3. Sampling of Ambient Air

Increased measurement accuracy is required for the air pollutants that cause acid rain such as sulfur dioxide, nitrogen oxides and photochemical oxidants, in order to achieve international consistency and global evaluations of concentration. As fluctuations in the flow rate have a significant effect on measurement accuracy when air is sampled, in particular, measurement accuracy has recently been improved through use of electric flow controllers such as mass flowmeters as well as the existing float flowmeter. Thus, general points to note when planning and carrying out sampling are described as follows.

3.1 Survey Plan

Normally, we need data on the relationship between pollutant concentration in ambient air and that at the emission source to survey environmental pollution. Air pollution concentration fluctuates in accordance with changes in the weather and emission sources, and the surveyed data also changes depending on the measurement device and person. It goes without saying that there should be minimal difference in data caused by measurement method. Measured data is significantly affected by the surrounding circumstances at the sampling site and changes in the weather, so a survey plan must be drawn up bearing such points in mind.

3.1.1 Selection of measurement point

Air pollutant concentration differs depending on the location and time. The measured value of each point must be representative of the peripheral air quality. However, pollutant concentration at each measurement point changes in accordance with the existence of local pollution sources, the peripheral natural environment (i.e. hills, trees, ponds, marshes) and the existence of manmade structures such as buildings and roads, and the height of the measurement point. Thus, measurement points should be representative of the area to minimize complications arising from the landscape and buildings, etc.

3.1.2 Installation height

Installment 1.5~2m above the ground is preferable when one considers the effect of air pollution on the human body and the area in which people are most active. However, the effects of buildings and suchlike that exist at this level should be minimized as much as possible in towns crowded with buildings because the data may not be representative of the degree of pollution in the local area when the survey site is set up at ground level, as opposed to a flat site.

The air temperature should be measured at 1.2~1.5m, and wind velocity should be measured 6~10 m above the ground for weather observations. When gaseous pollutants are measured, follow the same procedure for air temperature measurements unless there is particularly strong gas adsorption on the ground. When high volume air samplers are used to measure particulate matter, dust fly up from the ground must be born in mind as well. Its installation must carefully be considered, especially when measurements are conducted on dry ground.

3.2 Flow Rate for Measurement of Ambient Air

3.2.1 Mass transfer measurement

Sampling the flow rate is most important when the pollutant concentration in the sampled air is measured using an automatic air-measuring instrument. Sampling involves the collection of targeted matter, while the sampling flow rate is required to obtain the transfer volume of the matter to be measured. Thus, when sampling is carried out, transfer volume of the targeted matter is obtained as dynamic or static flow rates using the sampling rate, collecting rate, and diffusion rate, etc.

3.2.2 Dynamic flow rate

Sampling flow rate can be obtained by the dynamic method using suction pumps, etc.

3.2.3 Static flow rate

When the vapor diffusion method for standard gas generation and molecular diffusion method for air sampling are adopted without using power such as a suction pump, mass transfer is obtained by the static method.

3.3 Flow Rate Measuring Instrument and Sampling Gas Flow Rate

When measuring air pollutant concentration, the air volume that is sampled together with the targeted components is measured. The flow velocity, volumetric flow, integrating flow (air volume), and pressure must be measured accurately as shown in Table 3.1.

Table 3.1 Measuring device for sample air volume

Measurement targets	Measuring instruments	Measurement range
Flow velocity	Pitot tube Hot wire anemometer	5 m/sec or more 0.05 ~ 40m/sec
Flow rate	Venturi meter Orifice meter Rotor meter (Float flowmeter) Mass flowmeter	1 L/sec ~ 100m^3/sec 1 cm^3/sec ~ 100m^3/sec 0.01 cm^3/sec ~ 50L/sec 0.2 cm^3/sec ~ 400L/sec
Capacity (Volume)	Soap film flowmeter (Precision film flowmeter) Wet gas meter Dry gas meter Roots meter	1 cm^3/sec ~ 1000m^3/sec Unrestricted Unrestricted Unrestricted
Pressure	Manometer Aneroid pressure gauge Brudon tube	0 ~ 2 atm 0 ~ 0.3 atm 0.2 atm or more

