III-1-3-15 MP-15, East Coast Swimming Lagoon

East Coast Swimming Lagoon is located in the east coast park and surrounding area is covered by turf and trees. The station was established on the roof of workshop of the lagoon. About 700 m to the north, East Coast Parkway is running which is extended to Changi airport. South side of the lagoon is facing with the sea.

High volume samplers were set for monitoring TPM and SPM.

Location of the monitoring station is shown in Fig. III-1-16, and Picture III-1-15 shows the instruments installed.

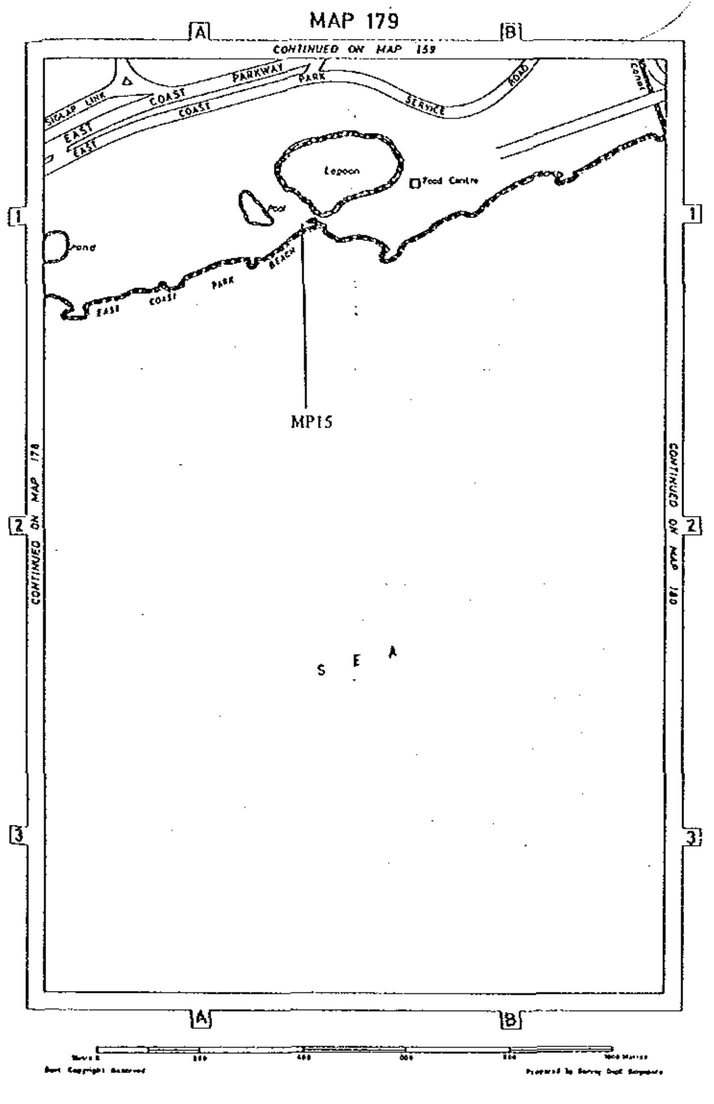
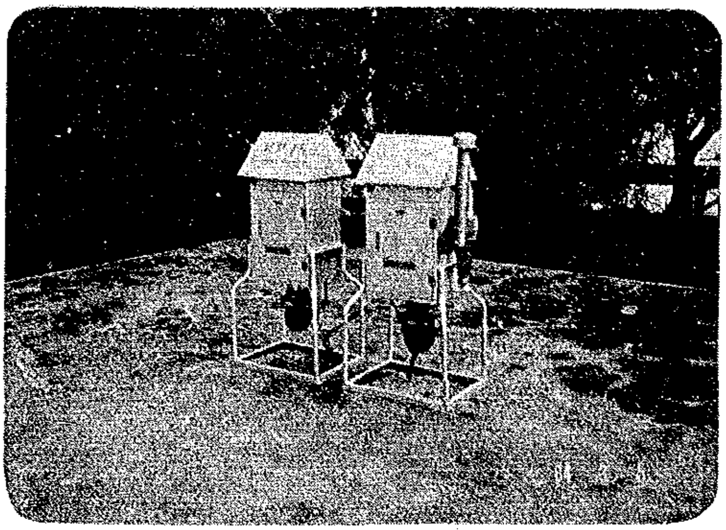
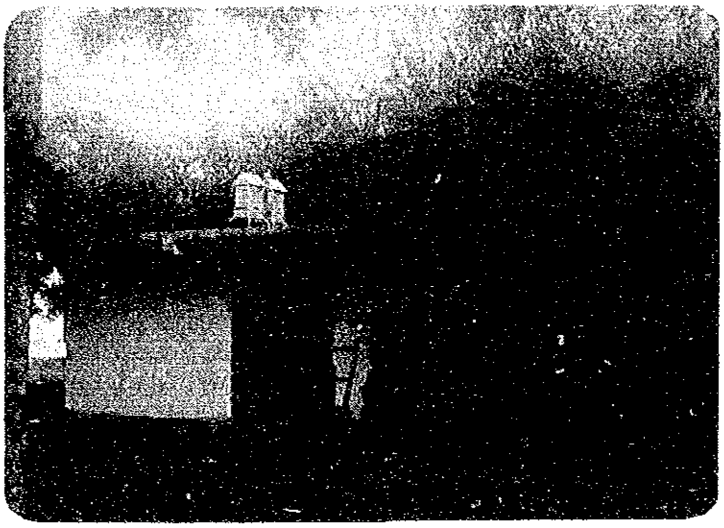


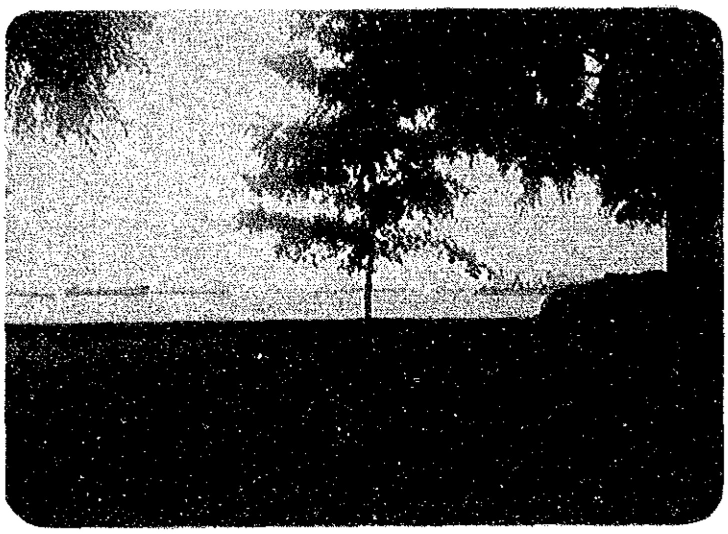

Fig. III-1-16 Location of monitoring station (MP-15)



Picture III-1-15-(1) High volume samplers installed in MP-15 (left-TPM, right-SPM)



Picture III-1-15-(2) Panoramic view of MP-15



Picture III-1-15-(3) Bird's eye view of swimming lagoon

III-1-3-16 MP-16, Ang Mo Kio Flatted Factory

Ang Mo Kio Flatted Factory is located in the north/east of Ang Mo Kio new town and in the immediate north side of the factory, Jalan Hwi Yoh road is running. In the south/west to south/east of the Factory, many number of factories are sited. Behind the factories, 10 to 20 stories housing apartments are built close together. In the north/west to north/east, there are tree planted areas.

The monitoring station was established on the roof top of Block No. 5001 (about 18 m) and TPM and SPM were monitored by high volume samplers.

Fig. III-1-17 shows the location of the monitoring station, and Picture III-1-16 shows the instruments installed.

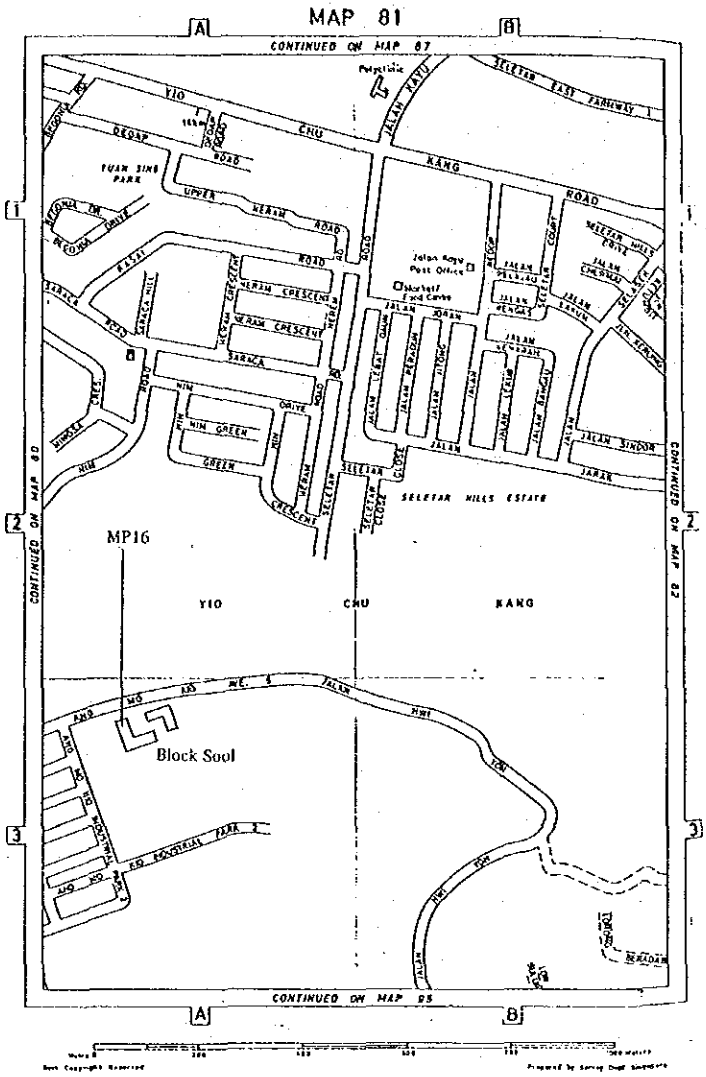
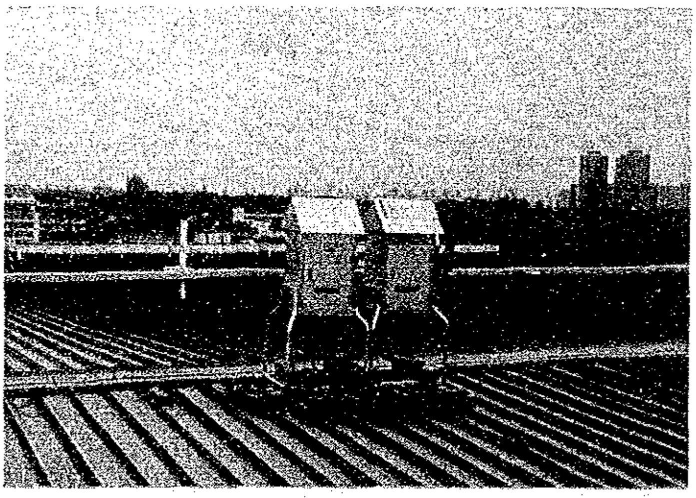



Fig. III-1-17 Location of monitoring station (MP-16)



Picture III-1-16 High volume samplers installed in MP-16 (left-TPM, right-SPM)

III-1-3-17 MP-17, Paya Lebar Police Station

Paya Lebar Police Station is located in about 3 km north of MP-14, and about 4.5 km south/east of MP-16. It is in the south side of the cross of Serangoon road and Paya Lebar road. Surrounding area is full of 2 stories houses and shops.

The monitoring station is set up on the turf of the garden of the police station (about 20 m from the cross).

TPM and SPM were monitored by high volume samplers.

Location of the station is shown in Fig. III-1-18 and Picture III-1-17 shows the instruments installed.

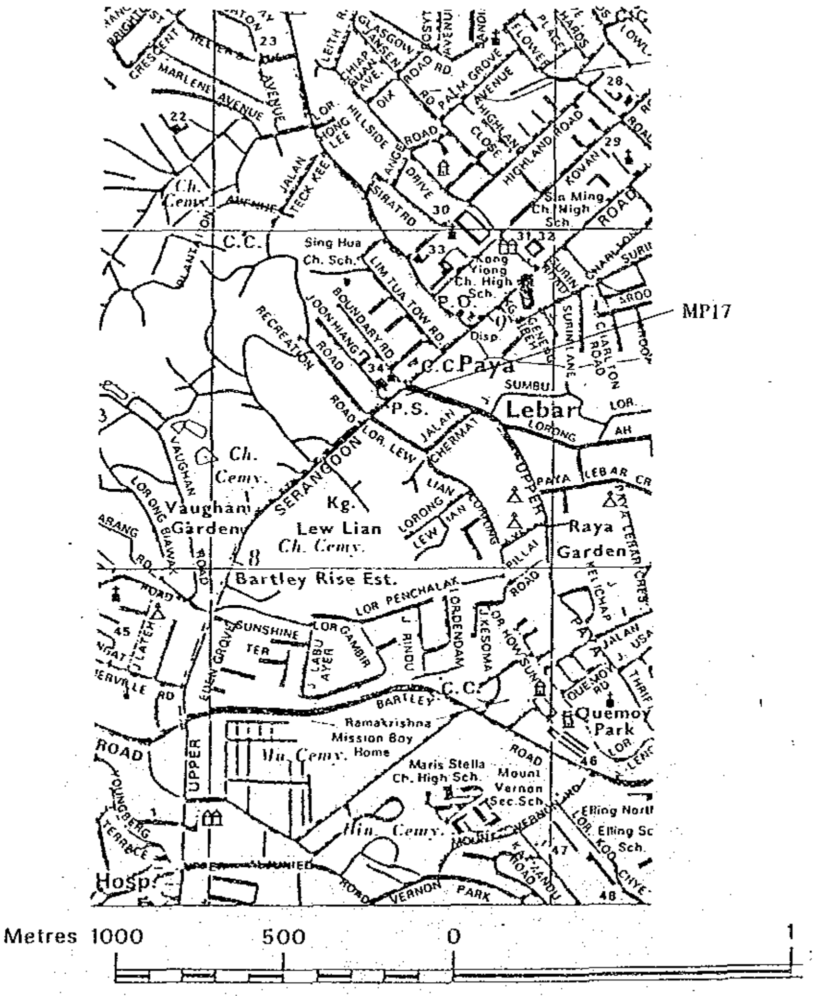
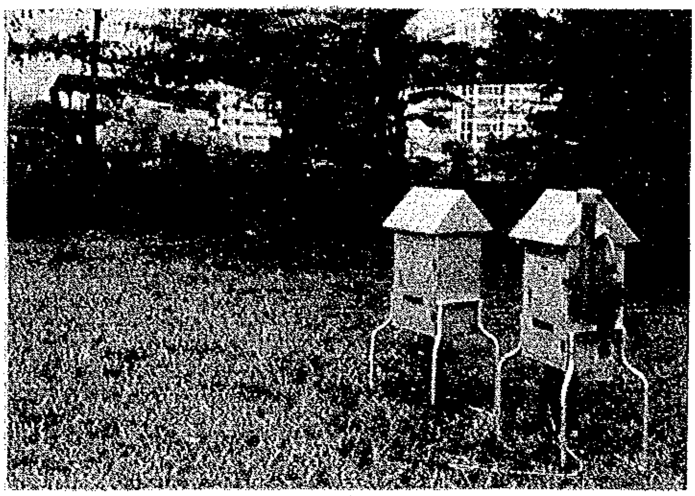



Fig. III-1-18 Location of monitoring station (MP-17)



Picture III-1-17 High volume sampler installed in MP-17 (left-TPM, right-SPM)

III-1-3-18 MP-18, Changi Community Center

Changi Community Center is located in the south/west of Changi airport, and in about 20 m west of the community center, Changi road is running. The monitoring station was set up on the roof top of the community center building of 2 stories (about 6 m high) which are surrounded by trees.

TPM and SPM were monitored by high volume samplers installed and location of the monitoring station is shown in Fig. III-1-19. Picture III-1-18 shows instruments installed.

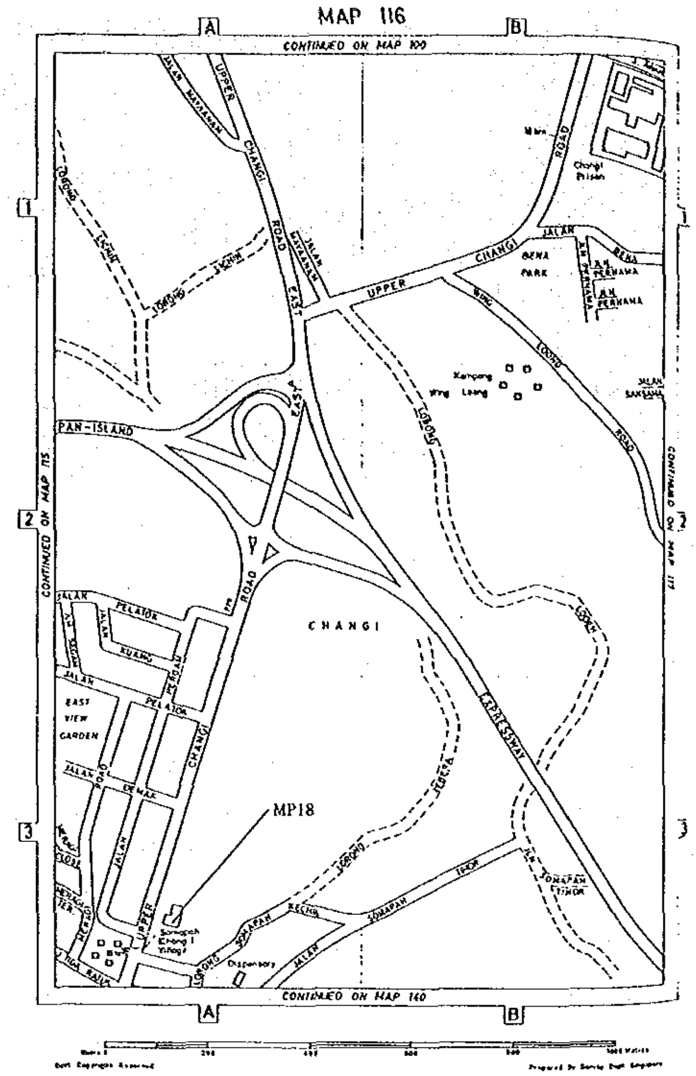
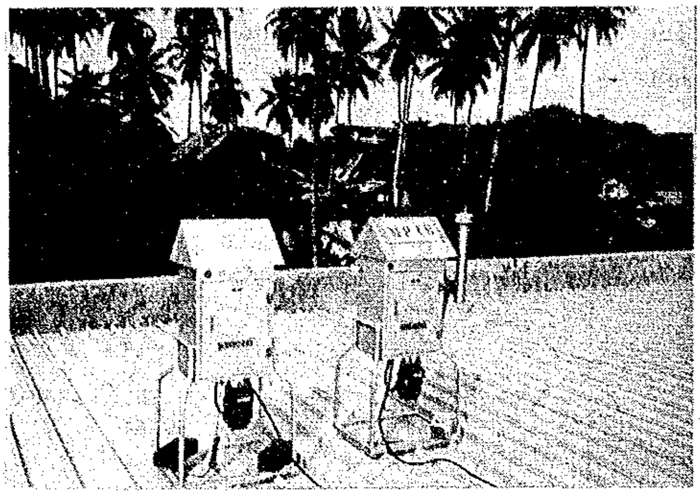
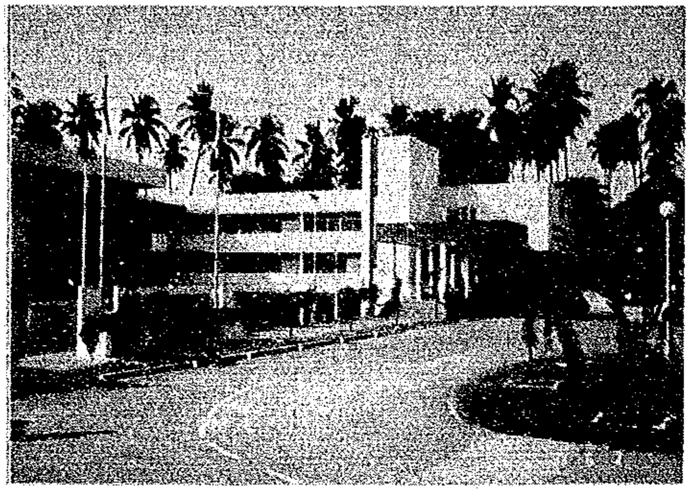



Fig. III-1-19 Location of monitoring station (MP-18)



Picture III-1-18-(1) High volume samplers installed in MP-18 (left-TPM, right-SPM)



Picture III-1-18-(2) Panoramic view of MP-18

III-1-3-19 MP-19, JTC Bedok Flatted Factory

JTC Bedok Flatted Factory is located in about 2.7 km north/west of MP-15, and in the north side of the Factory, Ann road is running. Surrounding area is full of 10 to 15 stories housing apartments.

The monitoring station was established on the roof top of 6 stories Flatted Factory (about 18 m high), and TPM and SPM were monitored by high volume samplers.

Location of the station is shown in Fig. III-1-20, and Picture III-1-19 shows the instruments installed.

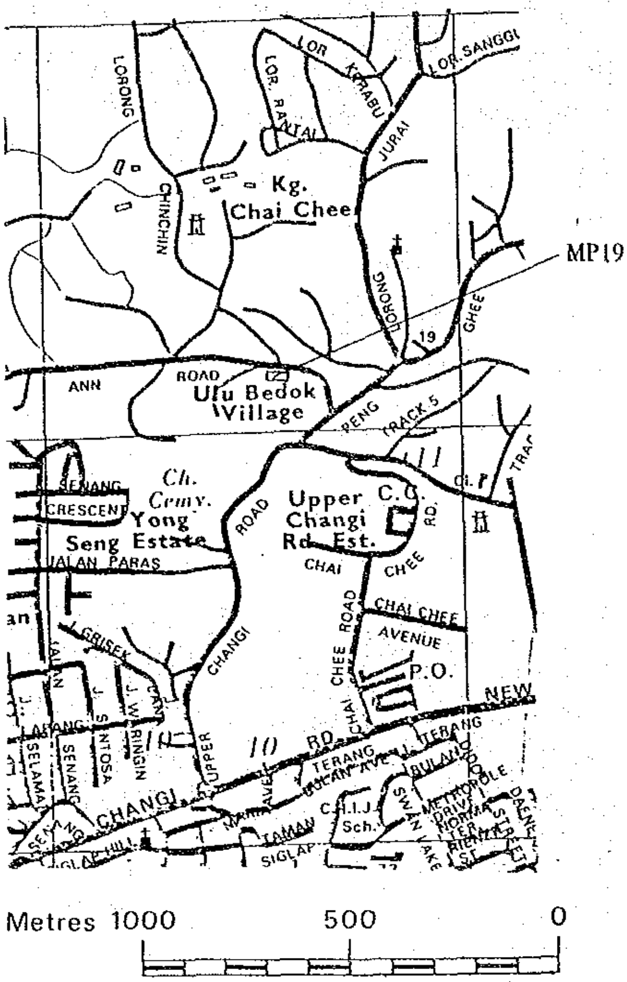
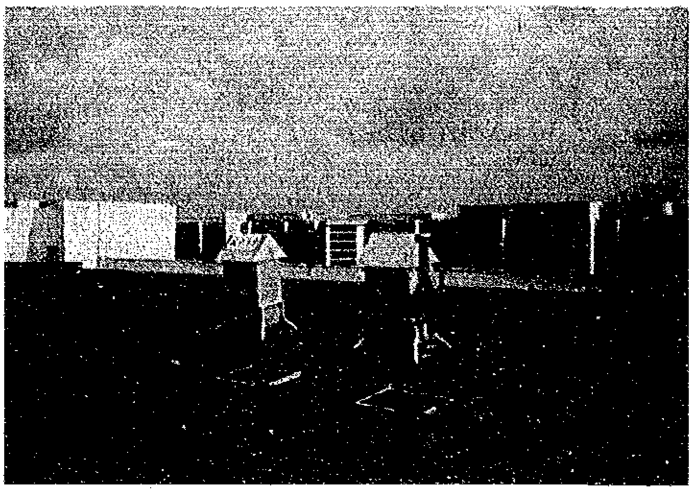



Fig. III-1-20 Location of monitoring station (MP-19)



Picture III-1-19 High volume samplers installed in MP-19

III-1-3-20 MP-20, Singapore Offshore Petroleum Services

Singapore Offshore Petroleum Services is located in the north of Changi airport, and surrounding area is now under development by JTC for the new industrial district.

The monitoring station was set up in the back side of the guard room near to Loyang Crescent road. TPM and SPM were monitored by high volume samplers. Besides the above, $SO_2$ concentration and wind direction & velocity were also monitored by $SO_2$ analyser and anemometer installed.

About 350 m south of the station, metal processing factories are sited, and during the 2nd to 4th field survey, new buildings of 3 stories were under construction.

Location of the station is shown in Fig. III-1-21, and Picture III-1-20 shows the instruments installed.

