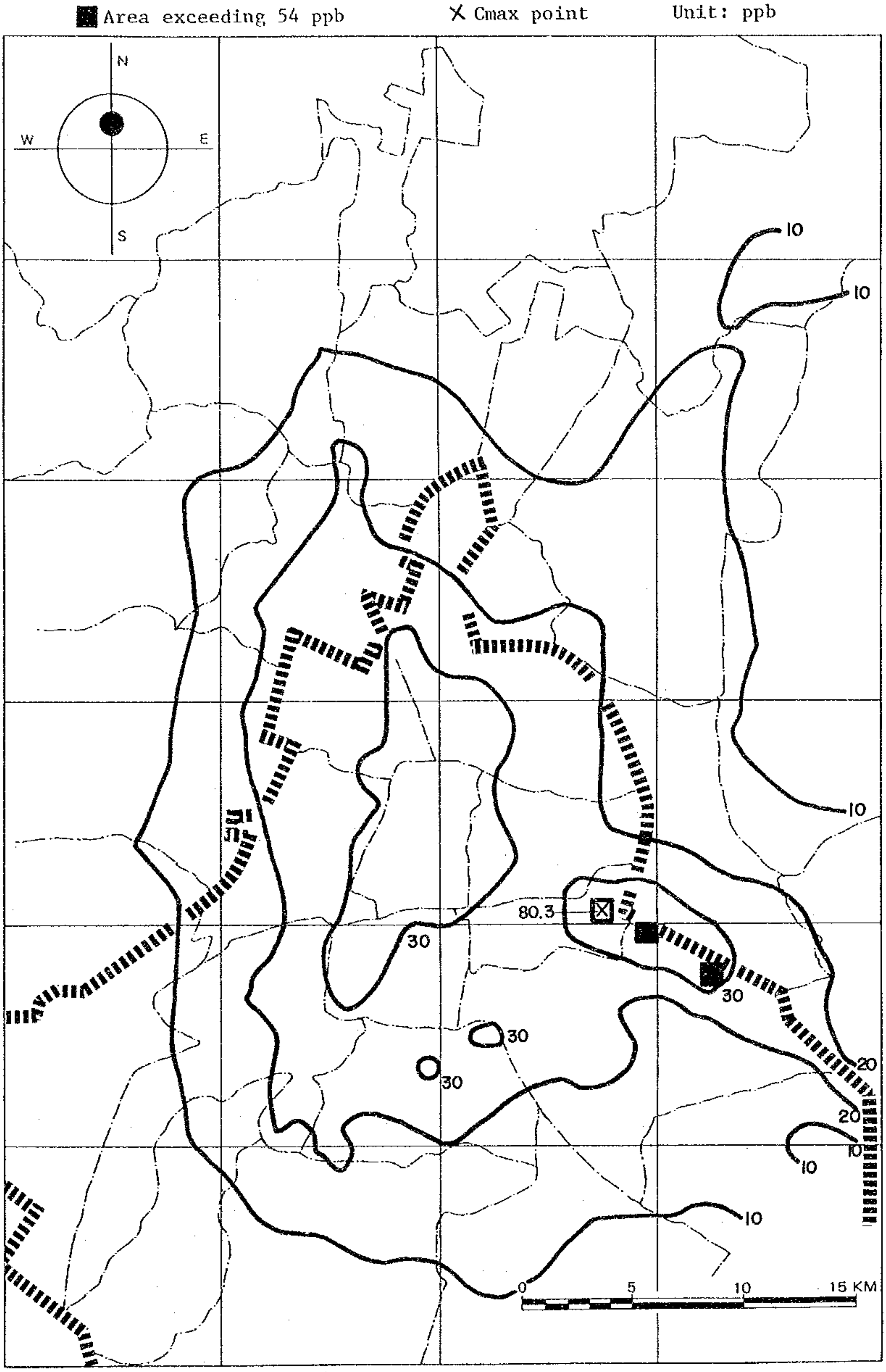


Figure 5.5.13 Annual Average Concentration Isopleths of SO_2
- 2001: With Long-term Control Measures -

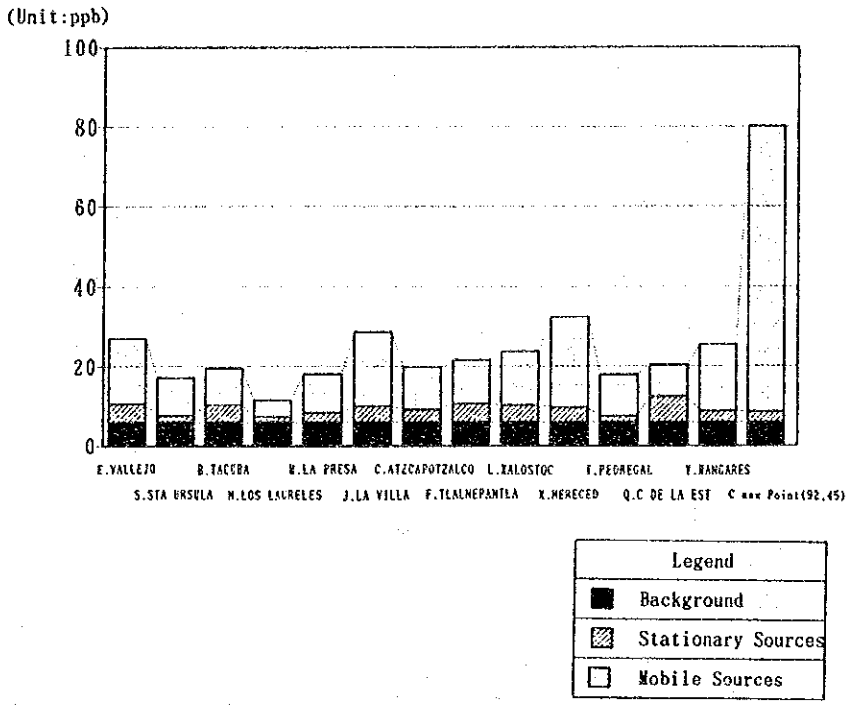


Figure 5.5.14 Contribution of Sources to SO_2 Concentration (2001: After the long-term measures)

Table 5.5.5 Contribution of Sources to SO_2 Concentration (2001: After the long-term measures)

Unit: ppb, (%)

Receptor	Total	Stationary Sources	Mobile Sources	Background
E. VALLEJO	26.95	4.77(17.7)	16.31(60.5)	5.87(21.8)
S. STA URSULA	17.17	1.79(10.4)	9.52(55.4)	5.87(34.2)
B. TACUBA	19.39	4.31(22.2)	9.21(47.5)	5.87(30.3)
M. LOS LAURELES	11.53	1.44(12.5)	4.21(36.5)	5.87(50.9)
H. LA PRESA	18.03	2.52(14.0)	9.65(53.5)	5.87(32.6)
J. LA VILLA	28.59	4.01(14.0)	18.72(65.5)	5.87(20.5)
C. ATZCAPOTZALCO	19.71	3.27(16.6)	10.58(53.7)	5.87(29.8)
F. TLALNEPANTLA	21.72	4.78(22.0)	11.07(51.0)	5.87(27.0)
L. XALOSTOC	23.67	4.26(18.0)	13.53(57.2)	5.87(24.8)
X. MERCED	32.33	3.74(11.6)	22.72(70.3)	5.87(18.2)
T. PEDREGAL	17.94	1.59(8.9)	10.48(58.4)	5.87(32.7)
Q. C DE LA EST	20.28	6.49(32.0)	7.93(39.1)	5.87(28.9)
Y. HANGARES	25.36	2.87(11.3)	16.62(65.5)	5.87(23.1)
C max Point(92,45)	80.27	2.60(3.2)	71.80(89.4)	5.87(7.3)