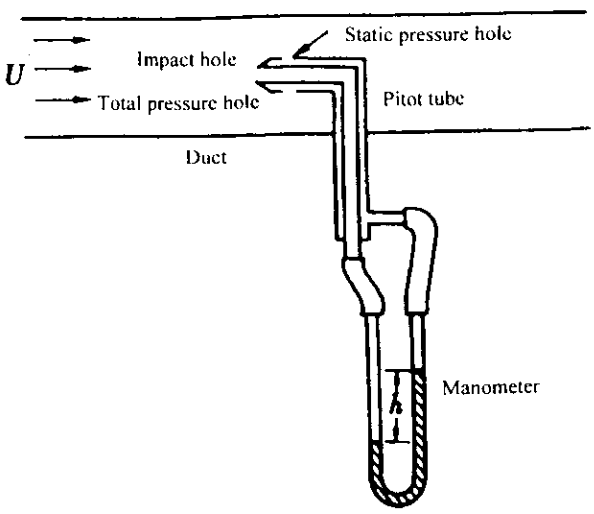


Figure 3.1 Pitot tube

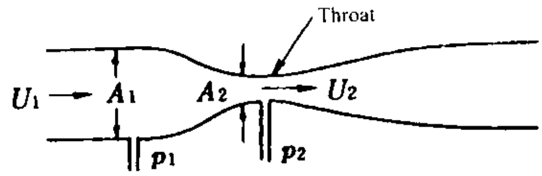


Figure 3.2 Venturi Meter

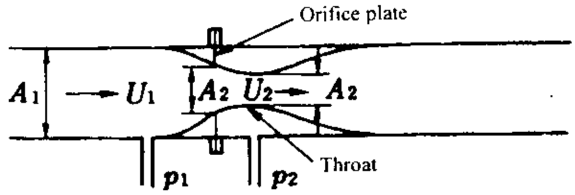


Figure 3.3 Orifice meter

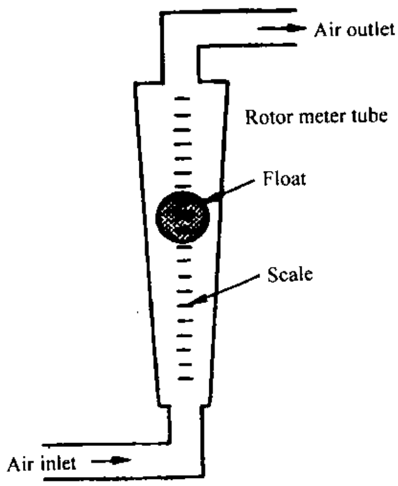


Figure 3.4 Rotor meter (float flowmeter)

