4.3.3 Vehicle fuel in MOT

(1) Fuel property

The National Iranian Oil Company (NIOC) has specified standards of each fuel consumed in Iran, which must be met. According to them, the maximum permissible amount of metallic lead and sulfur in normal gasoline is 0.56/lit and 0.1w% respectively, and specific gravity must be 0.73, while the maximum permissible amount of sulfur in gas oil is 1.0w%, and specific gravity must be 0.83 to 0.86.

The JICA study team analyzed the components of normal gasoline and gas oil, and found that the metallic lead content was 0.22 g/lit and the sulfur content was 86 wtppm in normal gasoline, and that the sulfur content in gas oil was 0.8 wt%, which met the NIOC standards.

Table4.3.3-1 shows the standards of European countries, the USA and Asian countries relating to the sulfur content in gas oil, and the actual values obtained from their analysis. The maximum permissible amount of sulfur in gas oil in all the developed countries is equal to or less than 0.2 w%, and among those countries the USA and Japan (effective from October, 1997) have a stricter standard of 0.05 w%. Also there are a few countries whose sulfur content amounts exceed 0.8 w%, which indicates that the amount of sulfur content in Iran's gas oil is one of the highest in the world.

(2) Fuel consumption

Table4.3.3-2 indicates the amount of fuel consumed by automobiles in the GTA. Amounts of sulfur contained in gas oil and gasoline is 1.0wt% (NIOC GAS OIL 606) and 0.1wt% (NIOC MOGAS 220) respectively.

Oxygenated gasoline has been used as vehicle fuel in Tehran since August 1990. Fig. 4.3.3-1 shows the percentage of oxygenated gasoline in the total gasoline consumption in Tehran from 1991 to 1995 on a yearly basis. Use of oxygenated gasoline has grown 0.28 % to 0.3 % a year, and extrapolation from the growth rate leads to the estimation that use of oxygenated gasoline will be about 4 % in 2001.

Table4.3.3-3 indicates an amount of gas oil consumed by railways in Iran. The total amount of SOx emissions was calculated from this amount of total consumption, and their results are outlined in Table4.3.3-4. In comparison with automobiles, an amount of SOx emitted by railways is very small and could therefore be ignored.

Table4.3.3-1 Comparison of sulfur content of diesel oil standareds

Europe, U.S. As of 1995

Countrie	Standard (Upper limits) wt %	Actual values wt %	Enforcement dates
EU Nations	0.2	0.04 - 0.3	Effective Oct. '94
	0.05		From Oct. '96
Belgium	0.2	0.11 - 0.7	Effective Oct. '89
Denmark	0.2	0.04 - 0.05	Effective Oct. '89
Irish Republic	0.3		
Italy	0.2	0.12 - 0.2	From Jan.'93(north) Oct. '93(south)
France	0.3	0.1 - 0.3	
Germany	0.2	0.05 - 0.19	
Greece	0.3		
Luxemburg	0.2	0.11 - 0.17	Effective Oct. '89
Netherlands	0.2	0.11 - 0.17	Effective Oct. '89
Portugal	0.3	0.23	
Spain	0.3	0.21 - 0.3	
United Kubgd	0.2	0.08 - 0.26	By BS EN 590 1993
U.S.	0.05		From Oct. '93

Asia

Countrie	Standard (Upper limits) wt %	Actual values wt %	Sulfur reduction plan
Chaina	0.5		
Hong Kong	0.2	0.1 - 0.47	Euro 1 in '95 Euro 2 in'96 0.05% in '96
India	1	0.24 - 0.88	Effective Oct. '89
Indonesia	0.5	0.33 - 0.36	
Korea	0.2	0.13 - 0.17	0.1% in '96 Predicted 0.05% in '98
Malaysia	0.5	0.1	0.3% in '97
Pakistan	1	0.76 - 0.87	
Philippines	0.8		0.5% in '96
Singapore	0.5	0.26 - 0.47	Predicted 0.3% in '96
Taiwan	0.3		0.05% in '97
Thailand	0.5	0.32	0.5% in Jan.'96 Predicted 0.05% in 2000
Japan	0.2	0.24 - 0.88	From Oct. '92
	0.05		From Oct. '97

Surce:The 3rd meeting of experts on motorization and the enviromental issue,part 2
Contents of countermeasures to prevent air pollution caused by motor vehicle,
Japan automobile standard internationalization center, December 6, 1995

Table4.3.3-2 Fuel consumption by vehicles in GTA

UNIT : 10^3 liter

Year / Type of Fuel	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Gas Oil	363,104	333,895	335,755	359,808	358,174	336,157	352,794	365,000	375,007	366,585	347,755
Normal Gasoline	1,698,628	1,619,713	1,736,912	1,752,064	1,935,085	2,067,530	2,188,519	2,320,360	2,434,406	2,467,244	2,599,646
Super Gasoline	148,457	20,469	4,421	8,584	6,298	6,362	13,023	41,609	76,206	99,252	124,473
Un-leaded Gasolin	....	....	....	....	....	3,499	24,364	41,686	38,235	58,060	68,224

Source:Air Quality Control Company(Quantity of gas oil consumption was amended in accordance with The URBAN AGE)

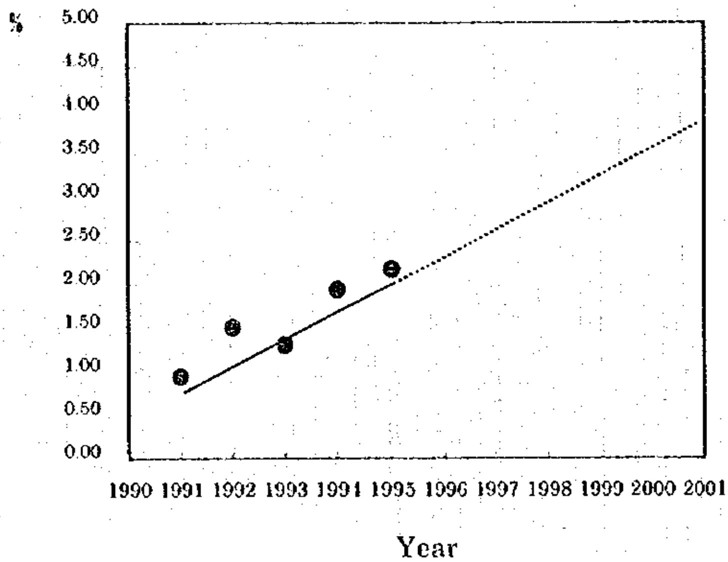


Fig.4.3.3-1 Percentage of oxygenated gasoline in the total gasoline consumption in GTA

Table4.3.3-3 Gas oil consumption in railway in IRAN

Unit : liter

	1994	1995
Electric diesel	144,397,090	165,399,967
Cranes	368,562	276,011
Tehran station	18,211,778	23,180,331
Total	162,977,430	188,856,309

Source : Iranian Islamic Republic Railway

Table4.3.3-4 Sox emission from raiway in IRAN

Unit : ton/year

	1994	1995
Electric diesel	2,484	2,845
Cranes	6	5
Tehran station	313	399
Total	2,803	3,249

4.3.4 Traffic volume survey

MOT has established an area in the central part of the City in which unauthorized vehicles entry is restricted. In addition, controls have also been placed on the entry of large trucks into the city, as well as on the flow of traffic by establishing a large number of one-way streets.

In order to analyze the present status of pollution and evaluate impacts of these measures, it is necessary to understand the current status, such as the traffic volume within Tehran and their daily fluctuation patterns. Such variables are characterized by places, time and land usage in each area of the City, such as, commercial, industrial and residential areas and are affected by traffic regulations or restrictions.

The objectives of this survey are to understand the characteristics inherent with the volume of traffic and their daily fluctuation patterns within Tehran, and to correlate these findings for preparation of an effective countermeasure.

The survey was implemented at the 20 major intersections in Tehran as indicated in Fig.4.3.4-1. In selecting these locations, (1) past traffic volume survey results, (2) road types, (3)present status of traffic control, and (4) land usage have been taken into consideration. The names of the survey points and their numbers shown in Fig.4.3.4-1 are as follows:

1 BOZORG-RAH-E-RESALAT

2 MEDAN-E-FATEMI

3 MEDAN-E-ENQELAB

4 MEYDAN-E-GOMROK

5 INTERSECTION, SHAHID MOSTAFA KHOMEYNI and MOLAVI

6 INTERSECTION, JOMHURI-YE-ESLAMI and FERDOWSI

7 BOZORG-RAH-E-SHAHID DOKTOR CHAMRAN

8 BOZORG-RAH-E-SHEYKH FAZL-OL-LAH-NURI

9 MEYDAN-E-RESALAT

10 MEYDAN-E-KHORASAN

11 MEYDAN-E-AZADI

12 MEYDAN-E-VALI-YE-ASR

13 MEYDAN-E-SHUSH

14 INTERSECTION, VALI-YE-ASR and ENQELAB

15 INTERSECTION, SOHRVARDI and SHAHID AYATOLLA BEHESHITI

16 INTERSECTION, SABALAN and DAMAVAND

17 JADDEH-YE-KHORASAN

18 INTERSECTION, FADA'IYAN-E-ESLAM and JADDEH-YE-VARAMIN

19 INTERSECTION, QUAZVIN and AZARI

20 BOZORG RAH-E-AYATOLLAH-E-SADR

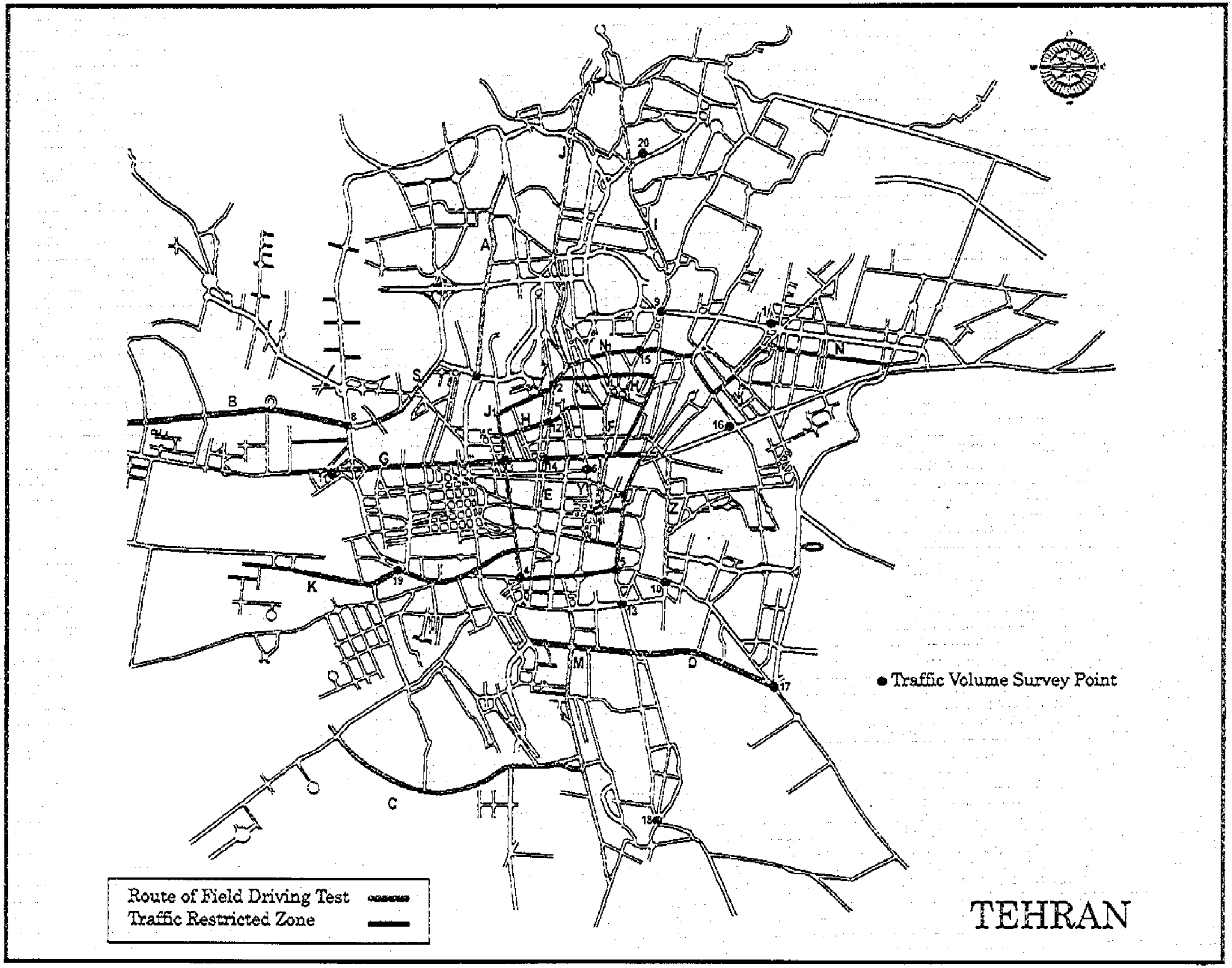
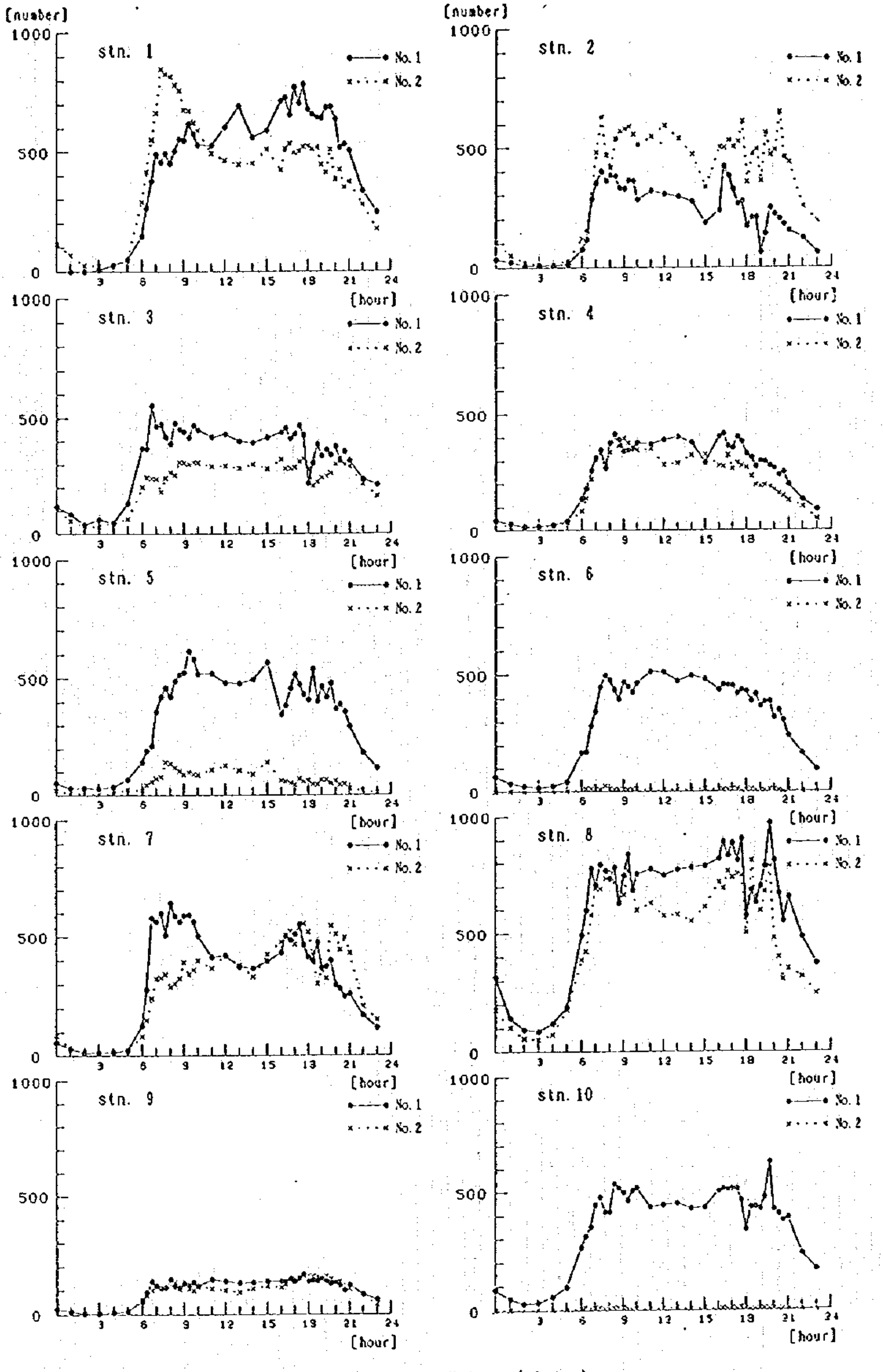


Fig.4.3.4-1 Survey Sites of traffic volume survey and survey routes of field driving test



Traffic Volume (10min.) 1996 Oct. 7 Monday

Fig.4.3.4-2(1) Fluctuation of daily traffic Volume

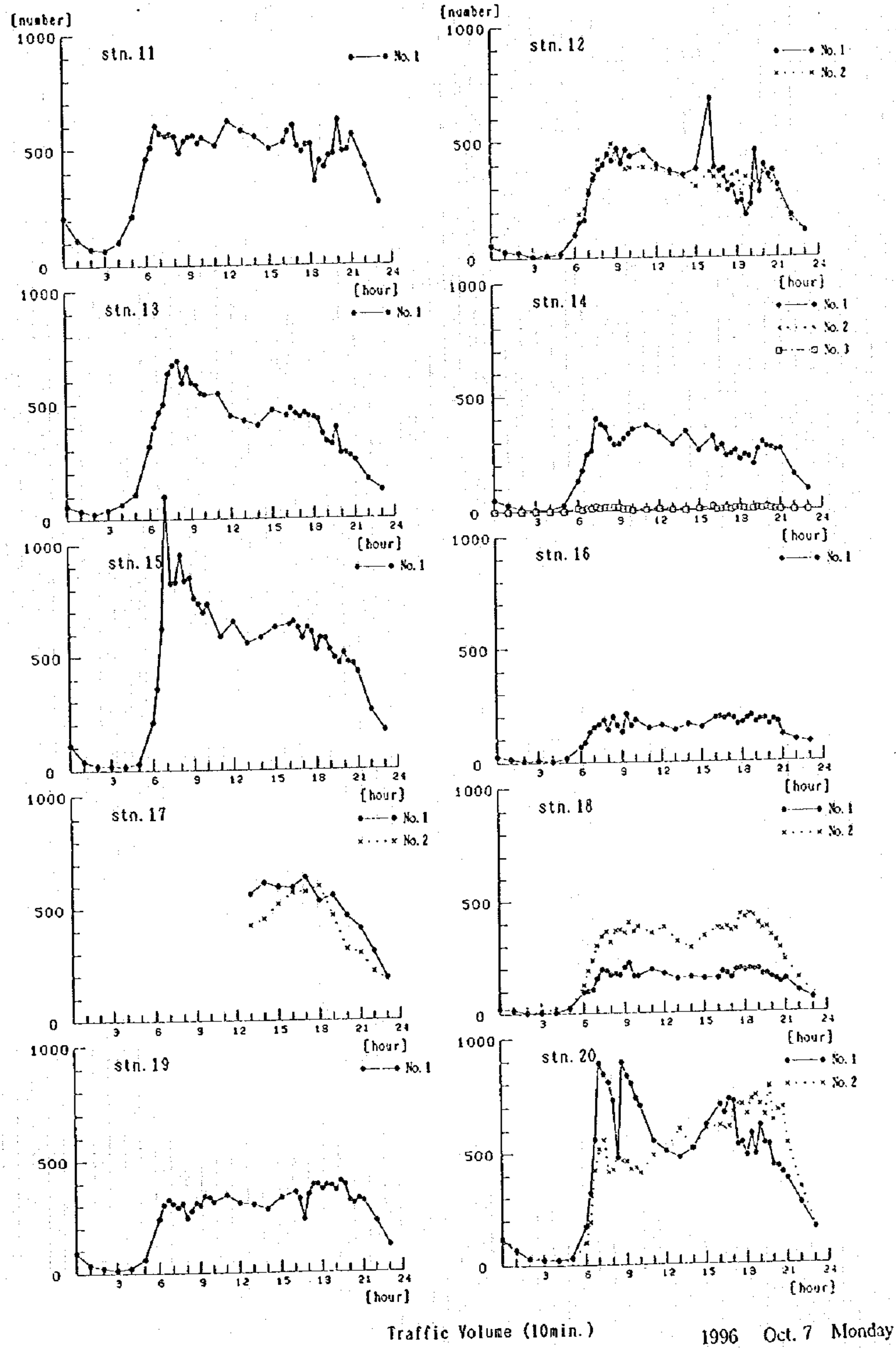


Fig.4.3.4-2(2) Fluctuation of daily traffic Volume

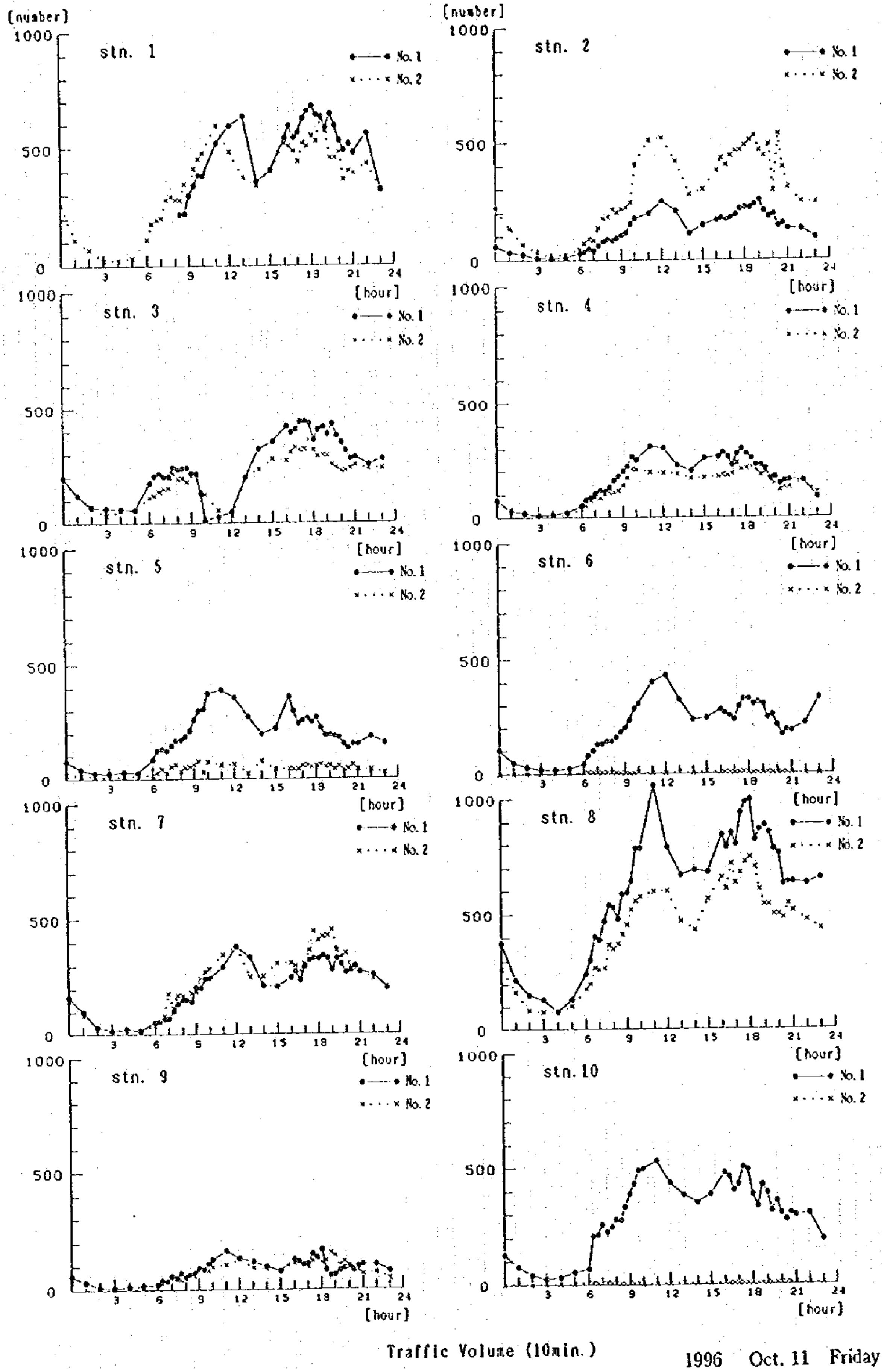
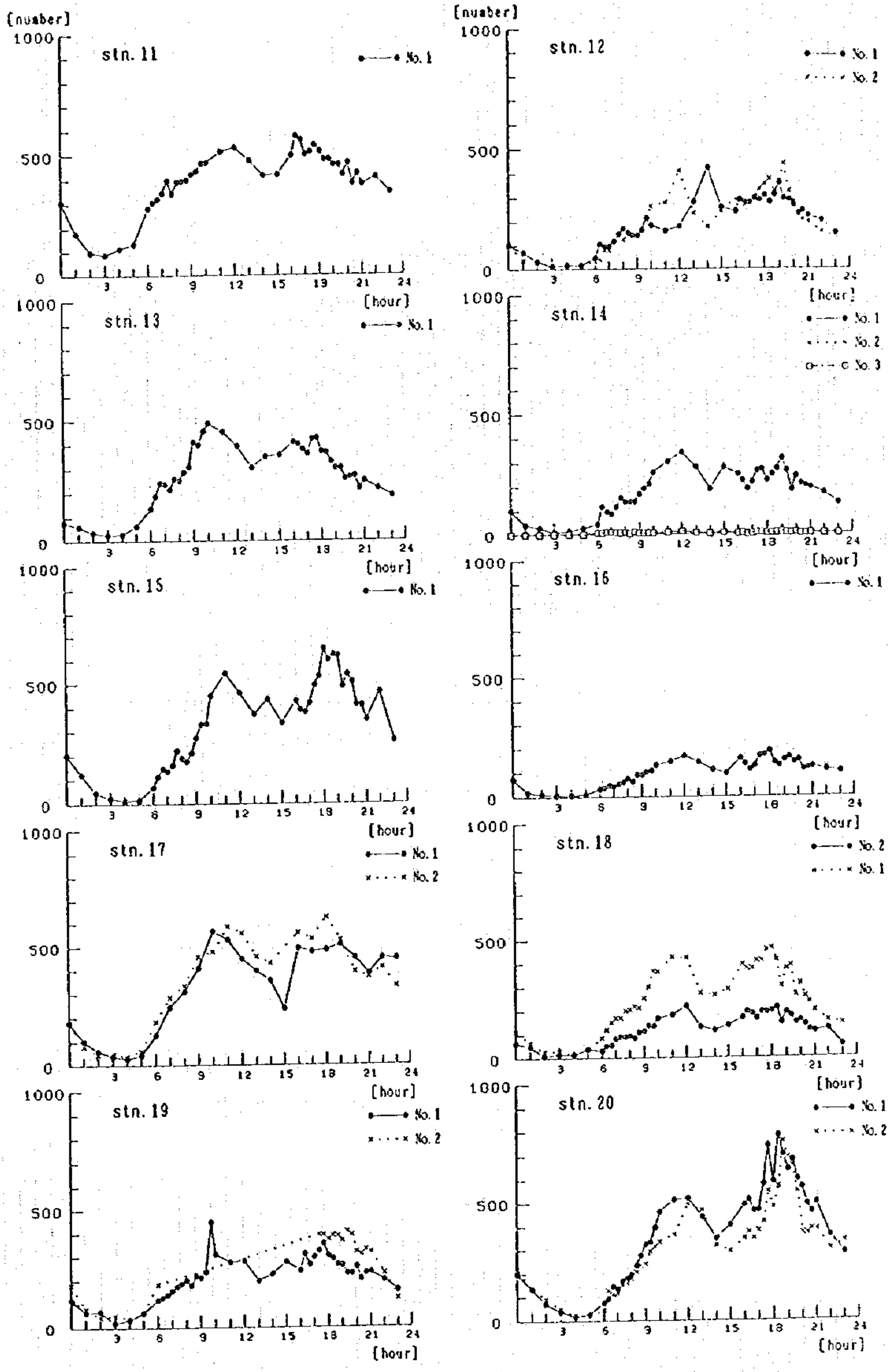


Fig.4.3.4-2(3) Fluctuation of daily traffic Volume



Traffic Volume (10min.)