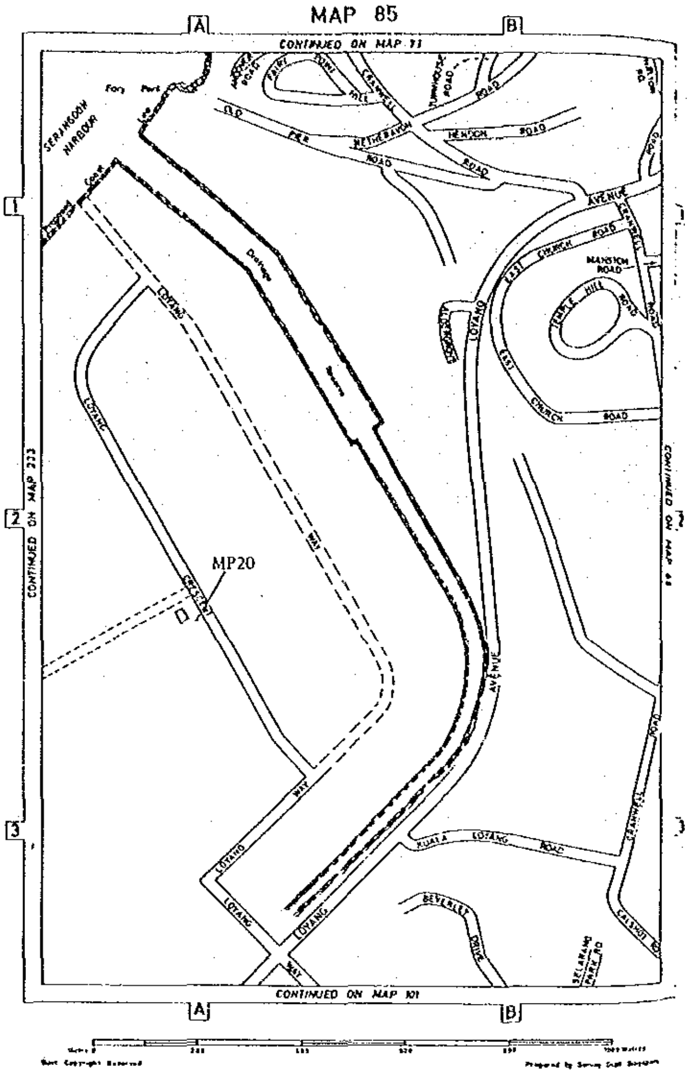
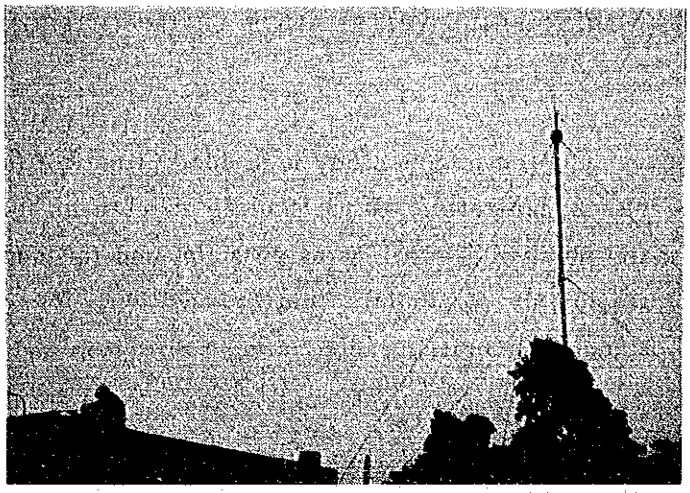
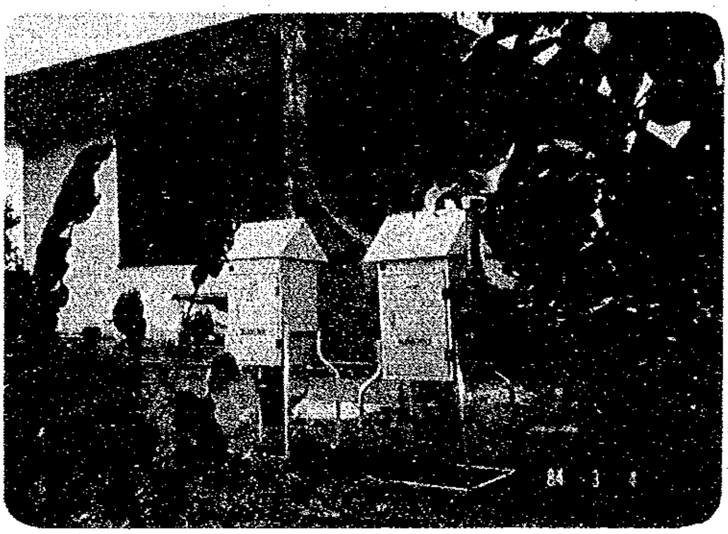



Fig. III-1-21 Location of monitoring station (MP-20)

Picture III-1-20-(1) High volume samplers installed in MP-20 (left-TPM, right-SPM)



Picture III-1-20-(2) Anemometer



Picture III-1-20-(3) Guards room ($SO_2$ analyser and recorder of anemometer are inside the room)

## CHAPTER 2 TRAINING ON MAINTENANCE OF MONITORING INSTRUMENTS

The field survey conducted in this study is divided into two; (a) the short term field survey to monitor the concentration of particulate matter in short period, setting up instruments at as many number of stations as possible, and (b) long term field survey to monitor the concentration of particulate matter and $SO_2$ for continuously one year together with meteorological conditions such as wind direction and velocity, temperature and so on.

The training on the maintenance of the instruments, therefore, has been conducted according to the above two described field survey.

The outline of the training is described hereunder and the details for handling methods of instruments will be described in the next chapter.

### III-2-1 Training for the Short Term Field Survey

The short term field survey includes the monitoring of concentration and size distribution of particulate matter, setting up 40 number of high volume samplers at 20 stations, and 3 sets of Andersen samplers at 3 stations. Before setting up these instruments at monitoring stations, all the instruments were collected for calibration. In parallel with the calibration of the instruments, the necessary training has been conducted to JTC officers concerned. The training has been given at the first field survey during November 26th to December 1st 1983. In the following 3 field survey, the calibration has been conducted by JTC officers for confirming the results of training. Picture III-2-1 shows the training for the maintenance of instruments.

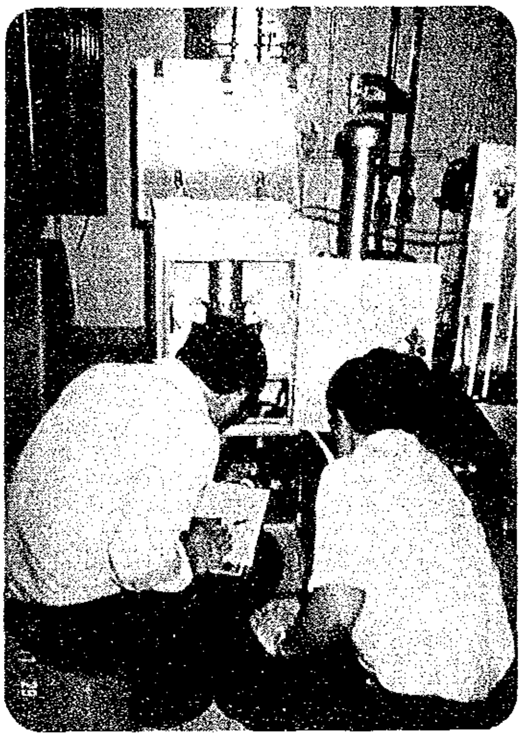
The training for checking system of the instruments and filter replacing methods have been conducted in parallel with the short term field survey at the site of monitoring stations.

The names of JTC officers joined in the training are listed in Table III-2-1 and Picture III-2-2 shows a part of training.

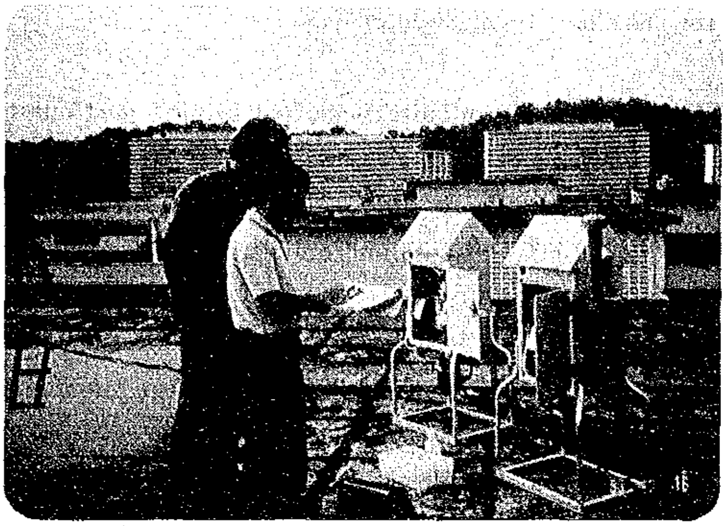
Table III-2-1 List of trainees on maintenance of instruments

| 1st field survey | 2nd field survey | 3rd field survey | 4th field survey |
|---|---|---|---|
| Team 1 | Team 1 | Team 1 | Team 1 |
| 1. Mr. Ng Hwee Choon | 1. Mr. Ng Hwee Choon | 1. Mr. Ng Hwee Choon | 1. Mr. Ng Hwee Choon |
| 2. Mr. Tang Tat Kwong | 2. Mr. Tang Tat Kwong | 2. Mr. Tang Tat Kwong | 2. Mr. Tang Tat Kwong |
| 3. Mr. Wu Seng Chook | 3. Mr. Wu Seng Chook | 3. Mr. Wu Seng Chook | 3. Mr. Cheong Mun Wah |
| Team 2 | Team 2 | Team 2 | Team 2 |
| 1. Mr. Tan Hua Soon | 1. Mr. Tan Hua Soon | 1. Mr. Tan Hua Soon | 1. Mr. Tan Hua Soon |
| 2. Mr. Simon Chui | 2. Mr. Sonny Yeoh | 2. Mr. Koh Cheng Hui | 2. Mr. Koh Cheng Hui |
| 3. Mr. Koh Cheng Hui | 3. Mr. Koh Cheng Hui | 3. Mr. Sonny Yeoh | 3. Mr. Sonny Yeoh |
| | | | 4. Mr. Lee Soon Weng |
| Team 3 | Team 3 | Team 3 | Team 3 |
| 1. Mr. Ng Soon Tong | 1. Mr. Ng Soon Tong | 1. Mr. Ng Soon Tong | 1. Mr. Ng Soon Tong |
| 2. Mr. Tan Suan Juan | 2. Mr. Tan Suan Juan | 2. Mr. Tan Suan Juan | 2. Mr. Tan Suan Juan |
| 3. Mr. Ling Hua Khai | 3. Mr. Ling Hua Khai | 3. Mr. Ling Hua Khai | 3. Mr. Ling Hua Khai |
| Team 4 | Team 4 | Team 4 | Team 4 |
| 1. Mr. Cheak Sek Thim | 1. Mr. Cheak Sek Thim | 1. Mr. Cheak Sek Thim | 1. Mr. Cheak Sek Thim |
| 2. Mr. Wong Kok Cheong | 2. Mr. Wong Kok Cheong | 2. Mr. Lim Chin Chong | 2. Mr. Lim Chin Chong |
| 3. Mr. Lim Chin Chong | 3. Mr. Lim Chin Chong | 3. Mr. Chan Yek Seng | 3. Mr. Chan Yek Seng |
| | 4. Mr. Chan Yek Seng | | |

Picture III-2-1-(1) Training on handling methods of high volume sampler



Picture III-2-1-(2) Training on calibration of high volume sampler



Picture III-2-2-(1) Training on checking system of high volume sampler

Picture III-2-2-(2) Training on filter replacement of high volume sampler

### III-2-2 Training for the Long Term Field Survey

In long term field survey, the monitoring of suspended particulate matter, $SO_2$, wind direction & velocity, solar & net radiation and temperature has been conducted for one year by continuous and automatic instruments. It was agreed that daily maintenance checks were carried out by JTC officers and calibration of instruments was conducted by Japanese team.

Before entering into through year monitoring, the necessary training on the maintenance has been given to JTC officers. The training has been conducted when the instruments were set up at the stations. As the training on the handling of instruments had been conducted in the previous study on $SO_2$ and meteorological conditions, the training has been concentrated in the handling and maintenance of Beta Ray Dust Analyser. Picture III-2-3 shows the training of Beta Ray Dust Analyser.

Picture III-2-3 Training on handling and maintenance of Beta Ray Dust Analyser

# CHAPTER 3 SHORT TERM FIELD SURVEY

The short term field survey has been conducted for 4 times in December 1983, March, June/July and September 1984, and during the respective period, the monitoring of particulate matter has been conducted for 14 days.

The daily average values of total particulate matter and suspended particulate matter were monitored at 20 stations (MP1-MP20) by high volume samplers, and size distribution of particulate matter (average values of 12 days) was monitored by Andersen samplers.

Besides the above, monitoring of SPM, $SO_2$, wind direction & velocity, solar & net radiation and temperature were monitored for one year by automatic and continuous monitoring instruments of which will be described in Chapter 4.

Further, everyday samples collected at 20 stations and 4 times a year were brought back to Japan for chemical analysis of which will be described in Chapter 5.

## III-3-1 Outline of Field Survey

Previously calibrated high volume samplers and Andersen samplers have been transported and set up at the monitoring stations shown in Table III-1-2. On the first day of monitoring, 4 divided teams have placed the filters in the high volume samplers, arranging the flow rate at 800 liter/minute during 9:30 to 11:00 a.m. As for the Andersen sampler (MP1, 2, 6), the filters had been previously installed before setting up and flow rate was set at 28.3 liter/minute. After the commencement of monitoring, the teams have patrolled the respective stations in the same sequence order once each in the morning and afternoon. At each patrol, the checking of operational conditions and adjustment of flow rate were conducted and noted on the recording papers as shown in Table III-3-1 and Table III-3-2.

Further the monitoring period for TPM was 14 days and for SPM was 12 days. Table III-3-3 shows the processes of field survey, and Picture III-3-1 shows parts of such survey processes.

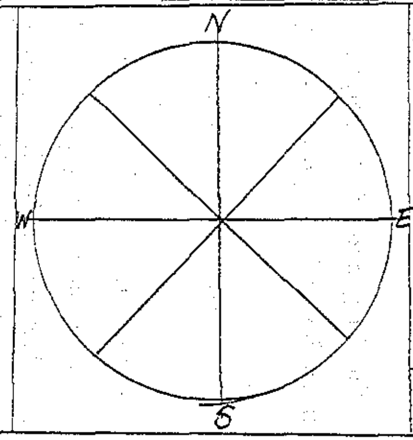
## Table III-3-1 Sampling record by high volume air sampler

| | | | | | | |
|---|---|---|---|---|---|---|
| Monitoring Station | | Instrument No. | | Without Cyclon / With Cyclon | Filter No. | |
| Monitoring Period | From: 198 , hour min.<br>To: 198 , hour min. | | | Total sampling hour<br>(a) ( hour min.) | Type of | Polyfrone / Quartz |

| Flow Rate | Date of Checking Month/Day/Hour/Min. | Record of flow rate by rotar-meter: Rotar Value | Adjusted Value(l/m) | Average Value(l/m) | Total Flow Rate | Record of flow rate by cummulative-meter: Counter Value | Count Number | Total Flow Rate |
|---|---|---|---|---|---|---|---|---|
| | Start: | | (b) | | $\frac{(b)+\text{--}(i)\times(a)}{N}$ | (j) | (j)-(k) | |
| | 1st Check | * | (c) | | | | | |
| | | ** | (d) | | | | | |
| | 2nd Check: | * | (e) | | | | | |
| | | ** | (f) | | | | | |
| | 3rd Check: | * | (g) | | | | | |
| | | ** | (h) | | | | | |
| | Finish | | (i) | | | (k) | | |

| Meteorological Conditions | | | |
|---|---|---|---|
| | Fair | Date:M,D,H.M. | / : |
| | Fair & Cloudy | Temperature | °c |
| | Fair & Rain | Humidity | % |
| | Cloudy | Visibility | Good |
| | Cloudy & Fair | | Bad |
| | Cloudy & Rain | | Normal |
| | Rainy | | |
| | Rain & Fair | Wind Velocity (m/s) | |
| | Rain & Cloudy | | |

Wind Direction




**Instructions**

(1) Flow rate adjustment should be performed about 5 minutes after operation of sampler
(2) At filter placement, No. printed side of filter should face downward.
(3) Read rotar-meter at the center of float

**Remarks:** * = before adjustment
** = after adjustment

Person in charge

## Table III-3-2 Sampling record by Andersen sampler

| Monitoring Station | | Instrument No. | | Sampling Time | | Person in charge |
|---|---|---|---|---|---|---|
| | | | | Hour | Minutes | |
| Monitoring Period | From: 198 , , . Morning, Afternoon hour min | | | | | |
| | To : 198 , , . Morning, Afternoon hour min | | | (1) | Min. | |

| Classified Stage (μm) | Filter Number | Date Month Day | Hour Min. | Flow Rate Q (l/min) | Date Month Day | Hour Min. | Flow Rate Q (l/min) | Date Month Day | Hour Min. | Flow Rate Q (l/min) |
|---|---|---|---|---|---|---|---|---|---|---|
| > 11 | | Start / | | | / | | a)<br>b) | / | | a)<br>b) |
| 11 - 7.0 | | / | | a)*<br>b)* | | | a)<br>b) | | | a)<br>b) |
| 7.0 - 4.7 | | | | a)<br>b) | / | | a)<br>b) | / | | a)<br>b) |
| 4.7 - 3.3 | | / | | a)<br>b) | | | a)<br>b) | | | a)<br>b) |
| 3.3 - 2.1 | | | | a)<br>b) | / | | a)<br>b) | / | | a)<br>b) |
| 2.1 - 1.1 | | / | | a)<br>b) | | | a)<br>b) | | | a)<br>b) |
| 1.1 - 0.65 | | | | a)<br>b) | / | | a)<br>b) | / | | a)<br>b) |
| 0.65 - 0.43 | | / | | a)<br>b) | | | a)<br>b) | | | a)<br>b) |
| < 0.43 | | | | a)<br>b) | | | | | | |

| | |
|---|---|
| Average Flow Rate (l/min) | (2) |
| Total (1)×(2) Absorbed Volume($m^3$) | (3) |
| Remarks; | |

*a) = before adjustment
*b) = after adjustment

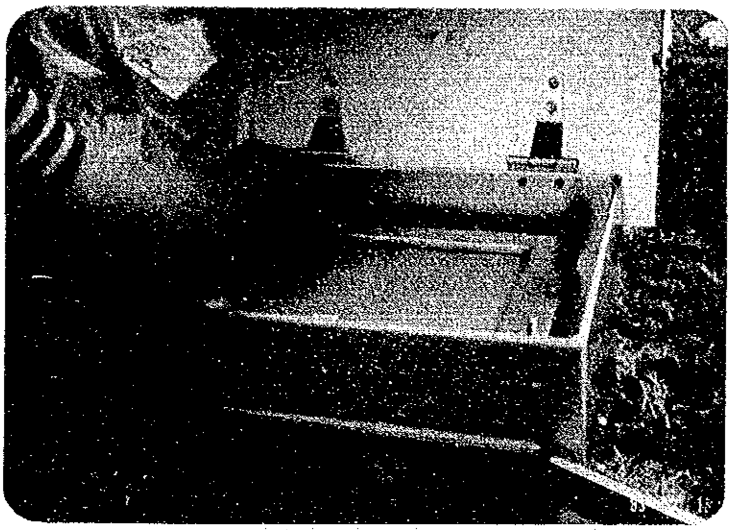
## Table III-3-3 Field survey processes

| 1st field survey | | | 2nd field survey | | | 3rd field survey | | | 4th field survey | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Monitoring of TPM & SPM | Size distribution of TPM | Date | Monitoring of TPM & SPM | Size distribution of TPM | Date | Monitoring of TPM & SPM | Size distribution of TPM | Date | Monitoring of TPM & SPM | Size distribution of TPM |
| | Setting up | Setting up | | Setting up | Setting up | | Setting up | Setting up | | Setting up | Setting up |
| 1983 Dec. 7 | | | 1984 Mar. 6 | | Monitoring at MP-6 started | 1984 June 21 | | | 1984 Sep. 13 | | Monitoring at MP-1 & 6 started |
| Dec. 8 | | | Mar. 7 | | | June 22 | | | Sep. 14 | | Monitoring at MP-2 started |
| Dec. 9 | | | Mar. 8 | | Monitoring at MP-1 started | June 23 | | | Sep. 15 | | |
| Dec. 10 | | | Mar. 9 | | | June 24 | | | Sep. 16 | | |
| Dec. 11 | | | Mar. 10 | | Monitoring at MP-2 started | June 25 | | | Sep. 17 | | |
| Dec. 12 | | | Mar. 11 | | | June 26 | | | Sep. 18 | | |
| Dec. 13 | | | Mar. 12 | | | June 27 | | | Sep. 19 | | |
| Dec. 14 | | | Mar. 13 | | | June 28 | | | Sep. 20 | | |
| Dec. 15 | | | Mar. 14 | | | June 29 | | | Sep. 21 | | |
| Dec. 16 | | | Mar. 15 | | | June 30 | | | Sep. 22 | | |
| Dec. 17 | | | Mar. 16 | | | July 1 | | | Sep. 23 | | |
| Dec. 18 | | | Mar. 17 | | | July 2 | | | Sep. 24 | | |
| Dec. 19 | | | Mar. 18 | | | July 3 | | | Sep. 25 | | |
| Dec. 20 | | | Mar. 19 | | | July 4 | | | Sep. 26 | | |
| Dec. 21 | | | Mar. 20 | | | July 5 | | | Sep. 27 | | |

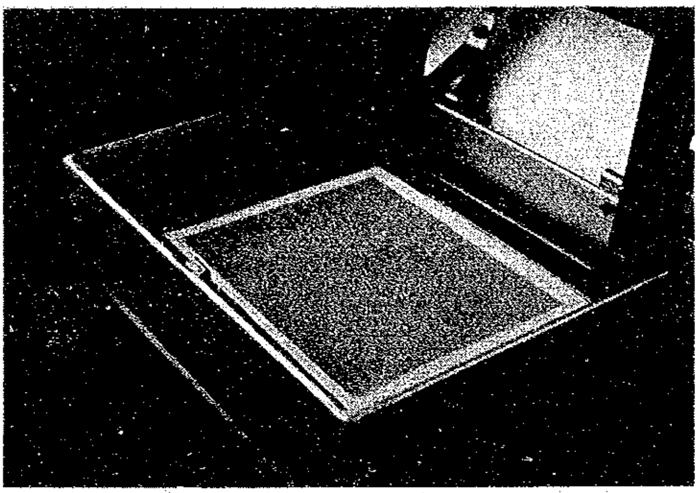
Monitoring of TPM & SPM
- ● ; Filter set and flow rate arranged
- o ; Filter replace, flow rate check and adjustment
- □ ; Replace filter for TPM and flow rate check
- ▲ ; TPM monitoring completed, withdrawal of high volume samplers
- △ ; Flow rate check and adjustment

Monitoring of size distribution of TPM
- ● ; Flow rate arranged
- o ; Flow rate check and adjustment
- △ ; Flow rate check
- ▲ ; Withdrawal of Andersen samplers

Note:
Monitoring period by Andersen samplers are different depending on instrumental troubles



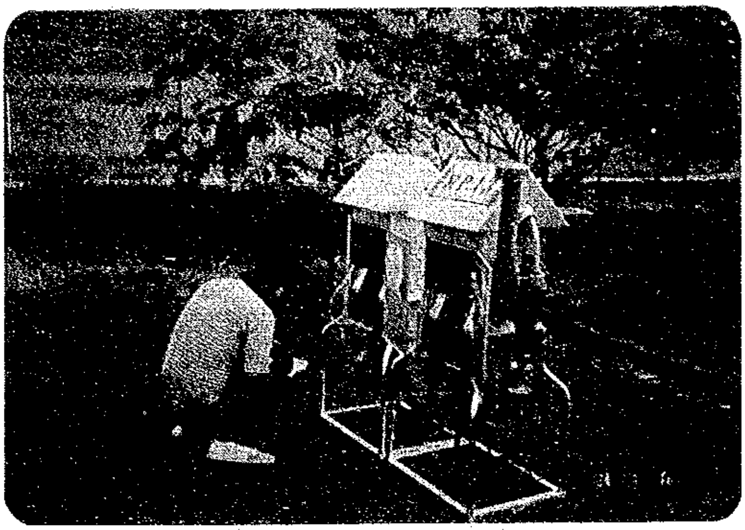
Picture III-3-1-(1) Placement of filter on high volume sampler



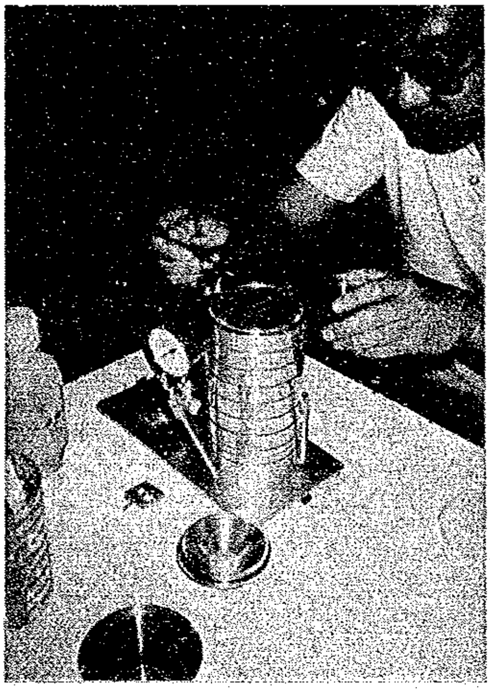
Picture III-3-1-(2) Particulate matter collected on filter