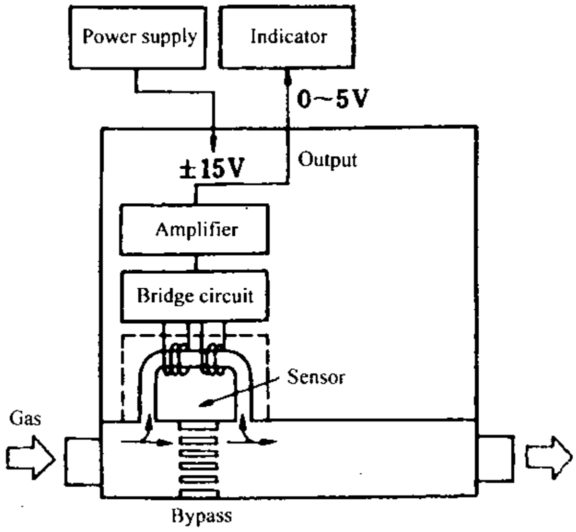


Figure 3.5 Mass flowmeter

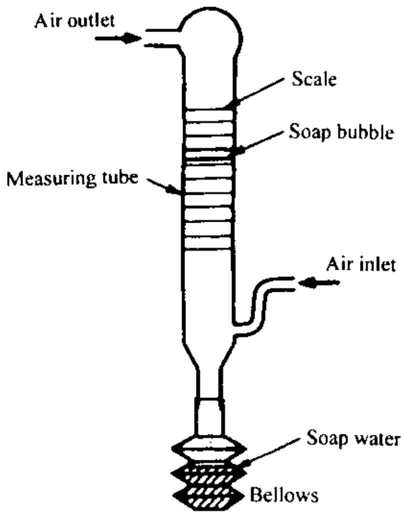


Figure 3.6 Soap film flowmeter

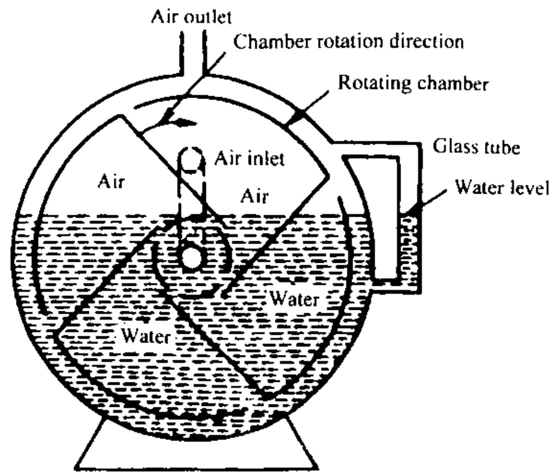
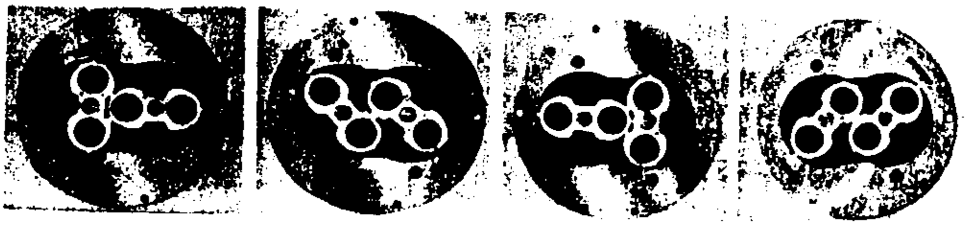
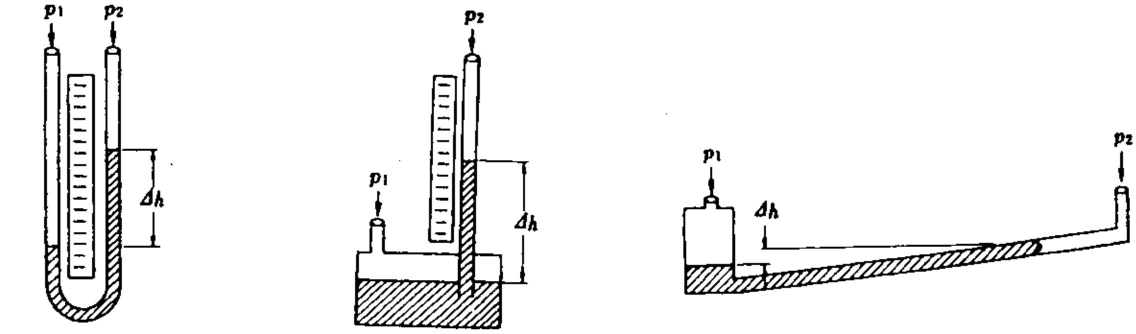


Figure 3.7 Wet gas meter



(a) (b) (c) (d)

Figure 3.8 Roots meter



(a) U-tube type (b) Storage tank type (c) Inclined tube type

Figure 3.9 Manometer

3.4 Flow Rate Adjustment in Ambient Air Samplings

3.4.1 Flow controller

A flow controller is used to stabilize and adjust the flow rate of the sample gas when measuring ambient air. There are two methods of adjustment – namely manual and automatic.

(1) Manual adjustment method

This is widely used to adjust the air sample flow rate, and comprises of a needle valve as the flow rate control valve, a filter for air inlet at the suction volume adjustment bypass side, and a capillary to prevent pulsation (orifice), etc.

Figure 3.10 shows an example of a manual air sampling flow rate adjustment system.