1996 Oct. 11 Friday

Fig.4.3.4-2(4) Fluctuation of daily traffic Volume

At each surveying point, a video camera with a recorder unit was installed to count traffics and classified by vehicle types and driving pictures were later played back. The types of vehicle were classified into seven categories, i.e. passenger cars, pick-ups, mini-buses, buses, mini trucks, trucks and motor cycles. Although recordings were made continuously over a 24hour period from midnight, measurements and counting were selectively carried out so as to meet the study objectives. The measurements were based on 10 minute periods from the beginning of every hour during the off-peak time, i.e. total of 10 minutes every hour, and additionally 10 minutes at a frequency of every 20 minutes during the peak hours totaling 30 minutes every hour.

-Measurement/Counting time in off-peak times;

12:00 midnight to 05:00, 10:00 to 15:00, 21:00 to 23:00

-Measurement/Counting time in peak times;

06:00 to 09:00, 16:00 to 20:00

The survey was carried out on two separate days; a normal working day and a holiday. As Thursday is a half-day and Friday is a holiday in Iran, Friday was selected as the holiday for the survey, and Monday was selected as the normal working day.

1st survey (working day) : October 7, 1996 (Monday)

2nd survey (holiday) : October 11, 1996 (Friday)

(1) Daily traffic volume fluctuations

The daily fluctuation patterns at each survey point are outlined in Fig.4.3.4-2(1) to 4.3.4-2(4). These daily fluctuations will be classified into the following three categories:

1) Restricted area pattern

This pattern may be applicable to the roads located in the restricted area and/or its vicinities. The survey sites numbered 6, 12, 14 corresponding to the restricted area, as well as 2, 3, 4 and 5 corresponding to the borders are included in this pattern.

The volume of traffic begins to increase from around 05:00, peaks between 07:00 and 09:00 and decreases after this hours until around 18:00. The rates of reduction are clearly similar at all survey points.

No remarkable peaks in traffic volume were observed in the mornings or evenings, while the main feature of this pattern is indicated by the daily fluctuation chart. The ratio of traffic volume among three periods in a day, i.e. prior to 05:00, between 05:00 and 06:00, and after 06:00, is approximately 1:10:5.

2) Main commuter road pattern

This pattern may be applicable to the main roads and highways linking the central part of Tehran with the suburbs. The survey sites numbered 1, 7, 10, 13 and 15 are governed by this pattern.

The traffic into the center of the city from the suburbs begins to increase around 05:00 and peaks between 06:00 and 09:00 in the same way as the above 1). The volume of traffic during the peak period is 1.5 to 2.0 times bigger than that observed in 1).

After the morning peak period, traffic volume is reduced until midday, and levels off during the hours of 12:00 and 15:00. The volume of traffic during this period was approximately a half or two-thirds of the morning peak period.

There were many locations where increases in traffic volume were recorded from about 15:00 until the peak reached at approximately 18:00. However, the evening peak was not so remarkable as the morning peak, with volumes remaining at around two-thirds to three-quarters of those recorded in the morning.

On the other hand, the above-mentioned phenomena were reversed for the traffic heading from the center of the city to the suburbs. In other words, a peak was recorded in the evening, reflecting commutation from the suburbs into the city center.

Observing both of these types indicates that traffic volume peaks were apparent in the morning and the evening, and the main feature of this pattern is in the indication of fluctuations in both types.

The ratio of traffic volume among five periods in a day -- prior to 05:00, between 05:00 and 12:00, between 12:00 and 15:00, between 15:00 and 21:00 and after 21:00 – was approximately 1:15:10:15:5.

3) By-pass pattern

This pattern may be applicable to the area surrounding Azadi Square in the western part of Tehran. The survey site numbered 8 and 11 are covered by this pattern.

Drastic increases in traffic volume was observed between 03:00 and 04:00, slightly earlier than the peaks described under 1), 2), which continued until about 06:00, leveled off between 06:00 and 09:00, and then began to decrease slightly. In other words, this pattern closely resembles that explained in 1), but the night-time traffic was 2.5 to 3 times greater than that of pattern described in 1).

It is thought that the reasons for the increased volume of night-time traffic at these survey sites is the effect of linking the western part of Tehran with the by-pass to the city of Karaj including a connection to the airport.

(2) Traffic volume features of each vehicle type

The followings are the results of the traffic volume survey corresponding to vehicle types:

1) Passenger cars

Patterns similar tendencies to the fluctuation of overall traffic volume explained in (1) were observed, because passenger cars accounted for a large percentage of all vehicle types.

2) Buses, mini-buses

The traffic volume in this sector was drastically smaller, but the fluctuation patterns were similar to those explained in (1)2). In other words, the fluctuations revealed the morning peak at around 07:00 and the evening peak at around 17:00, because companies and schools run buses in the city for business and student commuters during this period.

Traffic volume for this sector was not significant in early morning or at night because public buses transport tourists, company employees and students who do not ride them during the night and early morning.

3) Trucks, mini-trucks

There were many survey sites that recorded increased traffic volume before 05:00 and after 21:00 in comparison with daytime traffic, because the entry of trucks into the city of Tehran during the daytime is restricted, and these restrictions are released at night.

At survey locations numbered 7 and 18, more traffic volume was observed on the trunk roads linking the suburbs with the center of Tehran, and less traffic in the restricted area.

4) Pick-ups

There was no remarkable peak in the morning or evening, and the fluctuation pattern was similar to that described under (1)1). In other words: namely, traffic volume began to increase after 05:00, leveled off between 09:00 and 18:00, and then dramatically decreased after that, indicating the fluctuation pattern of this vehicle type. As pick-ups are mostly used for transporting small-scale cargo, the traffic volume at survey points 4, 5 and 13, located near bazaars, was greater, but almost non-existent during the night and early morning when commercial activities are halted.

5) Motor cycles

The fluctuation pattern was similar to that of passenger cars. The highest level of traffic volume was recorded at survey points 4, 5, 10 and 13 near bazaars.

This report concentrates on the traffic volume on normal working days. It was thought that these data would be more important from the viewpoint of the effects on atmospheric pollution, because there are more working days than holidays. Simulations will be carried out with the use of the traffic characteristics observed on working days during the current phase of the study, but examinations will be carried out on the characteristics of holidays' traffic volume in the near future to incorporate the outcome in simulations if necessary.

4.3.5 Field driving test

As the pollutants contained in automobile exhaust gas differ according to the vehicular driving conditions, it is necessary to clearly understand the driving conditions in the relevant areas in order to verify and forecast the amount of pollutants to be emitted into the atmosphere. In order to examine the driving conditions within the city of Tehran, an automobile was mounted with speedometers and other measurement instrument and driven through pre-determined roadways at different times. A driving cycle, i.e. a test mode reflecting actual conditions within the city of Tehran, was determined on the basis of average speed, idling, acceleration, deceleration, and a comparison of stable-speed ratio obtained from the results of the driving tests. The concentration, volume and temperature of the exhaust gas emitted during two of the driving tests were also measured, emission coefficients were calculated at ten second intervals, and a survey was carried out to verify a relationship between driving conditions and the emission coefficients.

The survey routes of the test drives are outlined in Fig.4.3.4-1. These routes were selected in consideration of the following points.

-Roads, which have much traffic volume and are thought to contribute to atmospheric pollution.

-Roads which have comparatively large intersections.

-The inclusion of several different types of roads (highways, trunk roads, etc.)

The names of the survey routes are as follows:

A BOZORG RAH—E—SHAHID DOKTOR CHAMRAN

B TEHRAN — KARAJ FREE WAY

C BEHESHT— E —ZAHRA,KARAJ RING ROAD

D BESAT HIGHWAY

E MEYDAN—E—GOMROK → MOLAVI → VALI—YE—ASR → INTERSECTION

DOCTOR HOSEYN—E—FATEMI

VALI—YE—ASR

F MOFATEH → SADI → EKBATAN → EMAMKHOMAYNI → BABHOMAYUN

DAVAR → BANZAM—E—KHORDAD → INTERSECTION

SHAHID MOSTAFA KHOMEYNI

BANZAM—E—KHORDAD

G MEYDAN—E—EMAMHOSEYN → ENQELAB → AZADI → MEYDAN-E-AZADI

H INTERSECTION → BOLVAR—E—KESHAVARZ → KARIM KHAN—E—ZAND

KARGAR

BOLVAR—E—KESHAVARZ

SHAHID HOJJAT—OL—ESLAM DOKTOR MOFATTEH → BAHAR—E—SHIRZ

SHORVARDI → INTERSECTION

SHORVARDI

OSTAD MOTAHHAR

I INTERSECTION → DOKTOR ALI—YE—SHARIATI → MEYDAN—E—QODS

DOKTOR ALI—YE—SHARIATI

BOZORG RAH—E—RESALAT

J MEYDAN—E—TAJIRISH → VALI—YE—ASR → INTERSECTION

VALI—YE—ASR

DOKTOR HOSEYN—E—FATEMI

J1 MEYDAN-E-FATEMI → INTERSECTION

KARGAR

KESHAVARZ

K MEYDAN—E—QAZVIN → QUAZVIN → AZARI

SHAHID RAJA'I

SHUSH

N MEYDAN AVVEL → SAD—O—CHEHEL—O—DOVVOM—E—GHARBI → GOLBARG → SHAHID AYATOLLAH MADANI → SABALAN

N1 DOKTOR BEHESHITI

N2 MOTAHHARI

S BOZORG RAH—E—SHEYKH FAZL-OL-LAH-E-NURI

X MEYDAN-E-ENQELAB → KHOMEYNI → MEYDAN-E-MOHAMMADIYEH

Y AMIRKABIR→MEYDAN-E-EMAMKHOMEYNI → MEYDAN-E-FERDOWSI

Z MEYDAN-E-KHORASAN → MEYDAN-E-EMAMHOSEYN

The measurement items and methods of measurement for the field driving tests are outlined in Table4.3.5-1, and the measurement systems are outlined in Fig.4.3.5-1.

Table.4.3.5-1 Testing items and method

ITEM	TESTING METHOD or EQUIPMENT
Car speed	Spatial filter type speed detector
Engine rpm.	Ignition puls detector for secondary high voltage code
Negative pressure	Digital pressure meter(Intake manifold)
Temperature of exhaust gas	Thermo couple
Dynamic pressure of exhaust gas	Pitot tube
Concentration of CO,CO2,HC	NDIR gas filter correlation method

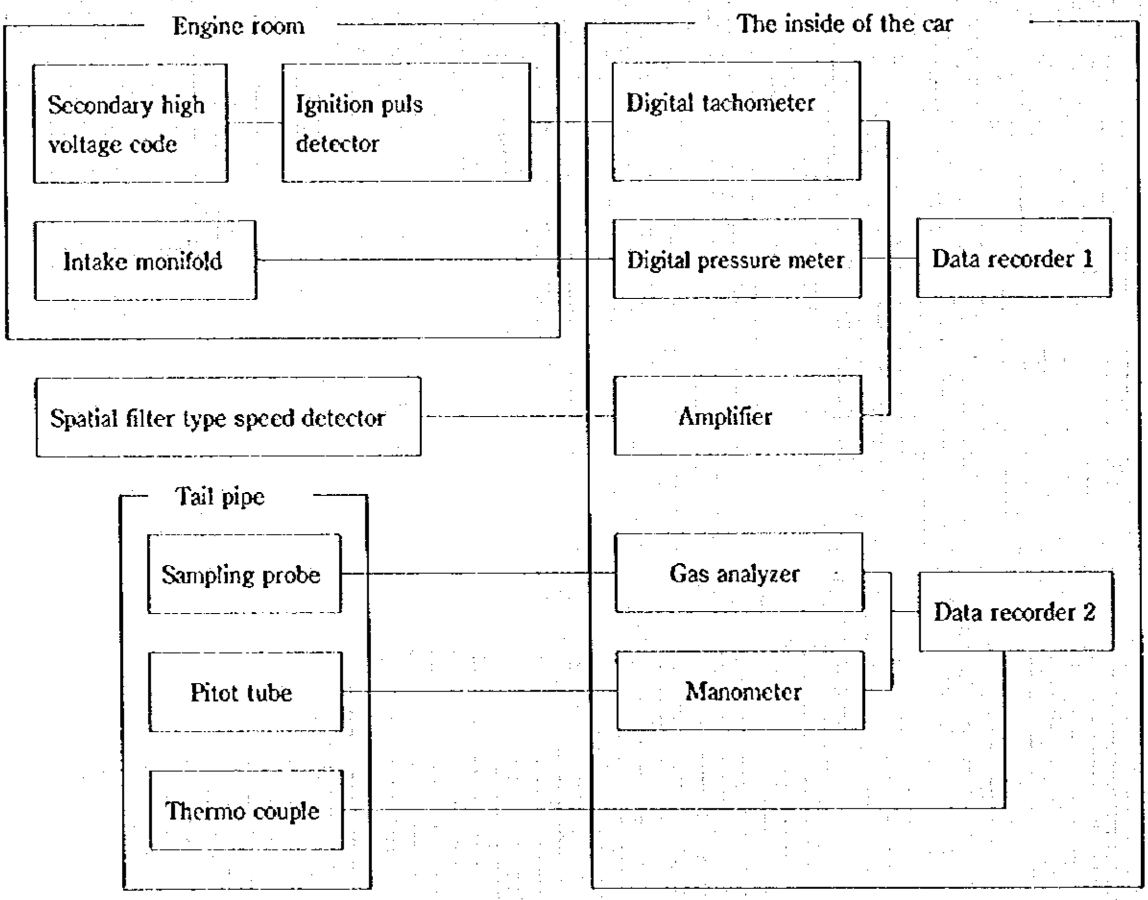


Fig. 4.3.5-1 Measurement system

The sampling interval was 0.5 seconds for the data recorder 1, and 10 seconds for the data recorder 2.

The survey was suspended if reasons other than normal congestion, such as road works and accidents, were delaying traffics on the selected roads. Also, abrupt overtaking was avoided and the vehicle was driven at the average speed dictated by the flow of traffic.

The test drives were implemented on normal working days and on holidays between September 29, 1996, and October 18, 1996. The surveys were conducted during the normal daytime including morning and evening peaks, but were not implemented at night.

A list of the field driving test results are provided in Table4.3.5-2(1). Fig.4.3.5-2 shows the emergence frequency of average vehicle speed ('average vehicle speed' will hereinafter be known as speed (2)), and Fig.4.3.5-3 through Fig.4.3.5-6 indicate the emergence frequency of idling, acceleration, deceleration and stable conditions.

The number of valid survey routes reached 70. Definitions of the terminology used hereinafter are as follows:

Speed (1) : Average vehicle speed excluding idling time.

Speed (2) : Average vehicle speed including idling time.

Idle : Ratio of the amount of time that the vehicle speed was 1.5km or less during running time.

Acceleration: Ratio of the amount of time that the acceleration speed was 1.5km/h/s or larger during running time.

Deceleration: Ratio of the amount of time that the deceleration speed was 1.5km/h/s or less during running time.

Stable : Ratio of the amount of time that the acceleration speed was -1.5km/h/s or larger, 1.5km/h/s or less during running time.

Table4.3.5-2(1) Results of field driving tests

Run No.	Route	Date	Time	Running Time	Distance	Speed(1)	Speed(2)	Ratio (%)			
				min.	km	km/h	km/h	Idle	Acceleration	Deceleration	Stable
2	H	1996/9/26	15:21:00	12.38	5.04	24.44	29.51	16.69	22.88	22.41	38.02
3	F	1996/9/29	15:54:00	30.80	8.75	17.05	21.71	20.73	18.45	19.29	41.53
4	E	1996/9/29	16:49:00	26.03	6.13	14.12	20.66	30.76	17.16	17.73	34.35
5	I	1996/9/29	17:32:00	19.69	7.12	21.69	24.82	12.36	24.55	24.50	38.60
6	G	1996/9/30	15:55:00	31.83	9.84	18.54	24.04	22.07	20.18	20.31	37.43
7	K	1996/9/30	16:50:00	15.11	3.91	15.54	18.67	16.55	20.96	20.30	42.20
8	M	1996/9/30	17:25:00	11.98	6.38	31.96	33.28	3.98	21.00	20.24	54.87
9	N	1996/10/1	9:53:00	21.47	8.61	24.07	27.50	12.07	18.56	19.33	50.04
10	N1	1996/10/1	10:17:00	9.16	2.83	18.56	23.65	21.02	18.02	17.56	43.40
11	N2	1996/10/1	10:28:00	8.79	2.77	18.93	27.35	29.76	18.10	17.06	35.07
12	N1	1996/10/13	18:59:00	15.73	2.67	10.20	15.31	31.73	13.82	15.36	39.09
13	N2	1996/10/13	19:17:00	9.78	2.83	17.37	21.92	20.12	18.76	21.48	39.64
14	I	1996/10/13	14:13:00	16.69	7.22	25.95	28.53	8.99	24.96	23.17	42.89
15	J	1996/10/13	14:35:00	26.50	10.11	22.90	27.17	15.38	16.89	17.92	49.81
16	H	1996/10/13	15:10	9.77	3.80	23.32	28.77	18.52	24.32	21.67	35.49
17	F	1996/10/2	15:28:00	20.14	6.83	20.34	23.57	13.57	19.40	18.08	48.94
18	E	1996/10/2	18:40:00	43.06	5.46	7.61	15.01	46.12	14.34	15.68	23.86
19	I	1996/10/4	9:18:00	12.44	7.11	34.31	35.50	3.28	16.01	16.34	64.37
20	J	1996/10/4	9:33:00	18.18	10.49	34.63	35.15	1.47	16.28	15.54	66.71
21	F	1996/10/4	10:06:00	12.50	6.69	32.08	33.59	4.31	21.60	21.07	53.20
22	E	1996/10/4	10:30:00	20.11	6.13	18.30	23.69	22.38	18.57	18.52	40.53
23	N2	1996/10/4	10:53:00	5.55	2.92	31.60	36.30	12.76	17.12	15.17	54.95
24	N1	1996/10/4	11:00:00	7.36	2.89	23.57	29.97	21.06	18.46	16.31	44.17
25	Y	1996/10/5	15:05:00	5.41	1.92	21.33	22.12	3.39	20.03	19.57	57.01
26	E1	1996/10/5	15:43:00	13.24	3.84	17.39	19.50	10.67	16.99	17.37	55.07
27	Z	1996/10/5	16:28:00	20.67	8.11	23.55	25.80	8.51	23.63	22.22	45.65
28	N1	1996/10/5	16:28:00	11.37	2.78	14.68	23.92	37.76	17.01	16.28	28.96
29	N2	1996/10/5	16:43:00	9.89	2.82	17.12	20.76	17.10	21.40	19.46	42.04
32	A	1996/10/8	15:59:00	14.52	17.91	74.01	75.97	2.53	14.52	15.96	66.09
34	C	1996/10/8	16:24:00	9.01	9.01	60.03	67.12	10.45	7.77	9.07	72.71
35	J1	1996/10/9	11:05:00	6.32	2.65	25.14	26.30	4.35	25.03	23.06	47.56
36	M	1996/10/9	11:37:00	10.80	5.79	32.15	33.55	4.09	24.61	22.07	49.23
37	D	1996/10/9	12:00:00	9.27	6.23	40.32	55.26	26.80	10.16	8.90	54.14
38	N	1996/10/9	12:27:00	21.72	8.74	24.16	27.96	13.24	22.95	20.76	43.05
39	N1	1996/10/9	14:43:00	8.48	2.83	20.06	27.81	27.04	15.14	16.42	41.40
40	N2	1996/10/9	14:53:00	8.23	2.81	20.50	25.77	19.84	19.64	17.91	42.61
41	H	1996/10/9	15:20:00	11.17	5.06	27.19	31.29	12.84	24.40	22.01	40.75
42	X	1996/10/10	15:42:00	20.28	4.94	14.61	18.16	19.43	14.67	14.67	51.23
43	Y	1996/10/10	16:13:00	6.28	2.00	19.13	20.97	8.49	17.11	17.51	56.90
46	Z	1996/10/11	10:38:00	24.78	8.40	20.33	23.43	12.98	21.19	19.78	46.05

Table4.3.5-2(2) Results of field driving tests

Run No.	Route	Date	Time	Running Time	Distance	Speed(1)	Speed(2)	Ratio (%)			
				min.	km	km/h	km/h	Idle	Acceleration	Deceleration	Stable
47	G	1996/10/11	11:03:00	40.42	9.98	14.82	21.15	29.17	18.76	18.28	33.79
48	K	1996/10/11	12:07:00	11.51	3.92	20.44	22.45	8.83	17.96	18.03	55.18
49	Y	1996/10/11	12:56:00	11.46	1.89	9.86	16.02	35.56	16.87	19.71	27.85
50	I	1996/10/11	18:18:00	26.01	6.93	15.98	19.94	19.06	20.06	21.88	38.99
51	J	1996/10/11	18:50:00	34.56	10.23	17.76	20.69	13.84	15.51	17.22	53.44
52	N2	1996/10/11	19:20:00	7.38	2.91	23.65	26.39	10.27	19.30	19.86	50.56
53	G	1996/10/12	8:56:00	32.97	9.83	17.90	22.40	19.84	19.11	18.30	42.75
54	X	1996/10/12	9:36:00	20.43	4.56	13.39	19.05	28.71	14.07	14.64	42.58
55	E1	1996/10/12	10:04:00	15.61	3.87	14.86	18.49	19.27	15.80	16.60	48.32
56	Z	1996/10/12	10:27:00	20.72	8.34	24.17	26.33	8.00	22.81	23.01	46.18
57	Y	1996/10/12	11:00:00	12.51	1.98	9.49	17.26	43.97	14.52	15.79	25.72
58	H	1996/10/14	8:50:00	13.19	5.06	23.02	27.40	15.60	22.74	21.60	40.05
59	G1	1996/10/14	9:23:00	20.58	5.17	15.07	21.04	27.87	18.63	19.16	34.35
60	G2	1996/10/14	9:43:00	10.74	4.60	25.70	28.58	9.78	25.99	23.35	40.88
61	A	1996/10/14	10:08:00	12.19	7.18	35.35	48.90	27.41	9.02	10.05	53.52
62	B	1996/10/14	10:30:00	10.68	12.79	71.91	73.23	1.80	10.93	12.02	75.25
63	C	1996/10/14	11:01:00	10.63	12.67	71.48	72.51	1.41	9.72	12.30	76.57
64	J1	1996/10/17	16:56:00	6.54	2.74	25.16	31.17	18.85	21.78	18.34	41.02
65	E1	1996/10/17	17:23:00	44.30	5.54	7.51	15.18	47.74	11.87	12.45	27.93
66	N2	1996/10/17	18:08:00	6.14	2.82	27.50	29.85	7.60	22.25	24.83	45.32
67	N1	1996/10/18	8:26:00	5.59	2.90	31.13	33.06	5.81	16.39	16.54	61.25
68	N2	1996/10/18	8:33:00	4.62	2.88	37.37	38.28	2.34	22.70	18.02	56.94
69	X	1996/10/18	8:44:00	9.13	5.04	33.12	36.51	9.22	12.77	11.68	66.33
70	E1	1996/10/18	8:58:00	8.08	3.84	28.52	28.80	0.93	24.54	22.78	51.75
71	Y	1996/10/18	9:28:00	13.42	6.07	27.14	29.72	8.51	20.31	20.81	50.37
72	E1	1996/10/18	9:45:00	14.37	9.90	41.35	46.58	11.14	12.41	12.24	64.21
73	S	1996/10/18	10:06:00	14.38	9.78	40.83	46.22	11.48	13.28	12.52	62.72
75	G2	1996/10/18	10:28:00	10.75	4.32	24.10	29.74	18.68	21.24	22.33	37.75
76	F	1996/10/18	10:52:00	13.31	6.77	30.51	34.88	12.34	22.73	20.79	44.15
77	Z	1996/10/18	11:28:00	32.72	8.15	14.95	23.65	35.61	15.79	15.77	32.83
AVE.				15.88	5.93	25.33	29.67	16.51	18.38	18.13	46.99
MAX.				44.30	17.91	74.01	75.97	47.74	25.99	24.83	76.57
MIN.				4.62	1.89	7.51	15.01	0.93	7.77	8.90	23.86

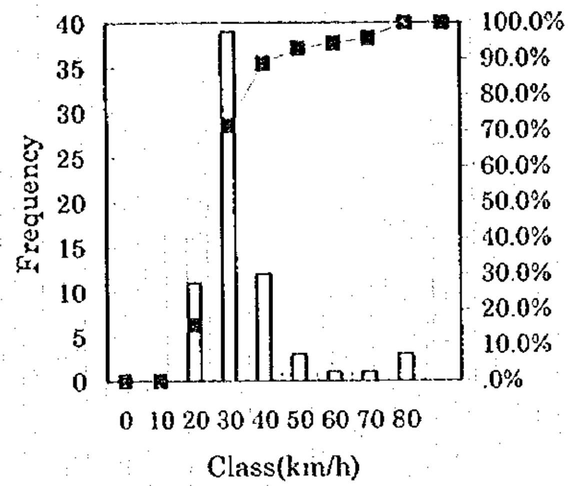


Fig.4.3.5-2 Emergence frequency of car velocity

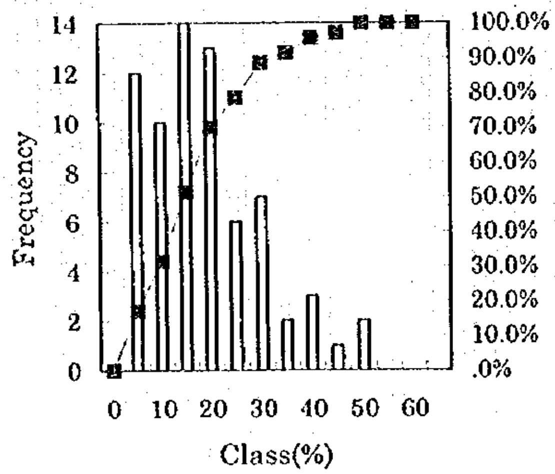


Fig.4.3.5-3 Emergence frequency of idling

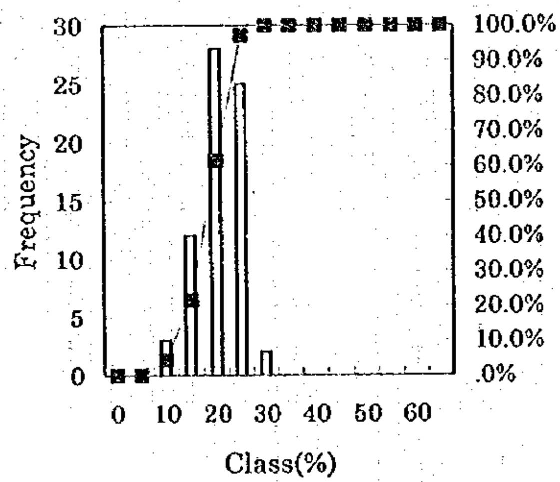


Fig.4.3.5-4 Emergency frequency of accelerating

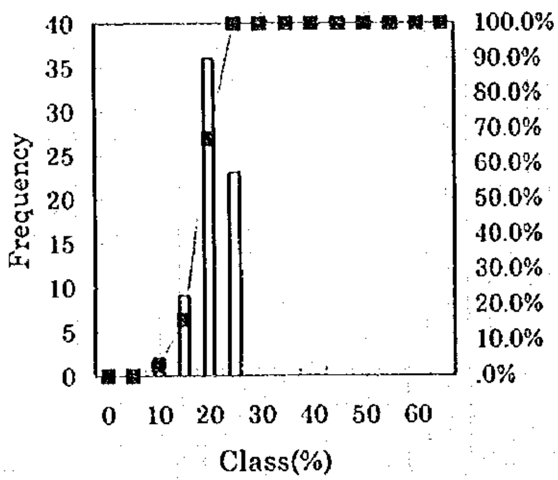


Fig.4.3.5-5 Emergence frequency of decelerating

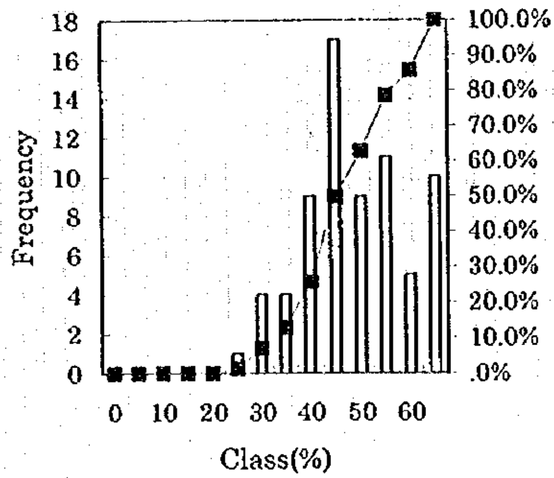


Fig.4.3.5-6 Emergence frequency of stable driving

All valid data including collected on highways show that the average vehicle speed during the daytime in the city of Tehran is 25.3km/h, the average idling ratio is 16.5%, the average acceleration ratio is 18.4%, the average deceleration ratio is 18.1% and the average stable speed is 47.0%. The figures excluding highways are 21.9km/h, 17.1%, 19.2%. 18.9% and 44.9% respectively. On trunk roads in Tehran during the peak rush hours, the idling ratio is large exceeding 40%. In the areas surrounding bazaars the ratio also exceeds 40% during the off-peak hours, which is a reflects commercial activities during the daytime and indicates congestion throughout the whole day. However, as the corresponding ratio of idling on the major trunk roads during the off-peak period is low, the final average idling ratio is also relatively low.