X Cmax point Unit: ppb

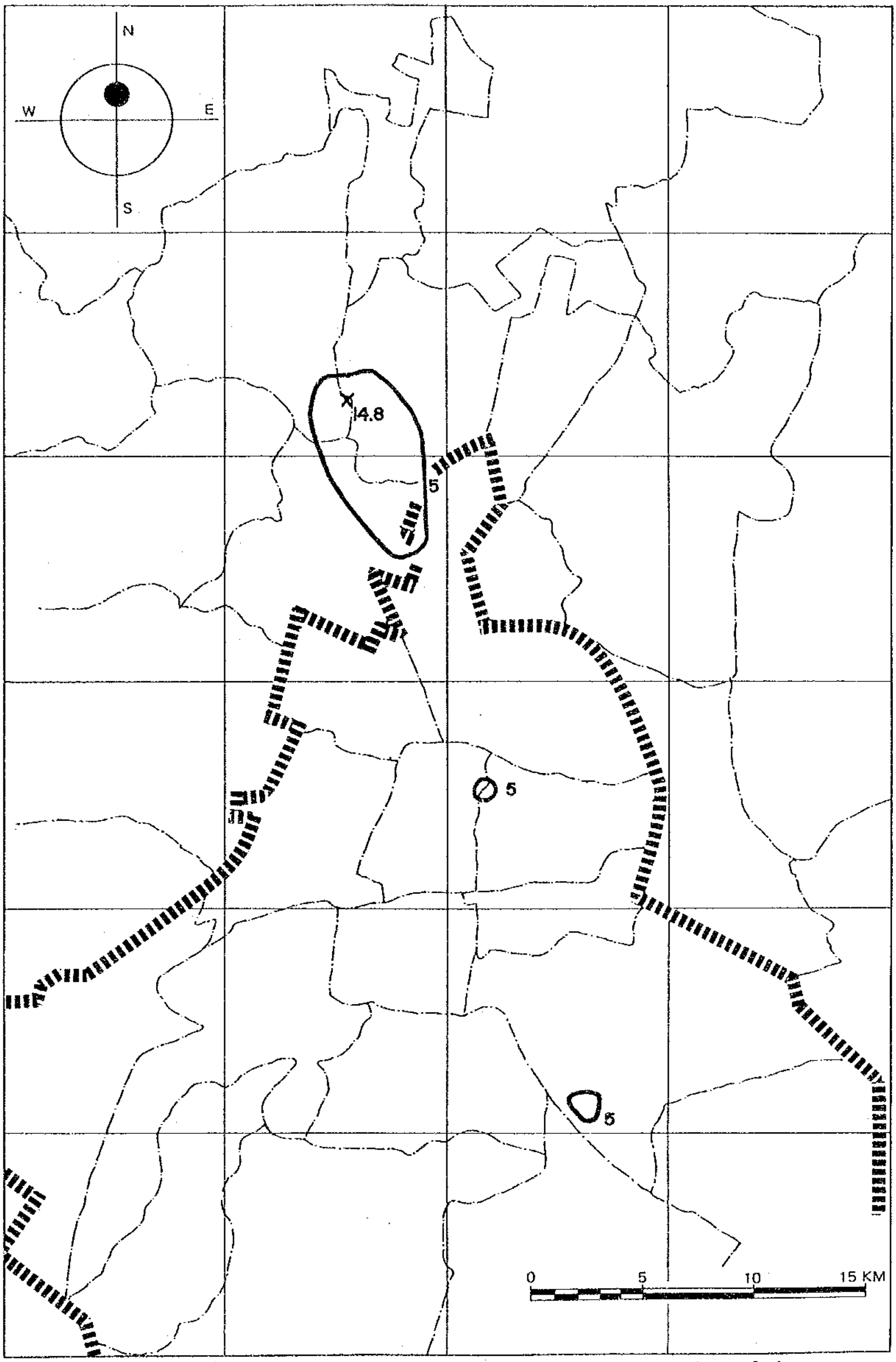


Figure 5.5.15 Contribution of Stationary Sources to Annual Average Concentration of SO_2

- 2001, With Long-term measures -

2) CO

Distribution of the annual average concentration of CO after the implementation of the long-term measures is shown in Figure 5.5.16.

According to this concentration distribution, areas exceeding 5.0 ppm disappear and the air quality standard can be achieved. The C_{max} point appears in the area to the north of IZTAPALAPA and the concentration is 4.29 ppm.

The annual average concentration at the receptors and C_{max} point is shown in Table 5.5.6. The annual average concentration at all the receptors and the C_{max} point is less than the target value of 5.0 ppm.

Table 5.5.6 Annual Average Concentration of CO
(2001: after the long-term measures)

Unit: ppm

Receptor	Total	Automobiles	Background
Z. LAGUNILLA	2.69	1.51	1.18
F. TLALNEPANTLA	1.97	0.79	
L. XALOSTOC	2.10	0.92	
X. MERCED	2.98	1.80	
T. PEDREGAL	1.81	0.63	
Q. C DE LA EST	2.04	0.86	
U. PLATELOS	2.60	1.42	
P. UAM-IZTAPALAPA	2.19	1.01	
K. ARAGON	1.97	0.79	
O. NEXAHUALCOYOTL	2.52	1.34	
D. IMP	2.48	1.30	
W. BENITO JUAREZ	3.01	1.83	
R. TASQUEÑA	3.06	1.88	
V. INSRUGENTES	4.39	3.21	
A. CUITLAHUAC	3.60	2.42	
C_{max} Point(64, 44)	4.29	3.11	

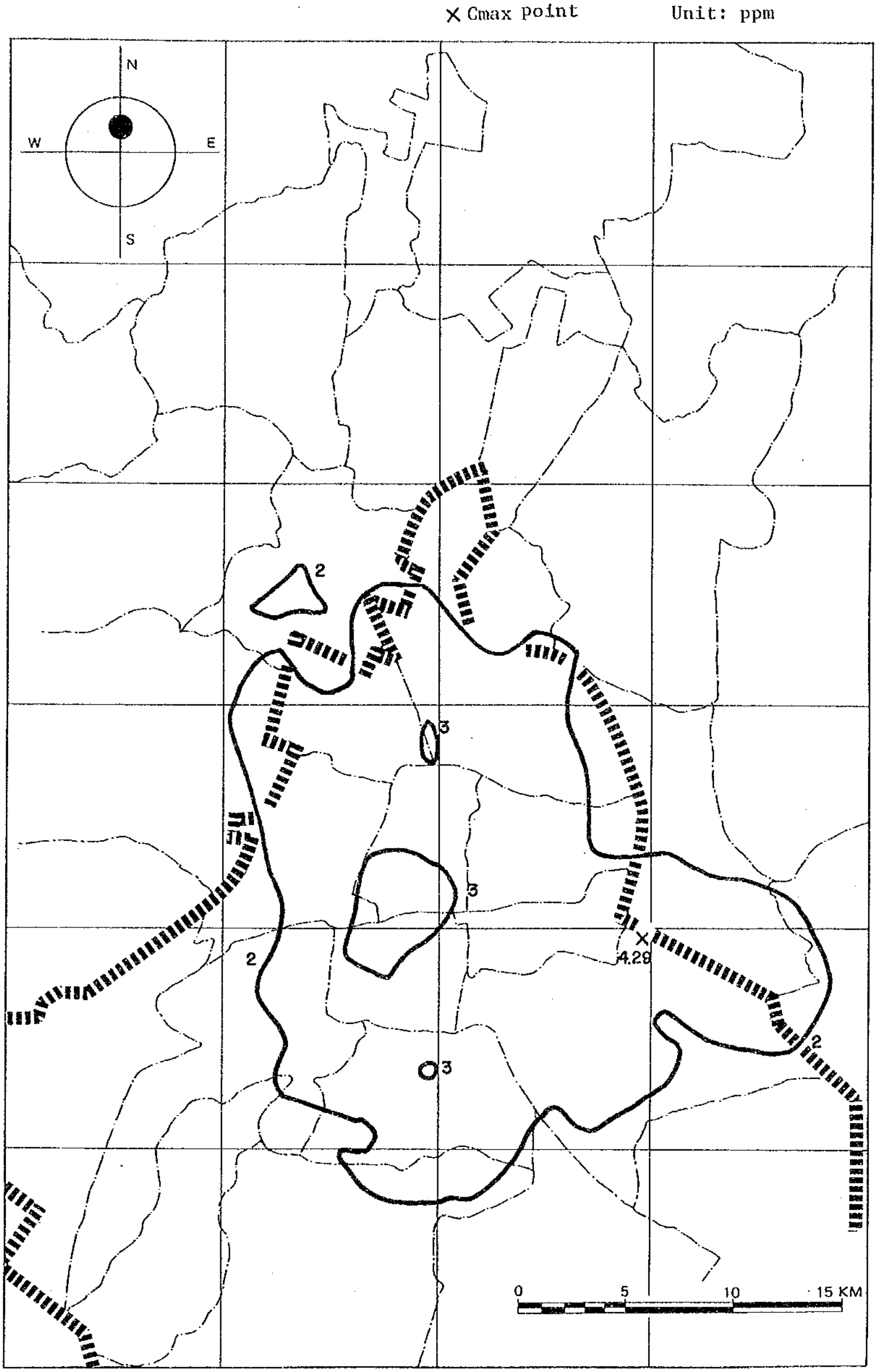


Figure 5.5.16 Annual Average CO Concentration Isopleths of CO
- 2001, With Long-term Measures -

3) NO_2

Distribution of the annual average concentration of NO_2 after the implementation of the long-term measures computed for the reference purpose is shown in Figure 5.5.17.

Contribution of each type of source to the concentration at the receptors and the Cmax point is shown in Figure 5.5.18 and Table 5.5.7.

Contribution of stationary sources to the annual average concentration distribution is shown in Figure 5.5.19, and that of mobile sources in Figure 5.5.20.