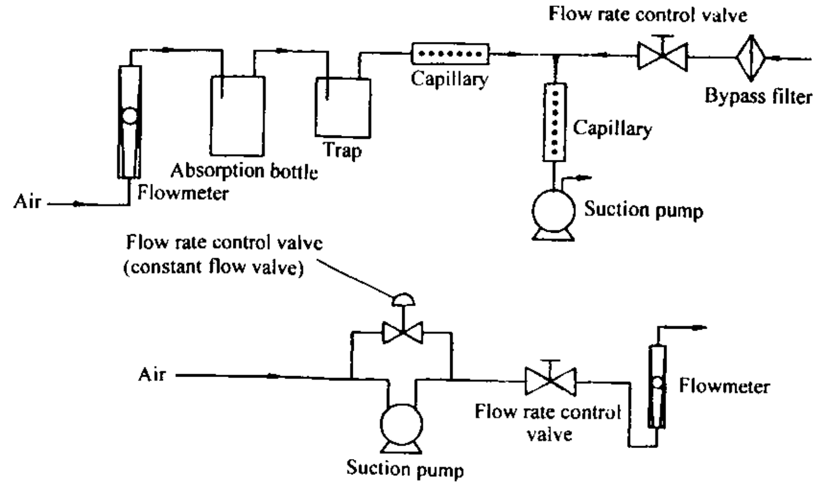


Figure 3.10 Example of an air sampling flow rate adjustment system (manual type)

(2) Automatic adjustment method

An automatic flow controller is used to stabilize the air sampling flow rate. There are three types, one of which controls the float position of the area flowmeter, another uses the mass flow controller, and the last is the pressure adjustment method. Figure 3.11 shows examples of an automatic air sampling flow rate adjustment systems

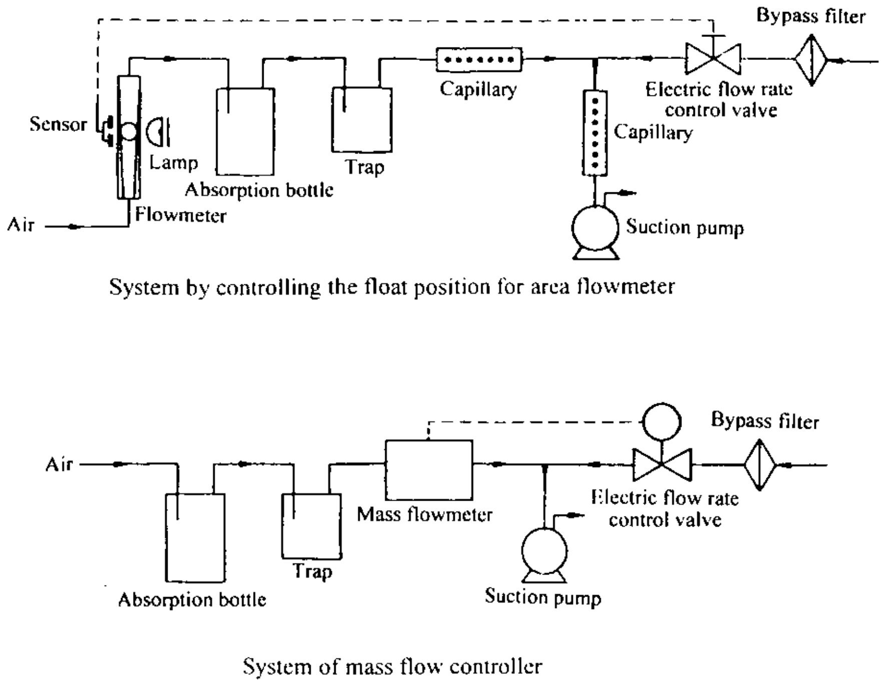


Figure 3.11 Examples of air sampling flow rate adjustment systems (automatic type)

3.4.2 Scale calibration of the flowmeter

The flowmeter must be regularly cleaned and recalibrated as the inside of the tube becomes dirty with use, which causes variance in the measurements. Recalibration should be carried out by comparison with the indicated value on the calibrated flowmeter (standard flowmeter).

(1) Preparation of the standard flowmeter

In general, the standard flowmeter should be calibrated in accordance with the method specified by the 'JIS Z 8761 Flow rate measurement method using a float area flowmeter', but it is calibrated using a wet gas meter or precision membrane flowmeter (soap-and-water membrane flowmeter) in the configuration shown in Figure 3.12 for simplified method.