On the other hand, according to surveys in Tokyo, the average vehicle speed during daytime is 18.9km/h, and the idling ratio is 41.6% during peak hours and 31.2% during off-peak hours. If these figures are compared with the survey in Tehran, the traffic congestion within the city of Tehran is not so bad.

The concentration of exhaust gas, CO, CO_2, HC, the amounts and temperature during driving were measured with a passenger car most commonly seen in Tehran (Paykan, 20-years old, 1600cc). Emission factors were calculated based on these measurement results, and relationship of vehicle speed, engine rotation and other factors were examined against each driving condition. Condition of maintenance for engine of the test car was in a state of deterioration.

The method of calculation of emission coefficients is as follows:

1) A pitot tube attached inside of vehicle's tail pipe measured total pressure and static pressure, and these measurements were recorded in a date logger. A thermos couple was also attached to the tail pipe and temperature was recorded in a data logger.

2) Mass of exhaust gas is obtained with the following equation:

$$\gamma = \gamma 0 \cdot \frac{273}{273 + \theta s} \cdot \frac{(Pa + Ps)}{760}$$

γ : Mass of moist exhaust gas unit (kg/m^3), 1.3kg/m^3 in case of air

$\gamma 0$: Mass of moist exhaust gas unit (kg/m^3) calculated at temperature of zero degrees Celsius and an atmospheric pressure of 760mmHg.

Pa : Atmospheric pressure (mmHg), approximately 660mmHg in case of Tehran.

Ps : Static pressure (mmHg) within tail pipe, 0mmHg in case of the survey.

θ s: Temperature within tail pipe (degrees Celsius).

3) Equation to obtain flow speed of exhaust gas:

$$V = C\sqrt{\frac{2gh}{\gamma}}$$

V: Flow speed (m/s)

C: Pitot tube coefficient (0.76)

h: Dynamic pressure (total pressure - static pressure)

g: Gravitational acceleration speed ($9.8m/s^2$)

4) Equation to obtain the flow rate of exhaust gas

$$Q = V \cdot 60 \cdot A$$

Q: Flow rate (m^3/min)

V: Flow speed (m/s)

A: Cross-sectional area of tail pipe (m^2)

5) Conversion of flow rate of exhaust gas obtained with equation 4) into flow rate in a standard condition

$$QN = Q \cdot \frac{273}{273+\theta s} \cdot \frac{(Pa+Ps)}{760}$$

QN : Flow rate of moist gas (m^3/min)

Q : Flow rate of exhaust gas (m^3/min)

Pa : Atmospheric pressure (mmHg), approximately 660mmHg in case of Tehran.

Ps : Static pressure (mmHg) within tail pipe, 0mmHg in case of this survey.

θ s : Temperature within tail pipe (degrees Celsius).

$$QN' = QN \cdot (1 - \frac{Xw}{100})$$

QN': Flow rate of dry gas (m^3/min)

QN: Flow rate of moist gas (m^3/min)

Xw: Water content in exhaust gas (%)

The water content in exhaust gas measured before the start of the field-driving test was 7%.

6) By multiplying the flow rate of dry exhaust gas obtained in equation 5) with the measured values of each property, volume of exhaust for each unit of time (g/mi.) was calculated. For example, if concentration is 5%, Em (g/min) volume of exhaust for each unit of time is as follows:

$Em = QN' \times 5 \times 10^{-2} / 22.4 \times 28$

22.4 is cubic content (liter) of the vapor 1 mol in a standard condition, and 28 is the molecular weight of CO. Emission factor, Ef (g/km) is calculated with the following equation if speed of vehicle during sampling is Sp (km/h).

$Ef = Em \times 60/Sp$

The data obtained when driving along the route mentioned below on October 20th, 1996, are outlined in Fig.4.3.5-7 to Fig.4.3.5-9, which indicate the relationship between the emission factor of each pollutant calculated in accordance with the procedures 1) to 6) above and vehicle speed, engine rotation, and negative pressure of intake manifold.

AQCC --> DOKTOR ALI-YE-SHARI'ATI --> VOLVAR-E-MIR DAMAD --> VALI-YE-ASR OSTAD MOTAHHARI --> AQCC

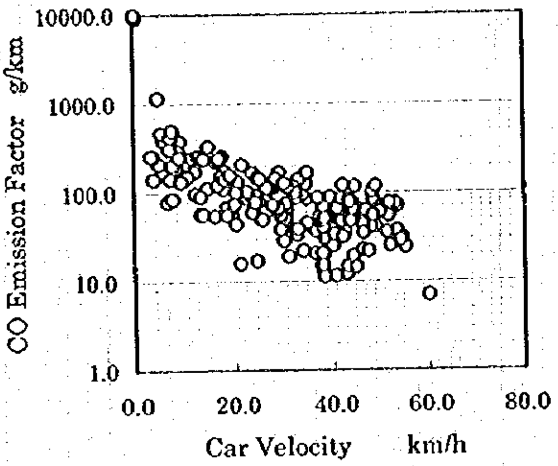
Driving was carried out for 33 minutes and 40 seconds from 14:04:00 to 14:37:40. The emission factor, vehicle speed, engine rotation and load pressure were plotted at 10second intervals. A driver and technical staff assigned to the measurements were in the car during the test drive. Because the measurement equipment weighed approximately 65kg, the total weight on board was as much as three adults.

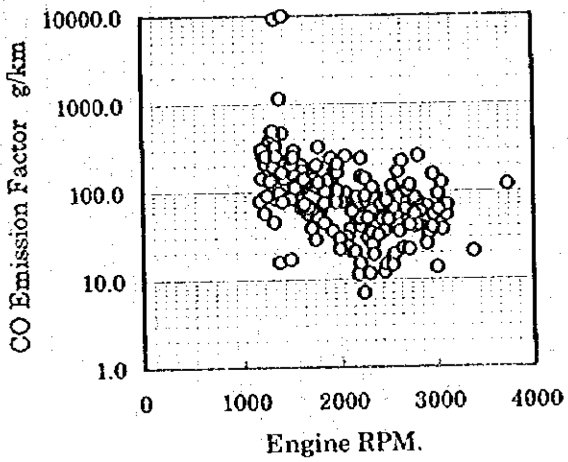
The average speed of the vehicle during driving was 28.0km/h, and the average exhaust coefficients for each pollutant was 210.9g/km for CO, 682.5g/km for CO_2 and 5.0g/km for HC. The relationship between the vehicle speed (V:km/h) and exhaust coefficients (EF:g/km) can be obtained with the following equations:

$$CO : EF = 1943.0 \cdot V^{-1.0} \quad (R=0.85)$$

$$CO_2 : EF = 8761.6 \cdot V^{-0.1} \quad (R=0.96)$$

$$HC : EF = 35.4 \cdot V^{-0.9} \quad (R=0.72)$$





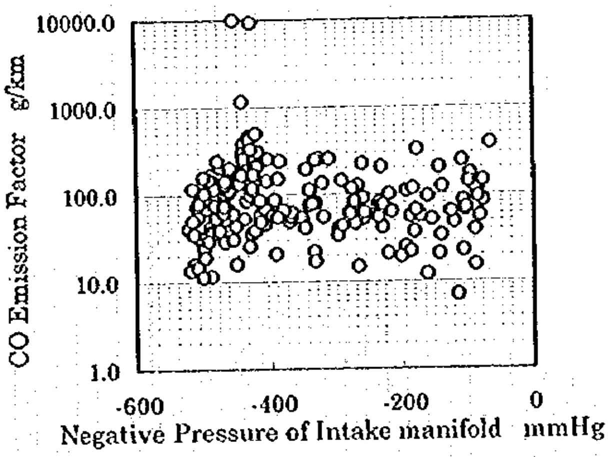


Fig.4.3.5-7 Relationship between CO emission factor and each parameter

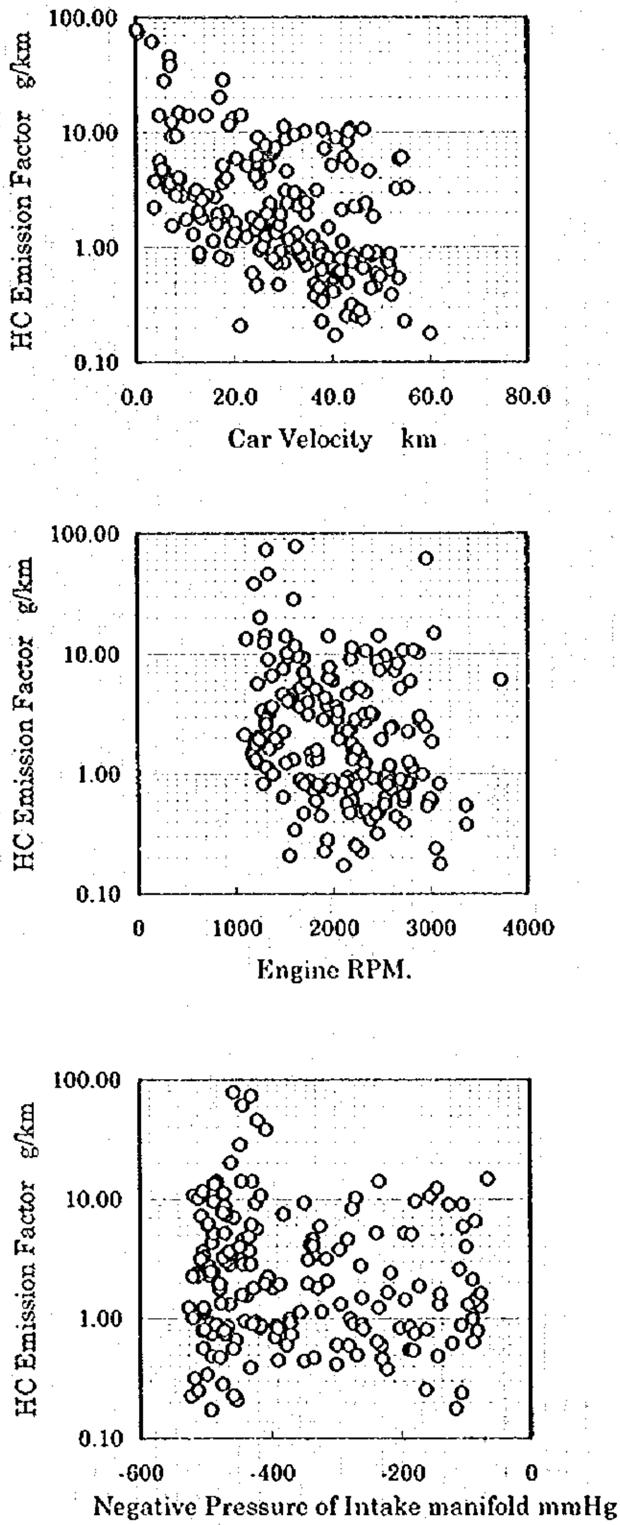
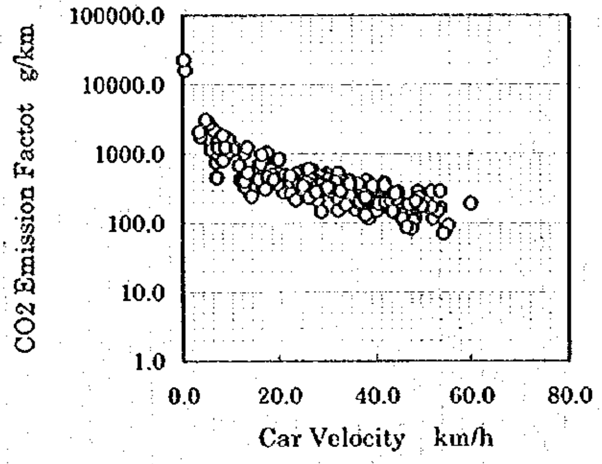
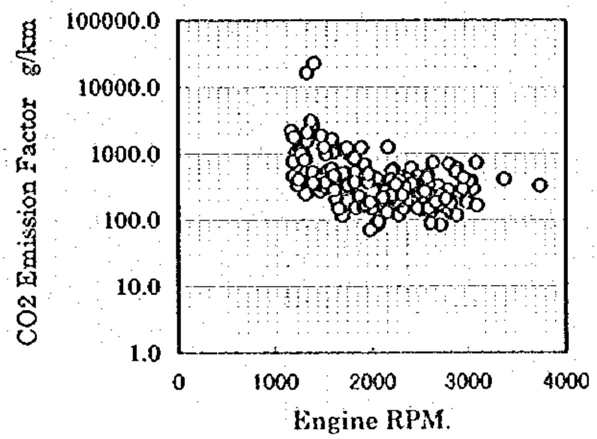


Fig.4.3.5-8 Relationship between HC emission factor and each parameter





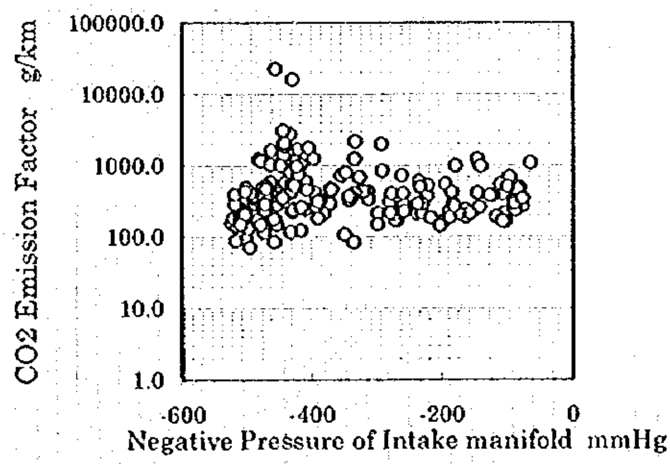


Fig.4.3.5-9 Relationship between CO2 emission factor and each parameter

Prior to determination of the driving mode that is the representative driving pattern in the city of Tehran, major elements were analyzed such as variables for average vehicle speed, idling, acceleration, deceleration and ratio of stable driving obtained during the field driving test. The correlation matrix of each parameter is indicated in Table4.3.5-3, and the position of eigen vectors is indicated in Fig.4.3.5-10. The correlation matrix reveals that each of the average vehicle speed and ratio of stable speed is positively correlated with each of the ratio of acceleration and that of deceleration. On the other hand, each of the average vehicle speed and ratio of idling is negatively correlated with each of the ratio of idling and that of stable speed.

Table4.3.4-3 Correlation matrix of each parameter

	Traveling Speed	Idling	Acceleration	Deceleration	Stable
Traveling Speed	1.00	-0.61	-0.30	-0.35	0.80
Idling	-0.61	1.00	-0.31	-0.26	-0.76
Acceleration	-0.30	-0.31	1.00	0.94	-0.37
Deceleration	-0.35	-0.26	0.94	1.00	-0.41
Stable	0.80	-0.76	-0.37	-0.41	1.00

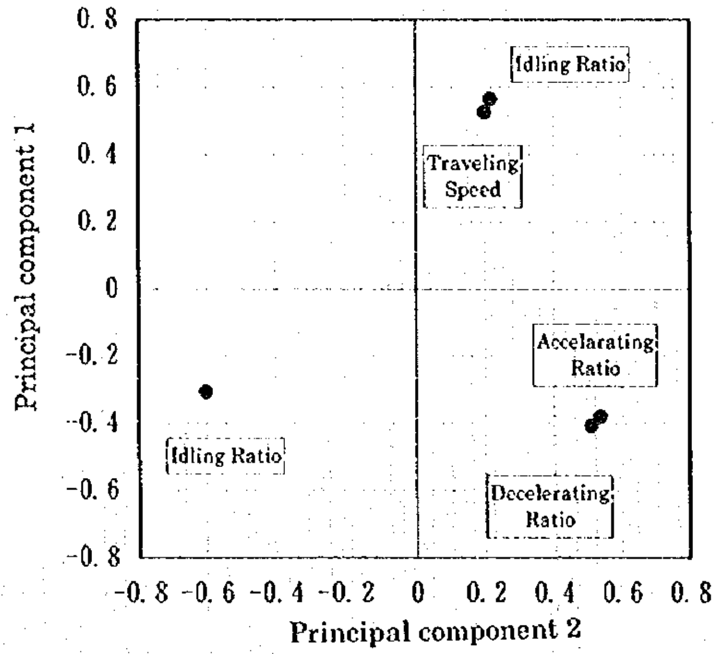


Fig.4.3.5-10 Positioning of each parameter

It is found that each of the following driving conditions can be categorized into the standards from the positioning results of variables:

- Driving speedily and stably (highways)
- The average vehicle speed is comparatively low when acceleration and deceleration are repeated. (trunk roads during off-peak hours on a normal working day)
- The average vehicle speed is comparatively low and much idling is done. (during peak hours on a normal working day in the vicinity of bazaars)

The positioning was plotted in Fig.4.3.5-11 reflecting the result of each driving test, with principal component 1 on the horizontal axis and principal component 2 on the vertical axis. For comparison purposes, the main elements for standard ECE mode, 10 mode, 10/15 mode and 11 mode are also calculated and plotted.

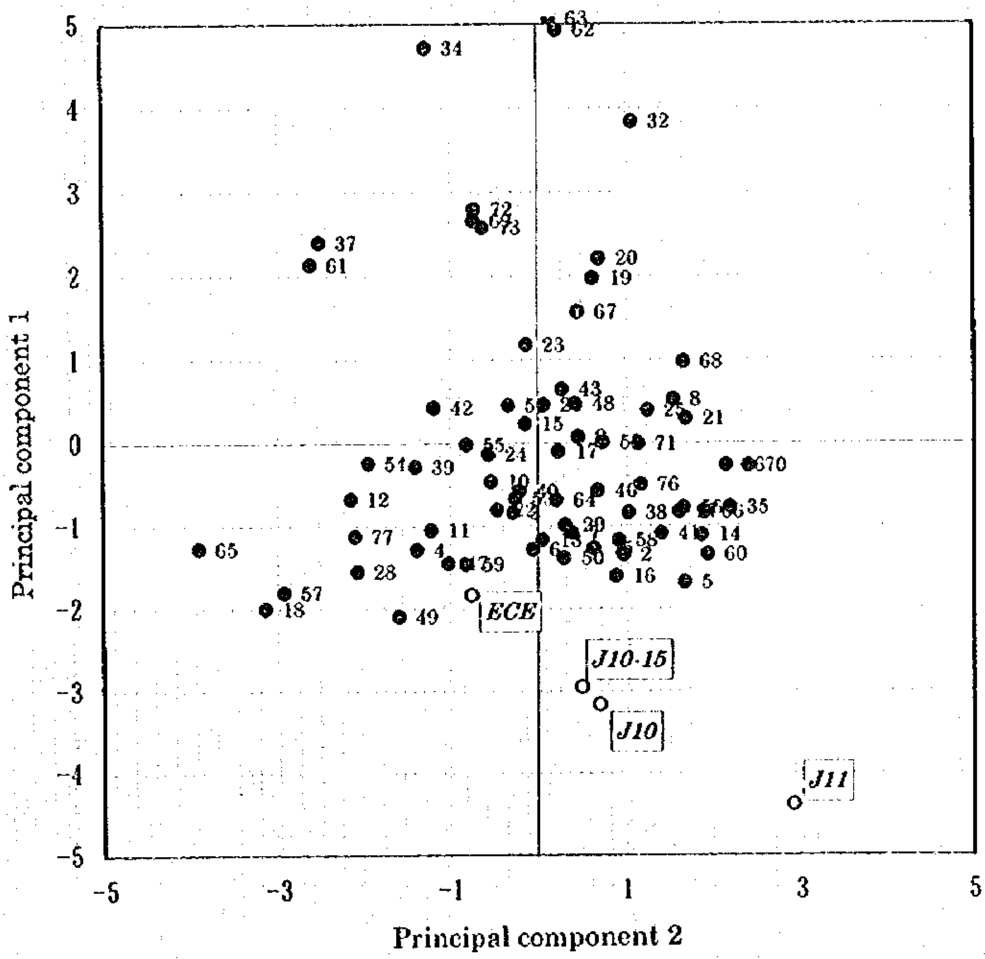


Fig4.3.5-11 Positioning of each test

Then, major elements obtained were analyzed in clusters as variables. The results are indicated in dendrogram on Fig.4.3.5-12. The driving results obtained from highways were excluded in the cluster analysis. The results of the driving survey based upon this dendrogram were categorized into four units, and the results obtained from the average survey results covering each cluster, were outlined in Table4.3.5-4. The driving results closest to these average values were chosen and determined as the Tehran mode. In addition, two examples were extracted from the results of driving on highways, and driving conditions for these six categories were determined as the representative driving mode in Tehran. These driving modes are indicated in Table4.3.5-5 and Fig.4.3.5-13.