Picture III-3-1-(3) Collection of filter

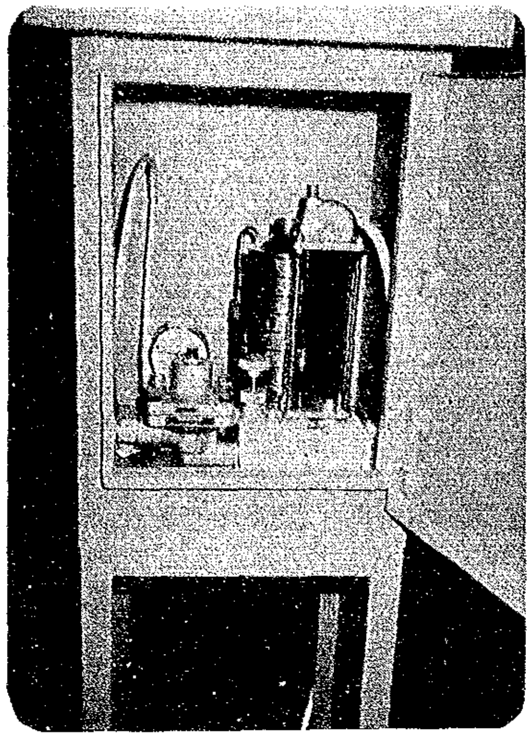
Picture III-3-1-(4) Flow rate check



Picture III-3-1-(5) Recording data

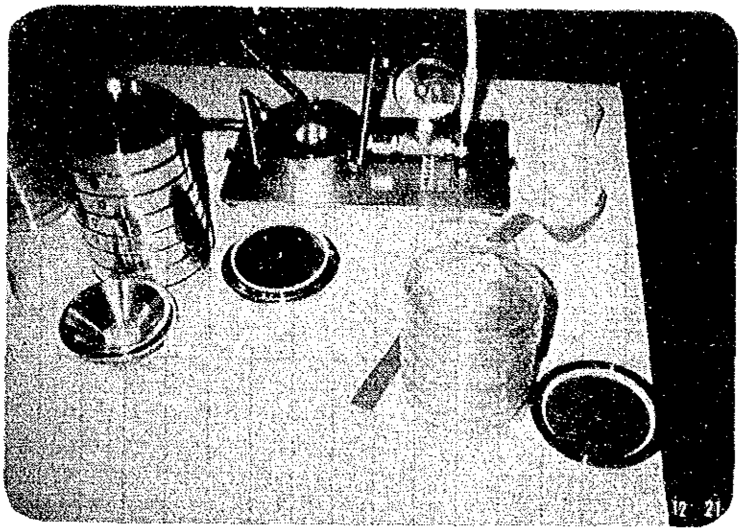


Picture III-3-1-(6) Placement of filters to Andersen sampler



Picture III-3-1-(7) Andersen sampler on monitoring

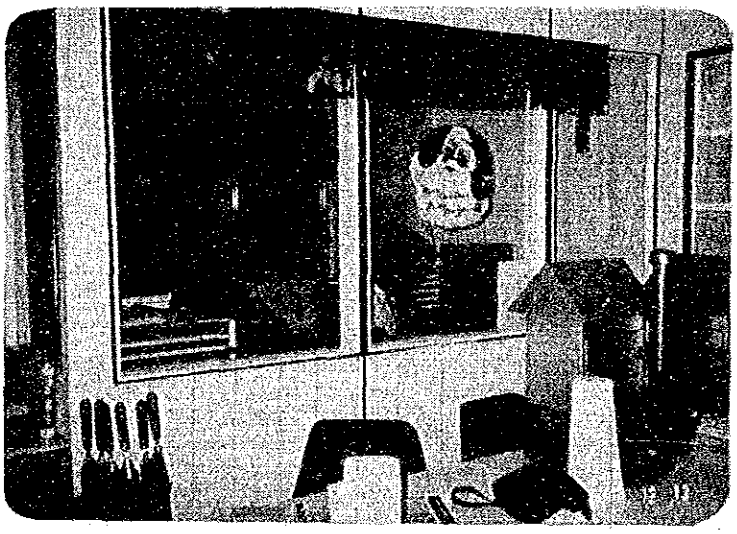
Picture III-3-1-(8) Flow rate check of Andersen sampler



Picture III-3-1-(9) Particulate matter collected on filters installed in Andersen sampler

The filters have been weighed by sensitive chemical balance after desicated in the air-conditioned room specially built in JTC Soil Laboratory. The filters were kept in the desicater before and after monitoring in order to keep constant conditions of filters. The values were recorded on the formula shown in Table III-3-4 and Table III-3-5. The concentration of particulate matter was calculated from the weight of filters before and after sampling and flow rate of air induction, as described later in this report.

Picture III-3-2 shows weighing of filters in air-conditioned room.



Picture III-3-2-(1) Air-conditioned room for weighing and desicating filters

Table III-3-4 Record of weight analysis of high volume sampler

| Monitoring Station | | Instrument No. | | | |
|---|---|---|---|---|---|
| | | | | | Without Cyclon |
| | | | | | With Cyclon |

| Filter No. | Sampling Period Month, Day, Hour, Min. | Incubating time before sampling | Incubating time after sampling | Sampling time(min) | Total Flow rate ($m^3$) | Weight before sampling | Weight after sampling | Sampled volume | Particulate concentr. ($\mu g/m^3$) | Laboratory Tem. (°c) | Laboratory Hum. (%) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | From: | | | | | | | | | | | |
| | To: | | | | | | | | | | | |
| | From: | | | | | | | | | | | |
| | To: | | | | | | | | | | | |
| | From: | | | | | | | | | | | |
| | To: | | | | | | | | | | | |
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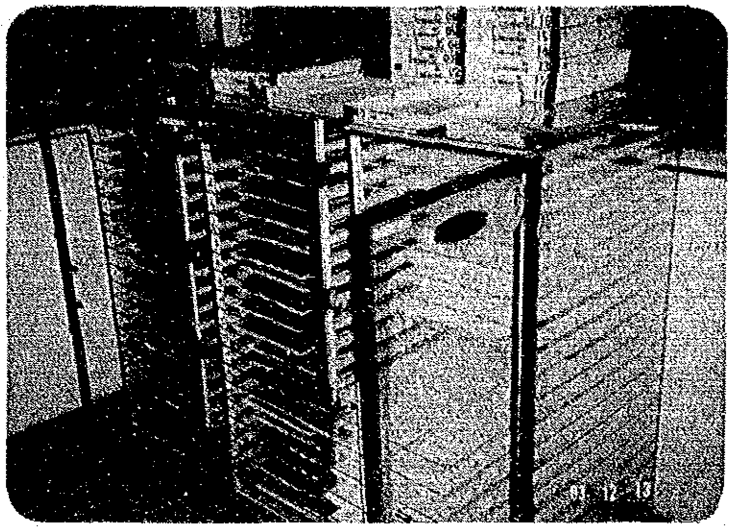
| | From: | | | | | | | | | | | |
| | To: | | | | | | | | | | | |
| | From: | | | | | | | | | | | |
| | To: | | | | | | | | | | | |

## Table III-3-5 Record of weight analysis of Andersen sampler

| | | | | | |
|---|---|---|---|---|---|
| Monitoring Station | | | Instrument No. | | |
| Monitoring Period | From: 198 , , , , . | | | | |
| | To: 198 , , , , . | | | | |
| Incubating Time Before Sampling | From: 198 , , , , . | | | | |
| | To: 198 , , , , . | | | | |
| Incubating Time After Sampling | From: 198 , , , , . | | | | |
| | To: 198 , , , , . | | | | |
| Absorbing Time | (1) min | Incubating time before sampling | min. | Incubating time after sampling | min. |
| Average Flow Rate | (2) l/min. | Total Flow Rate (1)x(2) | (3) $m^3$ | | |

| Classified Stage ( m) | Filter No. | Weight(mg) After sampling | Weight(mg) Before Sampling | Sampled Volume (mg) | Particulate Conc. by Size($mg/m^3$) | Remarks | |
|---|---|---|---|---|---|---|---|
| >11 | | | | (4) | | | |
| 11 - 7.0 | | | | (5) | | | |
| 7.0 - 4.7 | | | | (6) | | | |
| 4.7 - 3.3 | | | | (7) | | | |
| 3.3 - 2.1 | | | | (8) | | | |
| 2.1 - 1.1 | | | | (9) | | | |
| 1.1 - 0.65 | | | | (10) | | | |
| 0.65 - 0.43 | | | | (11) | | | |
| <0.43 | | | | (12) | | | |
| Total Sampled Particulate(mg) (4)+ ------(12) | | / | / | (13) | / | Temperature of laboratory | °c |
| Total Particulate Conc.($mg/m^3$) (13)/(3) | | / | / | / | | Humidity of laboratory | % |

Remarks:



Picture III-3-2-(2) Desicater of filters

Picture III-3-2-(3) Weighing of filters

## III-3-2 Monitoring of TPM and SPM by High Volume Sampler

### III-3-2-1 Instruments and handling method

(1) High volume sampler

The high volume samplers used in this study is so-called EPA type and the main function is to absorb ambient air by the speed of 0.6-1.3 $m^3$ per minute and for 24 hours continuously for collecting particulate matter on the filters. The instrument (KIMOTO Model-120A) is designed to install filter holder in the shelter cover in order to avoid the rain drops and other fall-out dust. And in order to identify the absorbing flow rate, the float type flow meter and accumulated gas meter are installed.

The high volume sampler for SPM (KIMOTO Model 121A) is installed with cyclon separater and it is designed to remove particulate matter over 10 microns before reaching to the filter.

The specifications of high volume samplers used in this study are shown in Table III-3-6 and Fig. III-3-1 shows outside view. Fig. III-3-2 shows outside view of the cyclon installed together with Picture III-3-3.

Table III-3-6 Specifications of high volume sampler

| | | |
|---|---|---|
| Main body | | |
| | Electric currency | : AC 100 V, 50/60 Hz |
| | Power consumption | : 600 VA |
| | Size | : 575(W) x 1,227(H) x 445 (D) mm |
| | Weight | : Motor pump 7 kg<br>Shelter 16 kg<br>Cyclon 4 kg (121 A only) |
| Sampling processes | | |
| | Filter size | : 203 x 254 mm |
| | Max. flow rate | : 1.7 $m^3$/min |
| | Flow rate adjustment | : by voltage regulater of 1 KVA |

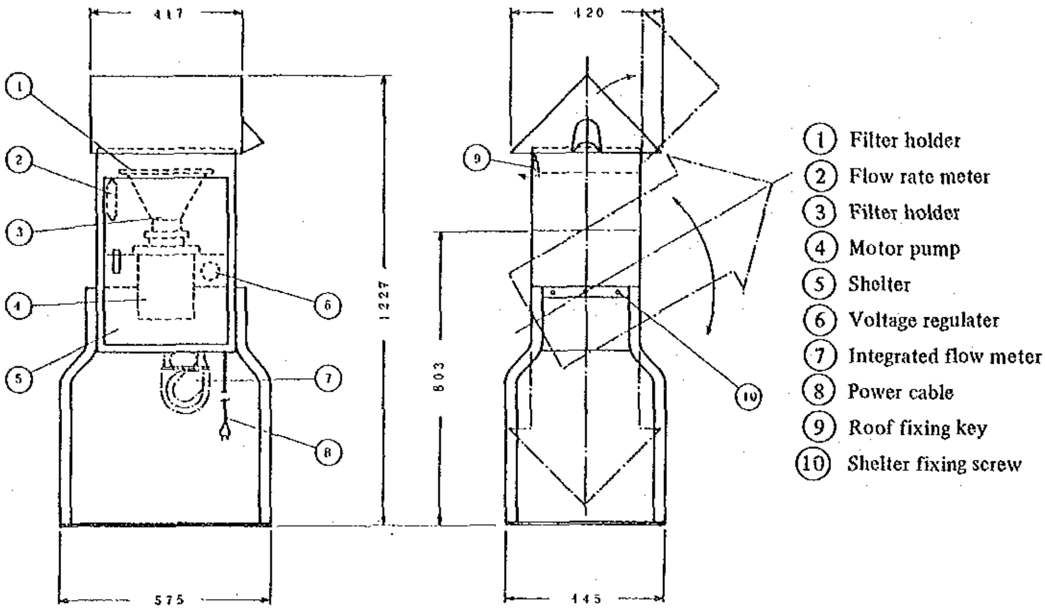



Fig. III-3-1 High volume sampler (120A)

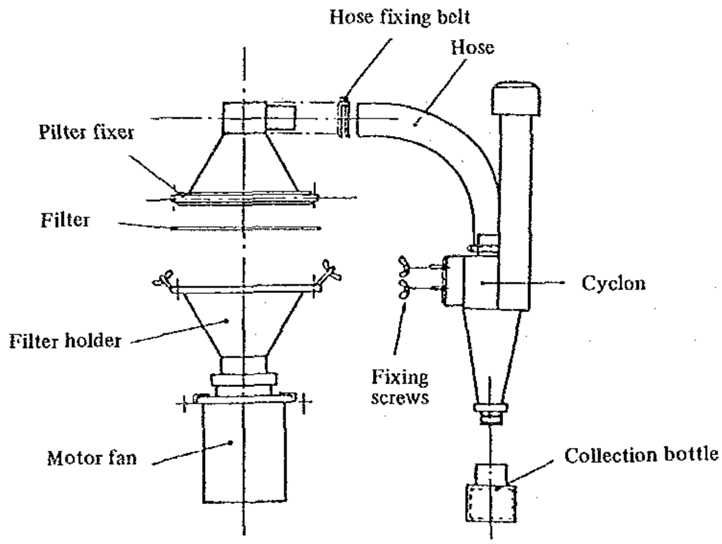



Fig. III-3-2 Cyclon for SPM (Model 121A)

Picture III-3-3 High volume sampler for SPM

The cyclon type separater used in this study has the function to generate rotary flow in the tube and to separate particle outside way by centrifugal force and to collect the particles falling down along the tube wall.

But it must be noted that the function to separate the particle under 10 microns is not so exact, and some of the finer particles under 10 microns are also separated out.

Fig. III-3-3 shows the efficiency curve by sizes of particles. From the figure, when the flow rate is set at 800 l/min (rate employed in this study), larger particles over 10 microns are separated 100%, but 50% of 3.6 microns is also separated.

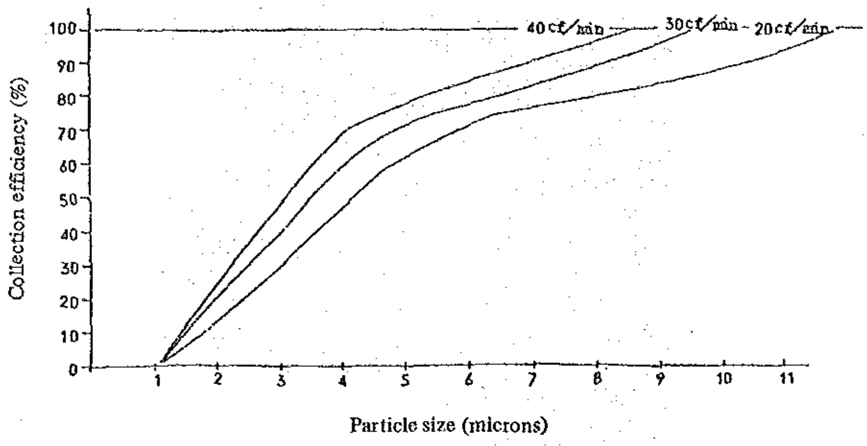



Fig. III-3-3 Collecting efficiency curve by particle size by cyclon

The filter placing methods are to place the previously weighed filter between adapter and gasket, and fix up, as shown in Fig. III-3-4.

At commencement of monitoring, the exact time and numbers indicated on the integrated flow meter are recorded.

5 minutes after electric power is switched on, adjust the flow meter at exact position (800 1/min).

At the end of monitoring, the data indicated on the integrated flow meter and float type flow meter are recorded before cutting off power.

The carbon brush installed in the motor has to be replaced after 500 hours monitoring and after replacement, calibration should be followed. In this study, the replacement of carbon brush has been undertaken by JTC officers, together with calibration after replacement.

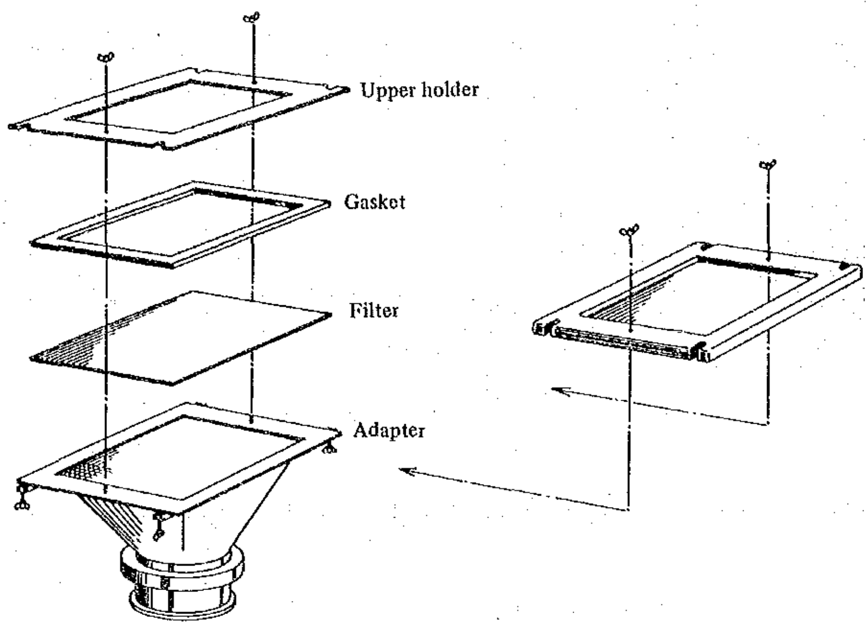



Fig. III-3-4 Placement of filter

(2) Orifice calibrator

Orifice calibrator is to calibrate the high volume sampler, and in this study, KIMOTO Model CB-10 was employed. The flow rate and mm Aq of calibrator are previously investigated by manufacturer. As shown in Fig. III-3-5, orifice calibrator is connected with high volume sampler, and the calibration of rotar and integrated flow meter of high volume sampler is conducted from the pressure difference of orifice calibrator.

The specifications of orifice calibrator is shown in Table III-3-7 and Picture III-3-4 shows the outside view.

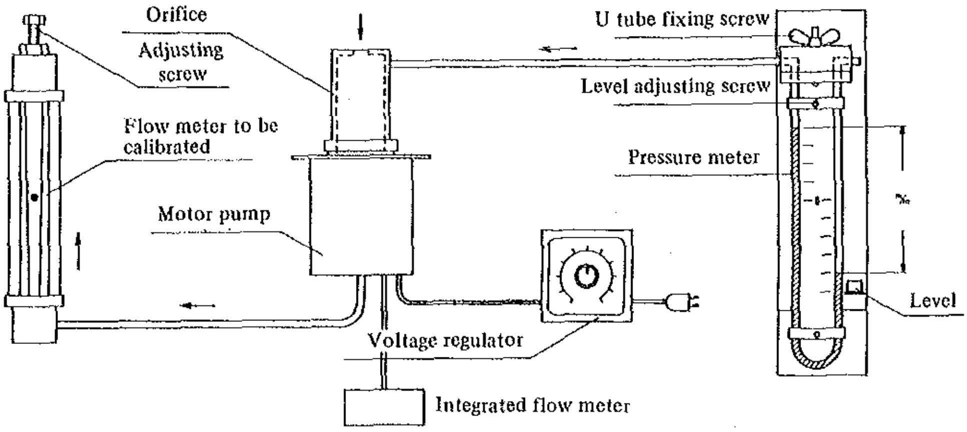
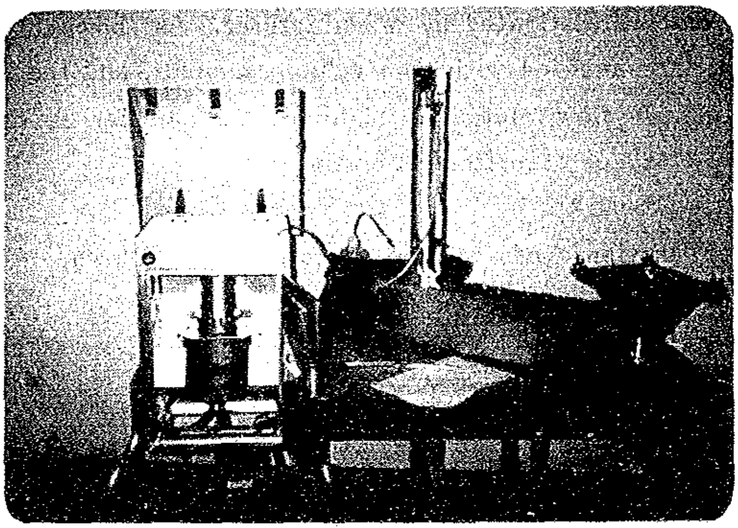



Fig. III-3-5 Flow rate calibration of high volume sampler by orifice calibrator

Table III-3-7 Specifications of orifice calibrator

| | | |
|---|---|---|
| Calibration range | : | 0 - 1,500 l/min |
| Size | : | main body case 130(W) x 155(H) x 680(L) mm<br>(H at operation 705 mm)<br>orifice $\phi$ 88 x H 180 mm |
| Weight | : | 4.5 kg |



Picture III-3-4 Outside view of orifice calibrator

Processes of calibration are as follows;

(a) Setting orifice calibrator on level position

(b) fill water into U tube upto 0 line,

(c) connect orifice tube with U tube

(d) take off filter adapter of high volume sampler, and set the orifice tube to connect with air inducing motor.

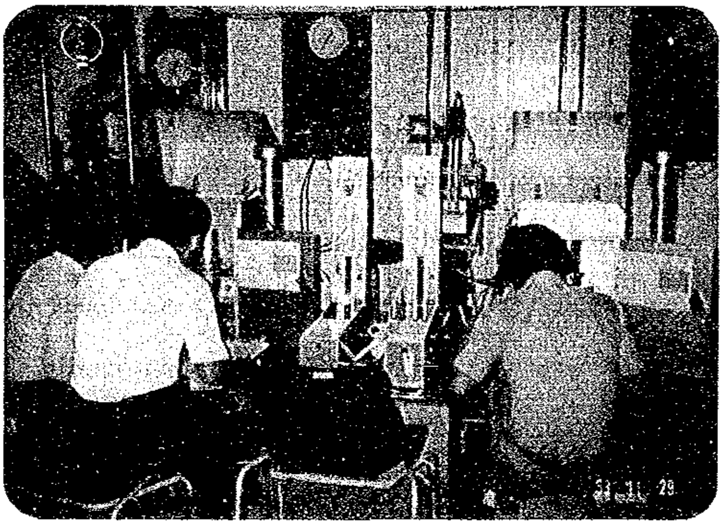
(e) motor of high volume sampler switched on, and adjust the water level at 1,500 l/min.

(f) in above (e), adjust the indication of rotar meter with 90% value of scale (45)

(g) according to the flow rate in order, calibration of different flow rates are followed, sliding down the rotating speed of motor, recording values of rotar meter corresponding to the flow rate. Count number (1 liter is 1 count) of integrated flow meter and time required for the count are recorded.

(h) obtain inducing capacity per 1 count, and illustrate on the graph the relation with respective flow rate.

Picture III-3-5 shows calibration by orifice calibrator.



Picture III-3-5 Calibration of high volume sampler by orifice calibrator

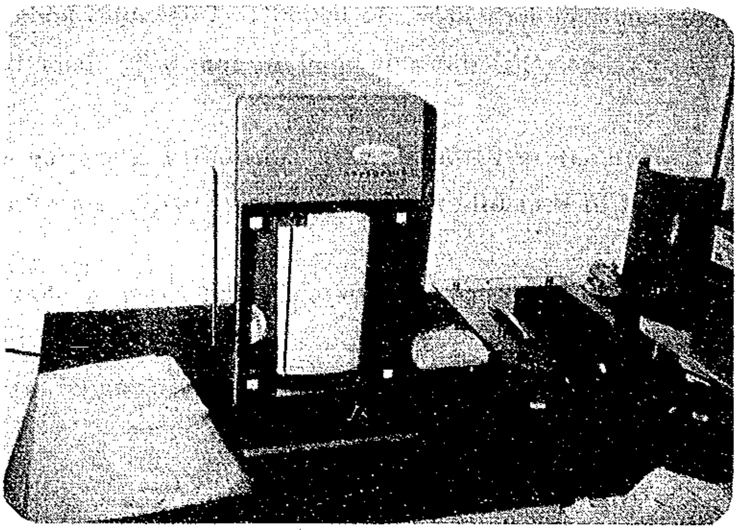
(3) Chemical balance

The precision chemical balance has beem employed for weighing the filters of high volume samplers and Andersen samplers. For weighing of filters of high volume samplers, sensibility for 0.1 mg is required and for Andersen sampler, 0.01 mg is required. In this study, therefore, Gartrusse 2004MP6 type semi-micro balance was used. This balance has the function of electronic scaling by magnetic compensation system and automatic balancing system. Weighing of under 166 g is scaled by electronic system and for over 16 g, automatic balancing system is applied. Handling of the instrument is very simple compared with other mechanical balances. It can weigh the weight of filters just by putting the filter on the balance, and the exact weight is indicated automatically. It is most fitted to weigh many filters in the limited time.