× Cmax point Unit: ppm

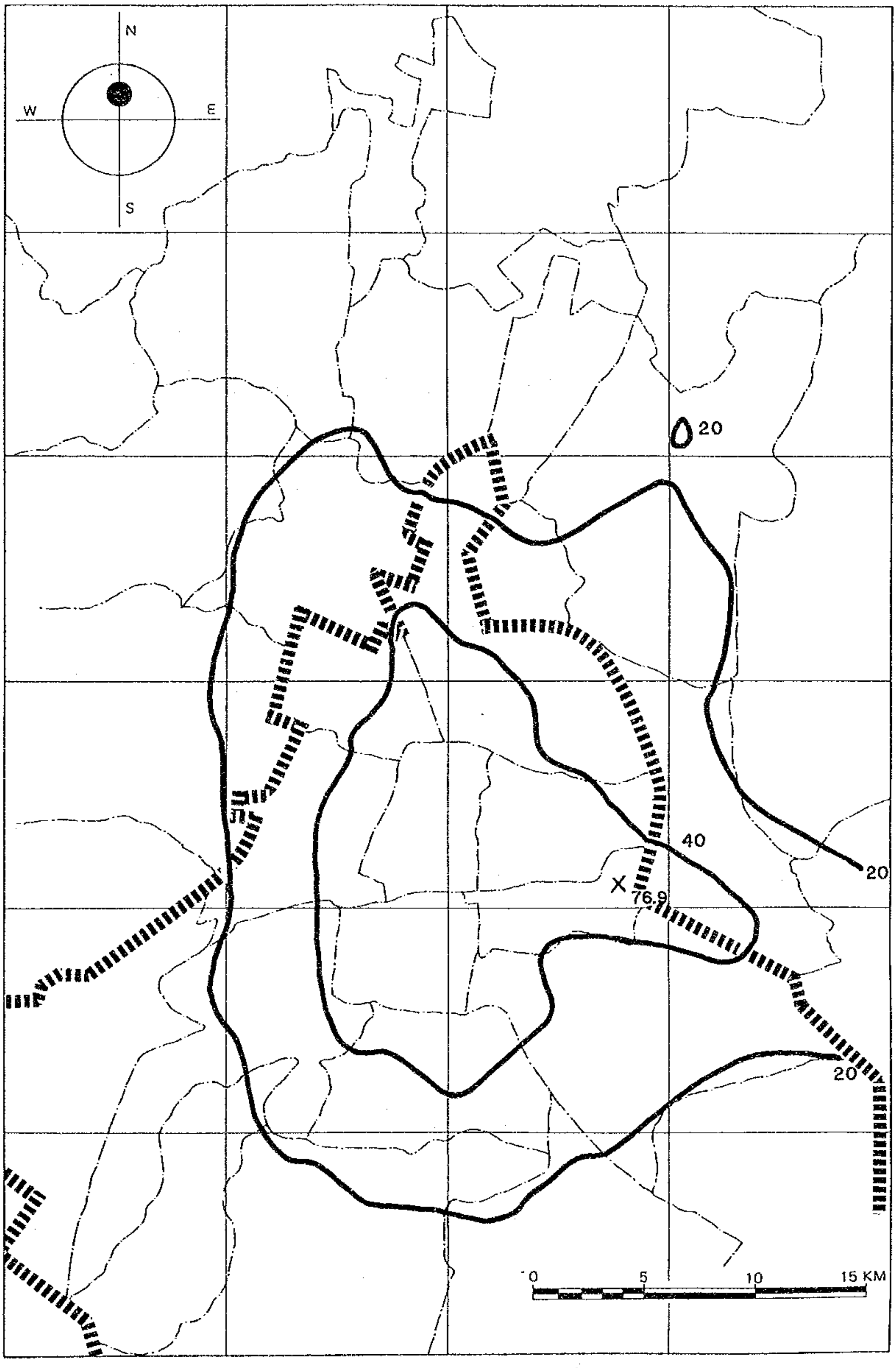


Figure 5.5.17 Annual Average Concentration Isopleths of NO_2
- 2001, With Long-term Control Measures -

(Unit:ppb)

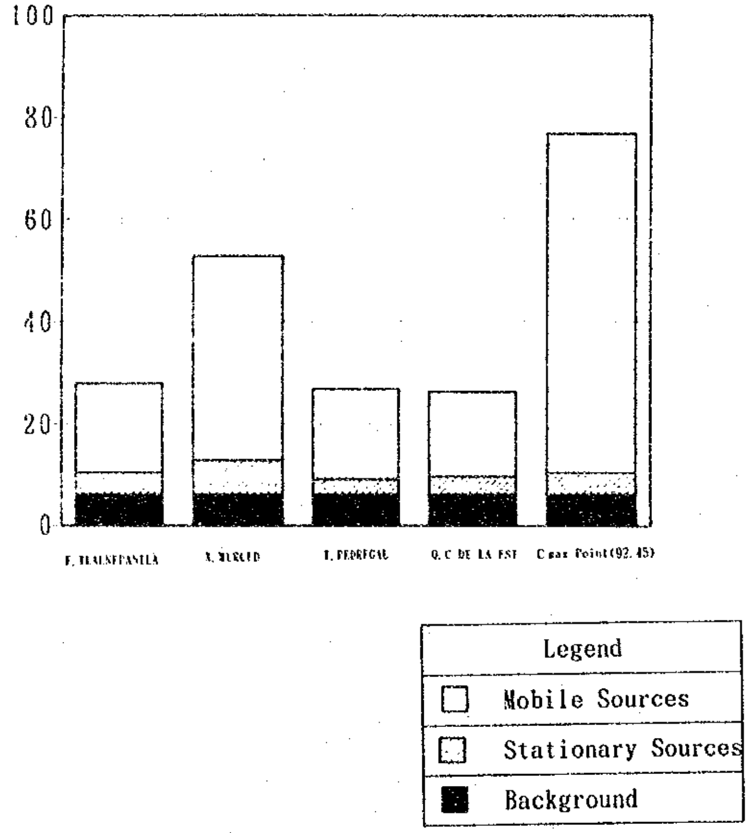


Figure 5.5.18 Contribution of Sources to NO_2 Concentration (2001: After the long-term measures)

Table 5.5.7 Contribution of Sources to NO_2 Concentration (2001: After the long-term measures)

Unit: ppb, (%)

Receptor	Total	Stationary Sources	Mobile Sources	Background
F. TLALNEPANTLA	27.88	4.33(15.5)	17.48(62.7)	6.06(21.7)
X. MERCED	52.84	6.76(12.8)	40.01(75.7)	6.06(11.5)
T. PEDREGAL	26.74	3.01(11.3)	17.67(66.1)	6.06(22.7)
Q. C DE LA EST	26.21	3.51(13.4)	16.64(63.5)	6.06(23.1)
C max Point(92.45)	76.90	4.31(5.6)	66.54(86.5)	6.06(7.9)

× C_{max} point

Unit: ppm

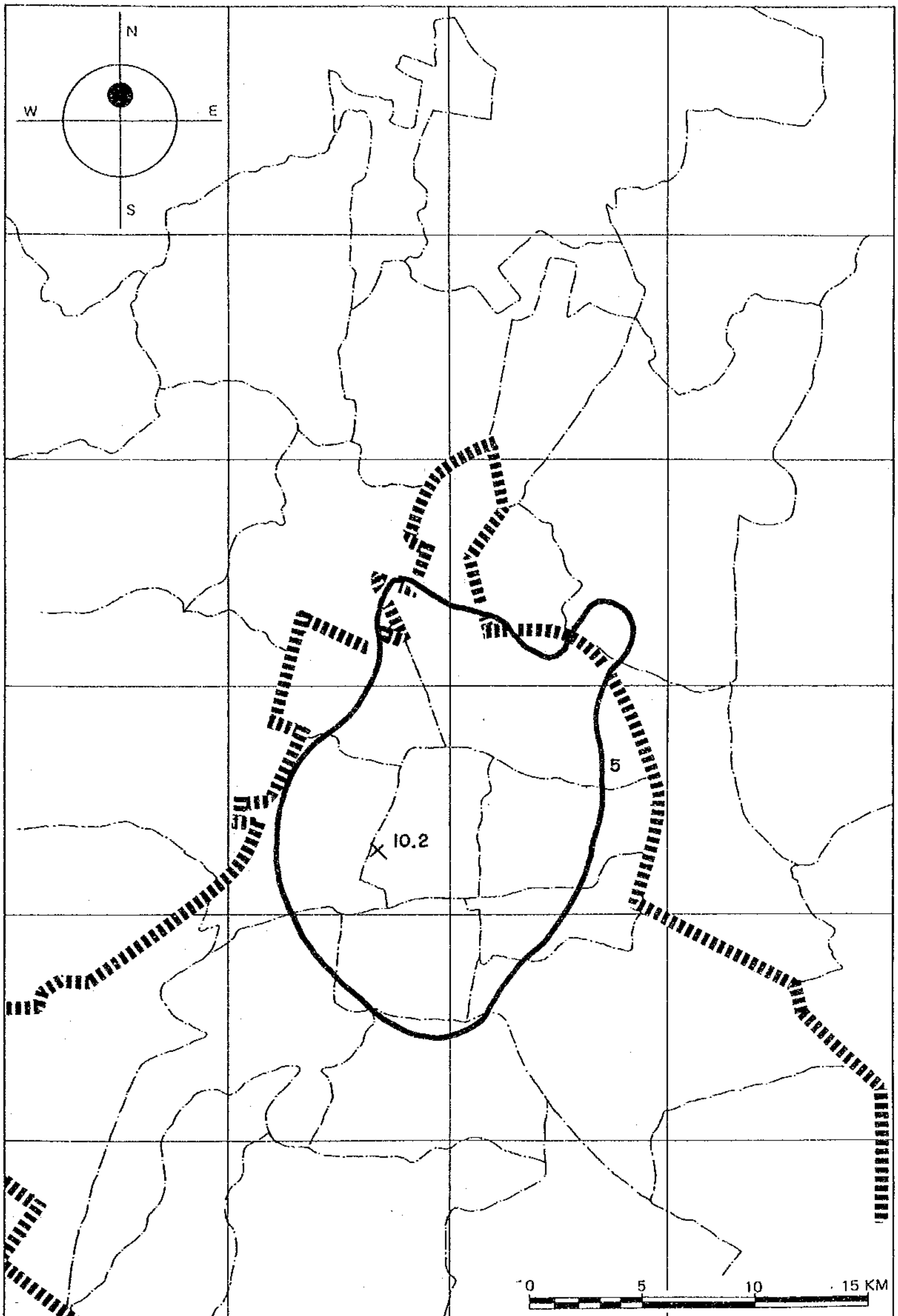


Figure 5.5.19 Contribution of Stationary Sources to Annual Average Concentration of NO_2 - 2001, With Long-term Control Measures -