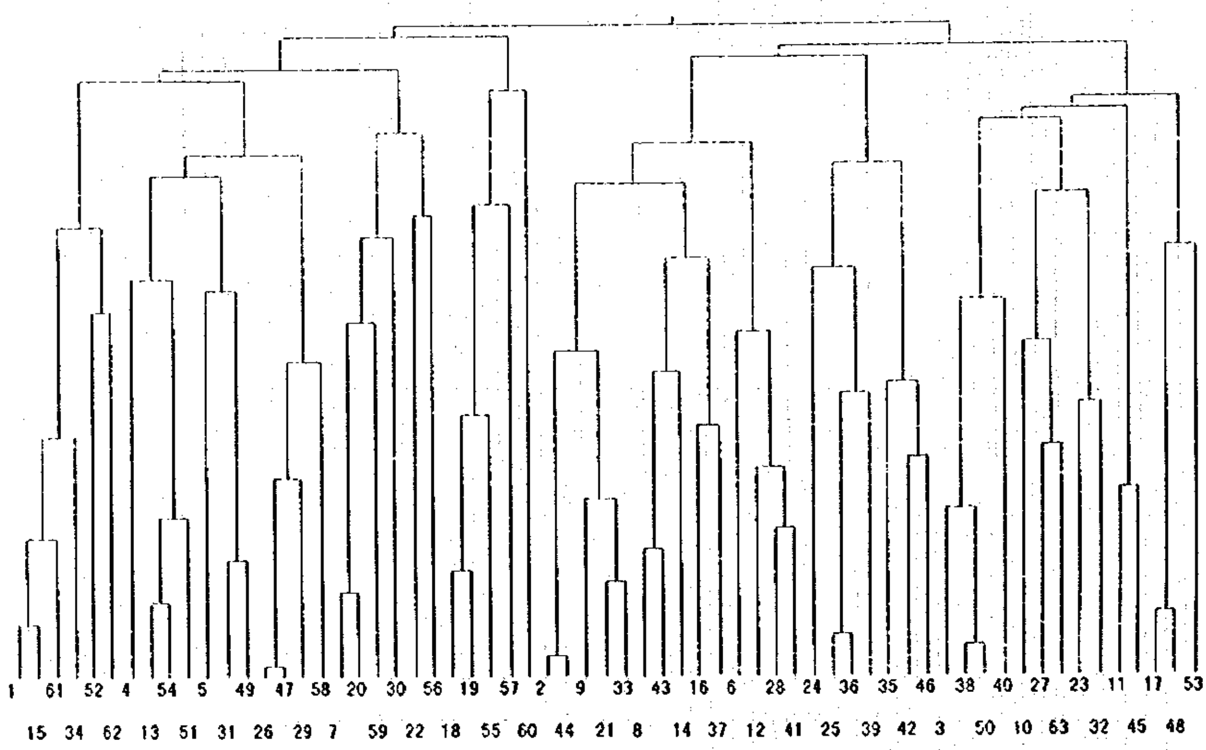


Fig.4.3.5-12 Dendrogram

Table4.3.5-4 Average value of each parameter included in each cluster

Cluster	Running Time	Running Distance	Speed(1)	Speed(2)	Ratio(%)			
	min.	km	km/h	km/h	Idling	Accelerating	Decelerating	Stable
Cluster 3	21.66	4.49	13.88	20.96	33.78	16.01	16.47	33.71
Cluster 2	17.58	5.45	18.82	22.33	15.46	18.49	18.60	47.44
Cluster 1	12.98	5.51	26.74	29.93	10.67	22.80	21.50	45.05
Cluster 4	11.94	7.09	34.91	37.36	6.18	14.77	14.47	64.57
Highway	11.53	10.80	56.28	62.74	11.70	10.77	11.55	65.99

Table4.3.5-5 Tehran mode

MODE	Run No.	Running Time	Running Distance	Speed(1)	Speed(2)	Ratio(%)			
		min.	km	km/h	km/h	Idling	Accelerating	Decelerating	Stable
Tehran 1	28	11.37	2.78	14.68	23.92	37.76	17.01	16.28	28.96
Tehran 2	29	9.89	2.82	17.12	20.76	17.10	21.40	19.46	42.04
Tehran 3	41	11.17	5.06	27.19	31.29	12.84	24.40	22.01	40.75
Tehran 4	69	9.13	5.04	33.12	36.51	9.22	12.77	11.68	66.33
Highway(1)	37	9.27	6.23	40.32	55.26	26.80	10.16	8.90	54.14
Highway(2)	32	14.52	17.19	74.01	75.97	2.53	14.52	15.96	66.99

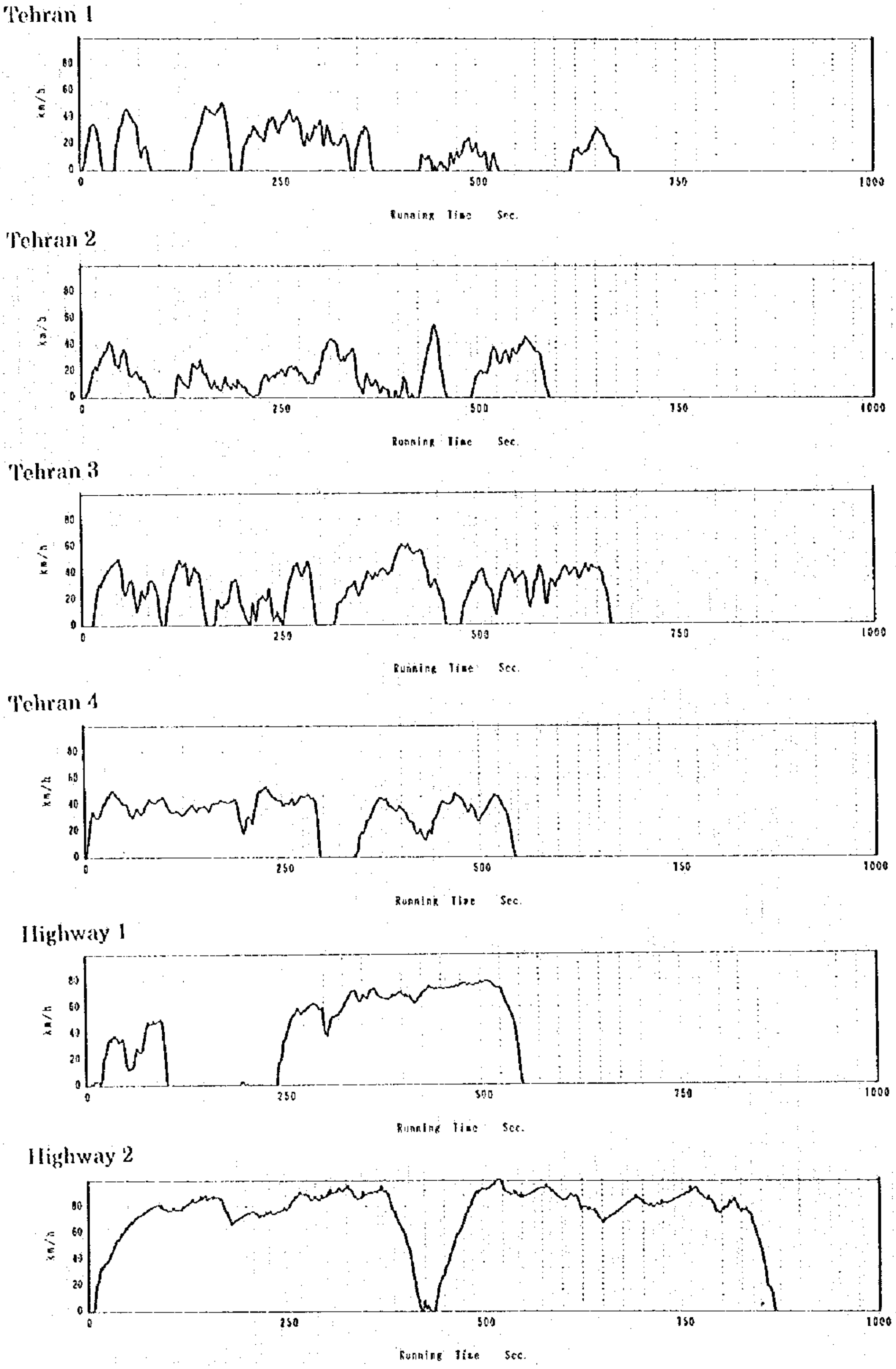


Fig.4.3.5-13 Tehran mode

4.3.6 Chassis dynamo test

Chassis dynamo tests are being continued in order to estimate an emission coefficient for CO, HC and NOx for selected vehicles. On the basis of the driving modes typical to Tehran determined in 4.3.5 and existing standard modes (ECE mode, EUDC, J10/15 mode, J11 mode), tests are being implemented on vehicle types outlined in Table4.3.6-1 and the age of vehicles, taking into consideration the number of automobiles registered in Tehran, import conditions, structural conditions and other factors.

Results of chassis dynamo tests conducted according to the plan mentioned above are shown in Table4.3.6-2.

Table4.3.6-3 shows the results of chassis dynamo tests conducted by AQCC on the basis of the ECE mode in 1992. Test vehicles were selected in consideration of the number of automobiles registered in Tehran, so that vehicles with average levels of engine maintenance would be chosen.

Emission factors for CO and HC are 62.4g/km and 5.12g/km respectively when a simple average is taken from emission factors of these 48 vehicles.

Fig.4.3.6-1 indicates a reliance on speed for the average emission factors of Japanese vehicles before and after emission control of CO and HC imposed in 1973 and 1975. Subsequently because the vehicle emission control, the emission coefficients fell as shown in the Figure.

For comparison, related example of emission factors are plotted, namely, the above mentioned emission factors calculated from existing data, regulation values of emission factors in Japan, and the past experience of chassis dynamo tests implemented in Mexico City in view of its similarities to Tehran in topography and high-aged vehicle characteristics.

Table 4.3.6-4 shows the results obtained from the second chassis dynamo test using the ECE mode after replacing the air filters and carburetors of each test vehicle indicated in Table 4.3.-9 with new ones.

The mean emission factors are 31.96 g/km for CO, 2.66 g/km for HC and 0.95 g/km for NOx, and the rate of emission is 51 %, 120 % and 101 % respectively compared with the results obtained from the first chassis dynamo test. While the emission of HC and NOx increased in the second test, the amount CO was reduced about 50 %, which indicates that replacement of the two parts is an effective way of reducing CO emissions.

In comparison with these results of chassis dynamo tests shown in Fig.4.3.6-1, emission factors reflecting actual situation of Tehran are determined.

Table4.3.6-1 Chassis dynamo test plan

CAR No	CAR TYPE	MANUFACTURED YEAR	TEST MODE				Total Number of Test
			1	2	3	4	
1	PAYKAN	1996	ECE	J10·15	H1		3
2	PRIDE	1996	ECE	J10·15	H1		6
3	PATROL	1996	ECE	J10·15	H1		9
4	REANULT 5	1996	ECE	J10·15	H1		12
5	PEUGEOT405	1996	ECE	J10·15	H1		15
6-1	PAYKAN	1971～1975	ECE	J10·15	J11	ECE+EUDC	19
6-2	PAYKAN	1971～1975	T1	T4	H1	H2	23
7	PAYKAN	1971～1975	T1	T2	T3	T4	27
8	PAYKAN	1971～1975	T1	T4	H1	H2	31
9	PAYKAN	1971～1975	J10	J10·15	J11		34
10	PAYKAN	1976～1980	ECE	J10·15	J11	ECE+EUDC	38
11	REANULT 5	1976～1980	ECE	J10·15	T3		41
12	PAYKAN	1976～1980	T1	T2	T3	T4	45
13	PAYKAN	1981～1985	ECE	J10·15	J11		48
14	PAYKAN	1981～1985	T1	T3	H1	H2	52
15	REANULT 5	1981～1985	ECE	J10·15			54
16	PAYKAN	1966～1970	J10	J10·15	J11		57
17	PAYKAN	1986～1990	T1	T4	H2		60
18-1	PAYKAN	1976～1980	ECE	J10 · 15	J11		63
18-2	PAYKAN	1976～1980	ECE	J10 · 15	J11		66
19	REANULT 5	1976～1980	T1	T4	H2		69

NOTE (1) T1:TEHRAN1 , T2:TEHRAN2 , T3:TEHRAN3 , T4:TEHRAN4 , H1:HIGHWAY1 , H2:HIGHWAY2

J10:JAPANESE10MODE , J10·15:JAPANESE10·15MODE

LA-4:US LA-4MODE

(2) Car No.1～No.5 :Brand New Car

(3) 18-1:Leaded Gasoline , 18-2:Unleaded Gasoline

Table4.3.6-2(1) Results of chassis dynamo tests

Car No.	Model	REG. No.	Manufactured year	Test Mode	Average speed(km/h)	HC g/km	NOX g/km	CO g/km	CO2 g/km
1	PAYKAN	New PAKAN	Brand new	ECE	18.70	3.03	0.85	91.42	318.33
				J1015	22.70	4.37	0.45	127.98	197.97
				H1	40.32	2.29	0.64	80.29	172.83
2	PRIDE	New PRIDE	Brand new	ECE	18.70	1.84	1.71	27.40	188.87
				J1015	22.70	1.38	1.03	28.74	135.14
				H1	40.32	0.97	1.24	22.16	113.01
3	PATROL	New PATROL	Brand new	ECE	18.70	4.41	3.70	60.18	378.75
				J1015	22.70	2.97	2.65	56.27	268.24
				H1	40.32	1.73	3.89	41.30	249.14
4	REANULT5	New RENAULT5	Brand new	ECE	18.70	2.05	1.64	23.07	207.69
				J1015	22.70	1.49	1.00	26.89	144.34
				H1	40.32	0.98	1.06	16.47	107.59
5	PEUGEOT	New PEUGEOT	Brand new	ECE	18.70	2.68	1.24	40.06	229.17
				J1015	22.70	1.90	1.02	40.74	180.56
				H1	40.32	1.40	1.31	31.00	148.03
6-1	PAYKAN	35833-THR-S	1973	ECE	18.70	5.21	0.41	158.61	271.17
				J1015	22.70	5.50	0.21	151.90	163.98
				J11	30.60	7.06	0.41	135.97	226.41
				ECEEUDC		3.03	0.93	100.26	223.91
6-2	PAYKAN	35833-THR-S	1973	T1	14.68	5.80	0.27	170.26	225.74
				T4	17.12	4.64	0.18	149.43	123.21
				H1	40.32	3.27	0.24	119.15	140.96
				H2	74.01	1.56	0.62	77.10	175.86
7	PAYKAN	21723	1975	T1	14.68	12.20	0.30	160.83	165.49
				T2	17.12	10.68	0.29	143.08	135.64
				T3	27.19	6.00	0.24	104.74	115.54
				T4	33.12	4.47	0.19	88.87	100.67
8	PAYKAN	2187-THR-S	1972	T1	14.68	4.60	0.79	97.61	212.31
				T4	33.12	1.97	0.49	48.88	135.55
				H1	40.32	1.94	0.78	44.79	129.02
				H2	74.01	1.28	1.44	38.69	173.54
9	PAYKAN	51727	1975	J10	17.70	3.86	0.50	80.15	181.64
				J1015	22.70	3.83	0.89	71.82	173.94
				J11	30.60	3.57	2.77	35.42	216.82
10	PAYKAN	63653-THR-25	1979	ECE	18.70	4.06	0.92	74.12	220.63
				J1015	22.70	3.40	0.38	87.90	149.42
				J11	30.60	5.42	1.01	68.60	169.77
				ECEEUDC		3.24	0.69	78.06	169.78

Table4.3.6-2(2) Results of chassis dynamo tests

Car No.	Model	REG. No.	Manufactured year	Test Mode	Average speed(km/h)	HC g/km	NOX g/km	CO g/km	CO2 g/km
11	REANULT	79492	1988	ECE	18.70	2.72	1.28	33.35	206.94
				J1015	22.70	2.34	0.86	38.62	128.28
				T3	27.19	2.42	0.86	32.82	118.41
12	PAYKAN	67446	1977	T1	14.68	3.17	1.16	81.51	212.27
				T2	17.12	3.09	0.57	85.74	175.17
				T3	27.19	2.16	0.71	57.03	152.00
				T4	33.12	1.42	0.56	42.99	128.66
13	PAYKAN	67322-Mashad-11	1981	ECE	18.70	3.85	1.08	85.41	220.82
				J1015	22.70	3.49	0.56	88.26	147.13
				J11	30.60	4.86	2.18	54.23	197.86
14	PAYKAN	94356	1983	T1	14.68	12.62	0.46	162.51	165.01
				T2	17.12	7.47	0.31	105.67	126.46
				H1	40.32	4.84	0.42	83.63	126.69
				H2	74.01	2.09	0.71	62.54	144.43
15	REANULT5	4259-THR-27	1982	ECE	18.70	3.59	2.75	35.75	200.65
				J1015	22.70	2.97	1.08	42.94	127.48
16	PAYKAN	85642-Thr-B	1969	J10	17.70	4.26	0.85	86.65	194.66
				J1015	22.70	5.93	0.83	101.37	157.32
	REANULT			J11	30.60	4.36	2.21	54.64	189.47
17	PAYKAN	85638-Thr-29	1989	T1	14.68	15.64	0.53	179.61	183.28
				T4	33.12	5.22	0.29	90.26	116.12
				H2	74.01	2.39	1.64	42.65	168.16
18-1	PAYKAN	42523-THR-27	1980	ECE	18.70	3.06	1.12	39.30	282.71
				J1015	22.70	2.04	0.77	54.59	191.49
			(Unleaded)	J11	30.60	3.88	1.82	24.31	239.27
18-2	PAYKAN	42523-THR-27	1980	ECE	18.70	2.47	1.16	40.64	279.83
				J1015	22.70	2.02	0.64	55.59	176.10
			(Leaded)	J11	30.60	2.75	1.76	26.38	220.82
19	REANULT	31948-Abandon-11	1979	T1	14.68	4.17	1.37	37.89	132.78
				T4	33.12	1.90	1.16	15.36	85.19
				H2	74.01	1.08	1.77	17.01	98.04

Table4.3.6-3 Results of chassis dynamo test conducted by AQCC(Befor tuning up)

No.	TYPE	REG.No	AGE	CC	HC	CO	NOX	CO2	HC+ NOX	Liter/ 100KM	KM/ Liter	Liter/ 100KM(MES.)
1	PAYKAN	12548	15	1725	14.64	125.80	0.58	131.49	15.22	16.37	6.11	19.11
2	PAYKAN	12877	11	1725	7.85	190.28	0.17	190.82	8.02	22.43	4.46	23.57
3	TOYOTA	14364	15	1600	4.54	65.19	0.32	158.60	4.86	12.00	8.33	12.42
4	PAYKAN	18789	9	1600	2.12	4.76	1.84	219.01	3.95	10.16	9.84	9.88
5	PAYKAN	21628	17	1725	3.88	83.15	0.49	178.22	4.36	13.99	7.15	12.74
6	PAYKAN	21878	6	1600	13.61	123.29	0.14	120.49	13.75	15.57	6.42	15.29
7	RENAULT	22119	1	1100	1.94	27.39	1.26	149.17	3.20	8.64	11.57	9.24
8	PAYKAN	23646	9	1600	2.80	27.09	1.48	206.95	4.28	11.26	8.88	10.19
9	PAYKAN	23673	11	1600	4.50	68.90	0.74	189.83	5.23	13.61	7.35	13.38
10	PAYKAN	24178	6	1600	4.77	75.06	0.37	139.50	5.14	11.88	8.42	13.22
11	PEUGECT	27573	15	1800	4.20	7.12	0.74	208.41	4.94	10.15	9.85	11.79
12	RENAULT	28954	14	950	2.53	21.57	1.19	130.02	3.72	7.49	13.35	7.65
13	CHEVROLET	29188	17	2500	7.49	82.30	0.61	285.99	8.09	19.13	5.23	16.88
14	CHEVROLET	29633	17	2500	3.33	37.99	1.17	217.65	4.51	12.55	7.97	12.74
15	RENAULT	31418	1	1100	2.04	23.94	0.96	149.70	3.00	8.44	11.84	4.78
16	NISSAN-VANET	31677	8	2000	4.28	81.90	2.03	384.38	6.31	22.95	4.36	17.2
17	NISSAN-VANET	33411	7	2000	4.43	100.98	0.94	298.21	5.37	20.52	4.87	17.52
18	RENAULT	33743	10	1100	2.92	19.02	1.28	163.73	4.20	8.84	11.31	8.6
19	BMW2002	33812	17	2000	1.92	14.30	1.42	185.01	3.35	9.31	10.74	9.24
20	RENAULT	34971	10	950	3.43	28.87	0.89	110.75	4.31	7.28	13.74	9.56
21	MAZDA-VANET	39951	7	1600	8.18	102.97	0.91	199.70	9.09	16.88	5.92	17.84
22	PAYKAN	44976	15	1725	3.60	63.84	0.72	187.95	4.33	13.40	7.46	12.74
23	PAYKAN	46926	15	1725	6.76	95.21	0.65	184.99	7.41	15.51	6.45	15.88
24	PAYKAN	46947	15	1725	2.05	18.76	1.02	306.08	3.08	14.91	6.71	14.97
25	BMW2002	47864	17	2000	4.93	55.90	0.93	208.11	5.86	13.58	7.36	-
26	CHEVROLET	49526	17	2800	10.91	109.94	0.3	179.32	11.21	16.85	5.93	17.2
27	TOYOTA	49887	15	1600	3.15	28.78	1.17	149.72	4.32	8.93	11.20	9.56
28	PEUGECT	53462	15	1800	5.27	60.18	0.56	154.31	5.82	11.57	8.64	13.06
29	NISSAN-VANET	53654	8	2000	4.13	33.08	2.49	266.33	6.63	14.44	6.92	16.25
30	TOYOTA	55475	9	2000	3.24	73.40	0.82	240.62	4.06	15.96	6.27	14.97
31	TOYOTA	55575	15	1587	6.59	100.98	0.27	165.64	6.86	15.04	6.65	13.7
32	PAYKAN	56551	22	1725	13.30	95.39	0.46	184.69	13.75	16.42	6.09	16.57
33	PAYKAN	57735	1	1800	2.23	38.70	0.47	199.77	2.70	11.66	8.57	10.13
34	PAYKAN	59961	22	1725	3.53	42.62	0.94	232.32	4.47	13.53	7.39	12.11
35	PAYKAN	63284	1	1800	2.74	49.54	0.84	207.54	3.59	12.81	7.80	11.79
36	JEEP-SIMORGH	63493	8	4229	4.13	23.39	1.18	403.59	5.31	19.76	5.06	18.8
37	JEEP-SIMORGH	63494	8	4229	3.00	30.58	3.32	376.24	6.32	18.90	5.29	20.71
38	PAYKAN	72475	17	1725	3.23	61.50	0.79	216.52	4.02	14.09	7.10	14.65
39	PEUGECT	73639	15	1800	2.21	25.10	1.3	209.25	3.51	11.14	8.98	11.47
40	MAZDA	75859	7	1600	6.63	101.16	0.53	228.76	7.16	17.81	5.61	15.93
41	PAYKAN	81585	22	1725	1.88	21.10	1.74	235.72	3.62	11.98	8.35	12.11
42	RENAULT	82716	14	950	5.20	104.46	0.61	130.72	5.80	13.57	7.37	11.47
43	PAYKAN	86369	22	1725	7.21	110.63	0.61	186.19	7.82	16.68	5.99	16.93
44	PAYKAN	89337	22	1725	8.47	120.16	0.14	130.83	8.60	15.10	6.62	16.57
45	PAYKAN	93861	9	1600	5.52	53.36	0.64	158.54	6.17	11.33	8.83	11.79
46	PAYKAN	94234	15	1600	3.47	40.71	1.54	179.24	5.01	11.08	9.03	13.06
47	RENAULT	94526	2	1100	15.50	114.47	0.44	162.97	15.98	17.09	5.85	15.41
48	RENAULT	94527	2	1100	1.66	11.50	0.99	158.75	2.65	7.93	12.60	8.08
	AVERAGE		11.9		5.12	62.42	0.9375	201.30	6.06	13.76	7.87	13.67

SOURCE : Air Quality Control Company

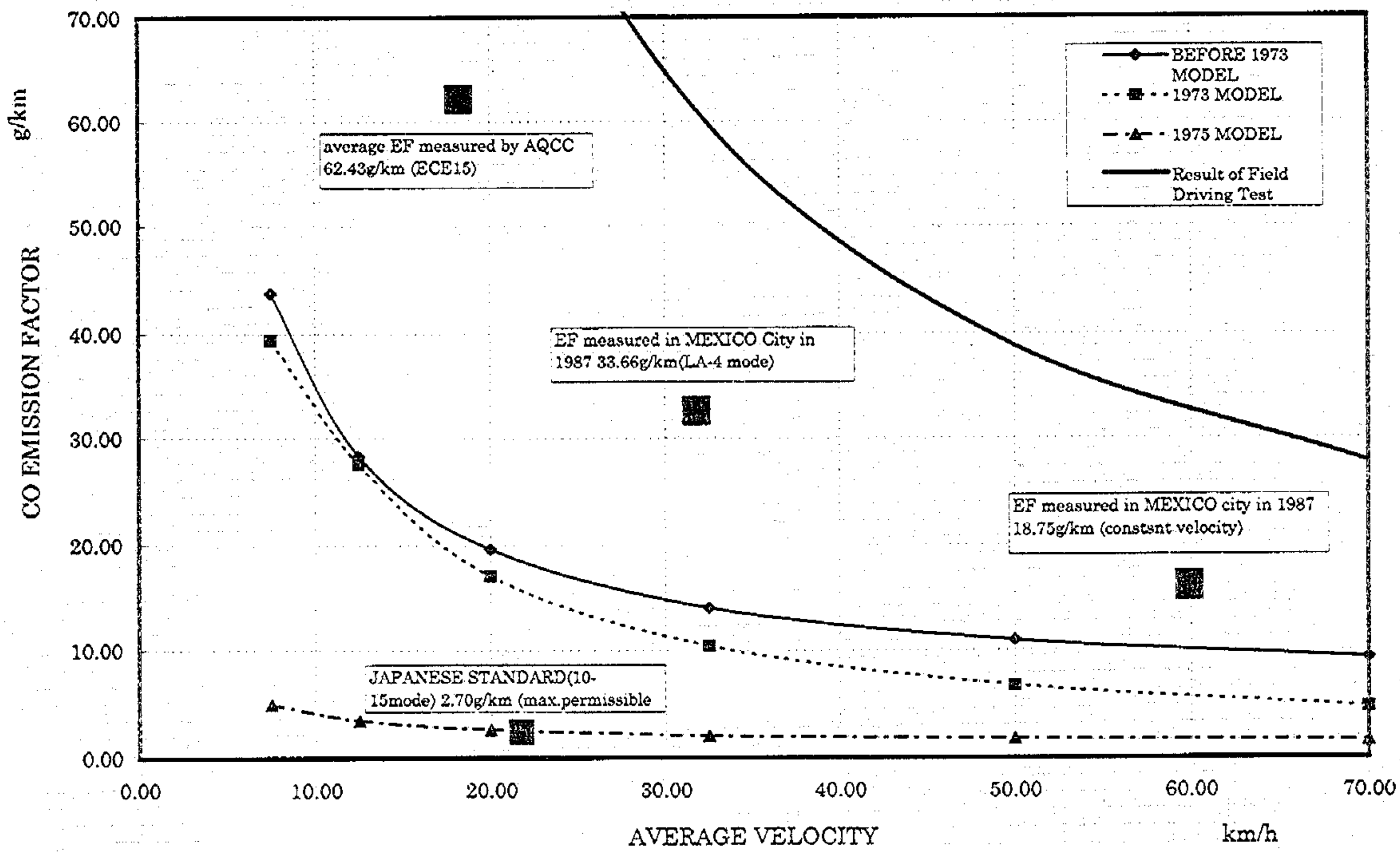


Fig.4.3.6-1 Reliance on speed for CO emission factors

Table4.3.6-4 Results of chassis dynamo test conducted by AQCC(After tuning up)

No.	TYPE	REG.No	AGE	CC	HC	CO	NOX	CO2	HC+ NOX	Liter/ 100KM	KM/ Liter	Liter/ 100KM(MES.)
1	PAYKAN	12548	15	1725	3.36	40.86	0.49	150.32	3.85	9.81	10.19	11.47
2	PAYKAN	12877	11	1725	3.84	110.01	0.07	164.61	3.92	15.24	6.56	19.75
3	TOYOTA	14364	15	1600	3.02	42.67	0.45	178.29	3.47	11.11	9.00	10.51
4	PAYKAN	18789	9	1600	2.06	4.77	1.31	189.94	3.37	8.89	11.25	8.92
5	PAYKAN	21628	17	1725	1.24	9.37	1.36	284.56	2.60	13.21	7.57	10.51
6	PAYKAN	21878	6	1600	4.25	54.66	0.79	178.39	5.04	12.10	8.26	11.47
7	RENAULT	22119	1	1100	1.81	23.82	1.41	129.19	3.22	7.51	13.31	8.92
8	PAYKAN	23646	9	1600	1.65	14.30	0.93	223.20	2.57	11.15	8.97	10.33
9	PAYKAN	23673	11	1600	1.98	14.49	1.25	210.88	3.23	10.45	9.57	11.79
10	PAYKAN	24178	6	1600	2.59	35.65	0.69	178.32	3.28	10.57	9.46	10.19
11	PEUGECT	27573	15	1800	1.64	7.19	0.82	250.87	2.46	11.65	8.58	13.06
12	RENAULT	28954	14	950	2.17	11.91	1.03	178.76	3.19	8.90	11.23	7.33
13	CHEVROLET	29188	17	2500	3.15	18.88	1.19	256.26	4.34	12.89	7.76	10.51
14	CHEVROLET	29633	17	2500	2.79	29.70	1.46	247.30	4.25	13.20	7.58	12.11
15	RENAULT	31418	1	1100	1.98	23.98	0.61	130.33	2.59	7.60	13.17	6.37
16	NISSAN-VANET	31677	8	2000	2.91	42.85	0.67	217.67	3.57	12.82	7.80	17.2
17	NISSAN-VANET	33411	7	2000	2.49	78.04	0.82	286.15	3.30	18.16	5.51	15.61
18	RENAULT	33743	10	1100	2.26	16.70	0.66	188.76	2.92	9.68	10.33	8.6
19	BMW2002	33812	17	2000	1.98	7.13	1.32	198.18	3.30	9.40	10.54	8.92
20	RENAULT	34971	10	950	2.27	14.21	1.05	148.43	3.32	7.75	12.90	7.65
21	MAZDA-VANET	39951	7	1600	3.67	64.49	1.03	199.87	4.71	13.63	7.34	14.34
22	PAYKAN	44976	15	1725	1.03	4.68	0.68	359.33	1.72	16.12	6.20	12.74
23	PAYKAN	46926	15	1725	2.08	23.31	0.95	262.14	3.03	13.31	7.52	11.21
24	PAYKAN	46947	15	1725	1.31	9.36	1.18	324.77	2.49	14.97	6.68	13.06
25	BMW2002	47864	17	2000	3.23	22.60	1.02	187.81	4.26	10.17	9.84	99.99
26	CHEVROLET	49526	17	2800	4.16	63.49	0.49	209.19	4.59	14.04	7.12	14.34
27	TOYOTA	49887	15	1600	2.12	13.18	1.05	189.58	3.16	9.46	10.58	9.56
28	PEUGECT	53462	15	1800	3.21	53.28	0.66	188.18	3.87	12.29	8.14	13.06
29	NISSAN-VANET	53654	8	2000	2.83	19.19	1.73	267.19	4.57	13.35	7.49	11.79
30	TOYOTA	55475	9	2000	2.69	58.56	0.93	265.89	3.62	15.97	6.26	14.34
31	TOYOTA	55575	15	1587	3.45	69.95	0.33	160.63	3.78	12.27	8.15	12.11
32	PAYKAN	56551	22	1725	1.81	9.41	1.48	287.47	3.29	13.42	7.45	12.11
33	PAYKAN	57735	1	1800	3.08	21.26	0.45	187.51	3.53	10.05	9.95	10.04
34	PAYKAN	59961	22	1725	2.78	32.95	0.93	246.58	3.71	13.39	7.47	11.47
35	PAYKAN	63284	1	1800	1.90	37.90	0.61	257.47	2.51	14.08	7.10	11.95
36	JEEP-SIMORGH	63493	8	4229	3.53	20.80	1.54	531.23	5.06	25.06	3.99	17.2
37	JEEP-SIMORGH	63494	8	4229	2.05	16.26	2.04	421.80	4.10	19.78	5.06	15.93
38	PAYKAN	72475	17	1725	2.41	27.98	0.99	332.95	3.40	16.76	5.97	12.74
39	PEUGECT	73639	15	1800	2.30	21.25	1.09	267.43	3.39	13.43	7.45	10.19
40	MAZDA	75859	7	1600	4.35	70.81	0.59	261.82	4.94	16.86	5.93	14.97
41	PAYKAN	81585	22	1725	2.05	4.75	1.38	228.67	3.43	10.57	9.46	10.83
42	RENAULT	82716	14	950	4.38	69.54	0.32	130.31	4.70	11.05	9.05	11.15
43	PAYKAN	86369	22	1725	4.53	50.33	1.01	219.15	5.54	13.62	7.34	12.74
44	PAYKAN	89337	22	1725	2.43	61.88	0.27	168.56	2.71	11.92	8.39	13.06
45	PAYKAN	93861	9	1600	2.33	10.78	1.05	198.97	3.38	9.73	10.28	10.51
46	PAYKAN	94234	15	1600	2.09	33.70	0.93	180.13	3.02	10.45	9.57	12.11
47	RENAULT	94525	2	1100	4.45	24.60	1.27	197.02	5.73	10.88	9.19	9.59
48	RENAULT	94527	2	1100	2.06	16.87	1.06	184.69	3.11	9.49	10.54	7.67
	AVERAGE		11.9		6.16	31.96	0.9467	227.22	3.61	12.46	8.52	13.58

SOURCE : Air Quality Control Company

4.4 Analysis of emission from mobile sources

4.4.1 Projection of characteristics of transportation and traffic in GTA

(1)Traffic volume

The database mentioned in 4.3.1 includes traffic volume in 1994 and 2001 classified by the car type and link. In this report, the traffic volume given by the database is used to calculate an amount of emission of CO, SOx, and NOx.