The specifications of the balance is shown in Table III-3-8 and Picture III-3-6 shows the outside view of the balance.

Table III-3-8 Specifications of chemical balance

| | |
|---|---|
| Weighing range | : upto 166 g |
| Minimum weighing value | : 0.01 mg |
| Range by electronic system | : 16 g |
| Automatic balancing | : 10 - 150 g |
| Tare measurable range | : 166 g |
| Standard deviation | : 0.02 mg |
| Maximum lineal deviation | : $\pm$0.03 mg |
| Stable time in range | : 5 seconds |
| Integrating time | : automatic |
| Power consumption | : 12 W |



Picture III-3-6 Outside view of chemical balance (filter is on inside plate)

The handling of chemical balance is as follows;

(a) Set the balance on the stable standing table in the air-conditioned room to avoid the influences of temperature fluctuation, vibration, and others.

(b) Cable is connected with power supply board, and confirm segment of each number which will indicate "±888.88888 g" after switched on. Soon later, indicater will be automatically to "0.00000 g".

(c) Sensibility of the instrument should be checked as it is influenced even by rotation of the earth.

(i) switch on the power, and wait at least 30 minutes for warming up.

(ii) close the both side sliding door.

(iii) push on tare switch and indicate "0.00000 g"

(iv) push stop switch and fix installed balance,

(v) put standard weight 15 g, and close the door,

(vi) confirm indicator "15,00000". Tolerable deviation is 0.00001 g. If exceeds the tolerable number, following check is necessary.

(d) The instrument is installed with sensibility adjusting programme, and the adjustment of sensibility is possible by inputting amendment factors.

(i) Put nothing on the scale plate and close the door.

(ii) Stop switch set at "stop", and gram signal will be indicated after stabilization.

(iii) Push tare switch and "0.00000 g" will be indicated.

(iv) Put standard weight (15μg) and close sliding door and wait gram signal indication.

(v) Set sensibility switch as "CAL" and amendment factors are measured. Indicater will flush point figures and "g". After amendment factors are fixed, it sounds electric signal and flush standard weight value.

(vi) Reset sensibility switch to the original position, and calibrate by standard weight.

(e) Weighing

(i) push tare switch and obtain zero point. After stabilised, gram signal will be indicated.

(ii) open sliding door, put the filter on the plate.

(iii) close sliding door, and record indicated gram signal.

(4) Ageing box

For storage of the filters desicated before and after sampling of particulate matter, the ageing boxes are employed in this study. In most cases, Ca $(NO_3)$ is inserted in the ageing box to keep the filters in constant humidity, but in this study, the doors of ageing boxes were kept open as the humidity of the air-conditioned room was kept constant at 55-65%. The specifications of the air ageing box are shown in Table III-3-9 and outside view of the same is shown in Picture III-3-2-(2).

Table III-3-9 Specifications of ageing box

| | | |
|---|---|---|
| Fron width | : | 400 (360) mm |
| Length | : | 525 (500) mm |
| Height | : | 1,040 (950) mm |
| Weight | : | 18 kg |
| Material | : | Alkali resin |
| Plate | : | 10 layers |

Remarks: in ( ), inside measurement

(5) Filters

In this study, quartz type filters have been used for TPM and SPM in the first 12 days (1st to 12th day), and in the final two days (13th and 14th day) Polyphlone filters have been used for chemical analysis of the particulate matter sampled.

The specifications of the filter used in this study are shown in Table III-3-10.

Table III-3-10 Specifications of filters

| | QM-A | PF-1 |
|---|---|---|
| Thickness (mm) | 0.45 | 1.00 |
| Percentage of vacant space (Vol.%) | | 72 |
| Tension ($kg/cm^2$) | 250-300 g/15 mm | 14 |
| Air resistance ($mmAq/m\text{-}min^{-1}$) | | 9 |
| Hole diameter (μm) | 6 | 5 |

Sampling character of particulate matter by materials has been studied by Industrial Pollution Control Association of Japan (IPCAJ). The said study has selected and taken up 4 types of filters (quarts, glass, membrane and Polyphlone) and experiments have been conducted in the same place and same time. The results of the study are shown in Table III-3-11.

Table III-3-11 Sampling characteristics of filters

| | |
|---|---|
| Quarts | 0.99 |
| Glass | 1.06 |
| Polyphlone | 0.94 |
| Membrane | 1.00 |

The above values are the relative comparison against the average values of all tested filters.

From the table, concentration differences are comparatively small, but glass filters show the higher value. This is because of the fact that acid gases is absorbed on the alkali components of glass fibre surface and the appearance weight may be increased. Polyphlone value is a little lower than average and it is considered that some of the particles are passed through filter.

When the concentration of particulate is calculated after weighing filter, the humidity is the most influencial factor. IPCAJ has conducted the study on (a) hygroscopic character of un-used filters and (b) hygroscopic character of particulate matter. In the said study, each 2 sheets of 4 types filters have been weighed under different conditions of humidity, and influences of humidity on the respective types of filters and also influences by the differences of materials were investigated. The results of IPCAJ's study are shown in Fig. III-3-6. From the figure, the weight of filters increase according to the degree of humidity. This tendency is most apparent in membrane filter, and then glass and Polyphlone follow in order.

The study on hygroscopic character of particulate matter has been conducted by using 2 sets of high volume samplers, placing quartz and Polyphlone filter respectively. Operation of instruments have been carried out for 2 days (about 8 hours each) and weighing was conducted under different humidity. The results of the study are shown in Fig. III-3-7.

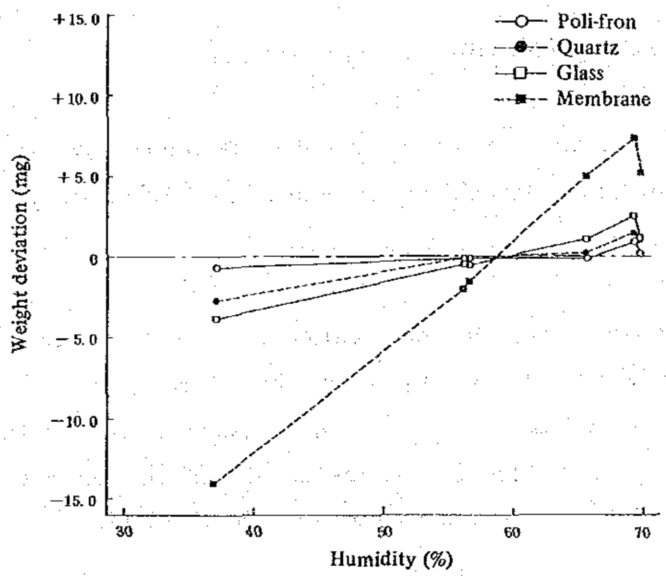



Fig. III-3-6 Weight deviation of filters by humidity

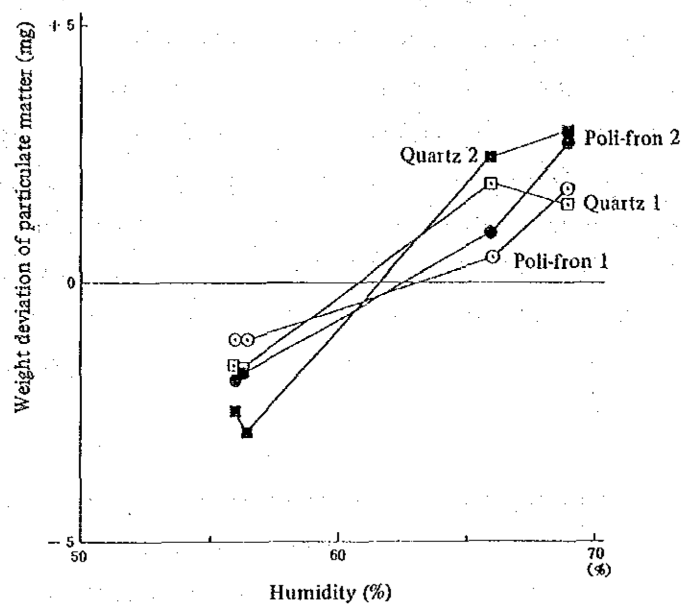



Fig. III-3-7 Weight deviation of particulate matter by humidity

III-3-2-2 Calculation of TPM and SPM concentration

(1) Calibration of Orifice calibrator by rootmeter

Prior to calibration of high volume samplers by orifice calibrator, the manufacturer conducts calibration of orifice calibrator. The outline is described hereunder.

The calibration of orifice calibrator is carried out by rootmeter (standard-flow-meter) as shown in the flow chart of Fig. III-3-8. In the calibration, flow rate $Q_a$($m^3$/min) measured by rootmeter and pressure difference $P_1$ (mm Aq) of monometer of orifice calibrator are obtained. The results of such calibration are shown in Table III-3-12.

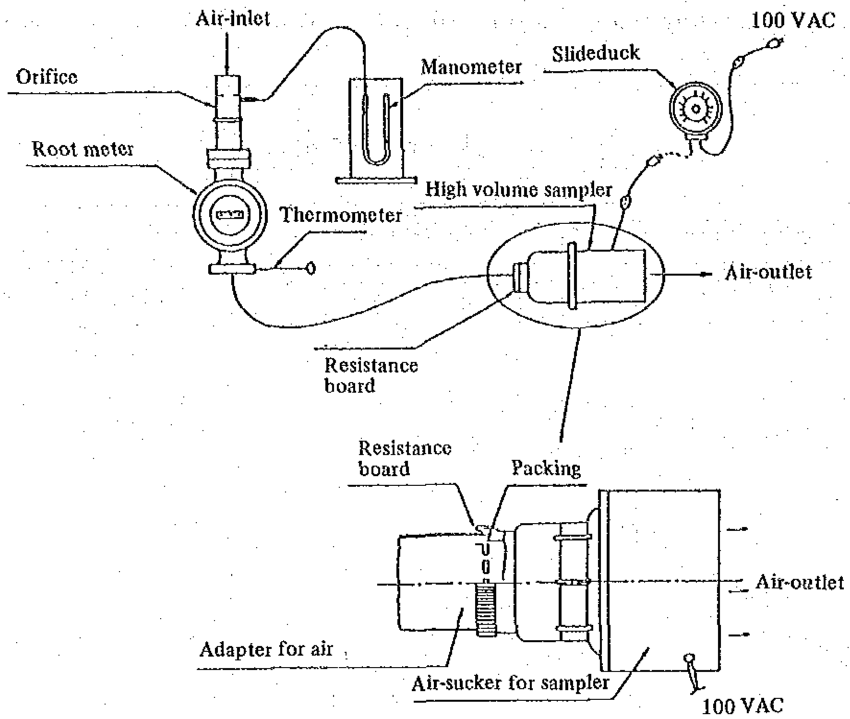



Fig. III-3-8 Calibration of orifice calibrator by rootmeter

In this study, the relation of flow rate $Q_a$ of rootmeter and pressure difference $P_1$ of monometer have been obtained by regression equation: $Q_a = h(P_1)$. The regression equation is three dimensional and the results of calculation are shown in Table III-3-13. Further the regression equation and data of calibration are plotted as shown in Fig. III-3-9.

Table III-3-12 Results of calibration of orifice calibrator by rootmeter

| Rootmeter | Orifice calibrator | |
|---|---|---|
| | 54H300504 | 54H300505 |
| $Q_a$($m^3$/min) | $P_1$ (mm Aq) | $P_1$ (mm Aq) |
| 1.8 | 340 | 350 |
| 1.7 | 301 | 310 |
| 1.6 | 266 | 274 |
| 1.5 | 233 | 240 |
| 1.4 | 202 | 208 |
| 1.3 | 174 | 179 |
| 1.2 | 148 | 152 |
| 1.1 | 124 | 127 |
| 1.0 | 101 | 103 |
| 0.9 | 81 | 83 |
| 0.8 | 64 | 66 |
| 0.7 | 49 | 51 |
| 0.6 | 35 | 37 |
| 0.5 | 25 | 26 |

Table III-3-13 Regression equation for calibration of orifice calibrator by rootmeter

| Rootmeter instrument No. | Regression equation |
|---|---|
| 54H300504 | $Q_a=0.2608 \times 10^{-7}\ P_1{}^3 - 0.2130 \times 10^{-4}\ P_1{}^2 + 0.8610 \times 10^{-2}\ P_1 + 0.3180$ |
| 54H300505 | $Q_a=0.2579 \times 10^{-7}\ P_1{}^3 - 0.2130 \times 10^{-4}\ P_1{}^2 + 0.8584 \times 10^{-2}\ P_1 + 0.3079$ |

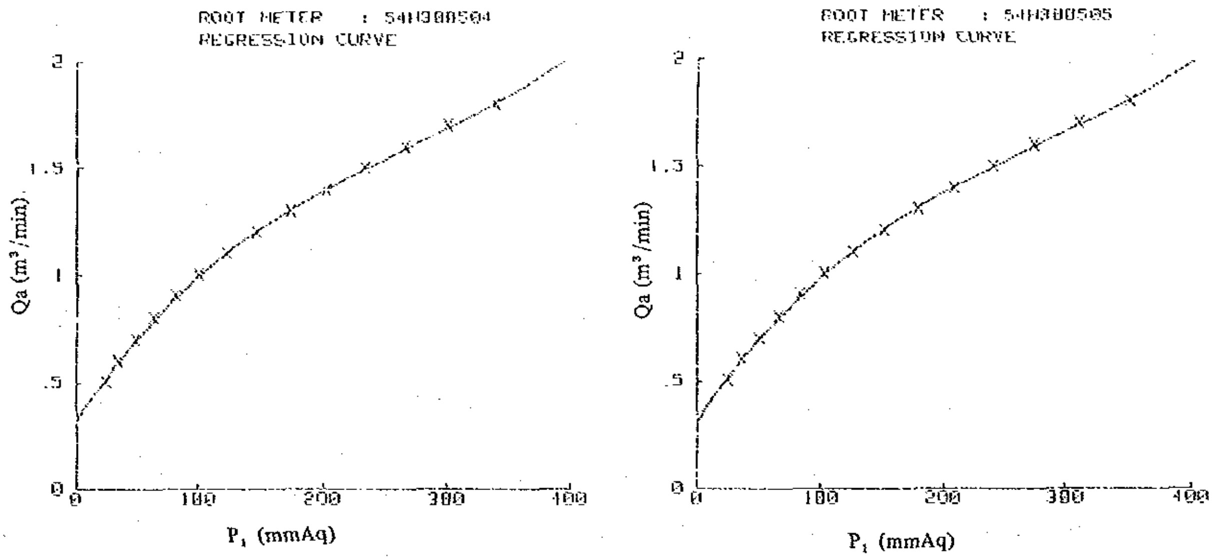



Fig. III-3-9 Calibration curve of orifice calibrator by rootmeter

(2) Calibration of high volume sampler by orifice calibrator

Using orifice calibrator which calibrated by rootmeter, the calibration of rotar meter and integrated flow meter both installed in the high volume sampler has been conducted. In this calibration, the orifice was installed on the upper part of motor pump of the high volume sampler and installed manometer in it. The voltage of motor fluctuated up and down by voltage regulater, changing the readings of manometer between about 15 to 45, and pressure difference $P_2$ of manometer and the time required for 20 times rotation of integrated flow meter were recorded on the form shown in Table III-3-14. The Table III-3-15 shows the corresponding orifice calibrator used for calibration of high volume samplers.

Following to the above, the air flow rate passing through orifice which is the flow rate ($Q_a$) of the high volume sampler has been calculated by the regression equation shown in Table III-3-13.

Table III-3-14 High volume sampler flow rate checking table

| | |
|---|---|
| Date | |
| Motor No. | |
| Checker | |

| Manometer P2 (mm Aq) | Rotar meter value | Count number | | | Time t (sec) | t/C.N (1/count) | Adjusted flow rate (l/min) |
|---|---|---|---|---|---|---|---|
| | | before (A) | after (B) | C.N (A)-(C) | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Table III-3-15 Orifice calibrator used for calibration of high volume samplers

| MP | 1st survey | | 2nd survey | | 3rd survey | | 4th survey | |
|---|---|---|---|---|---|---|---|---|
| | TPM | SPM | TPM | SPM | TPM | SPM | TPM | SPM |
| 1 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 2 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 3 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 4 |
| 5 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 4 |
| 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 7 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 8 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 9 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 10 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 11 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 12 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 13 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 14 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 15 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 16 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 17 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 18 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 19 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 20 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

4: 54H300504
5: 54H300505

The calibration has been conducted before the 1st to 4th field survey respectively, but due to the temperature difference at the time of calibration, the flow rate of high volume samplers have been adjusted by Equation III-3-1.

$$Y=Q_a \times 1{,}000 \times \left(\frac{273 + To}{273 + Ta} \cdot \frac{Pa}{Po}\right)^{1/2}$$ Equation III-3-1

where;

Y: flow rate (l/min) of high volume sampler at temperature of calibration

$T_o$: temperature ($^{o}$C) at calibration (Table III-3-16)

$T_a$: temperature at calibration of orifice calibrator by rootmeter (25$^{o}$C)

$P_a$: atmospheric pressure (760 mmHg) at calibration of orifice calibrator by rootmeter

$P_o$: Atmospheric pressure (760 mmHg) at calibration of high volume sampler

Table III-3-16. Temperature at calibration of high volume sampler

| Time | Temperature |
|---|---|
| The 1st Field Survey | 25.0°C |
| The 2nd Field Survey | 28.9°C |
| The 3rd Field Survey | 29.2°C |
| The 4th Field Survey | 29.2°C |

From these results, the regression equation has been obtained for flow rate Y of high volume sampler adjusted by the temperature at calibration, and the readings of rotar meter RC.

$$Y = f(RC) \qquad \text{Equation III-3-2}$$

Further, flow rate YY, one rotation of integrated flow meter, has been calculated from the time SE required for x times rotation of integrated flow meter.

$$YY = \frac{SE\ (sec)}{X\ (rotation)} \times \frac{Y\ (\ell/min)}{60\ (sec/min)} = \frac{SE.Y}{60x} \qquad \text{Equation III-3-3}$$

where;

YY: flow rate (l/count) of one rotation of integrated flow meter
SE: time required for x times rotation of integrated flow meter (sec)
Y: flow rate (l/min) of high volume sampler adjusted by temperature at calibration (III-3-1)

As shown in Fig. III-3-10, the calibration curve of the integrated flow meter is usually drawn, obtaining flow rate from the readings of rotar meter (dotted line ① of Fig. III-3-10) in the first place, and then obtaining flow rate of integrated flow meter corresponding to the flow rate of above (dotted line ② of III-3-9). But the above method is depending on the two stage assumption, and so in this study, the equation has been obtained to express directly the readings of rotar meter and flow rate of 1 rotation of integrated flow meter. This regression equation has been applied to three dimensional.

$$YY = g(RC) \qquad \text{Equation III-3-4}$$

An example of calculation results of regression equation Y=f(RC) and YY=g(RC) is shown in Table III-3-17 and in Fig. III-3-11.

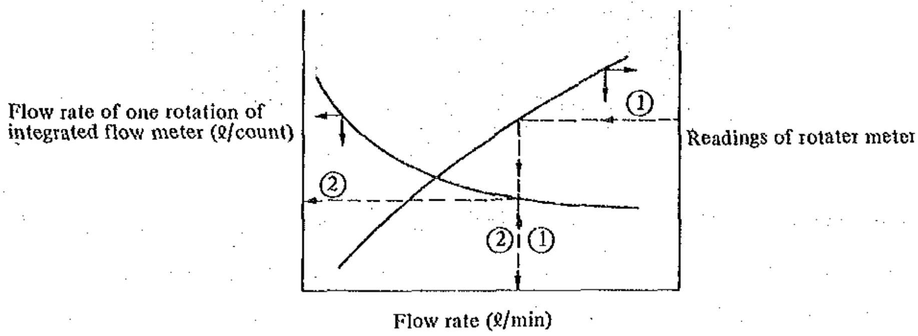



Fig. III-3-10 Flow rate calibration curve of high volume sampler

(3) Flow rate calculation of high volume sampler

The reading of flow meter (rotar meter and integrated flow meter) of high volume sampler at the field monitoring is, in principle, conducted for 3 times; when the filter is set, the filter is replaced and intermediate patrol. Therefore, the total air sucking volume by high volume sampler is obtained as the sum of sucking volume indicated in the flow meter.

In this study, the volume was calculated from air volume $R_1$ of rotar meter and air volume obtained from rotating numbers of integrated flow meter, $R_2$. The Equations III-3-5 and III-3-6 are shown.

$$R_1 = \sqrt{\frac{273+TEMP}{273+TC}} \times \frac{f(RC_1)+f(RC_2)}{2} \times \Delta T \times \frac{1}{1000} \qquad \text{Equation III-3-5}$$

$$R_2 = g\left(\frac{RC_1+RC_2}{2}\right) \times (IC_2 - IC_1) \times \frac{1}{1000} \qquad \text{Equation III-3-6}$$

where;

TC: temperature (°C) at calibration
TEMP: temperature (daily average)(°C) at sampling
$RC_1$: readings of rotar meter at starting air sampling
$RC_2$: readings of rotar meter at finishing air sampling
$IC_1$: count number of integrated flow meter at starting air sampling
$IC_2$: count number of integrated flow meter at finishing air sampling
$\Delta T$: time engaged for sampling (min)

$R_1$: air volume obtained from readings of rotar meter ($m^3$)

$R_2$: air volume obtained from rotar number of integrated flow meter ($m^3$)

Table III-3-17 An example of calibration results of high volume sampler by orifice calibrator

SITE.NO. 1
INST.NO. 18300919
DATE 1983 12
TEMP. 25.0°C

| ROTER METER (SCALE) | MANOMETER (MM AQ.) | NUMB. OF ROTATION (COUNT) | ACC. METER AVE. (SEC/N COUNT) | FLOW RATE (L/MIN) | ACC. METER FLOW (L/COUNT) |
|---|---|---|---|---|---|
| 28. | 49. | 20 | 44.0 | 691.8 | 25.36 |
| 33. | 64. | 20 | 38.1 | 788.6 | 25.00 |
| 38. | 81. | 20 | 33.3 | 889.5 | 24.65 |
| 43. | 101. | 20 | 29.4 | 997.1 | 24.43 |
| 47. | 124. | 20 | 26.8 | 1107.8 | 24.69 |
| 51. | 148. | 20 | 24.4 | 1210.2 | 24.61 |

REGRESSION CURVE(1) Y = f(RC)

X : ROTOR METER (SCALE UNIT)
Y : TURE FLOW RATE (L/MIN.)

| A0 | A1 | A2 | A3 |
|---|---|---|---|
| 0.8917287552E 03 | -0.3770468704E 02 | 0.1374697168E 01 | -0.1004183576E-01 |

Y = A0 + A1 * X + A2 * X**2 + A3 * X**3

MULTI. CORR.= 0.9997
STD. ERROR = 5.13

REGRESSION CURVE(2) YY = g(RC)

X : ROTOR METER (SCALE UNIT)
Y : ACC. METER (L/COUNT)

| A0 | A1 | A2 | A3 |
|---|---|---|---|
| 0.3210393568E 02 | -0.3905153280E 00 | 0.6099616128E-02 | -0.2565882528E-04 |

Y = A0 + A1 * X + A2 * X**2 + A3 * X**3

MULTI. CORR.= 0.6647
STD. ERROR = 9909.48

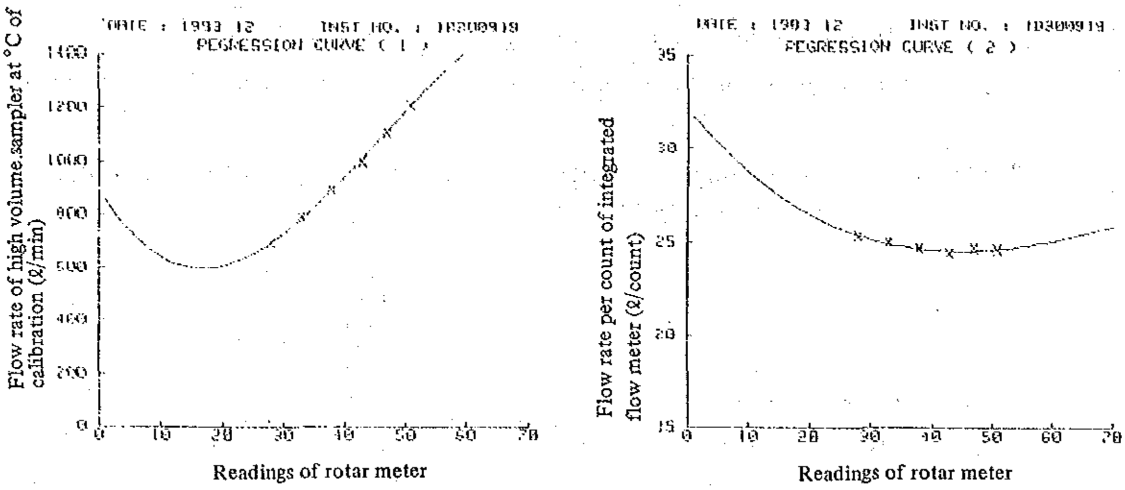



Fig. III-3-11 An example of calibration curve of high volume sampler

Following to the above calculation, the total air sampling volume ($V_1$ & $V_2$) has been obtained by summing up sampling volume $R_1$ and $R_2$ recorded at the time of intermediate patrols. The equations are III-3-7 and III-3-8.

$$V_1 = \sum_{i=1}^{n} R_1(i)$$ Equation III-3-7

$$V_2 = \sum_{i=1}^{n} R_2(i)$$ Equation III-3-8

(4) Calculation of TPM, SPM concentration by high volume sampler

The concentration of TPM and SPM has been calculated by weighing filters before and after samplings. The ambient concentration of particulate matter has been calculated by the following Equation III-3-9.

$$C = \frac{We - Ws}{V} \times 10^3$$ Equation III-3-9

where;

C: concentration of particulate matter ($\mu g/m^3$)

We: weight of filter after sampling (mg)

Ws: weight of filter before sampling (mg)

V: sampling volume ($m^3$)

An example of calculation of sampling volume and concentration of particulate matter is shown in Table III-3-18 and Table III-3-19. (All results are shown in the part for reference materials.)