(2) Standard flowmeter and confirmation of the flow rate for high volume air samplers

Flowmeter for a high volume air sampler is calibrated as per the configurations shown in Figures 3.13 and 3.14.

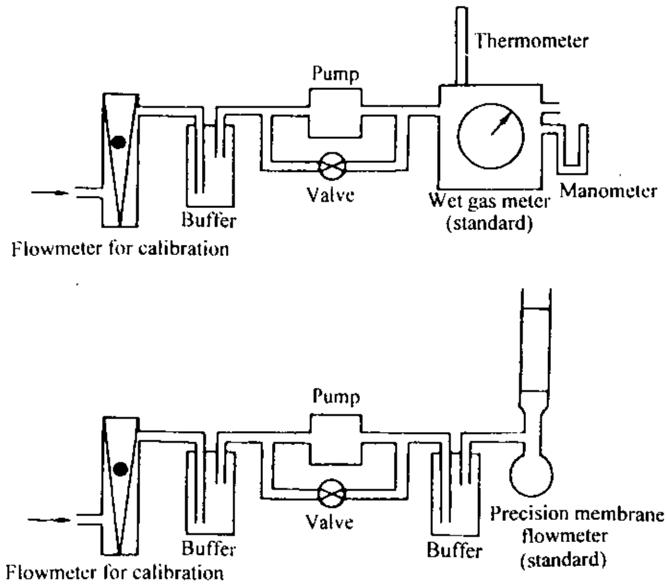


Figure 3.12 Example of scale calibration for standard flowmeter

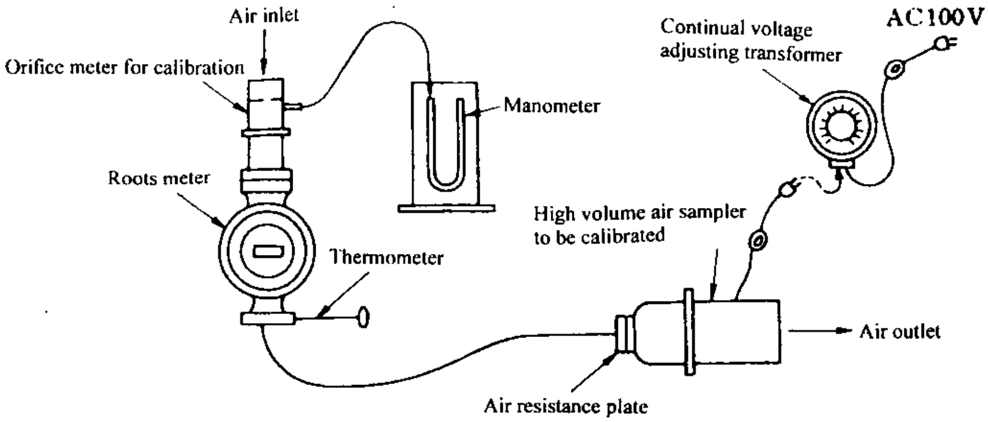


Figure 3.13 Making calibration curve for a calibration orifice based on roots meter

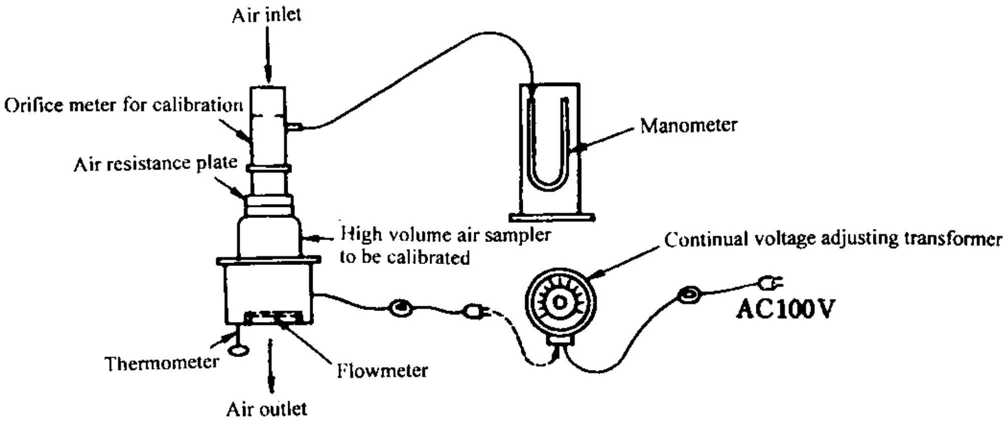


Figure 3.14 Flowmeter calibration of a sampler based on a calibration orifice meter