(2) Car velocity

The database mentioned above includes the average speed of each link estimated by TCTTS.

In this report, the traffic speed given by the database is used to calculate amount of emission of CO, SOx and NOx.

(3) Emission factor

The emission of CO, SOx and NOx is specified according to each vehicle type as shown in Table 4.4.1-1, on the basis of the results of chassis dynamo tests, field driving tests and analysis of existing data.

CO emission factors

It is known that as amount of CO emissions from diesel automobiles is negligible compared with that of gasoline automobiles. Accordingly, it was assumed in this report that CO was not emitted from diesel automobiles but only from gasoline automobiles. We made regression analysis of the results of the chassis dynamo test conducted by the study team, and then specified the CO emission factor as a function of vehicle speed on the basis of the vehicle's age and by taking the existing data into account. For example, when a five year old passenger car is running 30.0 km/h, the emission factor (EF) is estimated at 26.4 g/km by applying 1242.0 for "a", -15.0 for "b "and 30.0 for "V" in the following equation:

$$EF = a \cdot V^{-1} + b$$

The results are shown in Table 4.4.1-1. In the case where a passenger car is aged 15 years, "a" is 1242.0, "b" is 18.1, and EF is therefore 59.5 g/km.

As for motor cycles, since the age of all motor cycles is not known, it is assumed that all motor cycles are 10 years of age. Furthermore, an emission factor for high altitudes (23.6 g/km) specified by the U.S. Environmental Protection Agency (EPA) was used.

Table4.4.1-1(2)Emission factor for each type of vehicle in Tehran

Car type	Pollutant	Car age	Component ratio		Equation : $EF = a+b \cdot v+cv^2$ (g/km)		
Motor cycle (Gasoline)	CO	Fix	-		23.6g/km		
	NOx	Fix	-		0.4g/km		
	SOx	Fix	-		-		
Bus・truck (Gas oil) (Direct injection)	Pollutant	Car age	Component ratio		Equation : $EF = a+b \cdot v+cv^2$ (g/ton km)		
	CO	-	Bus	Truck	a	b	c
		-	-	-	8.723E-01	2.080E-02	2.130E-05
Bus・truck (Gas oil) (Direct injection)	Pollutant	Car age	Component ratio		Equation : $EF = a+b \cdot v+cv^2$ (g/ton km)		
	NOx	-	Bus	Truck	a	b	c
		0 ～ 10	38 %	50 %	1.583E+00	-4.001E-02	4.108E-04
		10 ～ 20	31 %	26 %	1.107E+00	-3.190E-02	3.238E-04
		20 ～	31 %	24 %	1.030E+00	-3.001E-02	2.835E-04
Bus・Truck (Gas oil) (Direct injection)	Pollutant	Car age	Component ratio		Equation : $EF = a+b \cdot v+cv^2$ (litre/ton km)		
	SOx	-	Bus	Truck	a	b	c
		0 ～ 10	38 %	50 %	7.891E-02	-2.047E-03	1.924E-05
		10 ～	62 %	50 %	1.008E-01	-2.895E-03	2.703E-05
Bus・Truck (Gas oil) (Direct injection)	Pollutant	Car age	Component ratio		Equation : $EF = a \cdot V^b$ (gton /km)		
	HC	-	Bus	Truck	a	b	c
		Fix	-	-	1.441	-0.555	-
Taxi (LPG) (4-stroke)	Pollutant	Car age	Component ratio		Equation : $EF = a+b \cdot v+cv^2$ (g/km)		
	CO	-	-		a	b	c
		Fix	-		28.0	1.2	-

Tble4.4.1-1(1)Emission factor for each type of vehicle in Tehran

Car type	Pollutant	Car age	Component ratio	Equation : $EF = a \cdot v^{-1} + b$ (g/km)		
Passenger car (Gasoline) (4-stroke)	CO	-	-	a	b	c
		0 ~ 10	44 %	1242	-15.0	-
		10 ~ 20	36 %	1242	18.1	-
		20 ~	20 %	1242	70.0	-
Passenger car (Gasoline) (4-stroke)	Pollutant	Car age	Component ratio	Equation : $EF = a + b \cdot v + cv^2$ (g/km)		
	NOx	-	-	a	b	c
		0 ~ 10	44 %	2.300E+00	-1.410E-02	7.337E-04
		10 ~ 20	36 %	1.374E+00	-1.275E-02	3.499E-04
		20 ~	20 %	5.045E-01	-1.367E-02	3.211E-04
Passenger car (Gasoline) (4-stroke)	Pollutant	Car age	Component ratio	Equation : $EF = a + b \cdot v + cv^2$ (litre/km)		
	SOx	-	-	a	b	c
		0 ~ 10	44 %	1.759E-01	-4.264E-03	3.710E-05
		10 ~	56 %	2.564E-01	-7.639E-03	7.250E-05
Passenger car (Gasoline) (4-stroke)	Pollutant	Car age	Component ratio	Equation : $EF = a \cdot V^b$ (g/km)		
	HC	-	-	a	b	c
		0 ~ 10	44 %	12.950	-0.556	-
		10 ~ 20	36 %	36.303	-0.556	-
		20 ~	20 %	70.300	-0.556	-

SOx emission factors

The amount of SOx emissions does not depend on the state of fuel combustion, while that of CO and NOx does. It can be obtained from the amount of fuel consumption and that of sulfur content. The value of emission to be obtained from the amount of fuel consumption is given by the following equation:

$Q=W \times Sp \times Si \times 10^{-2} \times 64/32$

Q : The amount of SOx emissions (g)

W : The amount of fuel consumption (litter)

Sp : Specific gravity

Si: The amount of sulfur content (wt%)

Accordingly, the amount of fuel consumption by passenger cars, buses and trucks are shown in Table 4.4.1-1 as a function of vehicle speed on the basis of a vehicle's age. The expression of fuel consumption shown in the Table is in terms of consumption per ton of gross vehicle weight. Consequently, in calculating the amount of fuel consumption, the results calculated according to the expressions in the table must be multiplied by the gross vehicle weight of each type of vehicle. In this report, we defined the gross vehicle weight as the average vehicle weight plus one-half of the maximum load capacity. The gross vehicle weight of each type of vehicle is as follows:

Bus : 10 ton

Mini bus : 3.0 ton

Truck : 8.0 ton

Pick up : 1.2 ton

When a 20 year old truck is running at 30.0 km/h, the amount of fuel consumption is calculated at 0.72 lit/km by applying 1.008E-01 for "a", 2.895E-03 for "b", 2.703E-05 for "c" and 30.0 for "V", and multiplying the obtained value, 0.12 lit /ton. km, with the gross vehicle weight, 6.0 ton.

$EF=a+b \cdot V+c \cdot V^2$

NOx emission factors

We specified NOx emissions from gasoline automobiles as shown in Table4.4.1-2, using the same procedure used to determine CO emissions: we made regression analysis, taking the existing data into account. Since chassis dynamo tests cannot be carried out on diesel automobiles in Tehran, it is impossible to specify NOx emissions comparing with the results obtained from the tests carried out on the spot. Accordingly, in calculating NOx emissions from buses and trucks, we used the equation introduced in the Japanese NOx manual.

As for motor cycles, on account of difficulty in knowing the ages of all motor cycles, as in the case of CO emissions, it is assumed that all motor cycles are 10 years of age, and the emission factors for high altitudes (0.4 g/km) specified by the U.S. Environmental Protection Agency (EPA) were used.

4.4.2 Analysis of emission amount from automobiles

The emission estimates of CO, SOx and NOx in GTA under the conditions specified in 4.4.1 are shown in Table 4.4.2-1.

Fig.4.4.2-1 Amount of CO, SOx,NOx and HC emission from automobiles

Year	No	Car type	Unit	Pollutants			
				CO	HC	SOx	NOx
1994	1	Mobile source(total)	ton/year	826,804	81,691	8,340	39,610
	(1)	Motor Cycle	ton/year	64,085	16,293	179	1,086
	(2)	Passenger Car	ton/year	478,017	41,296	1,177	21,865
	(3)	Taxi	ton/year	158,572	13,336	331	5,381
	(4)	Pick Up	ton/year	105,660	9,099	262	5,030
	(5)	Mini Bus	ton/year	4,164	360	1,325	1,245
	(6)	Bus	ton/year	8,492	756	2,995	2,784
	(7)	Truck	ton/year	7,814	551	2,071	2,219

4.5 Analysis of emission from stationary source

4.5.1 Measured results of target emission source

The results of measurement of exhaust gas emissions from stationary source described in section 3.4.2(4) are evaluated below.

(1) Brick manufacturing company (Sofal Jadid)

CO emission is very high although natural gas is used and an excess air ratio is very high, supposedly due to improper combustion of fuels in a furnace. It is believed that combustion can be improved by exchange of burner tips and that much energy can be saved by cutting an excess air ratio.

(2) Thermal power plant (Besat)

Measurement was conducted when natural gas was fueled. Further NOx can be reduced by cutting an excess air ratio since it is higher than in the case of usual operation of a thermal power plant.

(3) Tehran Refinery

Outlet temperatures of exhaust gas are higher than 430 C, meaning that energy conservation is possible through waste heat recovery with concurrent reduction of pollutants. As SOx emission is very high due to burning of high sulfur residues, countermeasures for total SOx reduction are to be considered.

(4) Tehran Cement

The SPM concentrations have been high in No.4 and No.6 facilities during the time of first and second field surveys although electrostatic precipitators are installed. NOx emission is high in all factories while CO emission is abnormally high in the No.4 factory. SOx are practically not emitted because SOx can be absorbed in the process by chemical reaction with CaCO3 except flue gas from utilities units.

(5) Combustion appliances for household use

Extremely high CO emission is observed in a hot water heater located on the closed ground floor supposedly due to imperfect combustion in the shortage of air supply. In general, CO emitted from the room heater is rather high compared with the projected emission factors, supposedly due to a lack of fresh air exchange in the closed room.

Table 4.5.1-1 shows the measured emission factors in comparison with the projected factors. Except some cases of CO, NOx and SOx mentioned above, the observed factors are almost the same with the projected ones within the allowable limit as shown in Fig 4.5.1-1.

Table 4.5.1-2 compares the measured concentration of SOx, NOx and SPM with the emission standards in Japan, the outcome of which are described below.

- SOx : The K value of emissions from Tehran Refinery is larger than the expected value of 3.0, while the K values of the other emission sources are within the allowable limit.

  (Note) Q=K *10^-3*He^2

  where, Q : Allowable limit of emission value of SOx (Nm3/h)

  K : Constant defined by areas

  1) General emission standard (3.0-17.5)

  2) Special emission standard(1.17-2.34)

  He : Effective height of stack(m)

- NOx : NOx emissions of all the factories other than the brick and power plants are 40% higher on an average than the emission standard in Japan.
- SPM: In Tehran Cement, 5 out of 7 measurements are higher than the standard in Japan.

As a whole, a great deal of emission of pollutants can be reduced by means of strict combustion control and waste heat recovery procedures, since so many cases of imperfect combustion are observed for the room heaters as an example due to a design philosophy which have not fully taken thermal efficiency into account as well as improper operation and maintenance of these equipment.

Table 4.5.1-1 : Comparison of emission factors between measurement & projected values

(1) First field survey

Item	Unit	Sofal Jadid		Besat		Tehran Refinery								Tehran Cement							
		(Brick)		(power plant)		2H-101		2H-151		2H-181		Boiler		No.4		No.5		No.6		No.7	
Date	-	96.09.22		96.09.24		96.09.28		96.09.29		96.10.01		96.10.02		96.10.05		96.10.06		96.10.08		96.10.09	
Fuel	-	Natural Gas		Natural Gas		Gas & Oil		Gas & Oil		Gas & Oil		Heavy Oil		Natural Gas		Natural Gas		Natural Gas		Natural Gas	
(Measured vs Projected)		Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd
Outlet Temp	C	97		-		429	180	-	180	446	180	426	180	148		188		128		115	
Excess Air Ratio		12.8		2.32		1.52		1.32		1.55		1.24		2.19		1.97		2.03		3.25	
Emission Factor																					
CO	g/Gj	113	7	0	7	27	16	-		49	16	0	16	2370	7	0	7	9.1	7	33	7
SOx	g/Gj	8.8	1	2.5	1	1747	1637	-		2150	1637	-	1637	9.4	1	0	1	0	1	0	1
NOx	g/Gj	68	73	60	234	297	325	-		382	325	98	325	365	73	140	73	471	73	538	73
SPM	g/Gj	0	6	-	6	28	70	-		28	70	5.3	70	321	6	5.3	6	372	6	23	6

(2) Second field survey

Item	Unit	Room Heater								Cooking Burner				Boiler		Tehran Cement						Tehran Refinery			
		Gas Oil		Kerosene		Fire Place		Heater(NG)		NG		LPG		Water heater		No.4		No.6		No.7		2H-101		Boiler	
Date	-	97.02.18		97.02.18		97.02.19		97.02.19		97.02.22		97.02.22		97.02.20		97.02.25		97.02.26		97.03.06		97.03.01		97.03.02	
Fuel	-	Gas Oil		Kerosene		Natural Gas		Natural Gas		Natural Gas		LPG		Natural Gas		Natural Gas		NG + HO		Natural Gas		FG + FO		Fuel Oil	
(Measured vs Projected)		Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd
Outlet Temp	C	-		-		-		-		-		-		-		145		158		126		429	180	460	180
Excess Air Ratio																2.17		2.31		2.19		1.73		1.14	
Emission Factor																									
CO	g/Gj	106	15	595	15	234	8	32.2	8	0	8	0	8	10200	8	1850	7	0	7	30.3	7	0	12	884	12
SOx	g/Gj	316	447	103	64	13.1	1	0	1	21.2	1	3.9	1	-	1	7.7	1	0	1	0	1	4870	1404	2100	1404
NOx	g/Gj	24.2	71	17.6	62	46.5	50	45	50	23.3	50	81.8	50	12.5	50	425	73	407	73	331	73	746	175	360	175
SPM	g/Gj	-	55	-	22	-	7	-	7	-	7	-	7	-	7	212	6	264	6	89.4	6	91.8	67	-	67

(Note) [shaded] Measured emission factors > projected emission facrors

Table 4.5.1-1 . Comparison of emission factors between measurement & projected values

(1) First field survey

Item	Unit	Sofal Jadid (Brick)		Besat (power plant)		Tehran Refinery 2H-101		Tehran Refinery 2H-151		Tehran Refinery 2H-181		Tehran Refinery Boiler		Tehran Cement No.4		Tehran Cement No.5		Tehran Cement No.6		Tehran Cement No.7	
Date	-	96.09.22		96.09.24		96.09.28		96.09.29		96.10.01		96.10.02		96.10.05		96.10.06		96.10.08		96.10.09	
Fuel	-	Natural Gas		Natural Gas		Gas & Oil		Gas & Oil		Gas & Oil		Heavy Oil		Natural Gas		Natural Gas		Natural Gas		Natural Gas	
(Measured vs Projected)		Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd
Outlet Temp	C	97		-		429	180	-	180	446	180	425	180	148		188		128		115	
Excess Air Ratio		12.8		2.32		1.52		1.32		1.55		1.24		2.19		1.97		2.03		3.25	
Emission Factor																					
CO	g/GJ	113	7	0	7	27	16	-		49	16	0	16	2370	7	0	7	9.1	7	33	7
SOx	g/GJ	8.6	1	2.5	1	1747	1637	-		2150	1637	-	1637	9.4	1	0	1	0	1	0	1
NOx	g/GJ	68	73	60	234	297	325	-		392	325	98	325	368	73	140	73	471	73	536	73
SPM	g/GJ	0	6	-	6	28	70	-		28	70	5.3	70	321	6	5.3	6	372	6	23	6

(2) Second field survey

Item	Unit	Room Heater Gas Oil		Room Heater Kerosene		Room Heater Fire Place		Room Heater Heater(NG)		Cooking Burner NG		Cooking Burner LPG		Boiler Water heater		Tehran Cement No.4		Tehran Cement No.6		Tehran Cement No.7		Tehran Refinery 2H-101		Tehran Refinery Boiler	
Date	-	97.02.18		97.02.18		97.02.19		97.02.19		97.02.22		97.02.22		97.02.20		97.02.25		97.02.26		97.03.05		97.03.01		97.03.02	
Fuel	-	Gas Oil		Kerosene		Natural Gas		Natural Gas		Natural Gas		LPG		Natural Gas		Natural Gas		NG + HO		Natural Gas		FG + FO		Fuel Oil	
(Measured vs Projected)		Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd	Meas'd	Proj'd
Outlet Temp	C	-		-		-		-		-		-		-		145		158		126		429	180	460	180
Excess Air Ratio																2.17		2.31		2.19		1.73		1.14	
Emission Factor																									
CO	g/GJ	106	15	595	15	234	8	32.2	8	0	8	0	8	10200	8	1850	7	0	7	30.3	7	0	12	884	12
SOx	g/GJ	316	447	103	64	13.1	1	0	1	21.2	1	3.9	1	-	1	7.7	1	0	1	0	1	4870	1404	2130	1404
NOx	g/GJ	24.2	71	17.6	62	46.5	50	45	50	23.3	50	61.8	50	12.5	50	425	73	407	73	331	73	746	175	360	175
SPM	g/GJ	-	55	-	22	-	7	-	7	-	7	-	7	-	7	212	6	284	6	86.4	6	91.6	67	-	67

(Note) [shaded] Measured emission factors > projected emission factors

Table 4.5.1-2 : Comparison table between measured emission concentration and emission standard in Japan

(1) First field survey

Item	Unit	Sofal Jadid		Besat		Tehran Refinery								Tehran Cement							
		(Brick)		(power plant)		2H-101		2H-151		2H-181		Boiler		No.4		No.5		No.6		No.7	
Date	-	96.09.22		96.09.24		96.09.28		96.09.29		96.10.01		96.10.02		96.10.05		96.10.06		96.10.08		96.10.09	
Fuel	-	Natural Gas		Natural Gas		Gas & Oil		Gas & Oil		Gas & Oil		Heavy Oil		Natural Gas		Natural Gas		Natural Gas		Natural Gas	
(Measured vs stadard)		Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd
SOx	K	0.27	3.00		3.00	3.22	3.00		3.00	4.10	3.00	4.81	3.00	0.11	3.00	0.03	3.00	0.02	3.00	0.02	3.00
NOx	ppm	69	250	132	150	154	100	125	100	168	100	212	150	311	250	199	350	418	250	516	250
SPM	g/m3	>0.005	0.1		0.15	0.023	0.1		0.1	0.024	0.1	0.023	0.15	0.56	0.1	0.009	0.1	0.67	0.1	0.045	0.1

(2) Second field survey

Item	Unit	Tehran Cement						Tehran Refinery			
		No.4		No.6		No.7		2H-101		Boiler	
Date	-	97.02.25		97.02.26		97.03.06		97.03.01		97.03.02	
Fuel	-	Natural Gas		NG + HO		Natural Gas		FG + FO		Fuel Oil	
(Measured vs stadard)		Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd
SOx	K	0.10	3.00	0.02	3.00	0.01	3.00	3.21	3.00	3.62	3.00
NOx	ppm	325	250	302	250	272	250	144	100	173	150
SPM	g/m3	0.34	0.1	0.43	0.1	0.15	0.1	0.036	0.1		0.15

(Note) [shaded] Measured concentration >standard in Japan

Table 4.5.1-2 Comparison table between measured emission concentration and emission standard in Japan

(1) First field survey

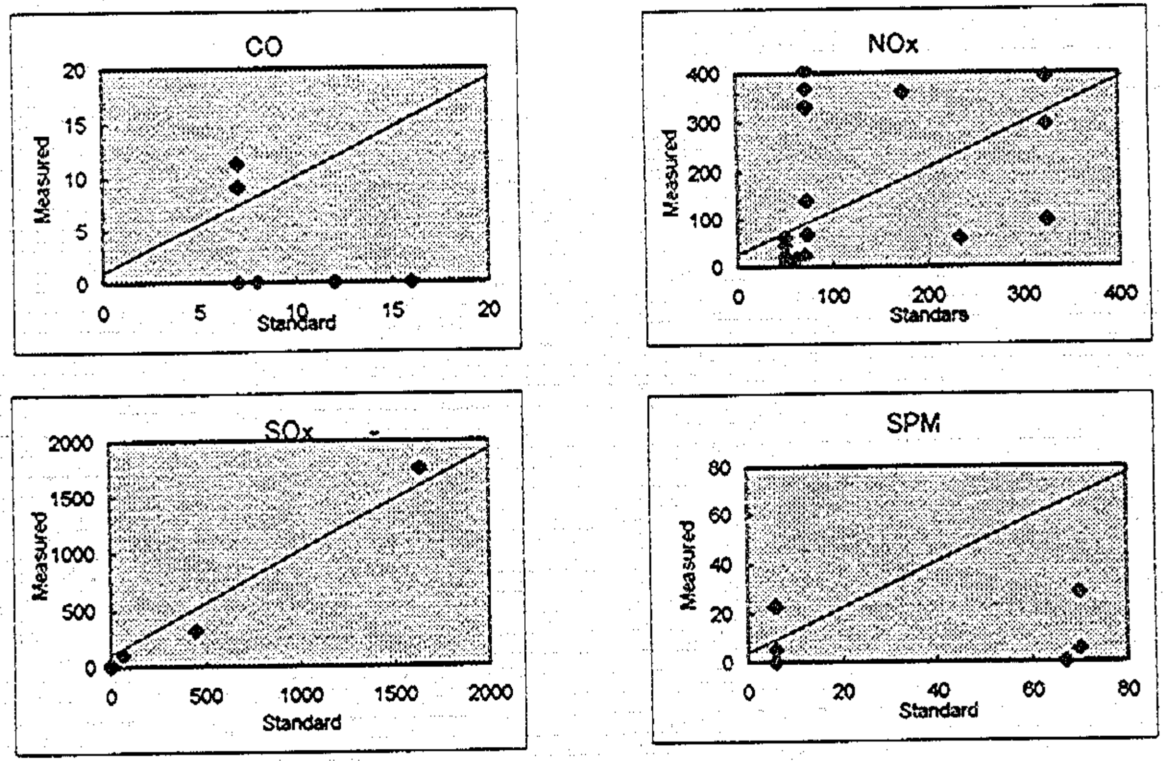
Item	Unit	Sofal Jadid		Besat		Tehran Refinery								Tehran Cement							
		(Brick)		(power plant)		2H-101		2H-151		2H-181		Boiler		No.4		No.5		No.6		No.7	
Date	-	96.09.22		96.09.24		96.09.28		96.09.29		96.10.01		96.10.02		96.10.05		96.10.06		96.10.08		96.10.09	
Fuel	-	Natural Gas		Natural Gas		Gas & Oil		Gas & Oil		Gas & Oil		Heavy Oil		Natural Gas		Natural Gas		Natural Gas		Natural Gas	
(Measured vs stadard)		Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd
SOx	K	0.27	3.00		3.00	3.22	3.00		3.00	4.10	3.00	4.81	3.00	0.11	3.00	0.03	3.00	0.02	3.00	0.02	3.00
NOx	ppm	69	250	132	150	154	100	125	100	166	100	212	150	311	250	199	350	418	250	516	250
SPM	g/m3	>0.005	0.1		0.15	0.023	0.1		0.1	0.024	0.1	0.023	0.15	0.56	0.1	0.009	0.1	0.67	0.1	0.045	0.1

(2) Second field survey

Item	Unit	Tehran Cement						Tehran Refinery			
		No.4		No.6		No.7		2H-101		Boiler	
Date	-	97.02.25		97.02.26		97.03.06		97.03.01		97.03.02	
Fuel	-	Natural Gas		NG + HO		Natural Gas		FG + FO		Fuel Oil	
(Measured vs stadard)		Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd	Meas'd	Stan'd
SOx	K	0.10	3.00	0.02	3.00	0.01	3.00	3.21	3.00	3.62	3.00
NOx	ppm	325	250	302	250	272	250	144	100	173	150
SPM	g/m3	0.34	0.1	0.43	0.1	0.15	0.1	0.036	0.1		0.15

(Note) [shaded box] Measured concentration >standard in Japan

Fig 4.5.1-1 : Comparison of emission factors between measurement and projected values



4.5.2 Estimation of emission quantities in GTA

(1) Summary of emission quantities

1) Total GTA

As shown in Table 4.5.2-1, contributions of stationary emission sources and mobile emission sources to total emission of air pollution in GTA are projected in the case of 1994 at 29% and 71% respectively, demonstrating the dominance of mobile sources.