FLOW(1) and FLOW(2) represent air sampling volume obtained by Equations III-3-7 and III-3-8 respectively, and CONC(1) and CONC(2) represent particulate matter concentration calculated from the above described $V_1$ and $V_2$ respectively.

Further, the comparison of sampling air volume obtained from 2 different methods is shown in the part of reference materials.

Table III-3-18 An example of readings of rotar meter, integrated flow meter, air sampling volume and concentration of particulate matter

| SITE | INST. | FILTER | DATE | TIME | ROTOR | ACC.METER | FLOW(1) | FLOW(2) |
|---|---|---|---|---|---|---|---|---|
| 1 | 18300919 | 01201 | 12 7 | 12 3 | ****** 33.0 | 2005 | | |
| | | | 12 7 | 17 58 | 33.0 33.0 | 11000 | 278.6 | 224.3 |
| | | | 12 8 | 12 12 | 34.0****** | 47836 | 869.7 | 917.3 |
| | | | | | | | 1148.3 | 1141.6 |

| B.WEIGHT | A.WEIGHT | D.WEIGHT | CONC.(1) | CONC.(2) |
|---|---|---|---|---|
| 4189.4 | 4263.4 | 74.0 | 64.4 | 64.8 |

FLOW(1) : BY ROTOR (M**3)
FLOW(2) : BY ACC. METER (M**3)

CONC. (MICRO G./M**3)

Table III-3-19 An example of calculation of air sampling volume of high volume sampler and concentration of particulate matter

| SITE-NO. | INST.-NO. | FILTER-NO. | DATE | FLOW(1) (M**3) | FLOW(2) (M**3) | WEIGHT(1) (G) | WEIGHT(2) (G) | DUST-W. (MG) | DUST-CONC.(*) (MG/M**3) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 18300919 | 01201 | 12/ 7-12/ 8 | 1148.3 | 1141.6 | 4.1894 | 4.2634 | 74.0 | 64.8 |
| 1 | 18300919 | 01202 | 12/ 8-12/ 9 | 1112.8 | 1178.2 | 4.1842 | 4.2486 | 64.4 | 54.7 |
| 1 | 18300919 | 01203 | 12/ 9-12/10 | 1097.5 | 1121.8 | 4.3110 | 4.3471 | 36.1 | 32.2 |
| 1 | 18300919 | 01204 | 12/10-12/11 | 1130.7 | 1144.4 | 4.3184 | 4.3747 | 56.3 | 49.2 |
| 1 | 18300919 | 01205 | 12/11-12/12 | 1039.5 | 1100.0 | 4.3386 | 4.3921 | 53.5 | 48.6 |
| 1 | 18300919 | 01206 | 12/12-12/13 | 1082.2 | 1142.2 | 4.2731 | 4.3554 | 82.3 | 72.1 |
| 1 | 18300919 | 01207 | 12/13-12/14 | 1154.4 | 1175.1 | 4.3659 | 4.4655 | 99.6 | 83.3 |
| 1 | 18300919 | 01208 | 12/14-12/15 | 1154.0 | 1162.9 | 4.3902 | 4.4678 | 77.6 | 66.7 |
| 1 | 18300919 | 03209 | 12/15-12/16 | 1118.0 | 1141.6 | 4.7028 | 4.7739 | 71.1 | 62.3 |
| 1 | 18300919 | 01210 | 12/10-12/11 | 1076.0 | 1102.3 | 4.3446 | 4.4277 | 83.1 | 75.4 |
| 1 | 18300919 | 01211 | 12/17-12/18 | 1180.0 | 1196.6 | 4.2838 | 4.3553 | 71.5 | 59.8 |
| 1 | 18300919 | 01212 | 12/18-12/19 | 1073.7 | 1134.6 | 4.1536 | 4.2156 | 62.0 | 54.6 |
| 1 | 18300919 | 01113 | 12/19-12/20 | 1090.0 | 1127.3 | 27.1473 | 27.2067 | 59.4 | 52.7 |
| 1 | 18300919 | 01114 | 12/20-12/21 | 1190.2 | 1241.7 | 27.5814 | 27.6422 | 60.8 | 49.0 |

FLOW(1) : CALCULATED BY ROTOR METER.
FLOW(2) : CALCULATED BY ACCUMULATIVE FLOW METER.
WEIGHT(1) : FILTER WEIGHT BEFORE USE.
WEIGHT(2) : FILTER WEIGHT AFTER USE.
(*) DUST-CONC. IS CALCULATED BY FLOW(2)

### III-3-2-3 Results of monitoring of TPM and SPM

The list of concentration of TPM and SPM calculated by equations described in III-3-2-2 is shown in Table III-3-20.

Further, in cases of accidental power supply stops happened during monitoring naturally cause inaccuracy of air sampling volume from rotar meter readings, and in this study the air volume has been obtained from the readings of integrated flow meter in such cases.

The records of troubles happened in the course of study are shown as follows;

| Monitor point | Item | Date | Monitored value (μg/m$^3$) | Remarks |
|---|---|---|---|---|
| MP-2 | SPM | 12/18-19, '83 | 48.6 | filter wet by rain |
| MP-11 | TPM | 12/9-10 | 32.5 | filter broken |
| MP-11 | SPM | 12/10-11 | 41.0 | filter wet by rain |
| MP-11 | TPM, SPM | 12/15-16 | 62.8<br>32.4 | power stop (average of 18h 45min) |
| MP-12 | TPM, SPM | 12/9-10 | 51.3<br>25.7 | starting delayed (average of 20h 30min) |
| MP-17 | TPM, SPM | 12/8-9 | 153.9<br>43.7 | power stop (average of 5h 40 min) |
| MP-17 | TPM, SPM | 12/12-13 | 108.7<br>33.0 | power stop (average of 4h 15 min) |
| MP-20 | TPM, SPM | 12/17-18 | 56.8<br>20.8 | power stop (average of 10h) |
| MP-11 | TPM, SPM | 3/8-9, '84 | 128.0<br>77.4 | power stop (average of 7h) |
| MP-20 | TPM, SPM | 3/16-17 | 57.6<br>34.3 | power stop (average of 19h) |
| MP-6 | TPM | 7/4-5 | 59.6 | power stop (average of 19h) |
| MP-12 | TPM, SPM | 6/29-30 | 116.6<br>26.8 | power stop (average of 3h 30min) |
| MP-13 | TPM | 7/1-2 | 74.5 | cable disconnection (average of 4h 20min) |
| MP-2 | SPM | 9/24-25 | 5.8 | cable disconnection (average of 5h) |
| MP-14 | TPM, SPM | 9/23-24 | 49.8<br>15.0 | power stop (average of 1h 30min) |
| MP-14 | TPM, SPM | 9/24-25 | 47.9<br>22.1 | power stop (average of 19h 50min) |
| MP-15 | TPM | 9/23-24 | 77.3 | cable disconnection (average of 6min) |
| MP-15 | TPM | 9/26-27 | 228.1 | power stop (average of 2h 10min) |

| Monitor point | Item | Date | Monitored value ($\mu g/m^3$) | Remarks |
|---|---|---|---|---|
| MP-17 | TPM, SPM | 9/13-14 | 50.6<br>25.9 | power stop (average of 9h) |
| MP-17 | TPM, SPM | 9/18-19 | 158.5<br>61.7 | power stop (average of 6h) |

## Table III-3-20-(1) Results of monitoring of TPM and SPM by high volume sampler (1st Field Survey)

| | | DATE OF MEASUREMENT (1983/12) | | | | | | | | | | | | | | ----12 DAYS---- | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 7-8 | 8-9 | 9-10 | 10-11 | 11-12 | 12-13 | 13-14 | 14-15 | 15-16 | 16-17 | 17-18 | 18-19 | 19-20 | 20-21 | MEAN | MAX | MIN |
| 1 | TPM | 64.8 | 54.7 | 32.2 | 49.2 | 48.6 | 72.1 | 83.3 | 66.7 | 62.3 | 75.4 | 59.8 | 54.6 | 52.7 | 49.0 | 60.3 | 83.3 | 32.2 |
| | SPM | 35.7 | 24.1 | 21.6 | 33.3 | 21.7 | 31.4 | 42.3 | 32.9 | 31.4 | 27.6 | 16.1 | 23.6 | | | 28.5 | 42.3 | 16.1 |
| | S/T | 55 | 44 | 67 | 68 | 45 | 44 | 51 | 49 | 50 | 37 | 27 | 43 | | | 48 | 68 | 27 |
| 2 | TPM | 65.1 | 71.4 | 47.6 | 52.1 | 53.9 | 44.3 | 59.0 | 61.4 | 51.7 | 49.2 | 57.9 | 45.8 | 25.3 | 31.3 | 54.9 | 71.4 | 44.3 |
| | SPM | 38.2 | 42.4 | 37.2 | 41.6 | 37.0 | 28.4 | 36.1 | 41.0 | 33.4 | 20.8 | 27.7 | ***** | | | 34.9 | 42.4 | 20.8 |
| | S/T | 59 | 59 | 78 | 80 | 69 | 64 | 61 | 67 | 65 | 42 | 48 | ***** | | | 63 | 80 | 42 |
| 3 | TPM | 64.3 | 54.0 | 42.3 | 43.2 | 47.8 | 55.1 | 74.0 | 53.1 | 50.6 | 47.6 | 57.6 | 42.7 | 35.0 | 42.0 | 52.7 | 74.0 | 42.3 |
| | SPM | 32.8 | 27.1 | 22.6 | 30.7 | 29.9 | 29.0 | 43.4 | 26.0 | 25.0 | 19.8 | 23.2 | 27.1 | | | 28.0 | 43.4 | 19.8 |
| | S/T | 51 | 50 | 53 | 71 | 63 | 53 | 59 | 49 | 49 | 42 | 40 | 63 | | | 54 | 71 | 40 |
| 4 | TPM | 73.9 | 61.7 | 42.7 | 54.1 | 57.2 | 83.4 | 125.2 | 94.4 | 82.9 | 95.0 | 114.3 | 72.1 | 89.2 | 105.9 | 79.7 | 125.2 | 42.7 |
| | SPM | 37.7 | 31.2 | 26.5 | 36.3 | 28.8 | 42.9 | 58.1 | 54.8 | 47.0 | 37.5 | 44.4 | 39.8 | | | 40.4 | 58.1 | 26.5 |
| | S/T | 51 | 51 | 62 | 67 | 50 | 51 | 46 | 58 | 57 | 39 | 39 | 55 | | | 52 | 67 | 39 |
| 5 | TPM | 75.7 | 57.4 | 41.0 | 52.4 | 50.2 | 85.3 | 130.1 | 91.1 | 91.7 | 98.9 | 98.4 | 69.5 | 83.0 | 77.8 | 78.5 | 130.1 | 41.0 |
| | SPM | 40.1 | 31.6 | 29.2 | 40.3 | 31.9 | 43.3 | 60.0 | 48.1 | 51.0 | 39.7 | 43.9 | 43.1 | | | 41.8 | 60.0 | 29.2 |
| | S/T | 53 | 55 | 71 | 77 | 64 | 51 | 46 | 53 | 56 | 40 | 45 | 62 | | | 56 | 77 | 40 |
| 6 | TPM | 51.2 | 42.2 | 36.0 | 31.2 | 39.2 | 52.9 | 77.2 | 87.2 | 64.1 | 53.8 | 66.7 | 48.0 | 40.0 | 54.4 | 54.1 | 87.2 | 31.2 |
| | SPM | 29.8 | 22.7 | 29.9 | 22.7 | 25.6 | 31.3 | 50.7 | 53.2 | 41.2 | 26.3 | 33.4 | 32.1 | | | 33.2 | 53.2 | 22.7 |
| | S/T | 58 | 54 | 83 | 73 | 65 | 59 | 66 | 61 | 64 | 49 | 50 | 67 | | | 62 | 83 | 49 |
| 7 | TPM | 95.7 | 93.3 | 64.2 | 69.5 | 79.0 | 118.7 | 155.6 | 148.0 | 110.3 | 108.7 | 100.3 | 82.9 | 98.7 | 100.5 | 102.2 | 155.6 | 64.2 |
| | SPM | 37.2 | 38.2 | 40.1 | 50.7 | 43.7 | 54.0 | 77.4 | 79.6 | 60.6 | 45.4 | 46.2 | 40.5 | | | 51.1 | 79.6 | 37.2 |
| | S/T | 39 | 41 | 62 | 73 | 55 | 45 | 50 | 54 | 55 | 42 | 46 | 49 | | | 51 | 73 | 39 |
| 8 | TPM | 35.5 | 37.6 | 21.5 | 31.6 | 35.1 | 41.1 | 62.1 | 77.5 | 45.8 | 44.4 | 54.2 | 29.8 | 35.6 | 35.2 | 43.0 | 77.5 | 21.5 |
| | SPM | 24.9 | 25.5 | 17.0 | 25.6 | 24.0 | 23.0 | 49.2 | 53.4 | 34.6 | 21.4 | 27.3 | 25.9 | | | 29.3 | 53.4 | 17.0 |
| | S/T | 70 | 68 | 79 | 81 | 68 | 56 | 79 | 69 | 76 | 48 | 50 | 87 | | | 69 | 87 | 48 |
| 9 | TPM | 46.2 | 42.0 | 28.0 | 35.3 | 46.9 | 42.2 | 74.4 | 79.1 | 53.6 | 42.0 | 54.0 | 43.8 | 39.4 | 34.5 | 49.0 | 79.1 | 28.0 |
| | SPM | 25.2 | 20.4 | 13.3 | 24.2 | 25.1 | 20.5 | 43.3 | 44.2 | 35.2 | 20.8 | 25.6 | 24.3 | | | 26.8 | 44.2 | 13.3 |
| | S/T | 55 | 49 | 48 | 69 | 54 | 49 | 58 | 56 | 66 | 50 | 47 | 55 | | | 55 | 69 | 47 |
| 10 | TPM | 51.4 | 50.2 | 34.4 | 49.3 | 46.0 | 40.1 | 73.7 | 64.6 | 47.5 | 42.6 | 59.2 | 47.1 | 34.6 | 37.9 | 50.5 | 73.7 | 34.4 |
| | SPM | 23.5 | 32.3 | 24.7 | 35.8 | 27.9 | 24.1 | 33.8 | 39.9 | 29.5 | 16.6 | 22.9 | 25.5 | | | 28.0 | 39.9 | 16.6 |
| | S/T | 46 | 64 | 72 | 73 | 61 | 60 | 46 | 62 | 62 | 39 | 39 | 54 | | | 57 | 73 | 39 |
| 11 | TPM | 49.1 | 48.5 | ***** | 33.2 | 46.4 | 51.5 | 83.3 | 74.0 | 62.8? | 52.2 | 63.4 | 49.4 | 34.7 | 39.9 | 55.1 | 83.3 | 33.2 |
| | SPM | 36.6 | 31.1 | 37.6 | ***** | 30.0 | 28.7 | 55.1 | 38.3 | 32.4? | 19.7 | 30.9 | 25.0 | | | 33.3 | 55.1 | 19.7 |
| | S/T | 75 | 64 | ***** | ***** | 65 | 56 | 66 | 52 | 52? | 38 | 49 | 51 | | | 57 | 75 | 38 |
| 12 | TPM | 79.2 | 60.9 | 51.3? | 54.7 | 56.5 | 78.4 | 71.1 | 55.5 | 50.9 | 55.9 | 67.3 | 47.8 | 47.7 | 42.5 | 61.7 | 79.2 | 47.8 |
| | SPM | 37.7 | 22.6 | 25.7? | 32.3 | 25.3 | 30.9 | 38.6 | 25.8 | 24.0 | 15.2 | 22.4 | 25.6 | | | 27.3 | 38.6 | 15.2 |
| | S/T | 48 | 37 | 50? | 59 | 45 | 39 | 54 | 46 | 47 | 27 | 33 | 54 | | | 44 | 59 | 27 |
| 13 | TPM | 36.4 | 28.1 | 24.2 | 29.6 | 31.4 | 47.4 | 64.0 | 57.8 | 34.1 | 40.8 | 50.6 | 37.6 | 34.5 | 36.9 | 40.2 | 64.0 | 24.2 |
| | SPM | 22.1 | 14.7 | 13.0 | 20.6 | 19.8 | 22.8 | 40.6 | 30.5 | 19.6 | 13.3 | 16.8 | 19.3 | | | 21.1 | 40.6 | 13.0 |
| | S/T | 61 | 52 | 54 | 70 | 63 | 48 | 63 | 53 | 57 | 33 | 33 | 51 | | | 53 | 70 | 33 |
| 14 | TPM | 62.7 | 46.1 | 39.7 | 43.3 | 44.9 | 58.8 | 76.1 | 53.8 | 46.2 | 50.2 | 61.9 | 51.3 | 44.0 | 45.9 | 52.9 | 76.1 | 39.7 |
| | SPM | 28.6 | 19.0 | 23.1 | 28.6 | 23.3 | 27.8 | 41.9 | 25.6 | 25.1 | 16.7 | 22.6 | 24.7 | | | 25.6 | 41.9 | 16.7 |
| | S/T | 46 | 41 | 58 | 66 | 52 | 47 | 55 | 48 | 54 | 33 | 37 | 48 | | | 49 | 66 | 33 |
| 15 | TPM | 55.4 | 34.4 | 30.0 | 37.4 | 35.5 | 38.9 | 38.6 | 49.2 | 30.7 | 38.4 | 50.5 | 38.5 | 31.4 | 30.4 | 39.8 | 55.4 | 30.0 |
| | SPM | 29.5 | 18.7 | 26.0 | 25.2 | 21.7 | 18.3 | 26.6 | 21.7 | 14.7 | 11.2 | 15.6 | 11.7 | | | 20.1 | 29.5 | 11.2 |
| | S/T | 53 | 54 | 87 | 67 | 61 | 47 | 69 | 44 | 48 | 29 | 31 | 30 | | | 52 | 87 | 29 |
| 16 | TPM | 52.3 | 39.3 | 24.0 | 31.5 | 39.8 | 56.1 | 79.2 | 64.7 | 34.2 | 35.0 | 45.2 | 32.7 | 28.2 | 32.6 | 44.5 | 79.2 | 24.0 |
| | SPM | 24.0 | 16.9 | 12.1 | 19.5 | 22.4 | 23.4 | 45.7 | 29.6 | 15.0 | 9.1 | 13.6 | 14.8 | | | 20.5 | 45.7 | 9.1 |
| | S/T | 46 | 43 | 50 | 62 | 56 | 42 | 58 | 46 | 44 | 26 | 30 | 45 | | | 46 | 62 | 26 |
| 17 | TPM | 118.8 | 153.9? | 68.5 | 65.0 | 94.6 | 108.7? | 131.7 | 121.1 | 78.2 | 132.9 | 144.5 | 76.9 | 103.4 | 126.9 | 103.2 | 144.5 | 65.0 |
| | SPM | 36.4 | 43.7? | 33.6 | 38.4 | 36.6 | 33.0? | 54.6 | 42.8 | 37.8 | 34.4 | 40.9 | 39.7 | | | 39.5 | 54.6 | 33.6 |
| | S/T | 31 | 28? | 49 | 59 | 39 | 30? | 41 | 35 | 48 | 26 | 28 | 52 | | | 41 | 59 | 26 |
| 18 | TPM | 85.0 | 58.1 | 49.7 | 47.6 | 62.2 | 73.9 | 78.6 | 49.5 | 43.4 | 43.1 | 53.0 | 36.8 | 25.5 | 27.4 | 56.7 | 85.0 | 36.8 |
| | SPM | 37.6 | 31.4 | 27.6 | 33.6 | 36.4 | 39.2 | 50.4 | 30.7 | 23.2 | 18.9 | 23.7 | 21.0 | | | 31.1 | 50.4 | 18.9 |
| | S/T | 44 | 54 | 56 | 71 | 59 | 53 | 64 | 62 | 53 | 44 | 45 | 57 | | | 55 | 71 | 44 |
| 19 | TPM | 73.3 | 59.7 | 49.9 | 54.2 | 60.7 | 78.7 | 103.1 | 68.8 | 57.5 | 70.7 | 79.9 | 57.3 | 45.6 | 58.1 | 67.8 | 103.1 | 49.9 |
| | SPM | 39.0 | 14.4 | 29.3 | 37.1 | 34.9 | 37.9 | 53.6 | 35.2 | 29.9 | 21.6 | 26.6 | 30.0 | | | 32.5 | 53.6 | 14.4 |
| | S/T | 53 | 24 | 59 | 68 | 57 | 48 | 52 | 51 | 52 | 31 | 33 | 52 | | | 48 | 68 | 24 |
| 20 | TPM | 66.1 | 29.2 | 21.5 | 23.1 | 29.4 | 50.2 | 69.8 | 53.9 | 39.0 | 46.5 | 56.8? | 27.5 | 42.4 | 44.0 | 41.5 | 69.8 | 21.5 |
| | SPM | 26.5 | 8.7 | 10.4 | 12.5 | 13.9 | 18.8 | 30.4 | 18.5 | 19.6 | 13.2 | 20.8? | 14.1 | | | 17.0 | 30.4 | 8.7 |
| | S/T | 40 | 30 | 48 | 54 | 47 | 37 | 44 | 34 | 50 | 28 | 37? | 51 | | | 42 | 54 | 28 |