3.5 Current Status and Subjects Concerning Flow Rate Measurement of Ambient Air

Air pollutant is collected into absorption solvent when sampling ambient air, so changes in flow rate give significant effects to measurement accuracy. Float type area flowmeter (rotor meter) is widely used for normal ambient air sampling. Rotor meters are affected by the temperature and pressure of the air sample, so mass flowmeters are sometimes used instead. However, mass flowmeters are also affected by moisture in the sampled air, so this cannot be considered to be absolutely accurate either. Therefore, attach a dehumidifier to the flow rate measurement line to improve the accuracy of the measuring sampling flow rate as much as possible and to try to reduce humidity-induced changes in the flow rate.

3.6 Sampling Gaseous Matter

When sampling air, the sampling vessels are selected in accordance with the objectives, which are carried out in various ways.

Air pollutants are not always found in the constant concentration. In particular, if the generation source is close to the sampling site, the concentration may vary with time, so it is preferable to conduct air sampling over a longer period to obtain the average concentration at that site.

3.6.1 Natural ventilation method

Open the mouth of the sampling vessel, fix it at the measurement point and wait for air to enter the vessel in accordance with the natural ventilation, then close the mouth to retain the sample. An advantage of this technique is that the average concentration within the time range at the measurement point can be obtained, but it is not such an accurate method.

3.6.2 Vacuum vessel method

Vacuum the sample vessel before collection, and sampling can be done by simply opening the valve at the collection point. This method is suitable for situations where ‘instant’ sampling is required.

3.6.3 Sampling method on the dynamic flow

Suck out the air from one sampling hole on the vessel using an air pump at the measurement site to introduce the sample gas through another sampling hole. This is the optimal method for air sampling if one considers time and sample gas representivity.

3.6.4 Displacement method

Place a bag within a vessel and introduce and expel the air sample to/from the bag by removing and refilling the gas in the vessel outside the bag. Advantages of this method include that the air sample within the bag can easily be emitted and reintroduced, but the bag material must be selected with due consideration for the component to be measured.

3.6.5 Concentrating methods

(1) Adsorption method

This adsorbs and collects matter including the targeted components by ventilating the sample gas through a tube filled with adsorbent. Activated carbon, silica gel, molecular sieve, alumina, and backing for gas chromatographs are used as the adsorbents. Of these, activated carbon is the most widely used.

(2) Low temperature concentrating method

Insert the sampling tube into a vessel cooled by a coolant to make use of the principle that components of higher concentration than the vapor pressure of the coolant’s components are collected. However, the efficiency for collecting the targeted components relies on the difference between the sample concentration and the vapor pressure value at the temperature of said component, the absorption rate, degree of dissolution to the collection material, shape of the trap, and gas flow rate, etc.

(3) Absorbent reaction method

The DNPH method, which is used to measure aldehyde within the air, is one such method.

3.6.6 Reaction solution absorption method

Put a suitable reaction absorption solvent for the targeted component into an impinger and sample the gaseous matter in the air at a constant suction flow rate.

3.7 Sampling Particulate Matter

3.7.1 Selection of sampling filter paper

Generally, there are five types of basic collection principles employed for filter papers, namely ‘Inertial collision effect’, ‘Screening effect’, ‘Diffusion effect’, ‘Gravity (Precipitation) effect’, and ‘Electrostatic effect’. It is known that diffusion is effective when the diameter of minute particles is approximately 0.1µm or less, while both diffusion and screening are suitable if they are between 0.1µm and 0.5µm, and inertial collision and screening are effective for particles of 0.5µm or more.

As for collection of the particulate matter, diffusion is effective for minute particles, while inertial collision, screening and gravity are effective for larger particles of about 2µm or more. Selection of the filter paper depends on the characteristics of the matter to be measured and the method of analysis. There are two types of filter paper for collecting particulate matter, namely fabric and porous membrane filters. The classification and type of each filter paper are shown in Table 3.2.