Concerning the contribution of each pollutant, stationary sources share 97% and 71% in SOx and NOx while mobile sources share 94%, 70% and 88% in CO, HC and SPM respectively.

The year of 1994 is selected for estimation of emission quantities, since publicized statistic data for energy consumption in Iran are available in the most abundance in this year among the several latest years.

Table 4.5.2-1 : Emission quantity of air pollutants in GTA (1994)

(ton/year,%)

Source	SOx	NOx	CO	HC	SPM	(Total)
Stationary	253,981	95,571	51,421	34,701	25,113	460,786
Mobile	8,340	39,610	826,806	81,690	182,717	1,139,163
(Sub-total)	262,321	135,181	878,227	116,391	207,830	1,599,949
Stationary	96.8	70.7	5.9	29.8	12.1	28.8
Mobile	3.2	29.3	94.1	70.2	87.9	71.2
(Sub-total)	100.0	100.0	100.0	100.0	100.0	100.0

The emissions from stationary sources in total Iran are projected in the same procedure with the case of GTA , which is shown in Table 4.5.2-2 for reference.

Table 4.5.2-2 : Stationary emission quantity of air pollutants in total Iran (1994)

(ton/year)

Source	SOx	NOx	CO	HC	SPM	(Total)
Stationary	1,186,885	470,315	140,181	168,212	95,486	2,061,079

(Note) Emissions from flaring associated gas are not included in this projection

2) Sector-wise emission

As shown in Table 4.5.2 -3 and Fig. 4.5.2 -1, the following features are revealed.

(a) SOx emissions from the manufacturing sector shares 64% of the total, followed by energy conversion of 19%, general service & household of 14% and the transport sector of 3%. In the manufacturing sector, nonmetal products have the biggest share of 32%, and Tehran Refinery alone 13%, while the transport sector shares only 3% in contrast to other kinds of emissions, since this sector uses low sulfur gasoline and diesel oil. The thermal power plants in GTA share only 6% since most of the fuels have already been substituted by natural gas except in winter when supply of natural gas is sometimes short.

(b) NOx emission has tendency similar to SOx although the share of the transport sector reaches 29% of total emission. Nonmetal products and Tehran Refinery have 11% and 9.0% shares respectively, followed by power plants of 8.7%. The general service and household sector has 11% share, though this sector has numerous consuming units.

(c) Most HC emission comes from the transport sector accounting for 70%, Tehran Refinery 14% and commercial & general 12%; the combined share of these 3 sectors totals 96%. HC emission sources of the commercial sector are represented by petrol stations, printing shops, dry cleaning shops and petroleum depots and not by shops of electric metal plating and painting, since information of these sources is not available despite their possible substantial volume. It is estimated that leakage of natural gas from rubber hose connections is substantial due to a lack of proper maintenance, especially in the commercial/household sector although their volume is not estimated at this stage.

(d) CO and SPM emissions are negligible in the case of stationary emission sources, since the transport sector has a dominant share of 94% and 88% respectively.

(e) Respecting the emission of stationary sources on the whole, nonmetal products, refinery, and iron & steel are ranked high as illustrated in Fig. 4.5.2-2, but as far as the average emission per company is concerned, iron & steel is the first, which implies that pollution control can be most effectively put into practice in this sector as shown in Fig. 4.5.2-3.

Table 4.5.2-3 : Sectorwise emission quantity of air pollutants in GTA (combustion+evaporation)
(Stationary source)

(ton/year)

	Sector	Emission volume											
		SOx		NOx		CO		HC		SPM		(Total)	
			(%)		(%)		(%)		(%)		(%)		(%)
1	Total Manufacturing	167,923	64.0	56,541	41.8	47,538	5.4	2,948	2.5	16,968	8.2	291,916	18.2
1.1	31 Food Products	21,242	8.1	8,275	6.1	3,577	0.4	534	0.5	3,059	1.5	36,687	2.3
1.2	32 Textile	8,118	3.1	2,921	2.2	4,516	0.5	278	0.2	888	0.4	16,721	1.0
1.3	33 Wood Products	979	0.4	301	0.2	994	0.1	52	0.0	113	0.1	2,439	0.2
1.4	34 Paper & Products	3,627	1.4	1,473	1.1	1,823	0.2	80	0.1	424	0.2	7,427	0.5
1.5	35 Industrial Chemicals	12,379	4.7	6,148	4.5	7,262	0.8	324	0.3	1,686	0.8	27,799	1.7
1.6	36 Non-metal products	83,425	31.8	15,430	11.4	6,688	0.8	774	0.7	5,526	2.7	111,844	7.0
1.7	37 Iron & Steel	19,252	7.3	13,402	9.9	7,145	0.8	327	0.3	2,720	1.3	42,846	2.7
1.8	38 Machinery	6,348	2.4	3,223	2.4	10,984	1.3	536	0.5	956	0.5	22,047	1.4
1.9	39 Other Industries	12,553	4.8	5,367	4.0	4,549	0.5	42	0.0	1,595	0.8	24,106	1.5
2	General Service and Household	35,720	13.6	15,051	11.1	2,893	0.3	15,347	13.2	5,291	2.5	74,301	4.6
2.1	Household	15,029	5.7	12,487	9.2	2,387	0.3	1,091	0.9	3,756	1.8	34,750	2.2
2.2	Commercial & General	20,691	7.9	2,563	1.9	506	0.1	14,256	12.2	1,535	0.7	39,551	2.5
3	Energy Conversion	50,289	19.2	23,900	17.7	953	0.1	16,401	14.1	2,836	1.4	94,380	5.9
3.1	Electric Generation	16,069	6.1	11,736	8.7	445	0.1	722	0.6	1,188	0.6	30,161	1.9
3.2	Refinery	34,220	13.0	12,164	9.0	508	0.1	15,679	13.5	1,648	0.8	64,219	4.0
	(Sub-total)	253,981	96.8	95,571	70.7	51,421	5.9	34,701	29.8	25,113	12.1	460,786	28.8
4	Transport	8,340	3.2	39,610	29.3	826,806	94.1	81,690	70.2	182,717	87.9	1,139,163	71.2
	(Total)	262,321	100.0	135,181	100.0	878,227	100.0	116,391	100.0	207,830	100.0	1,599,949	100.0

Fig 4.5.2-1(1) : Sctorwise emission quantity of air pollutants in GTA (1994)

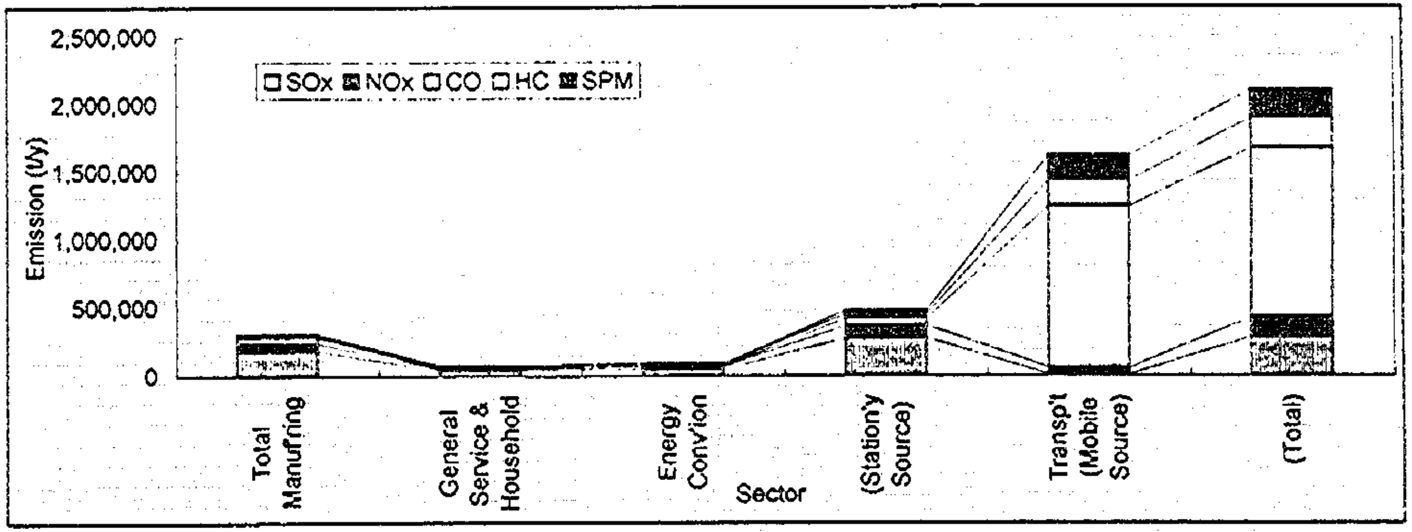


Fig 4.5.2-1(2) : Sctorwise emission quantity of air pollutants in GTA (1994)

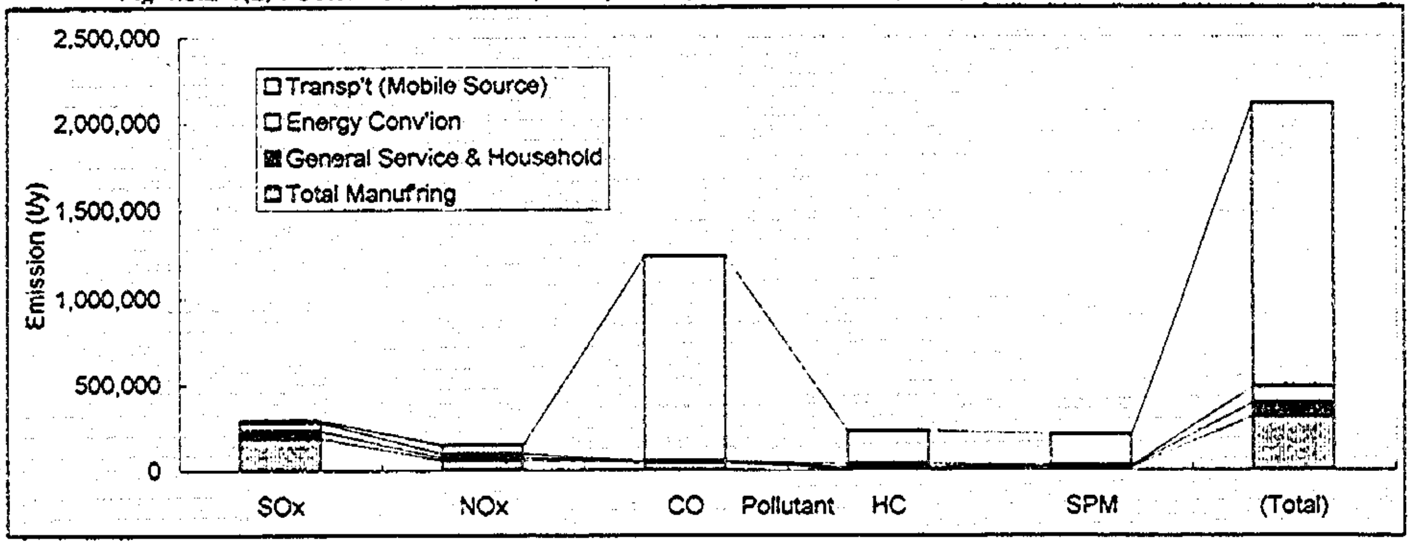


Fig4.5.2-2 : Sctorwise emission quantity of air pollutants in GTA (1994)

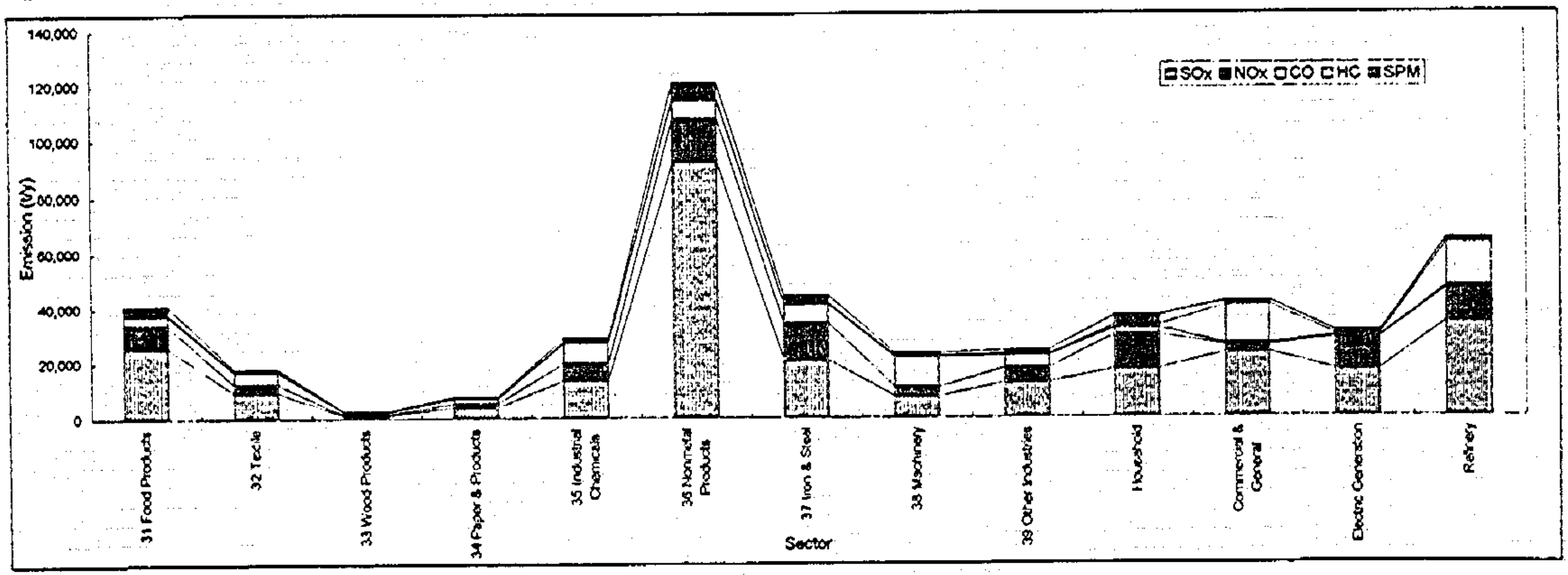
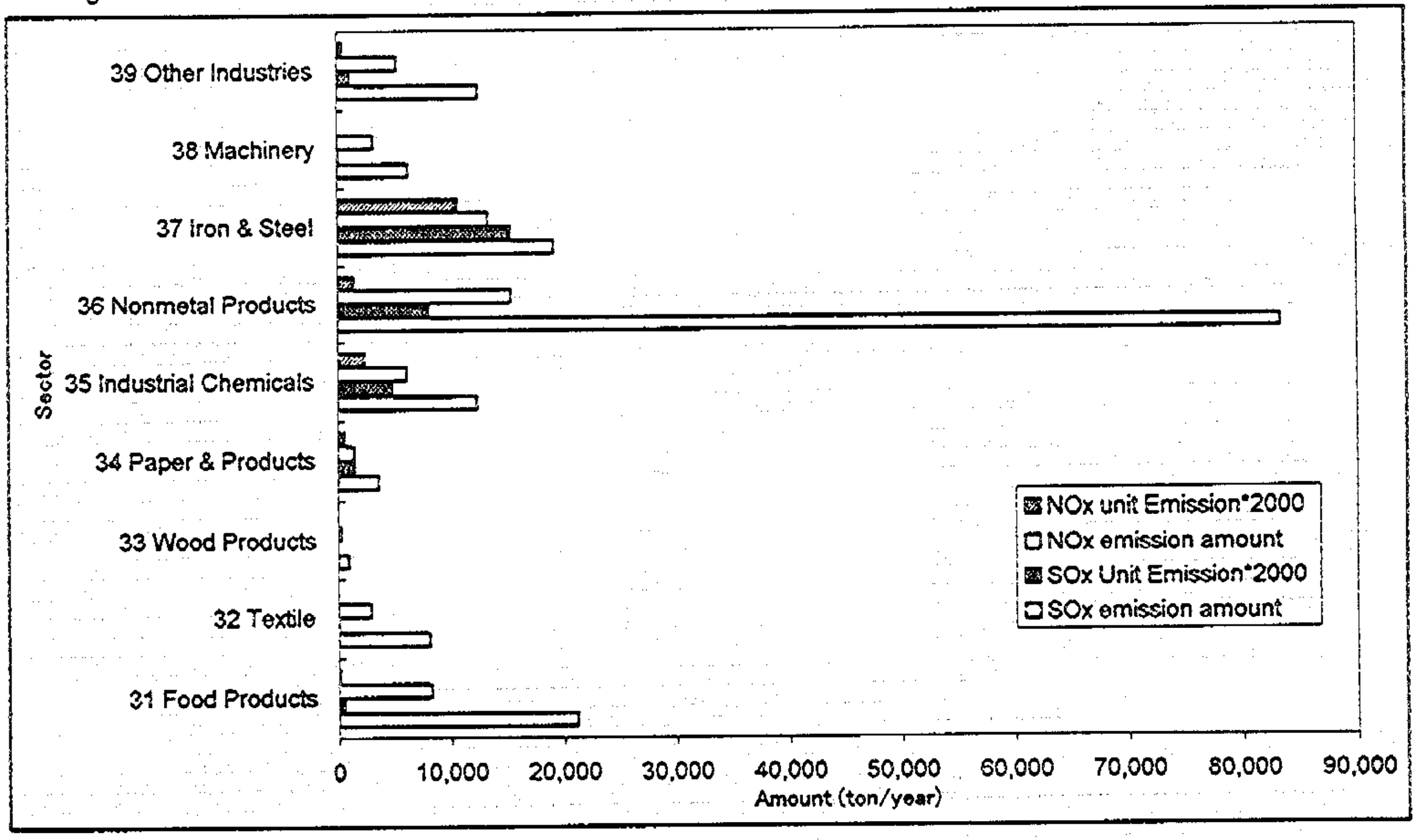


Fig 4.5.2-3 : Sectorwise emission & unit emission of SOx & NOx in manufacturing industries



3) District-wise emission

In order to project dispersion of pollutants in GTA by means of the simulation model developed by the project team, district-wise emission quantities of air pollutants in GTA are projected as shown in Table 4.5.2-4 and Fig. 4.5.2-4, showing that the districts 20, 18, 16, 4, 9, 5 and 19 have higher ranks, among which district 20 spearheads since there are Tehran Refinery and Ray thermal power plant in this district. As shown in Table 4.5.2-5, Tehran Refinery and thermal power plants (Besat, Firouz, Ray) in the energy conversion sector have big shares of emission : 19% and 18% for SOx and NOx, 12% for HC only by Tehran Refinery when compared to the total emission amount of each pollutant in GTA.

Table 4.5.2-5 : Emission quantities of pollutants by companies of energy conversion sector in GTA (1994)(combustion+evaporation)

	Sector	Capacity	District	Emission quantity					(Total)
				SOx (t/y)	NOx (t/y)	CO (t/y)	HC (t/y)	TSP (t/y)	(t/y)
1	Tehran refinery	220,000b/d	20DB	34,243	12,058	497	14,184	1,649	62,631
2	Thermal power plants	1,709Mw		16,106	11,748	451	723	1,191	30,219
2	- Besat	391Mw	16	14,172	5,022	207	288	684	20,372
2	- Firouz	75Mw	2	6	713	21	49	19	808
2	- Ray	1,243Mw	20DB	1,928	6,013	223	386	488	9,038
	(Total)			50,349	23,806	948	14,907	2,840	92,850
	GTA			262,321	135,181	878,227	116,391	207,830	1,599,950
	Ratio to GTA (%)			19.2	17.6	0.1	12.8	1.4	5.8

(2) Major procedures for projection of energy consumption

Fundamental procedures for projecting emission quantities of pollutants are shown in Fig. 4.5.2-5. Detailed projection procedures for the following items are described in APPENDIX 4.5.2 of this report.

①Fuel consumption in GTA

②Emission factors of fuels

③Emission quantity of pollutants in GTA

Table 4.5.2-4(1) : Districtwise stationary emission quantity of pollutants in GTA (1994)

(ton/year)

	Emission \ District	1	2	3	4	5	6	7	8	9	10
1	Combustion										
	SOx	2,468.9	2,662.3	3,670.2	14,106.2	13,991.7	7,756.3	3,706.0	4,644.6	13,028.3	2,640.7
	NOx	1,087.5	1,914.3	1,691.1	6,563.5	5,534.8	3,056.1	1,400.7	1,872.2	5,964.0	1,087.1
	CO	472.6	534.2	940.4	6,082.7	4,594.9	2,260.9	1,006.0	1,232.6	5,502.8	480.1
	HC	63.6	139.3	110.1	355.6	328.0	169.4	107.9	125.7	343.6	80.4
	SPM	368.5	406.2	526.3	1,912.9	1,646.9	958.0	466.7	615.6	1,661.1	366.2
	(Sub-total)	4,461.2	5,656.3	6,938.0	29,021.0	26,096.2	14,240.7	6,687.4	8,490.9	26,499.6	4,654.4
2	Evaporation/Adjustment										
	SOx										
	NOx										
	CO										
	HC	525	361	453	729	929	1,071	873	323	691	466
	SPM										
	(Sub-total)	525	361	453	729	929	1,071	873	323	691	466
3	Total Emission										
	SOx	2,469	2,662	3,670	14,106	13,992	7,756	3,706	4,645	13,028	2,641
	NOx	1,087.5	1,914.3	1,691.1	6,563.5	5,534.8	3,056.1	1,400.7	1,872.2	5,964.0	1,087.1
	CO	472.6	534.2	940.4	6,082.7	4,594.9	2,260.9	1,006.0	1,232.6	5,502.8	480.1
	HC	609.2	500.7	562.8	1,084.6	1,257.1	1,260.7	980.6	448.6	1,034.3	546.7
	SPM	368.5	406.2	526.3	1,912.9	1,646.9	958.0	466.7	615.6	1,661.1	366.2
	(Total)	5,006.7	6,019.7	7,390.7	29,750.0	27,025.2	15,312.0	7,560.1	8,814.0	27,190.5	5,120.7

	Emission \ District	11	12	13	14	15	16	17	18	19	20	Total
1	Combustion											
	SOx	5,412.6	9,932.4	5,385.7	3,026.3	10,799.7	22,836.5	4,177.6	30,520.4	12,077.6	81,466.9	254,331.6
	NOx	1,969.1	2,962.4	2,535.1	1,326.7	3,639.5	7,653.8	1,809.4	10,000.4	3,302.0	30,079.4	95,449.0
	CO	1,570.8	2,723.7	2,069.7	556.6	1,928.1	1,601.8	1,156.3	6,920.1	1,900.2	7,835.6	51,409.2
	HC	131.3	206.7	148.7	100.6	226.5	450.8	110.9	516.3	180.4	1,694.5	5,630.4
	SPM	663.0	1,056.0	717.6	435.5	1,142.0	1,566.1	551.9	3,013.2	1,046.7	5,927.2	25,037.9
	(Sub-total)	9,746.6	16,880.2	10,876.7	5,444.6	17,735.7	34,100.1	7,806.3	50,970.3	18,506.9	127,022.8	431,858.3
2	Evaporation/Adjustment											
	SOx					-351						-351
	NOx										122	122
	CO										12	12
	HC	872	2,606	403	471	937	166	218	859	177	15,716	29,070
	SPM					65					10	75
	(Sub-total)	872	2,606	403	471	651	166	218	859	177	15,862	28,926
3	Total Emission											
	SOx	5,413	9,932	5,386	3,026	10,449	22,839	4,178	30,520	12,078	81,466	253,981
	NOx	1,969.1	2,962.4	2,535.1	1,326.7	3,639.6	7,653.8	1,809.4	10,000.4	3,302.0	30,201.4	95,571.0
	CO	1,570.8	2,723.7	2,069.7	556.6	1,928.1	1,601.8	1,156.3	6,920.1	1,900.2	7,847.8	51,421.2
	HC	1,003.0	3,013.0	551.3	571.7	1,163.1	639.3	328.7	1,375.0	357.2	17,412.5	34,700.5
	SPM	663.0	1,056.0	717.6	435.5	1,207.0	1,566.1	551.9	3,013.2	1,046.7	5,937.2	25,112.9
	(Total)	10,618.5	19,686.6	11,279.4	5,915.6	18,388.3	34,266.5	8,024.1	51,828.9	18,683.7	142,884.8	460,786.4

(Note) Adjustments are made for Cemnt Factories, Flare Stack of Refinery

Table 4.5.2-4(2) : Total stationary & nobile emission in GTA (1994)

(ton/year)

	Emission \ Pollutant	SOx	NOx	CO	HC	SPM	(Total)	(%)
1	Stationary	253,980.8	95,571.0	51,421.2	34,700.5	25,112.9	460,786.4	28.8
2	Mobile	8,340.0	39,610.0	826,806.0	81,690.0	182,717.0	1,139,163.0	71.2
	(Total)	262,320.8	135,181.0	878,227.2	116,390.5	207,829.9	1,599,949.4	100.0

Fig 4.5.2-4 : Districtwise emission quantity of air pollutants in GTA (1994)