## Table III-3-20-(2) Results of monitoring of TPM and SPM by high volume sampler (2nd Field Survey)

| | | DATE OF MEASUREMENT (1984/ 3) | | | | | | | | | | | | | | ----12 DAYS---- | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6-7 | 7-8 | 8-9 | 9-10 | 10-11 | 11-12 | 12-13 | 13-14 | 14-15 | 15-16 | 16-17 | 17-18 | 18-19 | 19-20 | MEAN | MAX | MIN |
| 1 | TPM | 112.9 | 123.4 | 83.4 | 104.5 | 90.1 | 99.6 | 97.8 | 102.6 | 118.2 | 111.6 | 71.9 | 75.7 | 44.9 | 74.9 | 99.3 | 123.4 | 71.9 |
| | SPM | 27.9 | 48.9 | 34.6 | 43.2 | 51.3 | 62.1 | 56.2 | 50.1 | 59.4 | 57.3 | 44.0 | 29.6 | | | 47.0 | 62.1 | 27.9 |
| | S/T | 25 | 40 | 41 | 41 | 57 | 62 | 57 | 49 | 50 | 51 | 61 | 39 | | | 48 | 62 | 25 |
| 2 | TPM | 73.3 | 77.6 | 73.3 | 80.0 | 93.0 | 65.8 | 62.6 | 56.0 | 65.2 | 44.9 | 42.5 | 38.3 | 34.5 | 36.6 | 64.4 | 93.0 | 38.3 |
| | SPM | 19.8 | 24.7 | 27.1 | 29.5 | 57.9 | 43.0 | 35.3 | 29.2 | 40.0 | 23.9 | 24.4 | 21.4 | | | 31.3 | 57.9 | 19.8 |
| | S/T | 27 | 32 | 37 | 37 | 62 | 65 | 56 | 52 | 61 | 53 | 57 | 56 | | | 50 | 65 | 27 |
| 3 | TPM | 82.2 | 86.5 | 76.2 | 78.5 | 105.4 | 85.7 | 81.3 | 72.7 | 81.1 | 78.2 | 62.1 | 67.4 | 40.4 | 51.4 | 79.8 | 105.4 | 62.1 |
| | SPM | 29.4 | 36.5 | 36.3 | 35.9 | 69.5 | 53.2 | 47.0 | 40.8 | 45.9 | 48.0 | 36.9 | 31.9 | | | 42.6 | 69.5 | 29.4 |
| | S/T | 36 | 42 | 48 | 46 | 66 | 62 | 58 | 56 | 57 | 61 | 59 | 47 | | | 53 | 66 | 36 |
| 4 | TPM | 94.4 | 87.2 | 80.7 | 97.2 | 97.4 | 98.9 | 97.3 | 100.8 | 116.8 | 95.9 | 79.2 | 52.2 | 35.9 | 82.7 | 91.5 | 116.8 | 52.2 |
| | SPM | 40.4 | 41.6 | 42.9 | 49.6 | 74.2 | 67.4 | 59.9 | 60.8 | 70.8 | 47.6 | 47.4 | 23.1 | | | 52.1 | 74.2 | 23.1 |
| | S/T | 43 | 48 | 53 | 51 | 76 | 68 | 62 | 60 | 61 | 50 | 60 | 44 | | | 56 | 76 | 43 |
| 5 | TPM | 90.6 | 95.2 | 87.7 | 87.8 | 98.2 | 93.7 | 124.5 | 99.2 | 115.2 | 107.2 | 70.8 | 75.0 | 46.9 | 95.3 | 95.4 | 124.5 | 70.8 |
| | SPM | 33.6 | 38.6 | 33.7 | 42.5 | 56.1 | 59.0 | 46.2 | 49.4 | 62.5 | 39.2 | 33.5 | 24.6 | | | 43.2 | 62.5 | 24.6 |
| | S/T | 37 | 41 | 38 | 48 | 57 | 63 | 37 | 50 | 54 | 37 | 47 | 33 | | | 45 | 63 | 33 |
| 6 | TPM | 77.7 | 81.1 | 70.5 | 107.2 | 85.4 | 109.2 | 102.8 | 111.0 | 107.6 | 91.1 | 64.1 | 35.5 | 21.4 | 69.7 | 86.9 | 111.0 | 35.5 |
| | SPM | 27.5 | 33.7 | 33.2 | 50.4 | 55.2 | 70.2 | 56.9 | 60.2 | 62.4 | 43.8 | 32.7 | 11.5 | | | 44.8 | 70.2 | 11.5 |
| | S/T | 35 | 42 | 47 | 47 | 65 | 64 | 55 | 54 | 58 | 48 | 51 | 32 | | | 50 | 65 | 32 |
| 7 | TPM | 124.0 | 141.3 | 118.9 | 145.3 | 146.9 | 137.6 | 146.5 | 149.9 | 176.0 | 155.7 | 175.5 | 112.6 | 87.1 | 176.4 | 144.2 | 176.0 | 112.6 |
| | SPM | 53.7 | 58.6 | 49.9 | 58.5 | 72.3 | 72.2 | 65.3 | 66.8 | 70.7 | 68.9 | 88.0 | 38.9 | | | 63.6 | 88.0 | 38.9 |
| | S/T | 43 | 41 | 42 | 40 | 49 | 52 | 45 | 45 | 40 | 44 | 50 | 35 | | | 44 | 52 | 35 |
| 8 | TPM | 54.5 | 64.8 | 70.3 | 87.4 | 70.9 | 76.2 | 88.3 | 91.2 | 74.7 | 93.9 | 99.2 | 53.0 | 31.8 | 100.8 | 77.0 | 99.2 | 53.0 |
| | SPM | 23.8 | 30.2 | 30.9 | 39.2 | 44.2 | 48.4 | 49.0 | 49.2 | 39.1 | 55.4 | 41.4 | 16.8 | | | 39.0 | 55.4 | 16.8 |
| | S/T | 44 | 47 | 44 | 45 | 62 | 64 | 55 | 54 | 52 | 59 | 42 | 32 | | | 50 | 64 | 32 |
| 9 | TPM | 68.8 | 82.1 | 69.5 | 86.9 | 96.0 | 78.1 | 78.4 | 94.4 | 93.3 | 139.8 | 141.3 | 60.7 | 53.1 | 105.3 | 90.8 | 141.3 | 60.7 |
| | SPM | 26.4 | 39.4 | 36.1 | 39.2 | 56.7 | 53.1 | 45.5 | 46.0 | 56.9 | 72.5 | 72.0 | 25.7 | | | 47.5 | 72.5 | 25.7 |
| | S/T | 38 | 48 | 52 | 45 | 59 | 68 | 58 | 49 | 61 | 52 | 51 | 42 | | | 52 | 68 | 38 |
| 10 | TPM | 57.6 | 57.9 | 62.4 | 65.0 | 74.4 | 73.5 | 70.9 | 74.3 | 66.3 | 62.2 | 63.8 | 55.4 | 40.2 | 61.6 | 65.3 | 74.4 | 55.4 |
| | SPM | 19.1 | 26.8 | 31.6 | 33.2 | 38.8 | 42.0 | 30.2 | 31.6 | 34.0 | 39.7 | 40.9 | 29.4 | | | 33.1 | 42.0 | 19.1 |
| | S/T | 33 | 46 | 51 | 51 | 52 | 57 | 43 | 43 | 51 | 64 | 64 | 53 | | | 51 | 64 | 33 |
| 11 | TPM | 74.2 | 90.9 | 128.0? | 66.2 | 84.9 | 79.3 | 82.5 | 84.4 | 75.5 | 106.4 | 88.6 | 60.2 | 48.8 | 82.8 | 81.2 | 106.4 | 60.2 |
| | SPM | 27.6 | 36.0 | 77.4? | 31.4 | 47.6 | 43.9 | 43.3 | 34.4 | 38.7 | 58.3 | 46.6 | 27.6 | | | 39.6 | 58.3 | 27.6 |
| | S/T | 37 | 40 | 60? | 47 | 56 | 55 | 52 | 41 | 51 | 55 | 53 | 46 | | | 48 | 56 | 37 |
| 12 | TPM | 87.9 | 92.2 | 97.3 | 100.1 | 120.7 | 89.6 | 80.0 | 97.7 | 91.1 | 123.2 | 88.8 | 92.7 | 72.6 | 72.8 | 96.8 | 123.2 | 80.0 |
| | SPM | 26.4 | 28.6 | 30.4 | 35.3 | 58.2 | 41.1 | 31.7 | 33.6 | 32.0 | 38.7 | 31.3 | 27.9 | | | 34.6 | 58.2 | 26.4 |
| | S/T | 30 | 31 | 31 | 35 | 48 | 46 | 40 | 34 | 35 | 31 | 35 | 30 | | | 36 | 48 | 30 |
| 13 | TPM | 67.2 | 70.7 | 81.0 | 79.6 | 101.8 | 76.5 | 73.3 | 71.9 | 76.7 | 94.0 | 55.5 | 57.7 | 36.4 | 52.8 | 75.5 | 101.8 | 55.5 |
| | SPM | 23.0 | 29.2 | 40.3 | 36.3 | 58.2 | 44.8 | 40.2 | 35.4 | 45.2 | 62.3 | 34.9 | 29.3 | | | 39.9 | 62.3 | 23.0 |
| | S/T | 34 | 41 | 50 | 46 | 57 | 59 | 55 | 49 | 59 | 66 | 63 | 51 | | | 53 | 66 | 34 |
| 14 | TPM | 69.8 | 75.6 | 70.4 | 60.6 | 88.7 | 75.1 | 69.4 | 73.4 | 77.3 | 101.2 | 54.8 | 76.3 | 45.0 | 49.4 | 74.4 | 101.2 | 54:8 |
| | SPM | 28.3 | 34.2 | 33.7 | 41.2 | 56.6 | 44.9 | 37.5 | 37.9 | 44.3 | 65.9 | 34.0 | 41.9 | | | 41.7 | 65.9 | 28.3 |
| | S/T | 41 | 45 | 48 | 68 | 64 | 60 | 54 | 52 | 57 | 65 | 62 | 55 | | | 56 | 68 | 41 |
| 15 | TPM | 56.8 | 51.1 | 49.6 | 59.6 | 62.6 | 67.4 | 55.3 | 57.5 | 53.3 | 49.0 | 52.3 | 58.6 | 42.5 | 29.0 | 56.1 | 67.4 | 49.0 |
| | SPM | 21.1 | 23.5 | 22.9 | 30.1 | 40.8 | 39.3 | 27.0 | 27.4 | 28.7 | 28.1 | 30.3 | 27.6 | | | 28.9 | 40.8 | 21.1 |
| | S/T | 37 | 46 | 46 | 51 | 65 | 58 | 49 | 48 | 54 | 57 | 58 | 47 | | | 51 | 65 | 37 |
| 16 | TPM | 62.9 | 70.0 | 77.5 | 69.2 | 104.3 | 83.6 | 86.3 | 80.3 | 85.8 | 110.4 | 88.3 | 79.0 | 56.3 | 77.5 | 83.1 | 110.4 | 62.9 |
| | SPM | 27.0 | 28.1 | 34.8 | 33.3 | 57.6 | 54.6 | 43.2 | 37.1 | 51.9 | 68.1 | 44.8 | 35.7 | | | 43.0 | 68.1 | 27.0 |
| | S/T | 43 | 40 | 45 | 48 | 55 | 65 | 50 | 46 | 60 | 62 | 51 | 45 | | | 51 | 65 | 40 |
| 17 | TPM | 145.2 | 117.6 | 123.8 | 146.5 | 133.9 | 120.5 | 117.9 | 140.1 | 131.3 | 121.0 | 62.5 | 81.4 | 70.4 | 62.8 | 120.1 | 146.5 | 62.5 |
| | SPM | 46.1 | 48.9 | 47.3 | 47.7 | 70.5 | 64.1 | 53.5 | 54.8 | 60.1 | 76.6 | 35.4 | 38.4 | | | 53.6 | 76.6 | 35.4 |
| | S/T | 32 | 42 | 38 | 33 | 53 | 53 | 45 | 39 | 46 | 63 | 57 | 47 | | | 46 | 63 | 32 |
| 18 | TPM | 60.6 | 63.1 | 55.9 | 49.6 | 73.6 | 57.4 | 47.1 | 52.7 | 62.5 | 89.0 | 74.3 | 80.5 | 64.6 | 61.5 | 63.9 | 89.0 | 47.1 |
| | SPM | 20.5 | 21.2 | 23.8 | 21.1 | 39.8 | 26.7 | 24.3 | 28.8 | 33.2 | 53.6 | 37.1 | 30.7 | | | 30.1 | 53.6 | 20.5 |
| | S/T | 34 | 34 | 43 | 43 | 54 | 47 | 52 | 55 | 53 | 60 | 50 | 38 | | | 47 | 60 | 34 |
| 19 | TPM | 70.5 | 58.1 | 54.4 | 66.7 | 70.7 | 67.4 | 58.7 | 63.9 | 62.8 | 63.8 | 48.0 | 54.9 | 60.4 | 46.9 | 61.7 | 70.7 | 48.0 |
| | SPM | 22.8 | 25.2 | 23.5 | 26.2 | 43.4 | 36.4 | 27.8 | 27.0 | 30.6 | 41.9 | 27.5 | 26.8 | | | 29.9 | 43.4 | 22.8 |
| | S/T | 32 | 43 | 43 | 39 | 61 | 54 | 47 | 42 | 49 | 66 | 57 | 49 | | | 49 | 66 | 32 |
| 20 | TPM | 54.1 | 49.3 | 46.0 | 46.1 | 59.1 | 59.2 | 68.2 | 46.2 | 44.2 | 58.1 | 57.6? | 64.7 | 79.2 | 74.0 | 54.1 | 68.2 | 44.2 |
| | SPM | 15.0 | 14.9 | 16.0 | 17.0 | 37.4 | 31.3 | 29.8 | 21.7 | 20.4 | 31.5 | 34.3? | 28.7 | | | 24.0 | 37.4 | 14.9 |
| | S/T | 28 | 30 | 35 | 37 | 63 | 53 | 44 | 47 | 46 | 54 | 60? | 44 | | | 44 | 63 | 28 |

Table III-3-20-(3) Results of monitoring of TPM and SPM by high volume sampler (3rd Field Survey)

| | | DATE OF MEASUREMENT (1984/ 6) | | | | | | | | | | | | | | ----12 DAYS---- | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 21-22 | 22-23 | 23-24 | 24-25 | 25-26 | 26-27 | 27-28 | 28-29 | 29-30 | 30-1 | 1-2 | 2-3 | 3-4 | 4-5 | MEAN | MAX | MIN |
| 1 | TPM | 41.9 | 45.0 | 87.3 | 41.1 | 32.3 | 44.7 | 57.1 | 53.8 | 52.1 | 37.7 | 72.2 | 57.4 | 37.9 | 59.6 | 51.9 | 87.3 | 32.3 |
| | SPM | 18.3 | 20.1 | 43.3 | 19.5 | 18.9 | 22.1 | 26.7 | 21.9 | 23.9 | 21.0 | 37.7 | 32.0 | | | 25.4 | 43.3 | 18.3 |
| | S/T | 44 | 45 | 50 | 47 | 59 | 49 | 47 | 41 | 46 | 56 | 52 | 56 | | | 49 | 59 | 41 |
| 2 | TPM | 49.1 | 55.0 | 77.7 | 41.7 | 40.1 | 46.6 | 53.5 | 60.2 | 54.9 | 42.5 | 51.0 | 40.1 | 24.1 | 22.3 | 51.0 | 77.7 | 40.1 |
| | SPM | 22.3 | 23.7 | 40.9 | 22.2 | 23.6 | 25.5 | 23.6 | 25.7 | 30.6 | 24.6 | 24.9 | 21.6 | | | 25.8 | 40.9 | 21.6 |
| | S/T | 45 | 43 | 53 | 53 | 59 | 55 | 44 | 43 | 56 | 58 | 49 | 54 | | | 51 | 59 | 43 |
| 3 | TPM | 55.9 | 70.0 | 88.2 | 39.7 | 58.6 | 52.7 | 64.2 | 73.9 | 64.5 | 43.5 | 45.9 | 69.9 | 40.6 | 42.4 | 60.6 | 88.2 | 39.7 |
| | SPM | 17.3 | 18.2 | 36.5 | 18.1 | 20.0 | 23.5 | 24.0 | 22.4 | 19.2 | 20.1 | 19.5 | 22.1 | | | 21.7 | 36.5 | 17.3 |
| | S/T | 31 | 26 | 41 | 46 | 34 | 45 | 37 | 30 | 30 | 46 | 42 | 32 | | | 37 | 46 | 26 |
| 4 | TPM | 59.3 | 51.3 | 99.3 | 43.8 | 49.3 | 74.8 | 78.6 | 81.3 | 60.7 | 48.2 | 71.7 | 61.8 | 52.4 | 46.3 | 65.0 | 99.3 | 43.8 |
| | SPM | 23.3 | 21.4 | 47.9 | 21.4 | 24.7 | 31.2 | 35.6 | 34.8 | 24.7 | 26.4 | 35.2 | 29.2 | | | 29.6 | 47.9 | 21.4 |
| | S/T | 39 | 42 | 48 | 49 | 50 | 42 | 45 | 43 | 41 | 55 | 49 | 47 | | | 46 | 55 | 39 |
| 5 | TPM | 61.7 | 70.6 | 104.4 | 58.9 | 46.9 | 80.6 | 94.0 | 65.3 | 58.1 | 36.4 | 69.7 | 57.9 | 56.3 | 52.4 | 67.0 | 104.4 | 36.4 |
| | SPM | 17.6 | 19.3 | 36.1 | 15.1 | 19.3 | 22.1 | 25.2 | 20.8 | 17.2 | 17.8 | 28.1 | 21.7 | | | 21.7 | 36.1 | 15.1 |
| | S/T | 29 | 27 | 35 | 26 | 41 | 27 | 27 | 32 | 30 | 49 | 40 | 37 | | | 33 | 49 | 26 |
| 6 | TPM | 60.2 | 66.5 | 106.2 | 34.9 | 78.5 | 69.1 | 82.5 | 76.4 | 61.9 | 48.8 | 79.4 | 48.5 | 66.0 | 59.6? | 67.7 | 106.2 | 34.9 |
| | SPM | 24.6 | 31.4 | 46.1 | 19.8 | 27.2 | 21.0 | 38.4 | 28.1 | 24.6 | 25.6 | 40.5 | 19.2 | | | 28.9 | 46.1 | 19.2 |
| | S/T | 41 | 47 | 43 | 57 | 35 | 30 | 47 | 37 | 40 | 52 | 51 | 40 | | | 43 | 57 | 30 |
| 7 | TPM | 125.6 | 130.3 | 291.8 | 102.5 | 132.3 | 173.6 | 181.5 | 148.3 | 132.1 | 99.3 | 107.6 | 124.4 | 122.4 | 135.4 | 145.8 | 291.8 | 99.3 |
| | SPM | 50.1 | 54.9 | 70.1 | 41.9 | 53.7 | 64.2 | 66.4 | 60.7 | 46.8 | 44.6 | 59.3 | 51.7 | | | 55.4 | 70.1 | 41.9 |
| | S/T | 40 | 42 | 24 | 41 | 41 | 37 | 37 | 41 | 35 | 45 | 55 | 42 | | | 40 | 55 | 24 |
| 8 | TPM | 123.4 | 112.8 | 110.4 | 39.4 | 99.1 | 104.3 | 108.4 | 134.6 | 101.7 | 68.0 | 51.0 | 48.0 | 65.1 | 58.7 | 91.8 | 134.6 | 39.4 |
| | SPM | 48.4 | 49.0 | 50.6 | 19.2 | 40.8 | 47.9 | 61.2 | 53.0 | 51.3 | 39.9 | 27.9 | 24.1 | | | 42.8 | 61.2 | 19.2 |
| | S/T | 39 | 43 | 46 | 49 | 41 | 46 | 56 | 39 | 50 | 59 | 55 | 50 | | | 48 | 59 | 39 |
| 9 | TPM | 105.1 | 84.2 | 111.7 | 62.0 | 101.9 | 128.6 | 129.9 | 116.1 | 122.4 | 67.3 | 79.2 | 114.7 | 104.7 | 84.0 | 101.9 | 129.9 | 62.0 |
| | SPM | 40.5 | 38.3 | 48.7 | 28.5 | 33.5 | 47.3 | 60.1 | 42.5 | 42.5 | 36.6 | 37.7 | 49.2 | | | 42.1 | 60.1 | 28.5 |
| | S/T | 39 | 45 | 44 | 46 | 33 | 37 | 46 | 37 | 35 | 54 | 48 | 43 | | | 42 | 54 | 33 |
| 10 | TPM | 49.7 | 36.4 | 82.7 | 56.1 | 39.7 | 47.6 | 51.9 | 55.8 | 56.2 | 48.3 | 74.9 | 51.7 | 37.3 | 32.4 | 54.2 | 82.7 | 36.4 |
| | SPM | 21.4 | 26.6 | 47.7 | 31.6 | 21.3 | 23.8 | 25.3 | 27.4 | 30.0 | 28.7 | 40.2 | 16.4 | | | 28.4 | 47.7 | 16.4 |
| | S/T | 43 | 73 | 58 | 56 | 54 | 50 | 49 | 49 | 53 | 59 | 54 | 32 | | | 53 | 73 | 32 |
| 11 | TPM | 110.5 | 121.2 | 101.5 | 83.9 | 74.1 | 76.1 | 111.2 | 117.3 | 117.5 | 85.4 | 73.9 | 92.7 | 71.1 | 73.4 | 97.1 | 121.2 | 73.9 |
| | SPM | 44.1 | 47.6 | 53.9 | 46.1 | 39.7 | 41.1 | 66.3 | 50.0 | 54.8 | 52.0 | 42.0 | 50.1 | | | 49.0 | 66.3 | 39.7 |
| | S/T | 40 | 39 | 53 | 55 | 54 | 54 | 60 | 43 | 47 | 61 | 57 | 54 | | | 51 | 61 | 39 |
| 12 | TPM | 57.9 | 48.4 | 100.2 | 46.0 | 48.6 | 61.1 | 65.1 | 69.0 | 116.6? | 31.3 | 50.1 | 44.5 | 45.1 | 45.5 | 56.6 | 100.2 | 31.3 |
| | SPM | 17.4 | 18.4 | 29.1 | 20.8 | 20.8 | 25.5 | 26.4 | 20.3 | 26.8? | 15.2 | 17.4 | 13.7 | | | 20.5 | 29.1 | 13.7 |
| | S/T | 30 | 38 | 29 | 45 | 43 | 42 | 41 | 29 | 23? | 49 | 35 | 31 | | | 37 | 49 | 29 |
| 13 | TPM | 47.9 | 56.2 | 72.7 | 47.4 | 88.8 | 58.0 | 68.3 | 56.7 | 62.9 | 43.4 | 74.5? | 42.3 | 53.1 | 44.0 | 58.6 | 88.8 | 42.3 |
| | SPM | 19.2 | 23.5 | 37.3 | 23.8 | 49.1 | 31.4 | 35.1 | 21.0 | 24.0 | 24.3 | 24.4 | 21.8 | | | 27.9 | 49.1 | 19.2 |
| | S/T | 40 | 42 | 51 | 50 | 55 | 54 | 51 | 37 | 38 | 56 | 33? | 52 | | | 48 | 56 | 37 |
| 14 | TPM | 53.2 | 57.9 | 95.5 | 60.1 | 57.0 | 57.5 | 76.4 | 68.1 | 67.7 | 47.5 | 58.7 | 56.1 | 42.8 | 36.4 | 63.0 | 95.5 | 47.5 |
| | SPM | 27.0 | 25.7 | 49.6 | 35.2 | 31.7 | 33.8 | 38.1 | 28.6 | 31.2 | 28.4 | 15.9 | 27.5 | | | 31.1 | 49.6 | 15.9 |
| | S/T | 51 | 44 | 52 | 59 | 56 | 59 | 50 | 42 | 46 | 60 | 27 | 49 | | | 50 | 60 | 27 |
| 15 | TPM | 37.6 | 37.2 | 57.1 | 36.8 | 29.4 | 40.6 | 41.9 | 44.9 | 44.8 | 25.1 | 36.1 | 22.3 | 21.0 | 20.2 | 37.8 | 57.1 | 22.3 |
| | SPM | 12.9 | 13.8 | 26.9 | 19.1 | 17.1 | 16.4 | 18.4 | 14.5 | 13.7 | 15.6 | 15.5 | 10.6 | | | 16.2 | 26.9 | 10.6 |
| | S/T | 34 | 37 | 47 | 52 | 58 | 40 | 44 | 32 | 31 | 62 | 43 | 48 | | | 44 | 62 | 31 |
| 16 | TPM | 90.6 | 81.8 | 109.9 | 70.1 | 70.3 | 78.4 | 102.0 | 95.7 | 95.7 | 67.5 | 75.2 | 87.1 | 67.9 | 55.5 | 85.4 | 109.9 | 67.5 |
| | SPM | 29.8 | 28.3 | 51.3 | 29.3 | 30.3 | 31.0 | 42.4 | 32.8 | 36.3 | 33.1 | 33.5 | 38.6 | | | 34.7 | 51.3 | 28.3 |
| | S/T | 33 | 35 | 47 | 42 | 43 | 40 | 42 | 34 | 38 | 49 | 45 | 44 | | | 41 | 49 | 33 |
| 17 | TPM | 54.6 | 64.6 | 111.8 | 57.7 | 50.5 | 51.4 | 71.1 | 71.3 | 75.2 | 56.4 | 73.2 | 68.7 | 40.0 | 36.5 | 67.2 | 111.8 | 50.5 |
| | SPM | 24.7 | 33.6 | 55.8 | 34.9 | 31.4 | 31.8 | 44.1 | 35.0 | 30.5 | 36.8 | 39.2 | 42.4 | | | 36.7 | 55.8 | 24.7 |
| | S/T | 45 | 52 | 50 | 60 | 62 | 62 | 62 | 49 | 41 | 65 | 54 | 62 | | | 55 | 65 | 41 |
| 18 | TPM | 59.9 | 49.3 | 72.2 | 66.3 | 44.6 | 52.4 | 70.2 | 71.2 | 59.8 | 49.0 | 51.7 | 66.1 | 42.0 | 37.9 | 59.4 | 72.2 | 44.6 |
| | SPM | 26.9 | 19.6 | 34.3 | 29.0 | 22.0 | 24.8 | 34.2 | 31.1 | 27.3 | 26.5 | 22.5 | 29.5 | | | 27.3 | 34.3 | 19.6 |
| | S/T | 45 | 40 | 48 | 44 | 49 | 47 | 49 | 44 | 46 | 54 | 44 | 45 | | | 46 | 54 | 40 |
| 19 | TPM | 54.1 | 55.0 | 95.5 | 58.1 | 50.8 | 50.2 | 66.2 | 64.5 | 61.0 | 46.1 | 57.4 | 49.4 | 41.7 | 29.0 | 59.0 | 95.5 | 46.1 |
| | SPM | 22.9 | 25.3 | 46.0 | 33.0 | 29.0 | 28.6 | 33.9 | 25.6 | 28.6 | 27.5 | 29.7 | 24.2 | | | 29.5 | 46.0 | 22.9 |
| | S/T | 42 | 46 | 48 | 57 | 57 | 57 | 51 | 40 | 47 | 60 | 52 | 49 | | | 51 | 60 | 40 |
| 20 | TPM | 77.8 | 76.2 | 96.9 | 98.4 | 70.9 | 67.1 | 88.3 | 82.5 | 95.6 | 40.0 | 56.6 | 132.1 | 56.7 | 61.8 | 81.9 | 132.1 | 40.0 |
| | SPM | 19.1 | 22.3 | 38.9 | 30.1 | 21.6 | 25.3 | 28.6 | 21.6 | 21.6 | 17.8 | 18.8 | 26.3 | | | 24.3 | 38.9 | 17.8 |
| | S/T | 25 | 29 | 40 | 31 | 30 | 38 | 32 | 26 | 23 | 45 | 33 | 20 | | | 31 | 45 | 20 |