× C_{max} point Unit: ppm

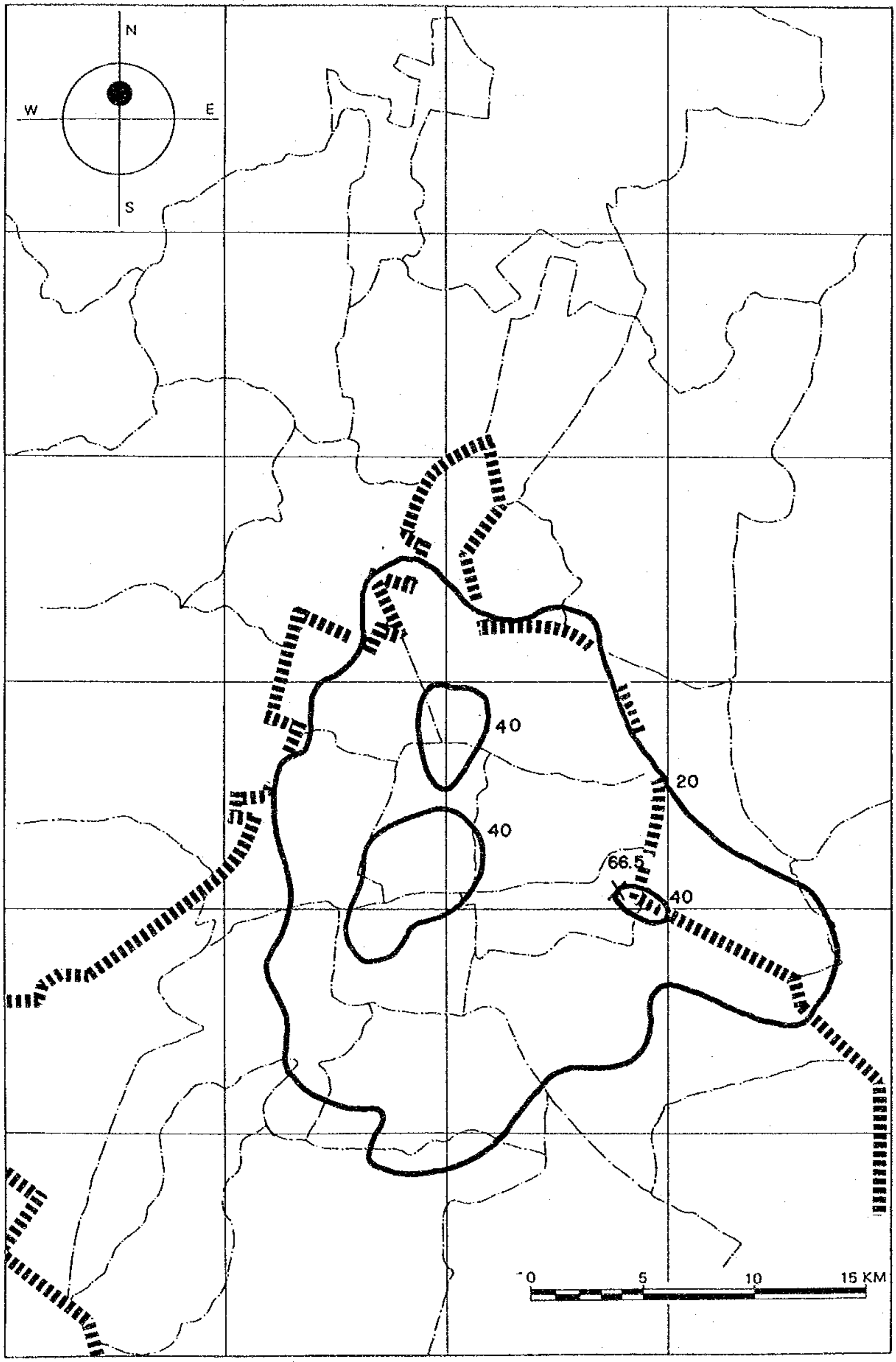


Figure 5.5.20 Contribution of Mobile Sources to Annual Average Concentration of NO_2
- 2001, With Long-term Control Measures -

5.5.3 Evaluation of the Control Measures

(1) SO_2

Areas where the air quality standard is not satisfied remain after the implementation of the short-term measures. But with the long-term measures, the ambient air quality standard can be achieved in most areas.

Note however that the areas greatly influenced by the automobile emissions may fail to achieve the standard level.

(2) CO

The CO concentration in some areas remains above the air quality standard level even with the short-term measures. With the long-term measures, the whole area satisfies the ambient air quality standard.

(3) Comments

Although the air quality simulation model adopted in this study is suitable to describe mesoscale time-averaged concentration distribution of pollutants, it is not capable to express adequately microscale air pollution phenomena. Therefore, the pollutant concentration at the immediate vicinity of particular sources was not sufficiently taken into consideration.

It is expected that higher levels of concentration occur in the vicinity of heavy traffic roads. To achieve the ambient air quality standard level at these areas, a further study on control measure is necessary after detailed investigation of roadside situations, meteorology, concentration occurrence pattern, and development of a simulation model suitable for the computation of roadside pollutant concentration.

CHAPTER 6 SUGGESTIONS ON THE IMPLEMENTATION OF AIR POLLUTION CONTROL MEASURES

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In Mexico City, various air pollution control programs have been planned and some of them are already on the stage of implementation. With active involvement of the Mexican Government in air pollution control, a substantial improvement in air quality can be anticipated in the future.

To abate a large-scale air pollution such as that in Mexico City, national and local governmental bodies have to administer a wide range of activities in social, economic, and technical fields. There is the need for a solid system of cooperation between governmental, industrial, and public sectors for successful implementation of abatement programs.

This chapter mainly presents some examples of administrative measures being or having been experienced in Japan as suggestions for implementation of air pollution control programs in Mexico City.

6.1 Monitoring and Management of Stationary Air Pollutant Sources

6.1.1 General Consideration

Stationary pollutant sources include factories and other establishments, and large ones and medium to small ones. There is wide variety in type of industry and kind of facility emitting pollutants.

For large pollutant sources, it is possible to install automatic measuring instruments for SO_2, NO_x, etc. on the flue for the continuous monitoring of compliance with emission standards. But for medium to small scale pollutant sources, inspections and improvement guidances are made mostly by manpower. Generally speaking, pollutant source monitoring system depends much on manpower. Whether the monitoring is made by automatic system or by manpower, successful result can not be expected when purpose and method of the monitoring are miscalculated. For the medium to small scale sources particularly, inspection and monitoring should be done for the purpose of giving guidance. An authoritarian method of administering pollution control does not bring about a substantial solution. It is important in attaining successful result to let a large number of small-capital enterprises take their own initiatives in pollutant source management. This can be done by giving appropriate guidances and persuasion rather than by authority. The followings are some suggestions on the methods for patrol inspection and for instrument monitoring.

6.1.2 Patrol Inspection and On-the-Spot Inspection/Guidance

(1) Patrol Inspection

Objects of the patrol inspection are pollutant sources such as of air pollutants (smoke, hazardous gases, etc.) in the area under the jurisdiction. Patrol inspection is carried out by 2 or more parties each of which consists of 2 staffs and one car. Each party conducts monitoring at several sites along the route determined beforehand.

a. Judgement of faulty smoke source

Each patrol party makes judgement on the state of smoke effluent at each source according to the following criteria

smoke: grade 2 in the Ringelmann smoke chart
dust: distinguished state of discharge
gases: distinguished state of discharge

For the source that has been judged faulty according to the above criteria, on-the-spot inspection and guidance described in (2) is carried out.

b. Method of smoke inspection

A smoke inspector in the patrol party selects stacks whose smoke emission is distinguished or expected to be so. He measures the smoke concentration in comparison with the Ringelmann smoke chart. The measurement is carried out for 30 minutes at an interval of 30 seconds, and the result is judged by the following criteria.

	Number of times at which smoke concentration exceeded the grade 2 in the Ringelman chart
Not faulty	less than 7 in 30 minutes
Faulty	7 or more in 30 minutes

(2) On-the-Spot Inspection and Guidance

a. On-the-spot inspection

The patrol party inspects the faulty facility for the necessary items, and makes evaluation using inspection and evaluation forms. (See Appendices for the inspection and evaluaiton forms.)

b. Method of evaluation

Evaluation of the facility is done by the bad mark system and the rating determined as follows:

Evaluation point	Rating
80 or more	A
60 - 79	B
40 - 59	C
20 - 39	D
less than 20	E

C. Guidance

Facilities rated C or worse are judged to be in necessity of guidance. The guidances on the faulty items are given orally or by the documental form prepared beforehand. Oral guidances have to be made on an unified basis. To do so, preparation of guidance manual is indispensable. The guidance manual should be made by each type of facility.

d. Preparation of pollutant source ledger

A ledger is prepared registering the pollutant sources on which on-the-spot inspection and guidance were made. The details are given in the Appendices.

6.1.3 Automatic Monitoring System for Pollutant Source

(1) Purpose

The purpose of introducing an automatic pollutant source monitoring system is to monitor continuously the state of pollutant emissions from large sources at a host station (control center), thereby enabling prompt actions when necessary.

(2) Outline of Automatic Monitoring System

Factories having a smoke and soot emitting facility of capacity greater than a specific value, or factories or establishments classified into the specific types of industry are referred to as "specified factories", hereafter.
SO_2 and NO_x concentration values in the flue gas are measured by the automatic flue gas analyzers installed at specified factories. These data together with other data such as fuel consumption are transmitted through the telemetric installation at the monitoring station to the air pollution control center (host station), where necessary data processing and computation are carried out by the data processor. With this whole system, everyday monitoring and monitoring pollutant emission quantity and fuel consumption in an emergency are carried out.

(3) Major Installations in the System

1) Telemetric Installation at Monitoring Station

Installed at specified factories. Following instruction from the control center, it operates and controls SO_2, NO_x, and fuel consumption measurement, and transmits the data to the control center.

2) Telemetric Installation at Host Station

Installed at the control center. It transmits instructions for measurement and control and other information to the monitoring stations, and receives data.

3) Communication Interface

Receiving an identification number of selected monitoring station from the control center, it selects a transmission route to the specified factory, connects the installations at the monitoring station and the control center, and exchanges signals between them.

4) Data Processor

Installed at the control center, it consists of memory unit, process unit, and control unit. Various processings such as computation of pollutant emission quantity and necessary reduction rate are carried out.

5) Input/Output Control Unit

Installed at the control center, it is used for exchanging data between telemetric installation, system control board and typewriters controlling data input and output.

6) System Control Board

System control board is furnished with switches and buttons necessary for the manual operation of the telemetric installation, data processor, and others. And it displays operational status of various devices.

7) Simultaneous Information Transmitter and Receiver and Its Control Board

Individual selection of specified factories, simultaneous transmission and receipt of instructions and informations, and forecast and warning for high concentration of SO_2, oxidants, etc. are made by these devices. These devices are installed at the control center, and their counterpart devices are installed at specified factories.

8) Measuring Instruments

Measuring instruments for flue gas installed at specified factories are SO_2 analyzer, NOx analyzer and flow meter.

(4) Ownership of the Installations

Various installations described above should be owned by the government sector except for the measuring instruments and the simultaneous information transmitter and receiver with the control board which are installed at and owned by the specified factory. Operation and management of these installations should be made according to the ownership.