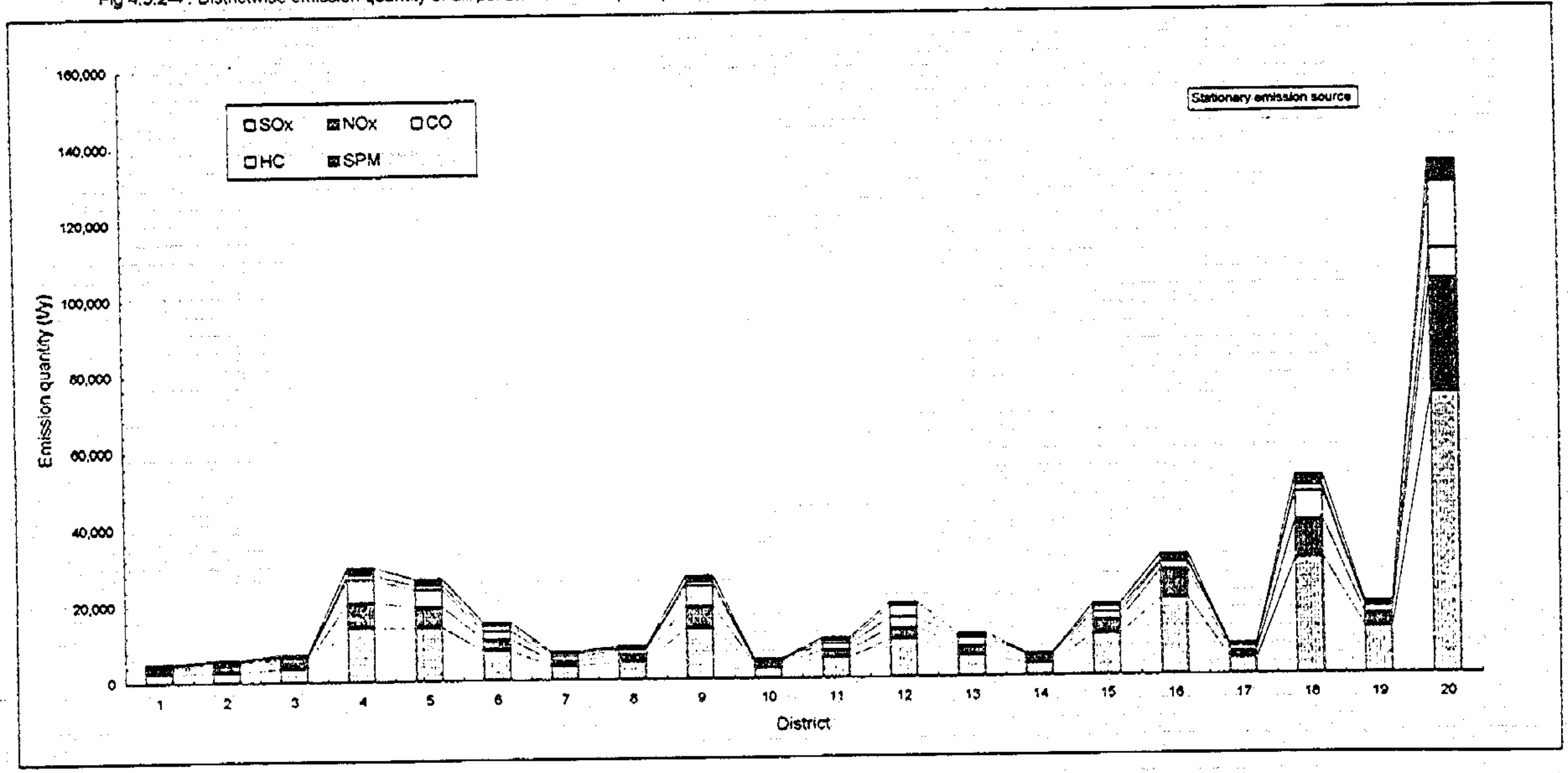
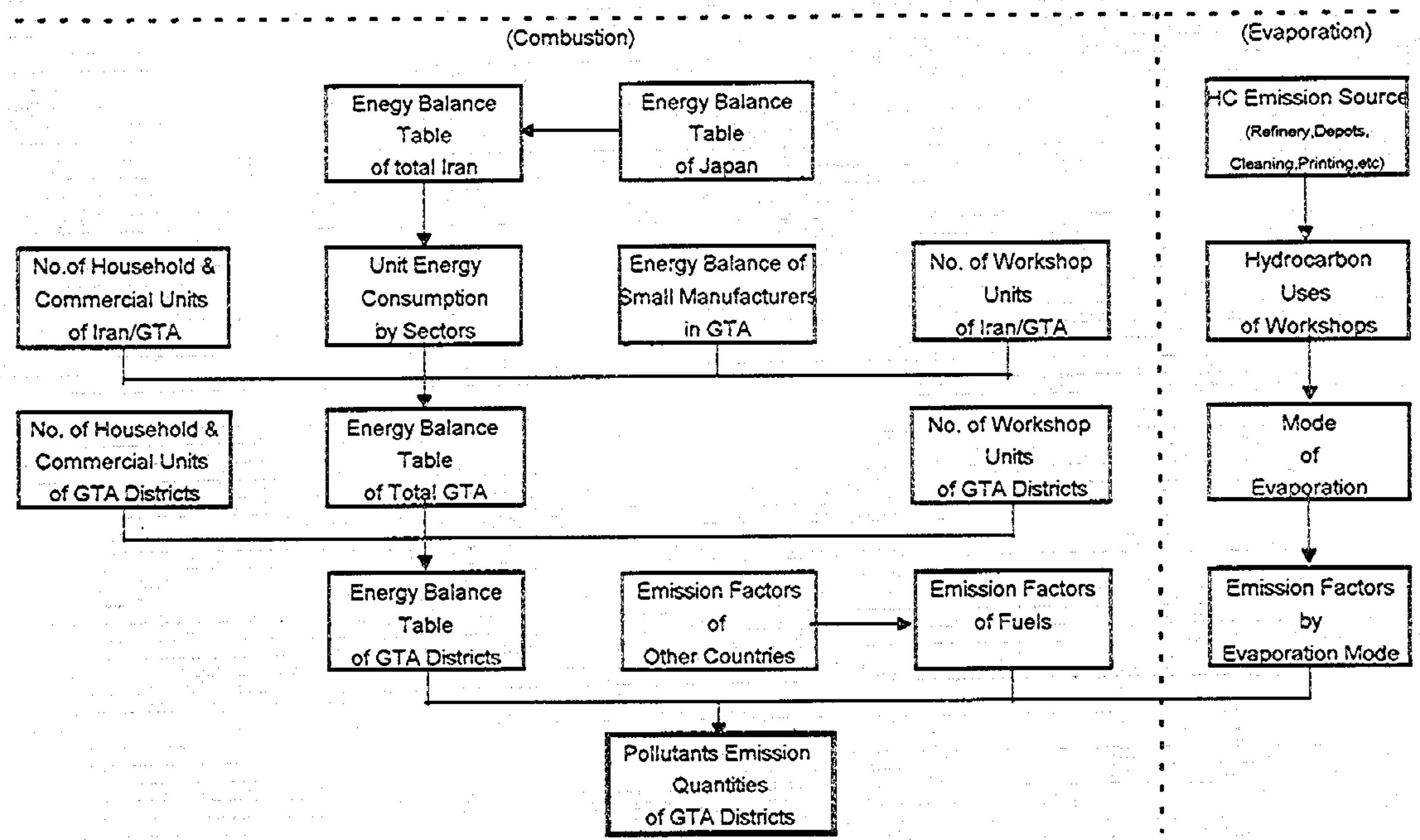


Figure 4.5.2-5 : Flow chart for stationary emission of pollutants



In order to supplement the above projection, questionnaires for data collection shown in APPENDIX 4.5.2 were delivered to 550 workshops belonging to the following 4 categories with respect to the number of employee, of which 190 responses were returned. About 40 critical units among them were interviewed by AQCC engineers for further verification.

1≦Small≦10 51≦Medium large≦100

11≦Medium≦50 101≦Large

The full compilation of responses and summary sheets for the companies having more than 100 employee are tabulated in APPENDIX 4.5.2. The data in these tables are incorporated in the projection of district-wise energy consumption.

Brief description of the categories for projecting pollutants are shown below.

	Sector	Category	Emission Type
1	Manufacturing Industry	Food,Textile,Wood,Paper,Chemicals, Nonmetal,Iron/Steel,Machinery,Other	Point (>100) & Area (≦100)
2	Commercial/Household	Restaurant,Hotel,Office,House,etc.	Area
3	Energy Conversion	Refinery,Power Plant	Point

1) Projection of the energy balance of total Iran (1994)

In order to estimate sector-wise energy demand of GTA, the sector-wise energy balance of total Iran in 1994 was firstly projected in the form of Table 4.5.2-6 for determination of an umbrella and/or ceiling of sector-wise energy consumption of GTA. The data in the dark cells in Table 4.5.2-6 are either collected or calculated mostly based on the energy balance tables of total Iran (1994) prepared by MOE. The energy table format follows the portfolio of IEA/OECD, which is the prevalent pattern in the world.

2) Projection of the energy demand in GTA (1994)

Based on the energy balance of total Iran, energy demand in GTA was projected as shown in Table 4.5.2-7 by means of proportional allocation of energy by the number of workshops or commercial/household units between GTA and total Iran in the case where individual figures could not be collected. The data in the dark cells in Table 4.5.2-7 are also

Table 4.5.2-6 : Sectorwise demand and supply energy balance in total Iran (1994)

(10^10kcal)

	Sector	Total Energy Supply/Cons. including Electricity	Total Fuel Supply or Consumption	Coal	Cokes, etc	Crude Oil	Petroleum Products	Fuel Oil	Gasoline	Naphtha	Jet Fuel	Kerosene	Gas Oil	Heavy Oil	Lube Oil	Other Petroleum Products	Refinery Off-gas	Oil Cokes	LPG	Natural Gas	LNG	City Gas	Hydro Electric Power	Total Electric Power	Commercial (MOE)	Domestic
1	Total Domestic Supply of Primary Energy	108,479	107,838	1,038		70,346	-2,012	-1,620	852			1,606	3,436	-7,366		-382				37,982			640			
1	Production	247,687	246,857	1,168		207,090														38,096			640			
2	Imports	6,340	6,340	397			5,940	5,940	852			1,606	3,482													
3	Exports	-145,368	-145,358	-23		-137,244	-7,960	-7,568						-7,568		-392				-131						
4	Inventory Changes																									
2	Total Energy Conversion	-17,412	-23,720	-469	744	-86,395	47,896	49,515	8,771		774	8,152	16,703	15,625	671	2,481		2,566	2,085	-14,975			-640	6,964	6,629	320
1	Electric Power Enterprizes	-17,223	-16,212				-6,592	-6,092					-1,016	-5,077						-11,620			-640	6,629	6,629	
2	Industrial Plants	-579	-1,159				-443	-443					-73	-370						-570				440		440
3	Heat Suppliers																									
4	City Gas																									
5	Coke Production	-122	-122	-866	744																					
6	Refined Petroleum	-4,077	-3,912			-86,396	54,226	56,940	8,771		774	8,152	17,683	21,368	518	2,481		2,566	1,753	-1,743				-155		-155
7	Petro Chemical	-868	-868				0	0												-868						
8	Others	505	506				506	0							-153				302							
3	Self-consumption & Loss	-6,229	-3,907			-2,992														-4,215				-1,622	-1,239	-83
4	Statistical Error	1,303	771	134		-1,239	445	60	184			287	-279	-52				-131	616	2,671				532	449	67
5	Total Final Energy Production	87,041	80,977	780	744	0	56,129	48,351	9,587		774	10,227	20,802	7,761	671	2,069		2,437	2,581	23,318			0	6,064	5,735	329
5	Total Final Energy Consumption	87,041	80,977	780	744	0	56,129	48,351	9,587		774	10,227	20,802	7,761	671	2,069		2,437	2,581	23,318				6,064	5,735	329
6	Industry	32,940	30,096	267	744		17,135	14,585	259			1,660	7,605	5,461				2,437	103	11,929				2,845	2,548	329
1	Agri.Forestry	6,420	5,965				5,965	5,890				371	5,594											455	455	
2	Mining & Construction																							332	332	
3	Total Manufacturing	26,388	24,130	267	744		11,170	8,636	259			670	2,211	5,461				2,437	103	11,929				2,226	1,737	329
3.1	31 Food Products	3,126	2,913	0	0		1,683	1,664	40			120	409	1,098				0	16	1,230				223		
3.2	32 Textile	1,600	1,303	1	0		587	554	29			117	231	277				25	8	615				297		
3.3	33 Wood Products	137	111	0	0		102	102	5			7	51	39				0	1	8				26		
3.4	34 Paper & Products	456	491	18	0		272	143	9			8	66	60				129	1	200				64		
3.5	35 Industrial Chemicals	2,764	2,621	16	8		1,290	690	42			46	446	156				542	7	1,357				143		
3.6	36 Ceramics Products	8,304	7,941	123	13		4,656	4,402	66			231	500	3,605				467	19	2,917				563		
3.7	37 Iron & Steel	7,273	6,549	126	702		642	464	22			20	279	142				153	26	5,079				724		
3.8	38 Machinery	1,274	1,061	2	11		529	505	45			128	226	104				0	26	516				213		
3.9	39 Other Industries	1,749	1,745	0	10		1,127	5	1			1	2	1				1,121	0	4				4		
7	General Service and Household	29,707	26,488	499			16,333	14,377				9,177	2,920	2,280					1,956	9,656				3,219	3,219	
1	Household	23,417	21,420	111			12,837	11,076				8,586	2,490						1,761	6,472				1,997	1,997	
2	Commercial & General	6,290	5,068	388			3,496	3,301				591	430	2,280					195	3,184				1,222	1,222	
8	Transport	19,903	19,904				19,904	19,379	9,328		774		9,277						522							
1	Passenger	11,616	11,616				11,616	11,094	8,318		676		2,100						522							
2	Cargo	8,285	8,285				8,285	8,285	1,010		98		7,177													
9	Non-energy	4,493	4,493				2,760								671	2,069				5,733						
	Heat Values for Conversion	(kcal/unit)		6950/kg	7200/kg	9250/l			8400/l	4000/l	8700/l	8900/l	9700/l	9700/l	9000/l	10100/l	9400/m3	8500/kg	12000/kg	9500/m3	13000/kg	10000/m3	860/kwh	860/kwh	860/kwh	860/kwh

(Note) [shaded box] Data available from data source in Iran

Table 4.6.2-7 : Sectorwise energy demand in GTA (1994)

(10^10 kcal)

Sector	Total Energy Consumption incl. Electricity	Total Fuel Consumption	Coal	Cokes, etc.	Crude Oil	Petroleum Products	Fuel Oil	Gasoline	Naphtha	Jet Fuel	Kerosene	Gas Oil	Heavy Oil	Lube Oil	Other Petroleum Products	Refinery Off-gas	Oil Cokes	LPG	Natural Gas	LNG	City Gas	Total Electric Power	Commercial Power	Domestic Power	Others
5 Final Energy Consumption(Iran)(1)	67,041	80,977	786	744	0	56,129	48,361	9,687		774	10,227	20,002	7,761	671	2,089		2,437	2,681	23,318			6,064	5,736	329	0
5 Final Energy Consumption(Iran)(2)(3)	111,386	106,207	908	744	0	66,332	67,664	9,687		774	10,227	21,178	15,788	671	2,089		2,437	2,681	38,223			6,179	5,736	444	0
5 Total Energy Consumption(Tehran)	27,491	26,551	276	327	0	11,450	9,877	2,308			1,491	5,677	3,017				1,081	472	5,713			1,800			
6 Industry	10,480	9,398	126	332		5,287	4,094	103			296	1,727	1,968				1,081	85	3,680			1,062			
1 Agr.Forestry																									
2 Mining																									
3 Construction																									
4 Total Manufacturing	10,480	9,398	126	332		5,287	4,094	103			296	1,727	1,968				1,081	85	3,680			1,062			
4.1 31 Food Products	1,307	1,304	0	0		1,420	1,195	9			169	735	195				0	17	181			63			
4.2 32 Textile	774	646	0	0		311	293	13			38	133	109				11	7	237			173			
4.3 33 Wood Products	85	44	0	0		47	45	3			4	23	12				0	0	2			21			
4.4 34 Paper & Products	297	225	8	0		132	74	4			3	40	27				57	1	88			39			
4.5 35 Industrial Chemicals	1,105	1,031	7	3		319	292	16			7	211	59				241	5	482			74			
4.6 36 Nonmetal Products	2,749	2,145	54	8		1,455	1,044	12			30	204	1,398				207	4	230			104			
4.7 37 Iron & Steel	2,759	2,365	55	313		393	380	10			3	176	110				66	19	2,191			394			
4.8 38 Machinery	616	452	1	5		369	327	33			36	199	59				0	31	298			164			
4.9 39 Other Industries	535	525	0	4		514	56	3			5	8	1				497	1	2			10			
7 General Service and Household	7,329	6,521				2,742	2,374				1,565	839	350					368	3,779			808			
1 Household	6,057	5,498				2,195	1,829				1,109	715						331	3,240			562			
2 Commercial & General	1,272	1,026				547	560				78	124	350					37	539			246			
8 Transport	2,581	2,581				2,581	2,547	2,205				337						197							
1 Passenger	2,081	2,081				2,081	2,047	1,966				76						38							
2 Cargo	500	500				500	500	239				261													
9 Energy Conversion	2,121	2,121				867	867					168	699						1,254						
1 Power Plant	1,088	1,088				351	351					147	204						737						
2 Refinery	1,033	1,033				516	516					21	495						517						
Heat Values for Conversion (kcal/unit)			6950/kg	7200/kg	9250/l			8400/l	8000/l	8700/l	8900/l	9200/l	9700/l	9800/l	10100/l	9400/m3	8500/kg	12000/kg	9800/m3	3000/l	10000/m3	860/kwh			

(Note)
(1) Exclusive of fuels for Energy Conversion sector
(2) Inclusive of fuels for Energy Conversion sector
3) Crude oil portion(2169) is allocated to gas oil and heavy oil in proportion to the ratio in Tehran refinery

[shaded] Data available from data source in Iran

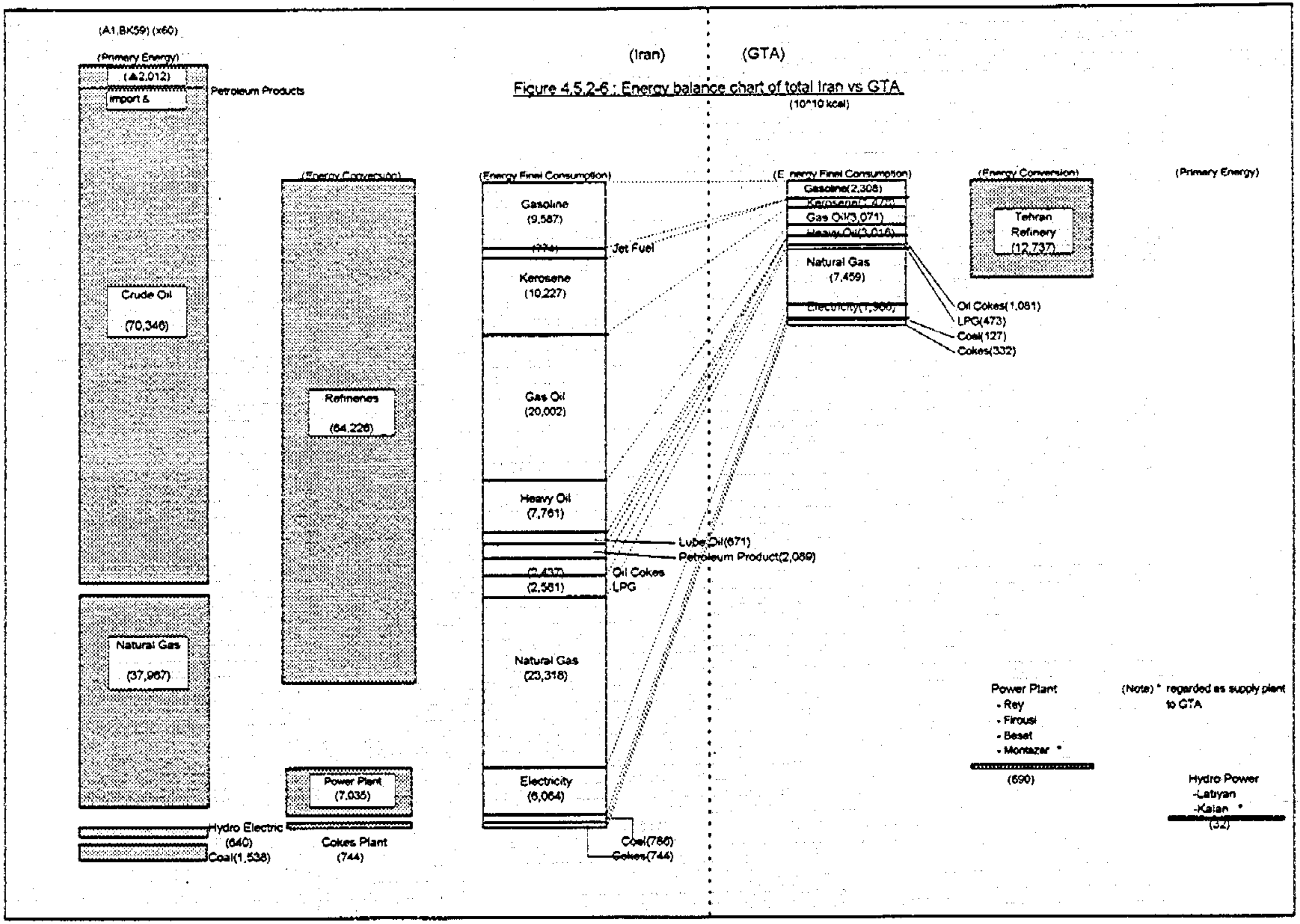


Figure 4.5.2-6 : Energy balance chart of total Iran vs GTA

collected mostly from the energy balance tables of MOE. Fig. 4.5.2-6 shows the energy balance of total Iran vs. GTA, which visually indicates the energy position of GTA in Iran in terms of primary energy production, energy conversion capacity and final energy consumption.

3) Projection of the energy demand in GTA districts (1994)

Energy demand in each GTA district in Table 4.5.2-9 is projected by proportional allocation of energy demand in GTA by the number of workshops or commercial/ household units in each district in Table 4.5.2-8.

(3) Emission factors of fuels

The emission factors by fuel combustion in Table 4.5.2-10 are evaluated on the basis of a variety of data sources in the world, some of which are verified through the field measurement, while the emission factors for HC evaporation are mostly collected in reflection of the factors of Japan shown in Table 4.5.2-11. SOx emission factors are calculated based on the sulfur content of fuels shown in Table 4.5.2-12.

(4) Emission quantities of pollutants in GTA

Consequently, emission quantities of pollutants are calculated as a result of multiplying energy consumption with corresponding emission factors except HC evaporation which is estimated as a result of case-by-case studies. Table 4.5.2-13 illustrates sector-wise SOx emission quantities in GTA, while Table 4.5.2-14 illustrates district-wise SOx emission quantities in GTA, for which data sheets are provided for all pollutants as shown in APPENDIX 4.5.2. The emission quantities from the energy conversion sector in GTA are separately evaluated as shown in Table 4.5.2-15, since the scale of facilities in this sector is very large. Evaporation amounts of HC in GTA are also estimated apart from emission through combustion as shown in Table 4.5.2-16.

(Note): Heat values used in the projection are shown in Table 4.5.2-17.

Table 4.6.2-8 : Sectorwise number of work units in GTA districts (1994)

(Industrial Units>10 persons)

ISIC / District	31		32		33		34		35		36		37		38		39		Subtotal		General Service & Household		
	Non	Big	Non	Big	Non	Big	Non	Big	Non	Big	Non	Big	Non	Big	Non	Big	Non	Big	Non	Big	Household	Commercial	Subtotal
1	9		2		1		3		3		1		0		4		0		23	0	65,789	5,246	71,035
2	2		0		0	1	0		5		2		0		7		2		18	1	92,703	6,942	99,645
3	13		4		0		5		5		1		2		15		0		45	0	60,952	6,752	67,704
4	14	2	19	1	11		12		48	1	3		7		143	3	42		299	7	129,771	17,337	147,108
5	20		44		1		12		56		15		6		82	1	7		245	1	89,503	6,817	96,320
6	16		41		0		34		10		4		3		35		5		148	0	67,479	16,667	84,146
7	1		18		1		19		6		2		0		20		2		69	0	76,955	15,043	91,998
8	6		3		2		0		6		3		0	1	28		10		58	1	92,189	10,781	102,970
9	21	2	43	3	2	1	8		53	9	8	2	9	1	135	7	9		268	25	55,635	7,675	63,310
10	2	2	9		0		0		2		1		0		5		3		22	2	77,638	11,885	89,523
11	6	1	85		0		15		2		0		0		10		11		129	1	63,417	20,061	83,478
12	2		144		1		69		3		1		0		21		11		252	0	65,970	60,314	126,284
13	9		9		9		3		14		2		5		45		3		99	0	48,468	7,450	55,918
14	3		13		1		3		1		1		0		5	1	2		29	1	96,621	13,349	109,970
15	7		25		1		4		4		16	2	3		33	2	2		96	4	124,597	21,898	146,495
16	10	1	17		1		1		4		16		1		17		3		70	1	73,585	12,242	85,827
17	3		8		2		0		6		2		2		21		8		50	0	76,224	12,216	88,440
18	36	4	20	1	9	1	10	1	40	7	52		15	3	119	8	13		313	25	67,698	13,687	81,385
19	5		13		3		2		5		27		4	1	23		1		83	1	48,802	9,022	57,824
20	27		60	1	3		5		35	1	104	1	13		70		7		325	3	73,022	11,224	84,246
Total GTA	211	12	578	6	48	3	206	1	310	18	261	5	70	6	838	22	139	0	2,661	73	1,547,018	286,608	1,833,626
	223		584		51		207		328		266		76		860		139		2,734				
Total Iran	920		920		107		285		561		2,051		107		1,010		200		6,151		9,626,945		

(Note) Non : Others than Big   Big : Personnel>100 in questionnaire

(Source) AQCC : Stationary Sources Survey (NO.2)

Table 4.6.2-9 : Districtwise fuel consumption for stationary emission source in GTA (1994)

(10^10 kcal)