## Table III-3-20-(4) Results of monitoring of TPM and SPM by high volume sampler (4th Field Survey)

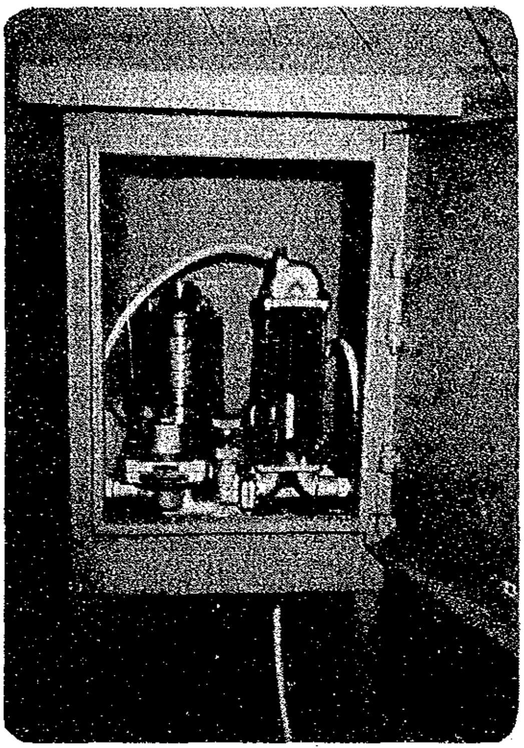
| | | DATE OF MEASUREMENT (1984/ 9) | | | | | | | | | | | | | | ----12 DAYS---- | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 13-14 | 14-15 | 15-16 | 16-17 | 17-18 | 18-19 | 19-20 | 20-21 | 21-22 | 22-23 | 23-24 | 24-25 | 25-26 | 26-27 | MEAN | MAX | MIN |
| 1 | TPM | 66.1 | 74.6 | 75.2 | 59.5 | 102.7 | 45.0 | 69.5 | 71.3 | 45.5 | 55.5 | 44.6 | 45.9 | 56.9 | 41.1 | 62.9 | 102.7 | 44.6 |
| | SPM | 33.7 | 35.6 | 40.9 | 38.5 | 68.9 | 22.4 | 37.2 | 41.1 | 20.7 | 31.6 | 23.2 | 21.9 | | | 34.6 | 68.9 | 20.7 |
| | S/T | 51 | 48 | 54 | 65 | 67 | 50 | 54 | 58 | 45 | 57 | 52 | 48 | | | 54 | 67 | 45 |
| 2 | TPM | 43.9 | 52.8 | 56.8 | 55.3 | 66.2 | 27.1 | 45.9 | 48.5 | 31.5 | 25.0 | 30.7 | 25.4 | 44.2 | 42.8 | 42.4 | 66.2 | 25.0 |
| | SPM | 23.8 | 29.3 | 29.1 | 42.2 | 44.5 | 15.6 | 27.5 | 29.6 | 15.0 | 13.9 | 16.2 | 5.8? | | | 26.1 | 44.5 | 13.9 |
| | S/T | 54 | 55 | 51 | 76 | 67 | 58 | 60 | 61 | 48 | 56 | 53 | 23? | | | 58 | 76 | 48 |
| 3 | TPM | 55.5 | 93.6 | 98.8 | 96.4 | 87.0 | 56.2 | 70.6 | 63.8 | 52.9 | 76.9 | 63.7 | 70.3 | 94.2 | 76.0 | 73.8 | 98.8 | 52.9 |
| | SPM | 25.0 | 35.8 | 37.4 | 54.4 | 54.6 | 22.1 | 41.7 | 34.7 | 25.6 | 29.7 | 19.1 | 15.7 | | | 33.0 | 54.6 | 15.7 |
| | S/T | 45 | 38 | 38 | 56 | 63 | 39 | 59 | 54 | 48 | 39 | 30 | 22 | | | 44 | 63 | 22 |
| 4 | TPM | 49.9 | 58.4 | 60.8 | 60.3 | 96.4 | 60.9 | 94.7 | 57.1 | 32.3 | 50.9 | 45.0 | 59.7 | 82.0 | 81.8 | 60.5 | 96.4 | 32.3 |
| | SPM | 28.9 | 31.2 | 31.7 | 37.4 | 62.6 | 33.3 | 61.6 | 36.0 | 16.9 | 31.9 | 27.1 | 33.7 | | | 36.0 | 62.6 | 16.9 |
| | S/T | 58 | 53 | 52 | 62 | 65 | 55 | 65 | 63 | 52 | 63 | 60 | 56 | | | 59 | 65 | 52 |
| 5 | TPM | 63.2 | 78.7 | 68.7 | 84.5 | 105.0 | 64.6 | 92.8 | 64.0 | 56.9 | 48.3 | 56.3 | 80.5 | 85.2 | 93.6 | 72.0 | 105.0 | 48.3 |
| | SPM | 26.6 | 35.1 | 32.3 | 36.8 | 60.1 | 21.6 | 50.5 | 33.1 | 18.8 | 19.1 | 22.5 | 17.1 | | | 31.1 | 60.1 | 17.1 |
| | S/T | 42 | 45 | 47 | 44 | 57 | 33 | 54 | 52 | 33 | 40 | 40 | 21 | | | 42 | 57 | 21 |
| 6 | TPM | 45.3 | 58.4 | 63.5 | 62.5 | 78.5 | 53.5 | 89.8 | 61.5 | 16.7 | 49.3 | 42.0 | 63.0 | 64.2 | 45.5 | 57.0 | 89.8 | 16.7 |
| | SPM | 21.5 | 22.8 | 22.1 | 28.2 | 45.8 | 25.0 | 49.5 | 33.1 | 6.8 | 25.8 | 21.2 | 22.6 | | | 27.0 | 49.5 | 6.8 |
| | S/T | 47 | 39 | 35 | 45 | 58 | 47 | 55 | 54 | 41 | 52 | 50 | 36 | | | 47 | 58 | 35 |
| 7 | TPM | 116.8 | 137.9 | 174.5 | 110.3 | 163.7 | 144.7 | 181.1 | 143.4 | 122.7 | 139.8 | 119.1 | 200.4 | 215.5 | 173.1 | 146.2 | 200.4 | 110.3 |
| | SPM | 40.2 | 44.4 | 65.0 | 49.9 | 68.6 | 51.9 | 64.8 | 53.9 | 39.6 | 52.4 | 38.9 | 52.5 | | | 51.8 | 68.6 | 38.9 |
| | S/T | 34 | 32 | 37 | 45 | 42 | 36 | 36 | 38 | 32 | 37 | 33 | 26 | | | 36 | 45 | 26 |
| 8 | TPM | 45.1 | 40.7 | 50.1 | 66.6 | 75.5 | 73.6 | 102.5 | 94.6 | 28.3 | 73.4 | 60.0 | 95.1 | 100.6 | 82.8 | 67.1 | 102.5 | 28.3 |
| | SPM | 21.7 | 20.8 | 24.0 | 38.3 | 48.2 | 43.7 | 52.8 | 49.8 | 11.1 | 29.5 | 34.6 | 40.2 | | | 34.6 | 52.8 | 11.1 |
| | S/T | 48 | 51 | 48 | 58 | 64 | 59 | 52 | 53 | 39 | 40 | 58 | 42 | | | 51 | 64 | 39 |
| 9 | TPM | 82.5 | 71.4 | 101.1 | 65.6 | 112.4 | 107.5 | 117.3 | 118.9 | 60.3 | 83.4 | 64.8 | 110.1 | 117.6 | 86.8 | 91.3 | 118.9 | 60.3 |
| | SPM | 32.3 | 32.3 | 47.4 | 33.2 | 57.0 | 49.5 | 56.9 | 56.2 | 23.5 | 43.6 | 32.4 | 52.0 | | | 43.0 | 57.0 | 23.5 |
| | S/T | 39 | 45 | 47 | 51 | 51 | 46 | 49 | 47 | 39 | 52 | 50 | 47 | | | 47 | 52 | 39 |
| 10 | TPM | 52.0 | 51.8 | 48.7 | 47.7 | 61.6 | 48.1 | 56.6 | 44.0 | 41.1 | 34.7 | 31.3 | 32.9 | 42.5 | 37.7 | 45.9 | 61.6 | 31.3 |
| | SPM | 25.8 | 20.8 | 20.1 | 26.5 | 39.6 | 25.1 | 30.6 | 20.1 | 16.0 | 17.7 | 13.2 | 15.2 | | | 22.6 | 39.6 | 13.2 |
| | S/T | 50 | 40 | 41 | 56 | 64 | 52 | 54 | 46 | 39 | 51 | 42 | 46 | | | 48 | 64 | 39 |
| 11 | TPM | 79.3 | 66.4 | 72.8 | 66.1 | 86.6 | 101.9 | 83.4 | 87.0 | 60.0 | 79.0 | 65.5 | 89.8 | 137.8 | 59.7 | 78.1 | 101.9 | 60.0 |
| | SPM | 34.1 | 31.5 | 31.7 | 35.8 | 52.5 | 53.0 | 43.3 | 45.3 | 33.6 | 40.6 | 28.4 | 43.1 | | | 39.4 | 53.0 | 28.4 |
| | S/T | 43 | 47 | 44 | 54 | 61 | 52 | 52 | 52 | 56 | 51 | 43 | 48 | | | 50 | 61 | 43 |
| 12 | TPM | 56.7 | 77.0 | 69.9 | 60.4 | 79.3 | 44.7 | 64.1 | 79.2 | 59.8 | 48.8 | 42.8 | 48.0 | 55.5 | 78.1 | 60.9 | 79.3 | 42.8 |
| | SPM | 24.4 | 31.1 | 30.1 | 34.3 | 41.6 | 18.3 | 33.2 | 34.3 | 23.3 | 17.7 | 18.0 | 18.2 | | | 27.0 | 41.6 | 17.7 |
| | S/T | 43 | 40 | 43 | 57 | 52 | 41 | 52 | 43 | 39 | 36 | 42 | 38 | | | 44 | 57 | 36 |
| 13 | TPM | 53.3 | 58.7 | 54.5 | 60.1 | 70.4 | 49.9 | 54.4 | 60.8 | 66.6 | 41.9 | 43.8 | 53.6 | 121.4 | 40.4 | 55.7 | 70.4 | 41.9 |
| | SPM | 29.7 | 31.2 | 25.8 | 36.4 | 49.0 | 31.0 | 32.5 | 36.6 | 36.5 | 23.5 | 22.6 | 27.9 | | | 31.9 | 49.0 | 22.6 |
| | S/T | 56 | 53 | 47 | 61 | 70 | 62 | 60 | 60 | 55 | 56 | 52 | 52 | | | 57 | 70 | 47 |
| 14 | TPM | 53.7 | 67.2 | 63.3 | 72.8 | 78.6 | 50.5 | 72.5 | 67.3 | 58.0 | 45.3 | 49.8? | 47.9? | 65.6 | 63.7 | 62.9 | 78.6 | 45.3 |
| | SPM | 27.7 | 35.7 | 31.7 | 42.9 | 49.9 | 25.3 | 43.4 | 36.3 | 31.0 | 23.5 | 15.0? | 22.1? | | | 34.7 | 49.9 | 23.5 |
| | S/T | 52 | 53 | 50 | 59 | 63 | 50 | 60 | 54 | 53 | 52 | 30? | 46? | | | 55 | 63 | 50 |
| 15 | TPM | 28.7 | 46.8 | 50.7 | 49.6 | 62.2 | 29.6 | 46.2 | 50.2 | 42.9 | 42.5 | 77.3? | 44.4 | 40.4 | 228.1? | 44.9 | 62.2 | 28.7 |
| | SPM | 15.2 | 26.2 | 27.0 | 29.5 | 43.8 | 12.8 | 31.8 | 26.9 | 23.9 | 20.0 | 12.1 | 14.6 | | | 23.6 | 43.8 | 12.1 |
| | S/T | 53 | 56 | 53 | 59 | 70 | 43 | 69 | 54 | 56 | 47 | 16? | 33 | | | 54 | 70 | 33 |
| 16 | TPM | 65.2 | 71.7 | 69.4 | 74.0 | 96.7 | 81.2 | 88.7 | 92.5 | 60.1 | 70.6 | 65.9 | 79.1 | 94.1 | 66.3 | 76.3 | 96.7 | 60.1 |
| | SPM | 31.1 | 31.9 | 30.7 | 40.4 | 59.7 | 46.0 | 50.7 | 46.5 | 25.3 | 34.5 | 27.6 | 30.7 | | | 37.9 | 59.7 | 25.3 |
| | S/T | 48 | 44 | 44 | 55 | 62 | 57 | 57 | 50 | 42 | 49 | 42 | 39 | | | 49 | 62 | 39 |
| 17 | TPM | 50.6? | 75.5 | 86.7 | 89.9 | 112.1 | 158.5? | 104.6 | 78.8 | 66.7 | 72.0 | 61.2 | 69.6 | 107.7 | 59.7 | 81.7 | 112.1 | 61.2 |
| | SPM | 25.9? | 37.0 | 40.9 | 48.5 | 64.5 | 61.7? | 56.0 | 42.1 | 31.2 | 33.8 | 27.7 | 31.7 | | | 41.3 | 64.5 | 27.7 |
| | S/T | 51? | 49 | 47 | 54 | 58 | 39? | 54 | 53 | 47 | 47 | 45 | 46 | | | 50 | 58 | 45 |
| 18 | TPM | 52.2 | 83.3 | 80.9 | 77.6 | 93.7 | 62.8 | 78.8 | 87.6 | 80.0 | 79.7 | 54.7 | 54.3 | 74.2 | 96.0 | 73.8 | 93.7 | 52.2 |
| | SPM | 27.9 | 44.3 | 39.4 | 44.0 | 61.3 | 34.8 | 46.6 | 52.9 | 36.6 | 49.0 | 27.4 | 27.4 | | | 41.0 | 61.3 | 27.4 |
| | S/T | 53 | 53 | 49 | 57 | 65 | 55 | 59 | 60 | 46 | 61 | 50 | 50 | | | 55 | 65 | 46 |
| 19 | TPM | 47.1 | 81.1 | 72.4 | 73.2 | 87.4 | 38.1 | 77.5 | 65.4 | 64.2 | 50.0 | 48.4 | 35.8 | 98.3 | 48.4 | 61.7 | 87.4 | 35.8 |
| | SPM | 25.4 | 36.0 | 32.7 | 37.0 | 48.3 | 18.9 | 42.6 | 35.2 | 31.5 | 27.4 | 20.8 | 17.2 | | | 31.1 | 48.3 | 17.2 |
| | S/T | 54 | 44 | 45 | 51 | 55 | 50 | 55 | 54 | 49 | 55 | 43 | 48 | | | 50 | 55 | 43 |
| 20 | TPM | 65.2 | 120.9 | 76.5 | 76.1 | 102.0 | 66.7 | 67.2 | 78.9 | 100.7 | 58.6 | 45.5 | 55.2 | 107.2 | 58.3 | 76.1 | 120.9 | 45.5 |
| | SPM | 23.4 | 32.7 | 30.4 | 39.6 | 63.4 | 32.7 | 29.6 | 35.9 | 36.3 | 28.7 | 18.1 | 18.9 | | | 32.5 | 63.4 | 18.1 |
| | S/T | 36 | 27 | 40 | 52 | 62 | 49 | 44 | 46 | 36 | 49 | 40 | 34 | | | 43 | 62 | 27 |

## III-3-3 Monitoring of TPM Size Distribution by Andersen Sampler

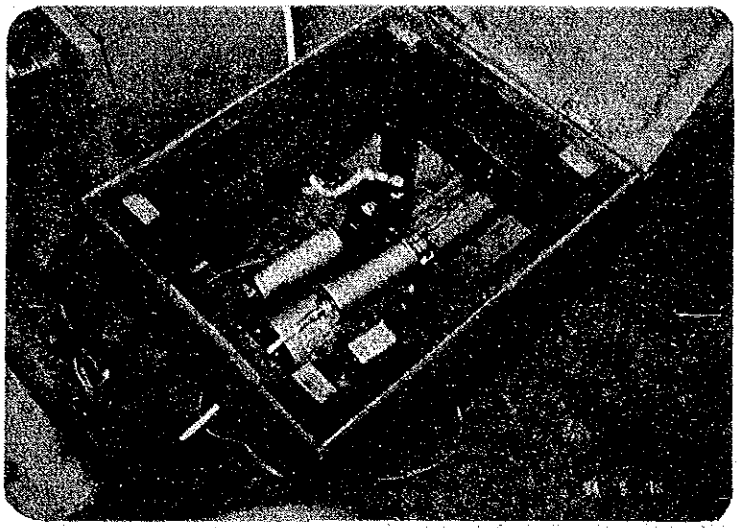
### III-3-3-1 Instrument and its handling methods

(1) Andersen sampler

Andersen sampler employed in this study is KORITSU KA-200 type which is equipped with multi-layer jet nozzles and designed to monitor size distribution of ambient particulate matter by impacter system. The sampler is composed by size classifying body, flow meter, pressure meter, pump and shelter, as shown in Picture III-3-7.



Picture III-3-7-(1) Classifier, flow meter, & pressure meter installed in shelter



Picture III-3-7-(2) Pump of Andersen sampler

The instrument is made of 8 layers stage rustless alminum alloy and each stage has 800, 400 and 200 numbers of jet nozzles and in the bottom of the stages, stainless steel round collector is installed. The diameters of the jet nozzles are designed to be smaller from the top to the bottom in order and so when the constant flow rate of air is sucked from the upper inlet, the jet air velocity is increasing in the lower stage. As shown in Fig. III-3-12, the larger size to smaller size particulates are collected by each stage in sequence by impacter system.

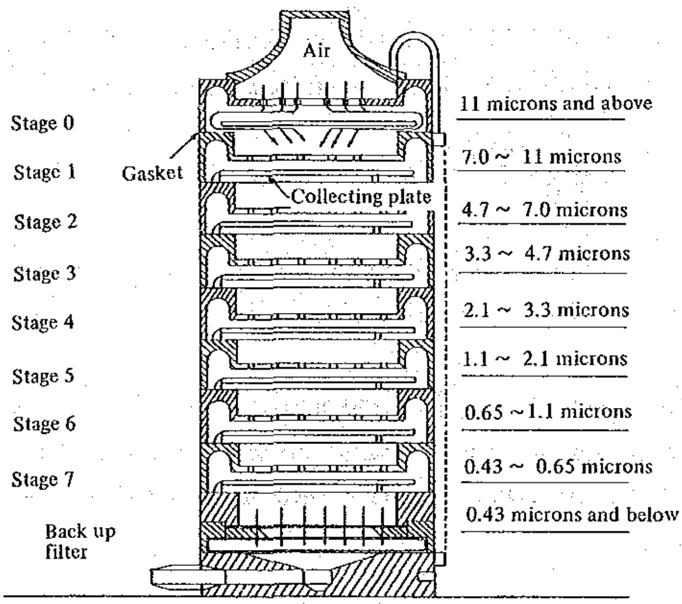



Fig. III-3-12 Structure of Andersen sampler

Generally the inertial impaction parameter of impacter is defined by the ratio of particulate size, flow velocity of particulate and section area of nozzle. By Ranz and Wong, the relation between them can be identified by the following equation.

$$\psi = \frac{C \cdot p \cdot Vc \cdot dp^2}{18\mu Dc}$$ Equation III-3-10

where;

C: Conningham slip correction factor = $1.00 + \frac{0.16 \times 10^{-4}}{dp}$

dp: size (cm) of particulate matter

$\mu$: air viscosity ($1.84 \times 10^{-4}$g/cm.sec)

p: density of particulate matter (g/cm$^3$)

Vc: air velocity passing through jet nozzles (cm/sec)

Dc: diameter of jet nozzle (cm)

$\psi$: none dimensional inertial impaction parameter (when impaction efficiency 50%, $\psi_{50}$=0.14)

When air sampling volume Q(cm$^3$/min), number of jet nozzles of the stage N, Vc is obtained by the following equation.

$$V_C = \frac{Q}{60\pi(D_C/2)^2 N}$$ Equation III-3-11

When Equation III-3-11 is substituted by Equation III-3-10, 50% dynamic particle size $dp_{50}$ can be obtained from the following equation.

$$dp_{50} = \sqrt{\frac{18\mu\psi_{50} N\pi \times 60 D_C^3}{4CQ}}$$ Equation III-3-12

Where, Q = 28,317 cm$^3$/min =28.3 l/min. And geometrical particle size is obtained as $\sqrt{dp^2/p}$.

By Equation III-3-12, the particle sizes of particulate matter collected at the respective stages are obtained and the categories or ranges of the particles are shown in Table III-3-21. And the collection efficiency by the size is shown in Fig. III-3-13.

Table III-3-21 50% cut-off values of each stage

| Stage | Nozzle diameter | Number of nozzle | Jet velocity | 50% cut-off value | Catalogue value |
|---|---|---|---|---|---|
| 0 | 1.18 mm | 800 | 0.54 $ms^{-1}$ | 10.0μm | 11.0μm |
| 1 | 1.18 | 400 | 1.07 | 7.0 | 7.0 |
| 2 | 0.91 | 400 | 1.85 | 4.7 | 4.7 |
| 3 | 0.71 | 400 | 2.98 | 3.3 | 3.3 |
| 4 | 0.53 | 400 | 5.34 | 2.1 | 2.1 |
| 5 | 0.34 | 400 | 13.0 | 1.03 | 1.1 |
| 6 | 0.25 | 400 | 24.0 | 0.62 | 0.65 |
| 7 | 0.25 | 200 | 48.0 | 0.42 | 0.43 |

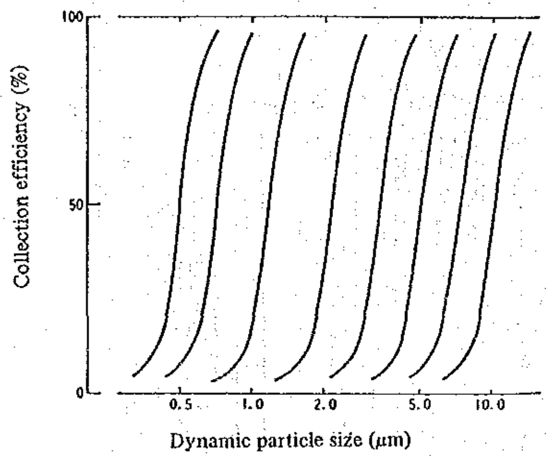
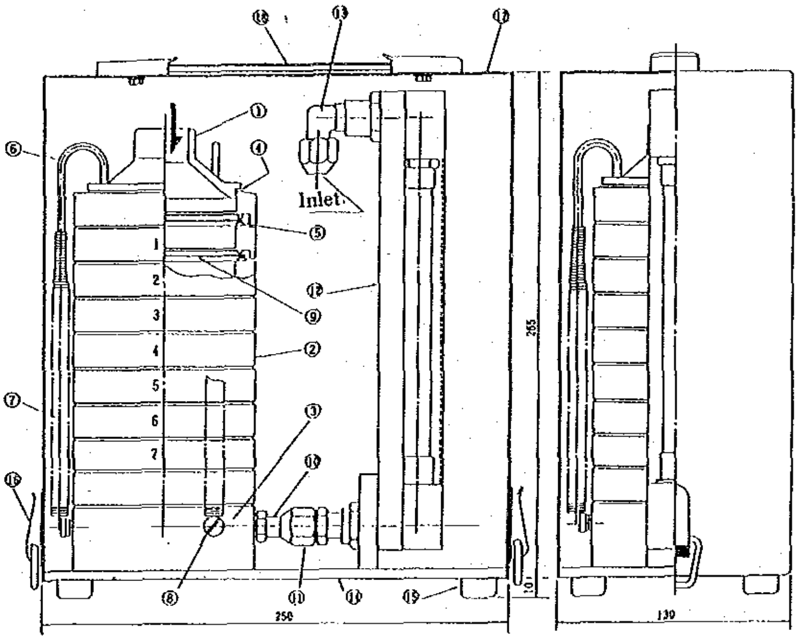



Fig. III-3-13 Classifying character of impacter

Table III-3-22 shows the specifications of Andersen sampler and Fig. III-3-14 shows outside view of Andersen sampler's main body.

Table III-3-22 Specifications of Andersen sampler

| | |
|---|---|
| Sampler main body: | 8 layer stages, size classifying sampler of suspended particulate matter |
| Pumping structure: | Rotary compressor, HITACHI<br>200 W RC - 20S type<br>Max. pressure 0.5 kg/cm$^2$<br>Constant pressure: 0.4 kg/cm$^2$<br>Air outlet volume: 55 Nl/min (constant pressure)<br>Output: 200 W<br>Voltage: 100 V |
| Connection: | Flow meter (float system)<br>Tokyo Keiki KK<br>Scale: 4 - 40 l/min<br>Elbow and Hitting: brass, nickel plated<br>Connecting tube: Nylon 11 3/8" (inner diameter) |




① Inlet nozzle
② Collecting stage
③ Stage installing rest
④ Ring (small)
⑤ Ring (large)
⑥ Tightening metal
⑦ Spring
⑧ Spring fixing screw
⑨ Collecting plate
⑩ Connector (a)
⑪ Connector (b)
⑫ Flow meter
⑬ Connector
⑭ Stand
⑮ Rubber stopper
⑯ Cover fixer
⑰ Case
⑱ Handle

Fig. III-3-14 Outside view of main body of Andersen sampler

The handling methods of Andersen sampler are as follows.