6.2 Motor Vehicle Inspection System

In this Study, it has been forecasted that the national ambient air quality standards would be met in the most area of AMCM by the next century, should the control measures for stationary sources and automobiles planned by the Mexican Government be implemented as scheduled. However, the results of the Study are based on the various assumptions. In the case of automobiles, one of these assumptions is that motor vehicles in use are replaced by new vehicles meeting new standards at an annual rate of 5%. As was stated earlier, rates of cost increase due to more stringent emission standards are higher for economy type vehicles. And this factor may suppress the replacement rate. Therefore, some measures have to be taken to encourage purchase of vehicles compatible with new emission standards and to discourage extended use of incompatible vehicles.

Another subject is establishment of maintenance and inspection systems. Since the lives of vehicles in Mexico are relatively long, proper maintenance and inspection of vehicles are essential, that in turn necessitate raising technical capacities of car mechanics and reinforcement of installations at inspection and maintenance workshops.

For reference, the motor vehicle inspection system employed in Japan is introduced below.

(1) General

Following are the description of the motor vehicle inspection system in Japan. As regards light motor vehicles, the inspection is carried out by a juridical person "Light Motor Vehicle Inspection Organization", and the contents of the inspection are nearly the same with those carried out by the government.

There are three major motor vehicle inspections. They are (a) the initial inspection applied to motor vehicles that are to be operated for the first time; (b) the continuation inspection applied to motor vehicles in use periodically once in every two years or once in a year; (c) the modification inspection applied to motor vehicles for which substantial modifications have been added.

1) Initial Inspection

The initial inspection is applied to motor vehicles that are to be operated for the first time on public roads, or those which are to be operated again after the cancellation of the registration due to the long absence of usage, etc. The inspection is carried out by the submission of the motor vehicle concerned at a Land Transport Office, but this submission does not apply to new motor vehicles for which the motor vehicle manufacturer has obtained the type designation from the Ministry of Transport. In the inspection, the motor vehicle concerned will be inspected whether it conforms to the Safety Regulations for Road Vehicles. The registration is done at the same time with the initial inspection. If the motor vehicle passes the inspection and the initial registration is completed, a motor vehicle inspection certificate is issued and motor vehicle registration license plate will be attached to the motor vehicle concerned.

2) Continuation Inspection

The continuation inspection is applied to motor vehicle that have been subjected to the initial inspection and registration. The period of inspection differs according to the category of motor vehicles, but usually once in every two years or once in a year.

The inspection is carried out on individual motor vehicles at a Land Transport Office by the submission of the motor vehicle concerned. However, in the case of motor vehicles that have been serviced and inspected by the maintenance garages designated by the government who are permitted to carry out the inspection instead of the government, it is not necessary to submit the motor vehicle to the Land Transport Office, since the government inspection is waived by the submission of the document to certify the fact of carrying out of the inspection. The designated maintenance garages must have the ability to inspect motor vehicles by themselves. In the continuation inspection, motor vehicles are inspected whether they conform to the Safety Regulations for Road Vehicles. The percentage of the inspection by the government account for approximately 41% of the total.

3) Modification Inspection

The modification inspection is applied to motor vehicles for which substantial modifications have been made in order to examine whether or not those motor vehicles conform to the Safety Regulations for Road Vehicles.

Modifications that are subjected to the inspection are as following examples.

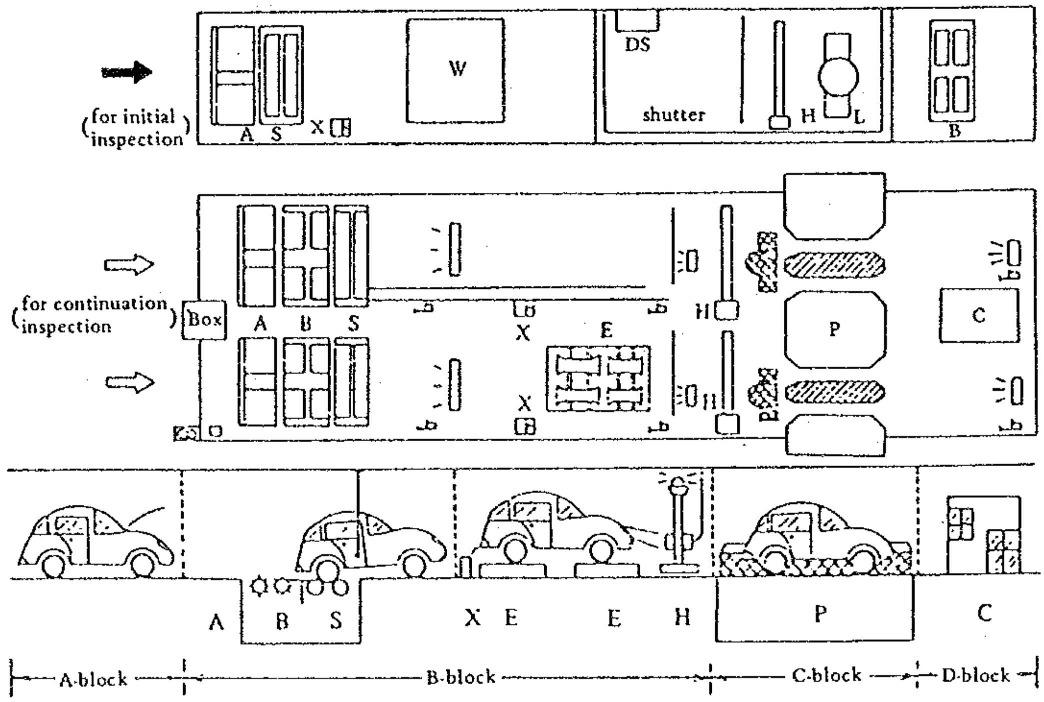
(a) Alteration of length, width or height

(b) Modification in the shape of body (e.g., modification of trucks to tank cars.)

(c) Mounting a different type engine

(d) Change of kind of fuels

(e) Changes in passenger capacity and/or maximum loading capacity



A : Side-slip tester
X : Exhaust emission tester
W : Weighing meter
B : Brake tester
H : Headling tester
DS : Diesel smoke tester
S : Speedometer tester
P : Pit
L : Testing lift
E : Equalizer
C : Control room

Figure 6.2.1 Layout of General Inspection Course

(2) Effective Term of Inspection Certificate

For motor vehicles that have been subjected to the inspection and registered, the motor vehicle inspection certificates are to be issued. The term until the date of the next inspection, i.e., the effective term of the inspection certificate differs as shown in Table 6.2.1 according to the category of motor vehicles, but usually one or two year. Although this continuation inspection is unnecessary during the term, motor vehicles must be subjected to the periodical maintenance by users' own responsibility to ensure safety and to prevent environmental pollution. The period of the maintenance is laid down by the Road Vehicles Act once in every six months for private motor vehicles, and once in every month for motor vehicles for business use.

Table 6.2.1 Effective Term of Inspection Certificate

Effective term	Category of motor vehicles	Example
1 year	① Passenger-carrier motor vehicles	Taxies, buses
	② Motor vehicles for carriage of goods	Trucks, tank lorries
	③ Motor vehicles for private use which are prescribed by Ministrial Ordinances	
	a. Motor vehicles for private use whose riding capacity is 11 persons or more	Buses for private use
	b. Motor vehicles for private use which are used exclusively for carriage of infants	Infant-carrier motor vehicles
	c. Passenger motor vehicles for private use which have been used for more than 10 years (11 years, in the case of motor vehicles which were given a term of three years at their initial inspection)	
2 years	① Passenger motor vehicles for private use,except new-motor vehicles, which have been used for less than 10 years	
	② Two-wheeled motor vehicles, Large-sized special motor vehicles	
3 years	New passenger motor vehicles for private use	

(3) Contents of Inspection

Inspection items and procedure are specified in detail by laws, ministerial order and circular notices, and the outline of the inspection is as indicated in the following.

The periodical maintenance of motor vehicles are obligatory in Japan by the Road Vehicles Act, and motor vehicles subjected to inspection are brought into inspection centers after having been subjected to the periodical maintenance required.

The inspection is carried out by means of the test equipment and test hammer for the functions and the appearance of the motor vehicle. The results and procedures of the inspection are displayed to the applicants. The applicants are to proceed for inspection according to the instructions given by the display. The test vehicle is to proceed to the next inspection block after the inspection to be tested in the block is completed. The standards of inspection is the Safety Regulations for Road Vehicles providing the safety and pollution control standards based on the Road Vehicles Act. The orders to have additional maintenance on the vehicle inspected will be given by the inspectors to the motor vehicle which does not comply with the Regulations and they are subjected to another inspection. The length of time required for the inspection varies according to the kinds of motor vehicles. The average inspection time is approximately 15 minutes for each passenger car.

Figure 6.2.1 shows a layout of the general inspection course.

1) Examples of Contents of Visual Confirmation Test at A-block

a. Confirmation of identity by chassis numbers
b. Lighting and attached conditions and damages of lamps
c. Attached conditions and damages of reflectors
d. Damages of rear-view mirrors
e. Operation of windshield wipers
f. Attached condition of seat belts and head-restraint devices
g. Wear of tire tread
h. Play of brake pedal
i. Play of steering wheel

2) Contents of Inspection by Test Equipment at B-block

a. Side-slip test

The motor vehicle is to run straightforwardly on the platform of the tester, and then, the side-slip amount of the wheels is measured. The standard is 5 mm or less when running one meter.

b. Brake test

The wheels are placed on two spline-shaped rollers, and the braking force is measured by the rotating rollers. The circumferential speed of the rollers is 3 to 6 cm/sec. The standards are as follows.

a) The sum of the braking forces of right and left wheels: not less than 60% of the axle weight.

b) The difference between the braking forces of right and left wheels: up to 8% of the axle weight.

c. Speedometer test

The wheels of the motor vehicle are rotated constantly so that the speedometer indicates 40 km/h. The indication of the speedometer tester is measured. The standard is $40^{+4.4}_{-5.2}$ km/h with the value indicated by the tester. A guide roller is provided with for front-wheel-driven vehicles to prevent the vehicles swing side-wards and to ensure safety and accurate inspection. As for diesel vehicle inspection courses, free-rollers are provided in parallel with the testers in order to allow the inspection of large-sized trucks with two-axle rear wheels.