	Fuel / District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1	Gasoline																					
	Industrial Non-big Unit	0.9	0.7	1.9	11.9	10.0	4.8	2.1	2.2	11.9	0.7	3.2	6.0	4.5	0.9	3.7	2.7	2.1	14.1	3.7	14.1	102
	Industrial big Unit																		1.0			1.0
	Commercial/Household	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Energy Conversion																					
	(Sub-total)	0.9	0.7	1.9	11.9	10.0	4.8	2.1	2.2	11.9	0.7	3.2	6.0	4.5	0.9	3.7	2.7	2.1	15.1	3.7	14.1	103.0
2	Kerosene																					
	Industrial Non-big Unit	7.8	2.3	11.7	23.2	26.3	18.5	3.7	7.3	28.6	2.7	11.6	13.7	11.4	3.8	11.0	12.1	4.7	43.4	9.6	42.5	298
	Industrial big Unit																					
	Commercial/Household	48.6	68.3	45.5	97.6	66.0	52.8	59.2	68.9	41.9	58.8	50.8	63.3	36.7	72.8	95.1	56.0	57.9	52.2	37.4	55.3	1,165
	Energy Conversion																					
	(Sub-total)	56.4	70.6	57.2	120.9	92.3	71.3	62.8	76.2	70.5	61.5	62.3	77.0	48.1	76.6	106.1	68.1	62.6	95.6	46.9	97.8	1,461.0
3	Gas Oil																					
	Industrial Non-big Unit	36.1	13.3	58.8	144.5	163.9	95.7	21.7	35.2	177.5	12.2	46.5	60.8	70.9	16.9	60.9	60.2	28.3	261.0	61.0	259.6	1,665
	Industrial big Unit		1.0		5.0				3.0	11.0		2.0				3.0			16.0		1.0	42
	Commercial/Household	32.7	45.8	31.1	67.5	44.3	38.4	42.1	47.3	29.0	41.0	38.0	56.6	25.6	50.4	67.1	39.3	40.5	37.2	26.5	38.6	839
	Energy Conversion																11.0				157.0	168.0
	(Sub-total)	68.7	60.2	89.9	216.9	208.2	134.1	63.7	85.5	217.5	53.2	86.5	117.4	96.5	67.3	131.0	110.5	68.9	314.2	87.4	456.2	2,734.0
4	Heavy Oil																					
	Industrial Non-big Unit	15.1	13.7	23.2	64.1	131.2	55.8	19.5	25.3	101.9	9.5	24.0	43.9	36.0	11.5	104.8	101.3	20.8	353.6	160.8	622.2	1,938
	Industrial big Unit				3.0					7.0						14.0	5.0			2.0		31
	Commercial/Household	6.4	8.5	8.2	21.2	8.3	20.4	18.4	13.2	9.4	14.5	24.5	73.7	9.1	18.3	26.7	14.9	14.9	16.7	11.0	13.7	350
	Energy Conversion																204.0				495.0	699.0
	(Sub-total)	21.5	22.2	31.5	88.3	139.5	76.1	37.9	38.5	118.3	24.0	48.5	117.6	45.1	27.9	145.5	325.2	35.8	370.3	173.8	1,130.9	3,018.0
5	LPG																					
	Industrial Non-big Unit	1.0	0.5	2.3	9.1	7.8	4.2	1.2	1.8	10.3	0.5	2.0	3.0	4.0	0.6	3.2	2.2	1.7	12.7	2.9	11.0	82
	Industrial big Unit																		2.0			2
	Commercial/Household	14.6	20.5	13.8	29.9	19.8	18.7	18.4	21.0	12.8	18.1	16.3	22.9	11.3	22.3	29.5	17.3	17.8	16.3	11.6	17.0	368
	Energy Conversion																					
	(Sub-total)	15.6	21.0	16.1	38.9	27.7	20.9	19.6	22.8	23.2	18.6	18.3	25.9	15.3	22.9	32.6	19.5	19.6	31.0	14.6	28.1	452.0
6	Natural Gas																					
	Industrial Non-big Unit	13.8	11.5	86.2	351.1	337.0	160.2	30.9	22.9	432.4	9.6	48.9	97.2	200.5	11.6	132.5	62.9	83.0	619.3	160.9	570.6	3,443
	Industrial big Unit		1.0		3.0				1.0	79.0	1.0	1.0			16.0	52.0	24.0		24.0		35.0	237
	Commercial/Household	150.1	210.8	141.9	306.7	203.7	171.2	189.2	215.5	131.9	185.8	167.6	234.8	116.1	229.1	302.5	177.6	183.3	167.1	119.2	174.8	3,779
	Energy Conversion		73.0														215.0				966.0	1,254
	(Sub-total)	163.8	296.3	228.1	660.8	540.7	331.5	220.1	239.5	643.3	196.4	217.5	332.0	316.6	256.6	487.0	479.6	266.3	810.4	280.1	1,746.5	8,713.0
7	Solid Fuel																					
	Industrial Non-big Unit	4.5	13.4	19.3	242.4	130.3	60.8	20.6	44.3	144.1	13.7	47.8	68.0	56.9	10.3	47.6	37.5	41.4	230.5	61.3	244.7	1,539
	Industrial big Unit																					
	Commercial/Household	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Energy Conversion																					
	(Sub-total)	4.5	13.4	19.3	242.4	130.3	60.8	20.6	44.3	144.1	13.7	47.8	68.0	56.9	10.3	47.6	37.5	41.4	230.5	61.3	244.7	1,539.4
8	Total																					
	Industrial Non-big Unit	79.1	55.5	203.4	846.3	806.5	400.1	99.7	136.8	906.9	48.8	183.9	292.7	384.2	55.6	363.6	278.8	182.0	1,534.7	460.0	1,764.8	9,085
	Industrial big Unit	0.0	2.0	0.0	11.0	0.0	0.0	0.0	4.0	97.0	1.0	3.0	0.0	0.0	16.0	69.0	29.0	0.0	43.0	2.0	36.0	313
	Commercial/Household	252.3	353.9	240.6	522.9	342.1	299.4	327.2	365.9	225.0	318.3	297.2	451.2	198.8	390.9	520.9	305.2	314.4	289.5	205.6	299.5	6,521
	Energy Conversion	0.0	73.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	430.0	0.0	0.0	0.0	1,618.0	2,121
	(Sub-total)	331.4	484.4	444.0	1,380.7	1,148.6	699.5	426.9	508.7	1,228.9	368.1	484.2	743.9	583.0	462.5	953.6	1,042.9	496.5	1,867.2	567.6	3,718.3	18,040

Table 4.5.2.-10 : Emission factors by combustion

	Sector	Fuel	Unit	SOx	NOx	CO	HC	SPM
1	Industry	Gasoline	g/Gj	37	165	7,744	298	41
		Kerosene	g/Gj	86	165	15	9	64
		Gas Oil	g/Gj	336	164	13	9	65
		Heavy Oil	g/Gj	1,268	175	12	9	67
		LPG	g/Gj	61	52	7	2	8
		Natural Gas	g/Gj	1	73	7	1	6
		Solid Fuel	g/Gj	590	250	170	0	74
2	Household & Commercial	Kerosene	g/Gj	86	62	15	11	22
		Gas Oil	g/Gj	336	71	15	4	55
		Heavy Oil	g/Gj	1,268	70	15	4	71
		LPG	g/Gj	61	36	9	3	8
		Natural Gas	g/Gj	1	50	8	3	7
		Solid Fuel	g/Gj	590	215	800	1	74
3	Transport	Gasoline	g/Gj	37	301	8,845	800	575
		Jet Fuel	g/Gj	129	224	120	63	23
		Gas Oil	g/Gj	345	831	765	559	9,190
		LPG	g/Gj	61	132	15	3	112
4	Power Plant & Refinery	Gas Oil	g/Gj	336	284	15	15	66
		Heavy Oil	g/Gj	1,637	325	16	16	70
		Natural Gas	g/Gj	1	234	7	16	6

(Note) Solid Fuel : Coal, Cokes, Oil Cokes

Table 4.5.2-11 : Data base for hydrocarbon emission

The following figures show the average statistical figures compiled by National and Local Governmental Organizations in Japan.

(1) Evaporating loss in refinery in Japan (1994)

		(kl-crude/year)
- Crude oil input (100%)		270,857,000
- Refining loss (1.3%)		▲ 3,521,000
- Oil cokes	0.86%	
- Flare	0.34%	
- Evaporation	0.10%	
- Fuel consumption for refining (4.2%)		
Heavy oil		2,675,386
Other petroleum fuel		123,326
LPG		14,050
Refinery gas		8,569,924

(Source) G/p59

(2) Yield of petroleum products (1994)

	(w%)		(w%)
- Gasoline	20.36	- Lube oil	1.09
- Naphtha	7.04	- Paraffine	0.07
- Jet oil	2.64	- Asphalt	2.64
- Kerosene	11.44	- LPG	3.81
- Gas oil	17.54		
- Heavy oil	32.27		
A type	12.09		
B type	0.07		
C type	20.11		

(Source) G/p65

(3) Emission of petroleum products in Tokyo (1994)

(Source) H/p6 (ton/year)

Emission Sources			Gasoline	Kero/Gasoil/Heavyoil
Storage Failities	Storage Tank	Breathing Loss	730	18.2
		Receiving Loss	1,353	42.4
Delivering Fcilities	Tank Lorry	Delivering Loss	1,276	5.2
Petrol Station	Receiving	Receiving Loss	2,166	13.1
	Delivering	Delivering Loss	5,250	17.5
		(Total)	10,775	96.4

(4) Emission factors for fuel oil handling facilities

Emission Sources			Petroleum Products	Emission Factors
Storage Failities	Cone Roof (5,000kl)	Breathing Loss per tank	Gasoline	210kg/day
			Crude Oil	90kg/day
			Kerosene	0.83kg/day
			Gas Oil	0.70kg/day
			Heavy Oil	0.15kg/day
		Receiving Loss	Gasoline	1.00kg/kl
			Crude Oil	0.52kg/kl
			Kerosene	0.0024kg/kl
			Gas Oil	0.0021kg/kl
			Heavy Oil	0.00045kg/kl
	Floating Roof (10,000kl)	Delivering Loss (wet wall) per lot	Gasoline	0.0016kg/kl
			Crude Oil	0.00048kg/kl
Loading Facilities	Ship	Receiving Loss	Gasoline	0.19kg/kl
			Crude Oil	0.12kg/kl
	Tank Lorry	Receiving Loss	Gasoline	0.89kg/kl
Filling Station	Unloading	Receiving Loss	Gasoline	1.08kg/kl
	Filling	Delivering Loss		1.44kg/kl

(Source) H/p62

(5) Other hydrocarbon emission sources

Workshop	No. of workshop	Emission Volume(t/y)	Emission per Shop(t/y)	Share ratio (%)
Printing	12,000	33,000	2.75	41
Metal surface treatment	5,300	12,000	2.26	15
Painting	20,000	10,000	0.50	13
Petrol Station	2,660	10,775	2.52kg/kl	13
Cleaning	7,100	6,700	0.94	8
Others	12,600	8,000	0.63	10
(Total)	59,660	80,475		100

(Source) K/p6

(6) Storage tank capacity of depots

(1,000 kl)

	Ray	Kan	Ghoochak	Nazi	(Total)
Gasoline	79	40	39	0	158
Kerosene	122	58	35	15	230
Gas Oil	151	76	41	30	298
Heavy Oil	240	0	0	0	240
(Total)	592	174	115	45	926

(7) Fuel handling amount of depots

(1,000 kl)

	Ray	Kan	Ghoochak	Nazi	(Total)
Gasoline	1,662	578	534	0	2,774
Kerosene	1,092	170	268	134	1,663
Gas Oil	1,581	766	634	315	3,296
Heavy Oil	2,372	0	0	0	2,372
(Total)	6,707	1,514	1,436	449	10,105

(Note) Handling amount are projected based on the data supplied by Depots as well as Table 4.5.2.2-1.

Table 4.5.2-12 : SOx emission factor calculation sheet

(Emission factor : g/GJ)

	Fuel	Specific Gravity	Heat Value	Sulfur Content	Emission Factor	Calculation Formula	Remark
1	Gasoline	0.75	8,400kcal/liter	0.086w%	37	0.75*0.86/(8400*4.187*10^-6)*2=37	
2	Jet Fuel	0.78	8,700kcal/liter	0.30w%	129	0.78*3/(8700*4.187*10^-6)*2=128.5	
3	Kerosene	0.80	8,900kcal/liter	0.20w%	86	0.8*2.0/(8900*4.187*10^-6)*2=86	
4	Gas Oil	0.86	9,200kcal/liter	0.80w%	336~345	8.6*0.8/(9200*4.187*10^-6)*2=336~345	
5	Heavy Oil	0.95	9,700kcal/liter	2.71w%	1,268	9.5*2.71/(9700*4.187*10^-6)*2=1268	For general use
				3.50w%	1,637	9.5*3.5/(9700*4.187*10^-6)*2=1637	For power plant and refinery use
6	LPG	0.55	12,000kcal/kg	10g/100ft3	61	1.52/(12000*4.187*10^-6)*2=60.5(1)	0.43Nm3/kg, C3=0.49Nm3/kg, C4=0.37Nm3/kg
7	Natural Gas		9,800kcal/m3	0.001w%	1	0.00783/(9800*4.187*10^-6)*2=0.38	NG=0.783kg/m3
8	Solid Fuel		8,090kcal/kg	1.00w%	590	10/(8090*4.187*10^-6)*2=590.4	

(Note) (1) 10g/100ft3=10g/2.8317m3=1.52g/kg

Table 4.6.2-13 : Sectorwise SOx emission quantity in GTA (1994)

(ton/year)

	Sector	Total Emission Volume	Coal	Cokes, etc.	Crude Oil	Petroleum Products	Fuel Oil							Lube Oil	Other Petroleum Products	Refinery Off-gas	Oil Cokes	LPG	Natural Gas	LNG	City Gas	Total Electric Power			Others
								Gasoline	Naphtha	Jet Fuel	Kerosene	Gas Oil	Heavy Oil										Commercial Power	Domestic Power	
	Emission Volume (Iran)																								
5	Emission Volume (Tehran)	262,624	3,120	8,196	0	250,944	223,054	3,585	0	0	5,328	43,299	170,853	0	0	0	28,885	1,205	385	0	0	0			
6	Industry	168,274	3,120	8,196	0	156,805	129,903	156	0	0	1,085	24,271	104,409	0	0	0	28,665	217	154	0	0	0			
1	Agri,Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
2	Mining	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
3	Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
4	Total Manufacturing	168,274	3,120	8,196	0	156,805	129,903	156	0	0	1,085	24,271	104,409	0	0	0	28,885	217	154	0	0	0			
4.1	31 Food Products	21,242	0	0	0	21,234	21,191	14	0	0	606	10,330	10,239	0	0	0	0	43	8	0	0	0			
4.2	32 Textile	8,118	7	0	0	8,101	7,809	20	0	0	137	1,869	5,783	0	0	0	275	18	10	0	0	0			
4.3	33 Wood Products	979	0	0	0	979	979	5	0	0	14	323	637	0	0	0	0	0	0	0	0	0			
4.4	34 Paper & Products	3,627	201	0	0	3,422	2,012	6	0	0	11	562	1,432	0	0	0	1,406	3	4	0	0	0			
4.5	35 Industrial Chemicals	12,379	178	83	0	12,096	6,145	25	0	0	26	2,965	3,130	0	0	0	5,940	13	20	0	0	0			
4.6	36 Ceramics Products	83,776	1,337	143	0	82,287	77,162	18	0	0	108	2,887	74,166	0	0	0	5,115	10	10	0	0	0			
4.7	37 Iron & Steel	19,252	1,369	7,735	0	10,058	8,335	15	0	0	11	2,474	5,836	0	0	0	1,672	48	92	0	0	0			
4.8	38 Machinery	6,348	26	125	0	6,188	6,107	51	0	0	130	2,797	3,130	0	0	0	0	79	11	0	0	0			
4.9	39 Other Industries	12,553	2	109	0	12,442	164	5	0	0	22	84	53	0	0	0	12,278	3	0	0	0	0			
7	General Service and Household	36,720	0	0	0	35,562	34,623	0	0	0	4,263	11,791	18,569	0	0	0	0	939	158	0	0	0			
1	Household	15,029	0	0	0	14,889	14,044	0	0	0	3,989	10,055	0	0	0	0	0	845	140	0	0	0			
2	Commercial & General	20,691	0	0	0	20,673	20,578	0	0	0	273	1,736	18,569	0	0	0	0	94	18	0	0	0			
8	Transport	8,340	0	0	0	8,340	8,292	3,427	0	0	0	4,865	0	0	0	0	0	48	0	0	0	0			
1	Passenger	4,202	0	0	0	4,202	4,153	3,056	0	0	0	1,097	0	0	0	0	0	48	0	0	0	0			
2	Cargo	4,139	0	0	0	4,139	4,139	371	0	0	0	3,767	0	0	0	0	0	0	0	0	0	0			
9	Energy Conversion	50,290	0	0	0	50,237	50,237	0	0	0	0	2,361	47,876	0	0	0	0	0	52	0	0	0			
1	Electric Generation	16,069	0	0	0	16,038	16,038	0	0	0	0	2,066	13,972	0	0	0	0	0	31	0	0	0			
2	Refinery	34,220	0	0	0	34,199	34,199	0	0	0	0	295	33,904	0	0	0	0	0	22	0	0	0			
3	Petrochemicals																								

Table 4.5.2-14 : Districtwise SOx emission quantity in GTA (1994)

(ton/year)

	Fuel / District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1	Gasoline																					
	Industrial Non-big Unit	1.4	1.2	3.0	18.6	15.5	7.5	3.3	3.4	18.5	1.1	4.9	9.3	7.0	1.4	5.8	4.2	3.2	22.0	5.8	21.9	158.7
	Industrial Big Unit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
	Commercial/Household	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Energy Conversion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(Sub-total)	1.4	1.2	3.0	18.6	15.5	7.5	3.3	3.4	19.4	1.1	4.9	9.3	7.0	1.4	5.8	4.2	3.2	22.0	5.8	21.9	159.6
2	Kerosene																					
	Industrial Non-big Unit	26.2	8.4	42.2	83.7	94.6	66.8	13.2	26.2	103.1	9.7	41.6	49.4	41.1	13.8	39.7	43.4	17.0	156.4	34.4	153.1	1,065.8
	Industrial Big Unit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Commercial/Household	174.8	245.9	163.7	351.4	237.5	190.0	213.0	248.2	150.9	211.7	182.8	227.8	132.2	262.1	342.4	201.6	208.4	187.8	134.6	199.2	4,265.8
	Energy Conversion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(Sub-total)	202.9	254.3	205.9	435.1	332.1	256.8	226.1	274.4	254.0	221.4	224.4	277.2	173.3	275.8	382.1	245.0	225.3	344.2	169.0	352.3	5,331.7
3	Gas Oil																					
	Industrial Non-big Unit	508.9	187.4	826.9	2,030.7	2,309.2	1,346.0	304.4	494.9	2,496.6	171.6	653.9	854.5	996.1	237.6	856.7	846.6	398.5	3,671.0	868.0	3,652.3	23,695.0
	Industrial Big Unit	0.0	1.6	0.0	30.3	1.6	0.0	0.0	2.6	165.4	2.6	2.2	0.0	0.0	0.0	92.6	19.4	0.0	178.0	0.0	98.5	593.1
	Commercial/Household	459.7	645.0	437.4	949.2	623.5	539.9	591.7	665.0	408.4	577.0	534.1	794.8	360.4	709.4	943.2	552.8	569.8	523.3	372.1	543.0	11,799.8
	Energy Conversion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,208.8	2,208.8
	(Sub-total)	968.6	834.2	1,264.3	3,010.2	2,930.2	1,885.9	896.1	1,162.4	3,070.4	751.3	1,190.2	1,649.2	1,356.5	947.0	1,892.5	1,418.8	968.4	4,370.3	1,230.1	6,502.6	36,297.4
4	Heavy Oil																					
	Industrial Non-big Unit	800.3	725.8	1,231.1	3,400.5	6,956.8	2,956.9	1,035.9	1,342.9	5,409.0	502.3	1,273.3	2,328.9	1,908.6	612.7	5,963.1	6,374.7	1,106.0	16,767.7	8,524.6	33,030.1	102,853.0
	Industrial Big Unit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	131.1	0.0	182.0	0.0	0.0	0.0	257.6	0.0	0.0	321.4	0.0	738.4	1,630.4
	Commercial/Household	340.1	450.1	437.8	1,124.0	442.0	1,080.6	975.3	699.0	497.6	770.6	1,300.6	3,910.4	483.0	865.5	1,419.7	793.7	792.0	887.4	584.9	727.7	18,581.9
	Energy Conversion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14,006.7	0.0	0.0	0.0	33,921.6	47,928.3
	(Sub-total)	1,140.4	1,175.7	1,668.9	4,524.5	7,400.8	4,037.5	2,011.2	2,041.8	6,037.7	1,272.9	2,756.0	6,239.3	2,391.6	1,478.2	7,240.3	20,175.1	1,898.0	19,976.4	9,109.5	68,417.9	170,993.6
5	LPG																					
	Industrial Non-big Unit	2.5	1.4	5.8	24.2	20.2	10.9	3.2	4.4	26.8	1.3	5.2	8.0	10.4	1.6	8.2	5.7	4.8	32.9	7.8	28.4	213.0
	Industrial Big Unit	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.1	4.1
	Commercial/Household	37.7	52.9	35.5	76.8	51.2	42.4	47.0	53.9	32.9	46.3	41.3	55.9	28.9	57.2	75.3	44.2	45.7	41.5	29.8	43.6	939.9
	Energy Conversion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(Sub-total)	40.1	54.3	41.4	100.9	71.4	53.7	50.2	58.3	59.7	47.7	46.5	63.9	39.3	58.8	83.5	49.9	50.3	78.4	37.2	72.1	1,157.0
6	Natural Gas																					
	Industrial Non-big Unit	0.6	0.5	3.6	14.7	14.1	6.7	1.3	1.0	18.1	0.4	2.0	4.1	8.4	0.5	5.5	2.6	3.5	25.9	6.7	23.9	144.1
	Industrial Big Unit	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.7	2.2	1.0	0.0	1.1	0.0	1.4	10.0
	Commercial/Household	6.3	8.8	5.9	12.8	8.5	7.2	7.9	9.0	5.5	7.8	7.0	9.8	4.9	9.6	12.7	7.4	7.7	7.0	5.0	7.3	158.2
	Energy Conversion	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	40.5	52.5
	(Sub-total)	6.9	12.3	9.6	27.7	22.7	13.9	9.2	10.0	27.0	8.2	9.1	13.9	13.3	10.7	20.4	20.1	11.1	34.1	11.7	73.1	364.8
7	Solid Fuel																					
	Industrial Non-big Unit	110.5	330.3	477.2	5,989.3	3,218.9	1,501.4	509.9	1,094.2	3,560.2	338.1	1,181.5	1,679.6	1,404.6	254.3	1,175.1	925.4	1,021.5	5,895.1	1,514.3	6,046.1	38,027.7
	Industrial Big Unit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Commercial/Household	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Energy Conversion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(Sub-total)	110.5	330.3	477.2	5,989.3	3,218.9	1,501.4	509.9	1,094.2	3,560.2	338.1	1,181.5	1,679.6	1,404.6	254.3	1,175.1	925.4	1,021.5	5,895.1	1,514.3	6,046.1	38,027.7
8	Total																					
	Industrial Non-big Unit	1,450.3	1,254.7	2,589.8	11,561.6	12,627.5	5,896.2	1,871.1	2,968.9	11,632.2	1,024.6	3,162.5	4,933.6	4,378.2	1,121.9	7,654.0	7,202.6	2,554.2	28,371.0	10,951.4	42,955.8	168,158.0
	Industrial Big Unit	0.0	1.6	0.0	30.5	1.6	0.0	0.0	2.6	300.7	2.7	184.2	0.0	0.0	0.7	352.3	20.4	0.0	507.4	0.0	838.5	2,238.4
	Commercial/Household	1,018.6	1,402.8	1,080.4	2,514.1	1,362.8	1,860.1	1,834.9	1,675.1	1,095.3	1,613.4	2,065.8	4,998.7	1,009.4	1,903.7	2,793.3	1,599.8	1,623.6	1,647.0	1,126.2	1,520.8	35,745.7
	Energy Conversion	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14,015.7	0.0	0.0	0.0	36,170.9	50,189.7
	(Sub-total)	2,468.9	2,662.3	3,670.2	14,106.2	13,991.7	7,758.3	3,706.0	4,644.6	13,028.3	2,640.7	5,412.6	9,932.4	5,385.7	3,026.3	10,799.7	22,838.5	4,177.8	30,520.4	12,077.6	81,465.9	254,331.6

Table 4.5.2-16 : Emission quantity of pollutants by combustion from energy conversion sector in GTA (1994)

1 Tehran Refinery

Code	Sector	District	Production	Fuel Consumption				Emission Volume						Chimney
				Gas Oil	HFO	NG	Total Fuel	SOx	NOx	CO	HC	SPM	(Total)	Height
			(10^6 b/y)	(10^10kcal)	(10^10kcal)	(10^10kcal)	(10^10kcal)	(t/y)	(t/y)	(t/y)	(t/y)	(t/y)	(t/y)	(m)
	Refinery	20DB	79 2	21	495	517	1,033	34,243	12,058	497	692	1,639	49,129	
(Note)	(Flare Stack)					40		0	122	12	2	10	146	

(Note) Cimney dimensions of Refinery

No 1 Refinery

	Heater	Height above grade (Feet)	ID (Feet)
1	H-101	25	10
2	H-102	100	5
3	H-151	140	5
4	H-201	100	4
5	H-251,252,255	200	
6	H-254	100	1
7	H-301	250	6
8	H-430	200	4
9	H-801		
10	Boiler	250	10
11	H-1101	108-9"	4-3"
12	H-1102	118-6"	4-11 1/2"
13	H-1202	151-11"	8
14	H-1301	120-8"	4-2"
15	H-1302		4-4"
16	H-1401	74	4-4"

No 2 Refinery

	Heater	Height above grade (Feet)	ID (Feet)
1	2H-101	250	12
2	2H-102	118	5-9"
3	2H-151	173	9
4	2H-161	150	5-3"
5	2H-201	100	4-6"
6	2H-202	100	4-6"
7	2H-251,252,253	200	13-6"
8	2H-254	100	4-6"
9	2H-301	250	9
10	2H-401,402	100	5-9"
11	2H-403	150-10 1/2"	6-6"
12	2H-404	150-10 1/2"	6-6"
13	2H-406	105	3-6"
14	2H-601	100	4
15	2H-801	138	12
16	2iN-1001	250	3 5-9"

(Source) Interview

2 Thermal Power Plant

Code	Sector	Capacity	District	Prodction	Fuel Consumption				Emission Volume						Chimney
					Gas Oil	HFO	NG	Total Fuel	SOx	NOx	CO	HC	SPM	(Total)	Height
				(Gwh)	(10^10kcal)	(10^10kcal)	(10^10kcal)	(10^10kcal)	(t/y)	(t/y)	(t/y)	(t/y)	(t/y)	(t/y)	(m)
	Besat	391MW	16	1,497	11	204	215	430	14,172	5,022	207	268	684	20,373	30
	Firouzi	75MW	2	174	0	0	73	73	6	713	21	49	19	808	
	Rei	1243MW	20DB	1,329	136	0	449	585	1,928	6,013	223	386	488	9,038	
		1325MW		3,000	147	204	737	1,088	16,106	11,749	451	723	1,190	30,219	

(Source) AAC/PS

3 Total

Code	Sector	Fuel Consumption					Emission Volume					
		Gas Oil	HFO	ROG	NG	Total Fuel	SOx	NOx	CO	HC	SPM	(Total)
		(10^10kcal)	(10^10kcal)	(10^10kcal)	(10^10kcal)	(10^10kcal)	(t/y)	(t/y)	(t/y)	(t/y)	(t/y)	(t/y)
	Tehran Refinery	21	495		517	1,033	34,243	12,058	497	692	1,639	49,129
	Thermal Power Plant	147	204		737	1,088	16,106	11,749	451	723	1,190	30,219
	(Total)	168	699	0	1,254	2,121	50,349	23,807	948	1,415	2,829	79,348

38 C D E F G H

39 **Table 4.5.2-16 : Total evaporation of HC in GTA (1994)**

40 (B38.H62) (ton/year)

	District	Commercial Shops	Depots & Refinery	(Total)
41	District	Commercial Shops	Depots & Refinery	(Total)
42	1	525		525
43	2	361		361
44	3	453		453
45	4	249	480	729
46	5	409	520	929
47	6	1,071		1,071
48	7	873		873
49	8	323		323
50	9	691		691
51	10	466		466
52	11	872		872
53	12	2,806		2,806
54	13	403		403
55	14	471		471
56	15	937		937
57	16	188		188
58	17	218		218
59	18	857	2	859
60	19	177		177
61	20	730	14,988	15,718
62	(Total)	13,080	15,990	29,070

Table 4.5.2-17 : Heat values of materials

Materials	Unit	Heat value
Crude oil	kcal/liter	9,250
Gasoline	kcal/liter	8,400
Naphtha	kcal/liter	8,000
Jet fuel	kcal/liter	8,700
Kerosene	kcal/liter	8,900
Gas oil	kcal/liter	9,200
Heavy oil	kcal/liter	9,700
Lube oil	kcal/liter	9,600
LPG	kcal/kg	12,000
Natural gas	kcal/m3	9,800
Coal	kcal/kg	6,950
Cokes	kcal/kg	7,200
Oil cokes	kcal/kg	8,500
Electricity	kcal/kwh	860

Note; Regarding the materials relating this section, please refer to Supporting report of following sections.

[Final report Supporting]

4.5.2 Estimation of emission quantities in GTA

4.5.2-1 Energy supply/demand balance in total Iran

4.5.2-2 Energy demand in GTA

4.5.2-3 Energy demand in GTA districts

4.5.2-4 Projection of emission factors for pollutants

4.5.2-5 Emission quantities of pollutants in GTA