(a) Preparatory work

All the collecting plates of the respective stages are completely cleaned up and dried up. (In this study, super-sonic cleaner was employed as described later.)

Collection plates (Polyethylene sheet) and back-up filters are weighed previously.

(b) Handling of instruments

(i) Taking off the key of the bottom part of the case, and taking out the main body from the case, the flow meter is connected with the pump by tube.

(ii) The back-up filters are placed on the back-up holder.

(iii) Install collection plates on the classified stages. (Picture III-3-8)

(iv) Taking off the cover of air inlet located in the upper part of sampler, the power is switched on. Adjusting flow rate by valve of the pump, fix the rate at 28.3 l/min as previously calibrated rotar meter and pressure meter indicate.

(v) Patrolling 2 or 3 times a day, confirm the flow rate is keeping at exact 28.3 l/min. If not, adjust the rate by moving the valve of the pump.

(vi) After the monitoring is completed (in this study, about 12 days), the collection plates and back-up filters are kept in the air-conditioned room for desicating for about 24 hours. And they are weighed by the chemical balance which has the capacity and function weighing 0.01 mg.

(c) Maintenance

After the monitoring is completed, all the stages are cleaned by super sonic cleaner with the neutral detergent, and dried up. They are kept in the case.

Picture III-3-8 Setting collection plate in the stage

(2) Wet type gas meter

The wet type gas meter was employed for calibration of flow rate of rotar meter installed in Andersen sampler, and in this study, SHINAGAWA-KEIKI WE-10A type gas meter was used.

This instrument is designed as the air coming from the inlet introduced into the front chamber which reaches to the round shape drum through blowing tube. The drum is divided into 4 rooms inside and they are sealed by water. The air enters into the respective divided rooms in sequence and exhausted out. This motion is repeated and rotating movement to the arrow direction is generated. The air exhausting volume for one rotation is constant and so the numbers of rotation is transmitted to integration mechanism. Thus the integrated flow rate is measured. The specifications of the gas meter are shown in Table III-3-23 and Fig. III-3-16 shows the outside view of the gas meter.

At calibration of rotar meter, the wet type gas meter, rotar meter, pressure-meter and the pump were connected in series, and the calibration of scale readings of the rotar meter was conducted from integrated flow rate meter. (Refer to III-3-3-2, calculation of TPM concentration by Andersen sampler.)

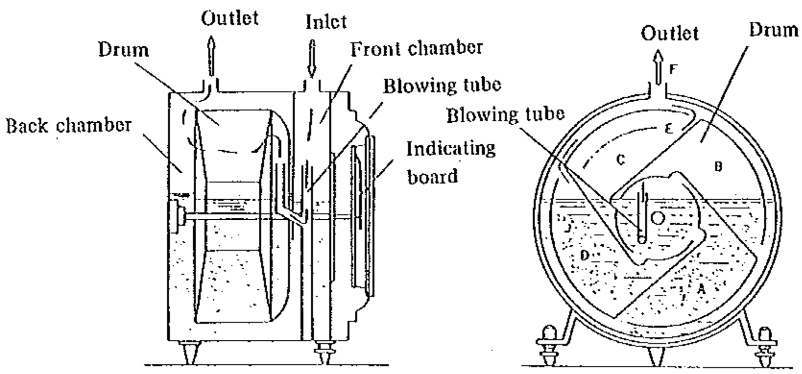



Fig. III-3-15 Mechanical structure of wet type gas meter

Table III-3-23 Specifications of wet-type gas meter

| | |
|---|---|
| Measuring range: | 20 - 6,000 l/h |
| Drum capacity: | 10 liter |
| Pressure loss: | under 15 mm $H_2O$ |
| Indicater board: | 1 rotation 10 liter, minimum reading 0.02<br>1 maximum integrating volume 9,999 $m^3$ |
| Maximum pressure: | 1,000 mm $H_2O$ |
| Pressure resistance: | 1,500 mm $H_2O$ |
| Tolerable temperature: | under 50°C |
| Weight: | Weight 37 kg, weight at operation 62 kg |

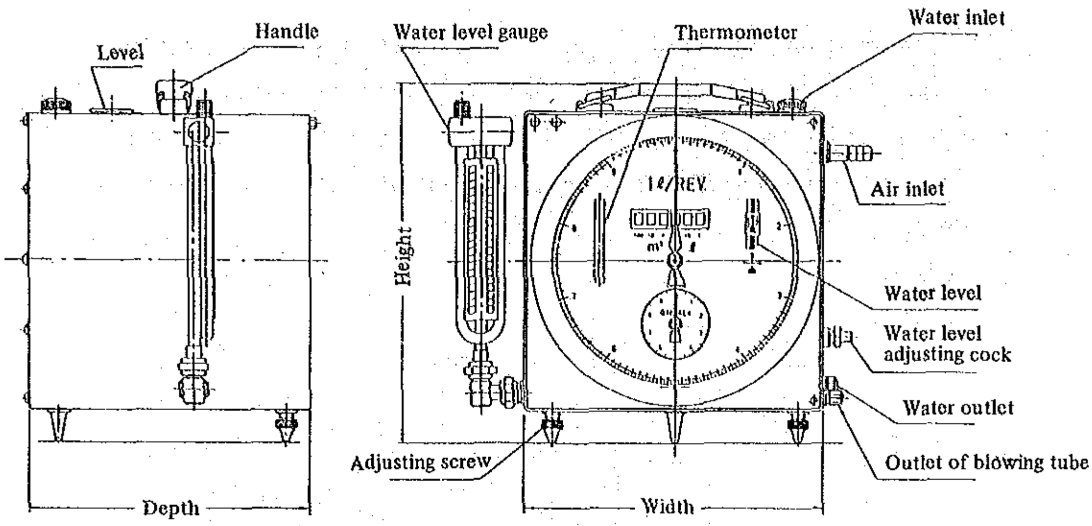



Fig. III-3-16 Outside view of wet type gas meter

The handling methods of the wet type gas meter are as follows;

(a) Installation

The wet type gas meter should be placed on the flat and stable (vibration free) table, and should be kept on exact level, using adjusting screw and level meter.

(b) Adjustment of water level

(i) Open the plug of water inlet located right back of the upper part of the meter, and pour the water about 2 mm above the water level indicater.

(ii) Confirmation of inside water of blowing tube
Take off the plug of outlet of blowing tube located in the right side of the meter, and confirm no water being inside the tube. If any water is inside the tube, the meter will not rotate and after confirming, close the plug.

(iii) Idle operation

Close the plug of water inlet, and connecting inlet tube, make idle operation for about 20 to 30 rotation.

After idle operation, keep the inside pressure at the atmospheric pressure, taking off the tubes of inlet and outlet. Then discharge water a little by little by water level adjusting cock located in the right side, and fix the water level at the center point of the level meter as shown in Fig. III-3-17.

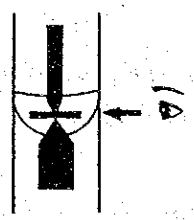


Fig. III-3-17 Adjustment of water level

(c) Leaking test

The inlet and outlet tubes are tightly connected for preventing any leakage, and the outlet is also closed. Then give pressure from the inlet and close. Confirm any fluctuation of water level guage.

(d) Measurement

Connect the tubes of inlet and outlet for measurement, and commence measurement after about 20 rotation of idle operation. When the difference of air and water temperature is found large, continue idle operation until the water temperature reaches to the same or near to air temperature.

(e) Discharging of water

After completing the measurement, the water contained in the instrument should be completely discharged, taking off the plug of water discharge located right back part. Confirm the complete discharging including the inside of the drum, by inclining the instrument backward.

(3) Super sonic cleaner

The super sonic cleaner was used for cleansing of classified stages collecting plates of Andersen sampler. In this study, Smithkline B-220 type super sonic cleaner was employed.

The super sonic cleaner is designed to generate high and low pressure waves in solution, produce numberless fine foams, and clean up all the contamination mechanically.

The Table III-3-24 shows the specifications of the super sonic cleaner and Fig. III-3-18 shows its outside view.

Table III-3-24 Specifications of super sonic cleaner

| | |
|---|---|
| Size of main body: | 355 x 191 x 229 mm |
| Size of solutiontub: | 229 x 127 x 100 mm |
| Super sonic output: | 100 W |
| Tub capacity: | 2.8 liter |
| Weight: | 3.5 kg |

Before operation, pour detergent solution into the tub, and put collecting plates of Andersen sampler using attached rack. It may take about 10 to 15 minutes to complete cleaning.

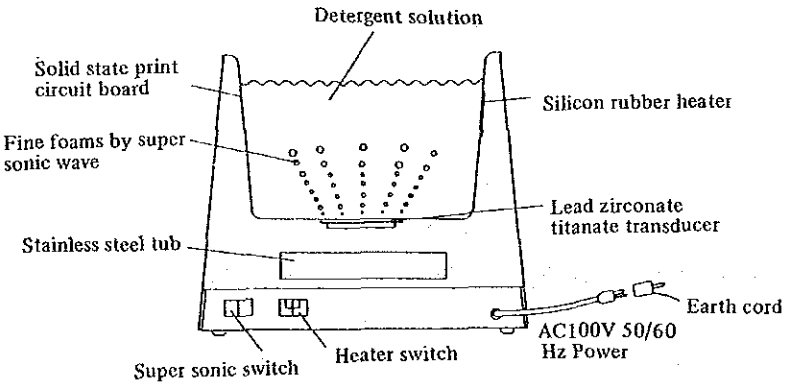



Fig. III-3-18 Outside view of super sonic cleaner

## III-3-3-2 Calculation of TPM concentration by size

### (1) Calibration of Andersen sampler

The rotar meter installed in Andersen sampler has been calibrated by wet type gas meter. The wet type gas meter, rotar meter, pressure meter and pump were connected in series as shown in Fig. III-3-19. For calibration, the pressure value indicated in pressure meter when flow rate of rotar meter is adjusted at 15, 20, 25, 30 l/min respectively are recorded. Also the time (sec) required 20 or 30 liter of flow of gas meter is measured. The results are shown in Table III-3-25, and Picture III-3-9 shows the calibration of Andersen sampler

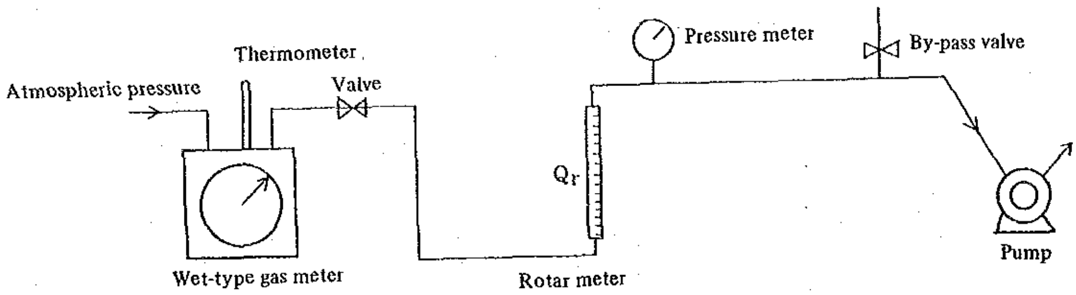
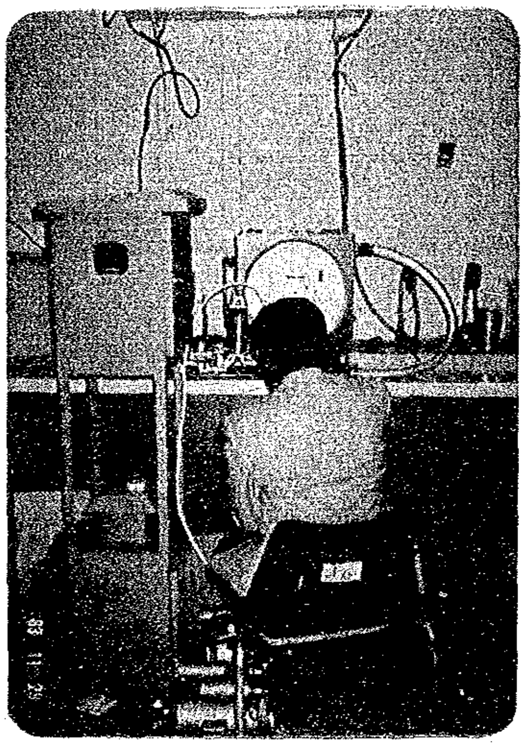



Fig. III-3-19 Calibration of rotar meter for Andersen sampler



Picture III-3-9 Calibration of Andersen sampler

# Table III-3-25 Calibration results of rotar meter for Andersen sampler

| Survey | MP No. | Rotar-M.No. | Rotar M. Reading (l/min) | Pressure (mmHg) | Air volume (l) | Time (sec) | Gas M. Temp (°C) |
|---|---|---|---|---|---|---|---|
| 1st Field Survey | MP1 | FB 0320 | 16.8 | 10.0 | 20.0 | 51.6 | 26.3 |
| | | | 20.0 | 15.0 | 20.0 | 42.4 | 26.3 |
| | | | 25.0 | 20.0 | 20.0 | 34.9 | 26.3 |
| | | | 30.0 | 28.0 | 30.0 | 44.5 | 26.3 |
| | | | | | | | |
| | MP2 | FB 0320 A | 17.0 | 5.0 | 20.0 | 51.7 | 26.5 |
| | | | 20.0 | 13.0 | 20.0 | 43.0 | 26.5 |
| | | | 25.0 | 20.0 | 20.0 | 35.9 | 26.5 |
| | | | 30.0 | 26.0 | 30.0 | 45.5 | 26.5 |
| | | | | | | | |
| | MP6 | FB 0320 B | 16.0 | 10.0 | 20.0 | 52.5 | 26.7 |
| | | | 20.0 | 14.0 | 20.0 | 43.2 | 26.7 |
| | | | 25.0 | 20.0 | 20.0 | 53.4 | 26.7 |
| | | | 30.0 | 28.0 | 30.0 | 44.8 | 26.7 |
| | | | | | | | |

| Survey | MP No. | Rotar-M.No. | Rotar M. Reading (l/min) | Pressure (mmHg) | Air volume (l) | Time (sec) | Gas M. Temp (°C) |
|---|---|---|---|---|---|---|---|
| 2nd Field Survey | MP1 | FB 0320 | 20.0 | 22.0 | 20.0 | 40.3 | 25.8 |
| | | | 25.0 | 35.0 | 20.0 | 32.6 | 25.8 |
| | | | 30.0 | 54.0 | 20.0 | 27.0 | 25.8 |
| | | | 35.0 | 72.0 | 20.0 | 23.4 | 25.8 |
| | | | 15.0 | 14.0 | 20.0 | 54.1 | 25.8 |
| | MP2 | FB 0320 A | 20.0 | 23.0 | 20.0 | 40.8 | 25.5 |
| | | | 25.0 | 35.0 | 20.0 | 33.2 | 25.5 |
| | | | 30.0 | 52.0 | 20.0 | 27.7 | 25.5 |
| | | | 35.0 | 72.0 | 20.0 | 23.8 | 25.5 |
| | | | 15.0 | 13.0 | 20.0 | 56.3 | 25.5 |
| | MP6 | FB 0320 B | 20.0 | 23.0 | 20.0 | 40.5 | 24.5 |
| | | | 25.0 | 33.0 | 20.0 | 33.3 | 24.5 |
| | | | 30.0 | 50.0 | 20.0 | 27.2 | 24.5 |
| | | | 35.0 | 75.0 | 20.0 | 23.3 | 24.5 |
| | | | 15.0 | 14.0 | 20.0 | 54.0 | 24.5 |

| Survey | MP No. | Rotar-M.No. | Rotar M. Reading (l/min) | Pressure (mmHg) | Air volume (l) | Time (sec) | Gas M. Temp (°C) |
|---|---|---|---|---|---|---|---|
| 3rd Field Survey | MP1 | FB 0320 | 15.0 | 15.0 | 20.0 | 53.2 | 24.5 |
| | | | 20.0 | 25.0 | 20.0 | 40.6 | 24.5 |
| | | | 25.0 | 38.0 | 20.0 | 32.6 | 24.5 |
| | | | 30.0 | 55.0 | 20.0 | 26.8 | 24.5 |
| | | | 35.0 | 73.0 | 20.0 | 23.7 | 24.5 |
| | MP2 | FB 0320 A | 15.0 | 15.0 | 20.0 | 55.9 | 24.5 |
| | | | 20.0 | 25.0 | 20.0 | 41.2 | 24.5 |
| | | | 25.0 | 35.0 | 20.0 | 33.5 | 24.5 |
| | | | 30.0 | 52.0 | 20.0 | 28.3 | 24.5 |
| | | | 35.0 | 70.0 | 20.0 | 24.4 | 24.5 |
| | MP6 | FB 0320 B | 15.0 | 17.0 | 20.0 | 54.7 | 24.5 |
| | | | 20.0 | 26.0 | 20.0 | 40.8 | 24.5 |
| | | | 25.0 | 40.0 | 20.0 | 33.2 | 24.5 |
| | | | 30.0 | 60.0 | 20.0 | 27.0 | 24.5 |
| | | | 35.0 | 80.0 | 20.0 | 23.3 | 24.5 |

| Survey | MP No. | Rotar-M.No. | Rotar M. Reading (l/min) | Pressure (mmHg) | Air volume (l) | Time (sec) | Gas M. Temp (°C) |
|---|---|---|---|---|---|---|---|
| 4th Field Survey | MP1 | FB 0320 | 16.0 | 15.0 | 20.0 | 50.9 | 27.0 |
| | | | 20.0 | 22.5 | 20.0 | 40.0 | 27.0 |
| | | | 25.0 | 34.0 | 20.0 | 32.3 | 27.0 |
| | | | 28.4 | 43.0 | 20.0 | 28.7 | 27.0 |
| | | | | | | | |
| | MP2 | FB 0320 A | 16.2 | 15.0 | 20.0 | 51.0 | 27.0 |
| | | | 20.0 | 23.0 | 20.0 | 41.3 | 26.8 |
| | | | 25.0 | 35.5 | 20.0 | 32.7 | 26.7 |
| | | | 30.0 | 49.5 | 20.0 | 27.7 | 26.7 |
| | | | | | | | |
| | MP6 | FB 0320 B | 15.9 | 18.0 | 20.0 | 51.3 | 26.6 |
| | | | 20.0 | 25.8 | 20.0 | 41.0 | 26.6 |
| | | | 25.0 | 36.0 | 20.0 | 32.8 | 26.5 |
| | | | 30.0 | 54.5 | 20.0 | 27.1 | 26.5 |
| | | | | | | | |

Following the above described, the flow rate calculated from time required by gas meter has been corrected into the flow rate at the designed condition (20°C) of rotar meter by the following Equation III-3-13.

$$Qg^{\circ} = \frac{273 + T_0}{273 + \text{Temp}} \times \nu \times \frac{60}{t} \qquad \text{Equation III-3-13}$$

where;

| | |
|---|---|
| $Q_g^o$: | gas meter flow rate at 20°C (l/min) |
| Temp: | gas meter temperature at calibration (°C) |
| To: | rotar meter designed temperature (20°C) |
| $\nu$: | measured air volume of gas meter (liter) |
| t: | time required for measured air flow (sec) |

Further, the flow rate $Q_r^o$ converted from reading value of rotar meter $Q_r$ into the one based on the designed condition of rotar meter is obtained by the following Equation III-3-14.

$$Q_r^{\circ} = Q_r \times \sqrt{\frac{273 + T_0}{273 + \text{Temp}}} \times \sqrt{\frac{760 - \Delta P}{P_0}} \qquad \text{Equation III-3-14}$$

where;

| | |
|---|---|
| $Q_r^o$: | flow rate of rotar meter at 20°C (l/min) |
| $Q_r$: | reading value of rotar meter (l/min) |
| $P_o$: | designed pressure of rotar meter (723 mmHg) |
| $\Delta$ P: | reading value of pressure meter (mmHg) |
| To: | designed temperature of rotar meter (20°C) |
| Temp: | temperature at calibration (°C) |

The relation between $Q_g^o$ flow rate of gas meter calculated by Equation III-3-13 and $Q_r^o$ flow rate of rotar meter calculated by Equation III-3-14 are applied to following Equation III-3-15.

$$Q_g^o = a(Q_r^o)^3 + b(Q_r^o)^2\ c(Q_r^o) + d \qquad \text{Equation III-3-15}$$

In the above equation, a, b, c and d are regression coefficient. An example of calculation by above equation is shown in Table III-3-26 and Fig. III-3-20. (All the results are shown in the part of reference.)

Table III-3-26 An example of relation between flow rate of wet type gas meter and rotar meter

1983 12 ROTOR NO. FB0320 TO= 20.0°C PO=723.MMHG

| | ROTOR METER (L/MIN) | PRESSURE DIF (MMHG) | AIR VOL. (L) | LAPSE TIME (SEC.) | TEMP. (°C) | FLOW RATE BY ROTUR (L/MIN) | FLOW RATE BY GAS METER (L/MIN) |
|---|---|---|---|---|---|---|---|
| 1 | 16.8 | 10.0 | 20.0 | 51.60 | 25.3 | 22.77 | 16.95 |
| 2 | 20.0 | 15.0 | 20.0 | 42.40 | 26.3 | 27.71 | 20.09 |
| 3 | 25.0 | 20.0 | 20.0 | 34.90 | 26.3 | 33.66 | 25.02 |
| 4 | 30.0 | 28.0 | 30.0 | 44.50 | 26.3 | 39.60 | 29.87 |

| A0 | A1 | A2 | A3 |
|---|---|---|---|
| -0.4987175296E 02 | 0.7821684608E 01 | -0.2700842560E 00 | 0.3632767008E-02 |

Y = A0 + A1 * X + A2 * X**2 + A3 * X**3

MULTI. CORR.= 1.0000
STD. ERROR = 0.00

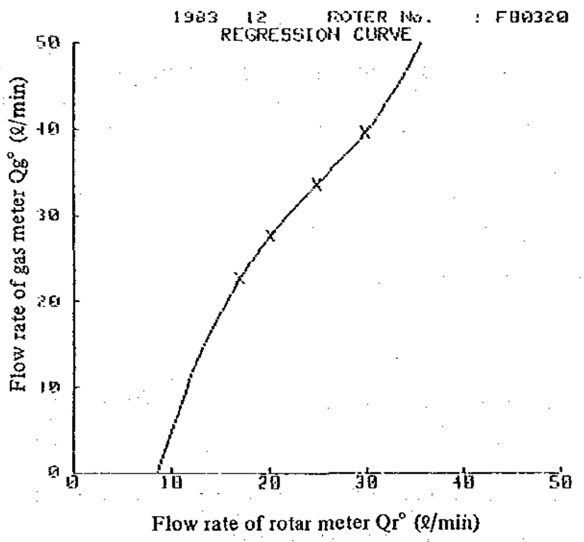



Fig. III-3-20 An example of relation of flow rate of gas meter and rotar meter under designed conditions

(2) Air sucking volume by Andersen sampler

Monitoring period of particulate matter by Andersen sampler was 12 days in each field survey, and during the period, patrols have been carried out two times a day and recorded the reading values of rotar meter and pressure loss of pressure meter.

At patrols, from the pressure meter readings, the designed flow rate (position of rotar meter, $Q_r$) was calculated which corresponds to real flow rate 28.3 l/min, and by adjusting valve of pump bypass, fix the rotar meter at the above calculated value. Thus the flow rate, $Q_r$, is adjusted but the pressure loss is also changed accordingly. So the procedures of recalculation of the proposed flow rate are repeated. Then the reading value of the rotar meter and pressure meter were recorded on the form shown in Table III-3-2.

The total air sucking volume of Andersen sampler was calculated by obtaining air sucking volume $R_i$ between (i-1) patrol to (i) patrol, and these volume were collected and summed up to obtain the total air sucking volume of the period.

In the first place, the flow rate of rotar meter before and after the adjustment at patrols was corrected into the flow rate of rotar meter at the designed conditions (20°C, 723 mmHg) by Equations III-3-16 and III-3-17.

$$QR^{o}_{a\,i-1} = \sqrt{\frac{760 - \Delta P_{a\,i-1}}{P_0}} \times \sqrt{\frac{273 + T_0}{273 + Temp}} \times Qr_{a\,i-1}$$ Equation III-3-16

$$QR^{o}_{b\,i} = \sqrt{\frac{760 - \Delta P_{b\,i}}{P_0}} \times \sqrt{\frac{273 + T_0}{273 + Temp}} \times Qr_{b\,i}$$ Equation III-3-17

where;

| | |
|---|---|
| $QR^{o}_{a}i\text{-}1$: | designed condition flow rate after adjusted at (i-1) patrol (l/min) |
| $QR^{o}_{b}i$: | designed condition flow rate before adjusted at (i) patrol (l/min) |
| $Qr_{a}i\text{-}1$: | rotar meter reading value after adjustment at (i-1) patrol (l/min) |
| $Qr_{b}i$: | rotar meter reading value before adjustment at (i) patrol (l/min) |
| To: | designed condition temperature of rotar meter (20°C) |
| Po: | designed pressure of rotar meter (723 mmHg) |
| Temp: | temperature at monitoring (average temperature during 9:00 a.m. to 9:00 a.m. of the next day)(°C) |
| ΔPai-1: | reading value of pressure meter after adjustment at (i-1) patrol (mmHg) |
| ΔPbi: | reading value of pressure meter before adjustment at (i) patrol (mmHg) |