3) Exhaust Emission Test

NDIR* type tester is employed to measure the volumetric concentrations of CO and HC emissions at idling operation. The standards are as follows.

CO: up to 4.5%

HC: up to 1200 ppm for vehicles with a 4-stroke engine, 7800 ppm for vehicles with a 2-stroke engine, and 3300 ppm for vehicles with a rotary-engine

(*NDIR: Nondispersive type infrared analyzer)

As for diesel vehicles, the smoke emission under no load and fully accelerated conditions is to be measured. The standard is not more than 50%.

4) Headlight Test

Condenser type headlight testers are employed to measure the brightness of the headlamps and the deviation of the optic axis on the main beam.

The standards are as follows.

a. Luminous intensity

4-lamp type: 12000 cd or more

2-lamp type: 15000 cd or more

b. Deviation of optic axis direction (in Japan, one must drive on the left.)

Right headlamp: up 0; down 2/100; left 2/100; right 1/100 or less

Left headlamp: up 0; down 2/100; left 2/100; right 2/100 or less

5) Inspection in the Pit at C-block

The pit is generally 2 - 3 meters deep and provided with a table lift adjustable up and down enabling inspectors to inspect in the most suitable posture.

The top of the pits is covered with acrylic resin and the bridges portion is provided with air curtains to prevent the exhaust emissions.

Examples of inspection items are as the following.

a. Brake fluid leakage from brake hose, pipes, etc., and the damages thereof

b. Looseness and damages of steering system

c. Water leakage from radiator

d. Play and distortion of propeller-shaft joint

e. Oil leakage and deformation of shock absorber

f. Damage of exhaust pipe

g. Attachments and damages of catalyzers and heat shielding plates

(4) Inspection Charge

Inspections are to be charged as shown in Table 6.2.2, and the operation of inspection center is managed by the income. Inspection charge is stipulated by the Cabinet Order according to the category of motor vehicles.

Table 6.2.2 Inspection Charge

Category of motor vehicle	Inspection charge
Small-sized motor vehicles (engine displacement up to 2.0 liters)	¥1,200 (approx. $9)
Ordinary motor vehicles (engine displacement exceeding 2.0 liters)	¥1,300 (approx. $10)

6.3 Ambient Air Quality Monitoring System

6.3.1 Continuous Monitoring and Short-term Measurement

It is difficult to know the actual conditions in ambient concentration of air pollutants at all the areas in a district. A huge cost and a great amount of labor are necessary to install measuring instruments and to conduct measurements at all the areas. Therefore, it is a common practice to install a station for continuous monitoring at a selected place which is considered to be representative of the district in ambient pollutant concentration.

In order to judge the state of air pollution in comparison with the ambient air quality standards and to judge the effect of air pollution control measures being applied, a network of the whole year continuous monitoring stations is needed.

Continuous monitoring station is generally classified into two types: general ambient air monitoring station and automobile exhaust gas monitoring station. The former is intended to measure general ambient air quality that is not directly influenced by the specific source of pollutants such as automobile exhaust gas, and hereinafter referred to as "general station". The latter is intended to measure air quality along principal roads influenced by automobile emissions.

Short-term and long-term evaluations of ambient air quality in contrast to the ambient air quality standards are usually made using the data at general stations.

In the places along principal roads such as crossings in high-storied building area or places of particular topography where automobile exhaust gas is not easily dispersed, high pollutant concentration is naturally expected. However, installing a monitoring station and conducting long-term measurement at all such places in a large urban area are physically and economically not possible. For such places, short-term measurement are conducted commonly, and the data are compared with those from the existing stations to know the actual situations. In the following description, some suggestions on the methods for continuous monitoring and short-term measurement are presented.

(1) Purpose of Continuous Monitoring

Purposes of continuous air quality monitoring include:

a. To evaluate the state of ambient air quality in contrast to the quality standards

b. To detect high-level pollution occurring under the particular meteorological conditions for the short period, and inform this to the public

c. To confirm effects of air pollution control measures for further promotion of ambient air quality management

(2) Functions of Continuous Monitoring

1) Evaluation of Air Quality in Contrast to the Quality Standards

Ambient air quality standards are generally set forth based on the measurement of one-hour values. And standard values are determined for the maximum one-hour value, the daily average of one-hour values, and the eight-hour average of one-hour values. Accordingly, judgement of compliance or non-compliance with the standard is made for short-term (one day) and long-term (one year) with the values of the averaging time specified in the standards.

2) Detection of Short-term High-level Pollution

Under the particular meteorological conditions such as the atmospheric inversion elevated to a certain height, air pollutants from emission sources on the ground are not dispersed beyond the inversion lid, and the state of the whole city being fumigated by smoke may take place. In such a case, human health and living environment may be damaged. Prior detection of high-level pollution is necessary to avoid such situation enabling administrators to request large scale factories in the area for their prompt cooperation.

3) Confirmation of Effects of Pollution Control Measures

The data obtained at the continuous monitoring stations are essential for conducting air quality simulation in the regional planning of reducing total quantity of pollutant emissions. At the same time, the monitoring network plays an important role in judging the progress of pollution abatement achieved by the pollutant reduction program.

4) Promotion of Ambient Air Quality Management

To promote environmental management plannings such as environmental impact assessment in advance of specific development programs, the air quality data at the continuous monitoring stations are indispensable. These data are greatly needed for the regional environmental management planning for urban areas, pollution abatement planning, and land-use planning. Moreover, continuous monitoring is important for elucidation of air pollution phenomena such as long distance transport of air pollutants and production of secondary air pollutants in the photochemical reactions.

(3) Basic Principles for Placement of Continuous Monitoring Stations

In general, continuous monitoring stations are dispersed over the entire region to measure and evaluate the region-wide air quality. But some stations can be placed relatively close to each others in the area where high concentration tends to occur due to particular pollutant sources. When the particular source is automobile exhaust gas, the automobile exhaust gas monitoring station is placed. Among the functions of continuous monitoring described in (2), the functions 1), 3) and 4) are mostly taken into consideration for the placement of the stations.
Since the stations have to be distributed to represent land use of each area, such as residence, commerce, industry and semi-industry, representativeness of a station is an important factor for the placement of monitoring stations.

(4) Design Concept for Network of General Monitoring Stations

Objectives of the design of the general monitoring station network are:

a. Each station to represent a particular area

b. Network to represent the region-wide air quality

To achieve these two objectives, the design has to satisfy two conditions as shown in Figure 6.3.1. One is the placement condition: how many stations and where to place. The other is the installation condition: which site to install.

(5) Short-term Measurement

Short-term measurement is carried out to know actual situation of air quality in the place where continuous monitoring is not made. Measured data are used to supplement the data at general or automobile exhaust gas monitoring stations for the evaluation of actual situation in contrast to the air quality standards. Measurements are made on the roadside of major roads and principal crossings with heavy traffic volume, or at the places where air pollution is expected due to increase in the traffic volume. Measuring items include NO, NO_2, CO, suspended particulates, Pb, and traffic volume. Duration of the measurement is about one month.

(6) Case of Mexico City Metropolitan Area

There are twenty-five automatically operated air quality monitoring stations in AMCM aiming to measure the concentration of SO_2, NO_2, NOx, CO, O_3 and HC. But many of these stations are capable of measuring only a few of these pollutants, and only one station is able to monitor all of them. It is therefore considered necessary to strengthen the ability of the existing monitoring network. It is desirable to monitor the five pollutants including TSP which are specified in the ambient air quality standards of Mexico at all the stations. It is also desirable to have at least one station in each DELEGACION and MUNICIPIO.

It is recommended that a study be carried out to strengthen the existing monitoring network taking account of the principles for placement and installation of monitoring stations as described above.

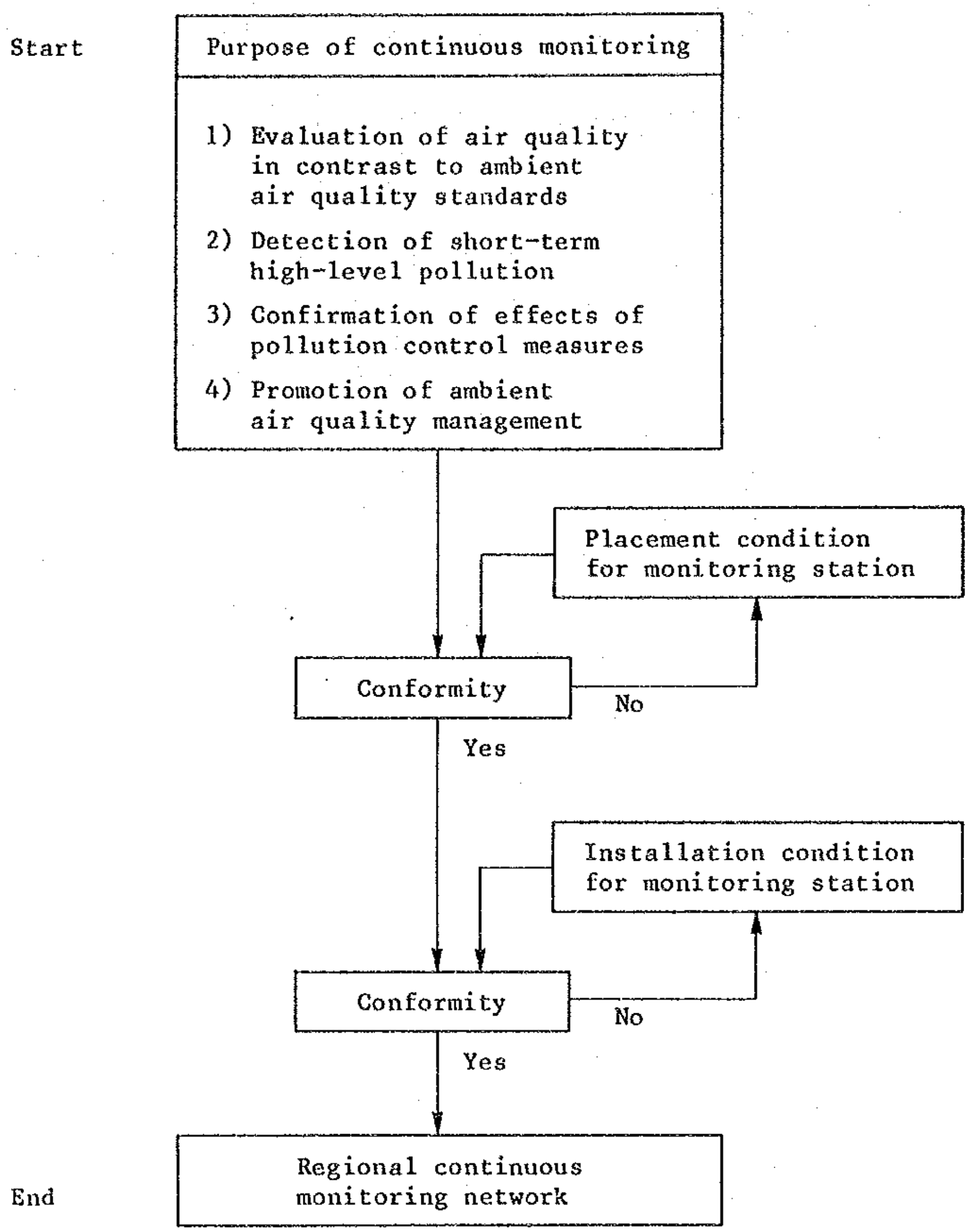


Figure 6.3.1 Design Flow for Regional Network of Continuous Air Quality Monitoring

6.3.2 Maintenance and Preservation of Monitoring Installations

(1) Significance and Necessity of Maintenance and Preservation

In the continuous monitoring of air quality, it is necessary to maintain the measuring instruments at their best condition. The purposes of continuous monitoring will be lost if the measurement is interrupted frequently. Preventive measures include periodic inspection and overhaul.

1) Periodic Inspection

Periodic inspection aims to maintain the precision of automatic measuring instruments. Inspection is made comprehensively on the performance of assemblies to find any deterioration and to restore the expected function.

2) Overhaul

Performances of measuring instruments gradually decline with time despite the periodic inspection. When continued performance of the instrument is found to be difficult in the periodic inspection, the instrument is disassembled and performance of each part is inspected and changed if necessary. Then, a test running is made for a certain period of time to insure the function and accuracy of all parts.

Since overhauling requires a long period interruption of measurement, its timing and frequency can not be determined unconditionally. It is generally carried out at the initial stage of the deterioration.

3) The Life of Installations

Although performances of various installations can be maintained by the periodic inspection and the overhaul, these installations will be some time or other worn out to be abolished and replaced. A guidance for the life of air pollution monitoring installations in Japan is shown in Table 6.3.1.

Table 6.3.1 Guideline for the Life of Air Pollution Monitoring Installation

Installation or device	Life (year)
Telemetric installation for air quality monitoring	15-20
Continuous automatic SO_2 analyzer (wet type)	4-5
Continuous automatic O_x analyzer	4-5
Continuous automatic CO analyzer	4-5
Continuous automatic AP analyzer	5-7
Continuous automatic NO_x analyzer	4-5
Continuous automatic HC analyzer	4-5
Continuous automatic wind vane and anemometer	4-5
Telemetric installation for SO_2 monitoring	15-20
Simultaneous information transmitter	15-20
Electronic street-display board	15-20
Monitoring TV	15-20
Telefax for meteorology	5-7
Teletypewriter	10-15
Telephone guide	4-5
Wireless installation	10-15

4) Spares

To prevent measurement interruption and to tackle with an emergency, it is desired to reserve for spares of instruments and their parts.

(2) Countermeasures to Mechanical Trouble

Mechanical troubles of installations are possible even under the solid maintenance system. Early revelation and prompt stopgap measure or repair are necessary to minimize the measurement interruption. To minimize the occurrence of mechanical trouble, the following measures are necessary:

a. Frequent inspection
b. Monitoring through telemeter
c. Overhauling and renewal

(3) Maintaining Accuracy of Measuring Instruments

1) Maintenance Guideline

Material of consumables for automatic measuring instruments and their replacement frequency may greatly affect the accuracy of measurement. In order to maintain a certain level of accuracy, a maintenance guideline is necessary. In the case of measuring instruments, the guideline should be prepared on the following:

a. Sampling system

b. Absorption and reaction system

c. Calibration

Accuracy of measurement will be assured by the inspection and the maintenance carried out in accordance with the guideline.

2) Calibration and Inspection

Simple span checkings such as zero span drift or light quantity adjustment are made as the routine work. In addition, static calibration using standard solutions and dynamic calibration using standard gases are made on the periodic basis. In Japan, The Measurement Law requires the inspection by the government certified organizations on continuous automatic CO analyzers (nondispersive infrared type), meteorological observation devices, and pH meters.

6.4 Ambient Air Quality Standards

Pollutants discharged into ambient air cause adverse effects on human health, deterioration of visibility, and degradation of cultural assets and natural environment. Pollutants that cause adverse effects on human health includes directly discharged pollutants (primary pollutants) and secondary pollutants formed through the reactions in the atmosphere such as photochemical oxidants and particulates.

Apart from the above, there is combined pollution in which plural kinds of pollutants exert a multiplication effect to cause severe adverse effect on human health. For natural environment, acid precipitation (acid rain, etc.) resulting from SO_x and NO_x emissions and oxidants affect not only near the source, but also distant places. Table 6.4.1 shows the outline of effects of individual pollutatns on human health.

Table 6.4.1 Outline of Effects of Pollutants on Human Health

Air pollutant	Effect on human health
SO_x	1) Contained about 0.35 pphm in clean ambient air. 2) Detectable by nose at 3 ppm and acutely irritable to nose and throat at 6 - 12 ppm 3) Causes bronchitis with a possibility of death when the concentration is high. 4) SO_2 turns into sulfuric acid mist through photochemical reactions, etc. This mist is irritable about 4 to 20 times more than SO_2.
CO	1) Substantial physiological harm 2) CO has considerably high affinity to hemoglobin in blood (about 210 times that of oxygen), thereby preventig respiratory gas exchange of erythrocytes. As a result, the function of oxygen supply to the body is weakened. 3) It is reported that 5% of CO hemoglobin in erythrocytes (resulting from breathing air of 30 ppm CO for 4 to 6 hours) causes functional disease. 4) More than 500 ppm of CO in air is said to cause intoxication (central and peripheral nerve paralysis), and 5,000 ppm (0.5%) of CO causes death.

(to be continued)

Air pollutant	Effect on human health
NO_2	1) 500 - 100 ppm: Local pneumonia and recovery in a few weeks 150 - 200 ppm: Pneumonia with a principal symptom of blockage of extremely thin bronchi (fibrous blocked fine bronchitis), and death in a few weeks 500 ppm: Acute poisoning, edema of lungs associated with bronchopheumonia, and death in a few days 2) Produces various reaction products (PAN, etc.) through photochemical reaction in air
Suspended particulate matter	1) Effect of suspended particulate matter on human health varies widely depending on the size, quantity, and chemical characteristics. 2) Deterioration of visubility 3) Silicon/fine coal dust cause pneumoconiosis. Cadmium and lead cause paralysis. Tar is a carcinogen. 4) Other damages such as allergic reaction, mucosa disease, etc.
Lead compound	1) These are ingested an average rate of 0.14 - 0.15 mg per day through foods and drinks. Large quantities of lead (6 - 10 mg/day), if ingested, may cause intoxication. 2) Lead intoxication begins with disorder in the digestive system, then proceeds to affect muscle and brain.
HC	1) Aromatic hydrocarbons are said to be responsible for cancer. 2) High hydrocarbon concentration causes irritation to mucosa, resulting in central nerve disorder. In particular, benzene and toluene are harmful. 3) Activated hydrocarbons (olefinic, aromatic) cause photochemical smog.

The United Mexican States and other countries have established ambient air quality standards considering to the above adverse effects on human health and WHO's recommended levels. Typical standards are shown in Table 6.4.2. Although a direct comparison of these values are not practical because of difference in the concept of establishment, the ambient air quality standard values of the United Mexican States are nearly equivalent to those of the USA and Canada. On the other hand, a comparison

Table 6.4.2 Ambient Air Quality Standards in Various Countries

	Sulfur dioxide (ppm)	Carbon monoxide(ppm)	Suspendid particulate matter (mg/m³)	Nitrogen dioxide (ppm)	Photochemical oxidants (ppm)	Definition
The United Mexican States	Daily average 0.13	8-hour average 13	Daily average 0.275	1-hour average 0.21	1-hour average 0.11	
Japan	Daily average 0.04 1 hour average 0.1	Daily average 10 8-hour average 20	Daily average 0.10 1-hour average 0.20	Within or less than the daily average of 0.04 - 0.06 zone	1-hour average 0.06	Levels desired to be maintained to protect human health
USA	Primary Standards Annual average 0.03 Daily average 0.14	8-hour average 9 10-hour average 35	Annual average 0.08 Daily average 0.26	Annual average 0.05 Short-term vaue not determined	1-hour average 0.12 (as ozone)	Levels judged to be necessary to protect the public health.
	Secondary Standards 3-hour average 0.5	Same as for the primary standards	Annual average 0.06 Daily average 0.15	Same as for the primary standards	Same as for the primary standards	Levels judged to be necessary to protect public welfare from known or predicable adverse effect.
West Germany	Long-term effect 0.05	9	0.15	0.04	None	A requirement to certify installation and operation of a certain facility. Once certification is granted, suspension of operation because of immission cannot be claimed by the neighboring inhabitants. (Claim for the preventive measures or compensation is possible.) Note: "Immission" includes air pollution, noise, vibration, light, heat, radiation, and similar environmental effect influencing human beings, animals, plants, and other properties.
	Short-term effect 0.15	26	0.30	0.11	None	
Canada	Max. Desirable Level Annual average 0.01 Daily average 0.06 1-hour average 0.17	8-hour average 5 1-hour average 13	Annual average 0.06	Annual average 0.03	Daily average 0.02 1-hour average 0.05	Long-term object, which is the basis of long-term development of pollution prevention policy and control technology for non-polluted areas.
	Max. Acceptable Level Annual average 0.02 Daily average 0.11 1-hour average 0.34	8-hour average 13 1-hour average 31	Annual average 0.07 Daily average 0.12	Annual average 0.05 Daily average 0.11 1-hour average 0.21	Annual average 0.02 Daily average 0.03 1-hour average 0.08	Practically possible levels as of present for proper protection of human life and welfare against polluting effect.
	Max. Tolerable Level Daily Average 0.31	8-hour average 18	Daily average 0.40	Daily average 0.16 1-hour average 0.53	1-hour average	Levels at which the appropriate preventive measures should be taken against urgent danger.

Note: Simple comparison of values is not appropriate because the concepts of establishment differ among the countries.

between the actual ambient air quality in Mexico City and the national standards of Mexico, which has been described in 3.3.2, shows that SO_2, NO_2, and CO concentrations are roughly within the standard range except a few stations (note that the measuring period is rather short). HC and O_3, on the other hand, exceeded the standard values. For suspended particulate matter, measurement is not complete and the concentration may possibly exceed the standard.

It is desirable for any country that ambient air quality standards be continually reviewed in the light of new scientific findings, and be revised if necessary.

6.5 Organizational Consolidation and Human Resource Fostering

To attain the successful result in air pollution control, a firm cooperation of various organizations with a number of competent staff is required. This Section introduces, for reference, the case of Tokyo Metropolitan Government which experienced intensive combats against severe air pollution in 1960s and 1970s.

Tokyo Metropolitan Government (hereinafter abbreviated as TMG) promulgated in 1949, Factory Pollution Prevention Ordinance, first among the local governments in Japan.

In 1969, a total of 210 staffs were working at the pollution control sections as shown below.

TMG Governor
- Other Bureaus
- Urban Development Bureau
  - Dept. Pollution Prevention Planning (54 staffs) (3 Sections)
  - Dept. Pollution Control Administration (102 staffs) (6 Sections)
  - Pollution Research Institute (54 staffs) (6 Depts. and one Section)
  - Other Departments

The major field of job was air pollution control, although water quality, odor, noise, factory license and high-pressure gas control were also dealt with. There were about 15,000 facilities emitting smoke and soot in Tokyo. At that time, air pollution was severe with the concentration of air pollutants as shown below:

SO_2: 0.060 ppm (annual average)

SPM: 0.30 mg/m^3 (annual average)

CO : 6.0 ppm (annual average)

The air pollution in the winter of 1969/70 was particularly severe. The SO_2 concentration exceeding 0.2 ppm appeared almost everyday inducing the announcements of smog warning for 16 consecutive hours a day.

In 1970, new types of air pollution were added: lead from automobile exhaust gas causing intoxication incidents, and photochemical oxidants. These were reported frequently on newspapers and TV as social problem, prompting TMG to consolidate the pollution control organization. The units dealing with pollution problems in Urban Development Bureau were reorganized and greatly enhanced under newly created Pollution Bureau as shown below, and the number of staffs increased to 550 (2.6-fold).

- TGM Governor
  - Other bureaus
- TMG Pollution Control Commission
  - Pollution Bureau (550 staffs)
    - Dept. Planning
    - Dept. Traffic Disaster Prevention
    - Dept. General Affairs (2 Sections)
    - Dept. Pollution Prevention Assistance (2 Sections)
    - Dept. Pollution Control and Guidance (4 Sections)
    - Dept. Inspection (7 Sections)
    - Pollution Research Institute (6 Depts. and one Section)
    - Tama District Pollution Control Office (3 Sections)

In the above organization, the units dealing with air pollutant source monitoring were 4 sections (59 staffs) in Dept. of Inspection and one section (27 staffs) in the Tama District Office. Ambient air quality monitoring was under the control of Monitoring Section (37 staffs with 23 assigned for air quality monitoring) of Dept. of Inspection, air pollution abatement planning was undertaken by a group (8 staffs) of Control Standard Section in Dept. of Pollution Control and Guidance, and research on the air pollution was undertaken by Atmosphere Dept. (26 staffs) in Pollution Research Institute. Besides, there were about the same number of clerical staffs for management enabling smooth conduct of technical tasks. Detailed staff arrangement is given in the Appendices.

As the result of such organizational consolidation, the air pollution in Tokyo has been remarkably improved. In 1987, annual average pollutant concentration in Tokyo (23 wards) became as follows:

SO_2 : 0.009 ppm (one-seventh of that in 1969)

SPM : 0.051 mg/m^3 (one-sixth)

CO : 0.9 ppm (one-seventh)

There has been no smog warning announced since 1972. Since the abatement of pollution necessitates manpower, money, substance, technology, and time, political stance of the government head is considered to be most important.

Training on air pollution abatement in TMG started with the preparation of guidance manuals for pollutant emitting facilities. This task began in 1965 by organizing a committee composed of scholars, engineers and administrators. Since then, the following guidance manuals were published.

- Smoke and soot treatment facilities for open-hearth furnace, electric furnace, aggregate drying oven, cast-iron cupola, solid waste incinerator, boiler, furnaces for non-ferrous metals, furnaces for ceramics, and others: 10 facilities, 12 volumes, 1966 - 1973.
- Dust treatment facilities for spray painting, molten zinc plating, and others: 6 facilities, 3 volumes (pp. 449), 1969-1971.
- Hazardous gas treatment facilities for hydrochloric acid, hydrogen fluoride, ammonia, chromic acid mist, oxides of nitrogen, hydrogen sulfide, benzene, toluene, methyl bromide, and others: 33 gases, 8 volumes, 1966 - 1976.
- Flue gas desulfurization, one volume (pp. 231), 1976.
- Hydrocarbon evaporation prevention facilities, one volume (pp. 86), 1972.
- Nitrogen oxides control facilities, one volume (pp. 174), 1976.
- Odor control facilities, one volume (pp. 273), 1973.
- Standard method for pollution control by manufacturing process, 3 volumes (pp. 1241), 1973 - 1975.

Using these manuals, raising the technical levels of staffs dealing with air pollution control was greatly promoted. Many of them are now actively involved in the related activities including presentation at the academic conferences, directing or conferring at Japan Society of Air Pollution, and educating younger generations.

The description above is only an example about organizational consolidation and human resource fostering. In the other cities in Japan, once referred to as pollution advanced cities such as Osaka, Yokohama and Kawasaki, the local governments have been taking similar courses for the abatement of environmental pollution.

RECOMMENDATION

RECOMMENDATION

(1) Source Control Measures

Implementation of the stationary source control measures being proposed by the Mexican Government will have a large effect in abating the air pollution in Mexico City, particularly of SO_2 pollution. Enforcement of the emission control regulations for motor vehicles set forth by the Government will gradually improve the CO, NOx and HC pollutions, although a relatively long period of time is required to bring about the full effect.

Detailed discussions on the problem of ozone is beyond the scope of this Study. However, a certain degree of improvement associated with the reduction in the NOx and HC emissions may be expected.

It is recommended that the source control measures planned by the Government be implemented as scheduled with rigorous enforcement of the emission regulations for stationary and mobile sources.

As supplements to the Government proposed source control measures, the following measures may be worthy to be considered.

a. Installation of a secondary air supply system in vehicles being used

b. Reduction of sulfur content of gasoline

c. Designation of one weekday to each private passenger car to halt the use

(2) Establishment of Detailed Rules and Regulations

General Law for Ecological Balance and Environmental Protection has provided a legal framework for promoting various air pollution control activities. Establishment of detailed rules and regulations relative to the Law is an urgent necessity. Although some vital rules, regulations and standards pertaining to air pollution control have been already set forth by the Government, the task should be continued intensively by the responsible agencies to whom active cooperations should be given by relevant authorities, industries and individuals.

(3) Monitoring and Inspection of Stationary Pollutant Sources

Monitoring of pollutant emissions at large factories can be made effectively by installing automatic measuring devices at sources and establishing a telemetric monitoring system controlled at a central station. Monitoring of a large number of medium to small scale pollutant sources depends largely on manpower. Inspection of smoke emitting facilities should be made in conjunction with giving concrete guidances to improve their performance. Preparation of a pollutant source ledger is also recommended for effective conduct of inspection.

(4) Motor Vehicle Inspection

It is important to maintain performance of emission control devices for life time of motor vehicles that is relatively long in Mexico. Therefore, establishment of a system to carry out periodic inspection of motor vehicles is required. A detailed study of establishing such system is recommended.

(5) Air Quality Monitoring

It is considered necessary to strengthen the existing air quality monitoring network of AMCM in the number of monitoring stations and in the ability of individual stations. It is recommended that a study be carried out to make up a rational monitoring network based on the existing one.

(6) Organizational Consolidation

Mitigation of the air pollution in Mexico City requires responsible agencies such as SEDUE and DDF to undertake a large amount of work in various fields. In the case of DDF, it is considered necessary to increase number of personnel to carry out various works relevant to air pollution control, i.e., management, technological study, vehicle inspection, stationary source inspection, air quality monitoring, legislative works, pubic relation, and etc. It is recommended that such organizational consolidation in conjunction with establishment of personnel training programs be considered.

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