Table 3.2 Classification and characteristics of each filter paper

Classification	Types	Product Example	Moisture Absorption Amount (mg)*
Fibrous Filters	Cellulose fiber	No.5A	1.4 ± 0.8
	Glass fiber	AP20	0.36 ± 0.04
		T60A20	0.03 ± 0.01
	Quartz fiber	2000QAST	0.17 ± 0.03
Porous Membrane Filters	Cellulose ester membrane	AA pore size 0.3µm	0.52 ± 0.11
	Fluoro pore membrane	AP07 pore size 10µm	0.07 ± 0.02
	Nuclear pore membrane	Pore size 0.5µm	0.09 ± 0.04
	Silver membrane	FM1.2 pore size 1.2µm	0.012 ± 0.005

* Changes in weight after being left in an environment with 90% relative humidity for 24 hours

3.7.2 Weighing of filter paper

Weigh the collection filter paper before and after use with a direct reading balance with a sensitivity of 0.1mg or greater after leaving it in a balance room with fixed temperature and humidity for 24 hours. Great care must be taken when weighing and handling the filter paper as it is easily damaged. Weigh each sample at least twice and confirm that such readings are nearly identical. If they differ substantially, repeat the weighing procedure until stable values are obtained.

3.7.3 Storing collection filter papers

It is best to analyze the filter paper immediately after sampling, but handling a number of samples is more effective in reality, so they should be stored in accordance with the type of filter paper material and analysis objective.

The storage method for filter paper that has been used for collection differs depending on the analysis objectives. Heavy metal components can be stored at room temperature after being placed in a plastic bag or suchlike to avoid contamination from within the room. Anionic or organic components are very volatile and easily deteriorate at room temperature, so they need to be kept refrigerated or frozen. Also, there are some substances whose concentration certainly decreases under light at room temperature such as benzo[a]pyrene. Thus, it is better to store samples that are used to analyze a number of components in a dark and frozen state.

3.7.4 Balance

(1) Points to note when setting up the balance

1) It is preferable to place the balance in an exclusive room such as a balance room. If there is no balance room, it should be placed somewhere that is used by few people and where the room temperature is stable.
2) The balance should not be placed anywhere that is at all unstable or shakable.
3) It should not be placed near a heat source such as a heater or in direct sunlight, but rather should be as far from any heat as possible.
4) If there is a balance room, the room humidity should ideally be 60% ± 10% and 20°C or more.

(2) Points to note on usage

1) When using a balance, maintain an upright posture and do not place your elbows on the balance table. Do not get too close to the balance either because the more minute the balance reading is, the more easily its zero point is affected by human body temperature.
2) Turn the operation handle very gently to make operating status of the balance.
3) When weighing a hygroscopic sample, it is best to weigh it after operation of the balance is settled.
4) When weighing a sample with electrostatic chargeability, such as a membrane filter, use aluminum foil or suchlike to prevent electrostatic charging before weighing.

4. Sampling of Flue Gas

This video introduces the sampling of sulfur oxides, nitrogen oxides, and sampling status for soot and dust as a representative film in the field to ensure understanding of flue gas sampling at their source.

There are various flue gas sampling methods which are specified per target item. This text only provides introductory information as it is impossible to give full details here. Refer to the JIS guidebook or suchlike for specific procedures on each item.

4.1 Flue Gas Sampling Position and Hole

In general, the best position for taking a representative gas sample is somewhere with a comparatively uniform flow, such as in a straight section of the duct or chimney as far as possible from any bends or areas where the cross section undergoes rapid change.

If there is a crack in the flue duct that allows much air to enter, the flue gas will lack uniformity, so this is not preferable.

Set-up a sampling hole for a collecting tube to be inserted rectangularly to the flow of the flue gas in a place where measurements can be carried out safely and easily. It is preferable to set up two sampling holes at a cross section of the flow duct which intersect each other rectangularly (at 90°). It is preferable to arrange the sampling hole with a diameter of 15cm or more so that a dust-sampling nozzle can be inserted. For this, a steel pipe (10~15cm long) with a flange is welded, and it should normally be closed with a lid.

Also, scaffolding and handrails should be arranged at the appropriate height as well as preparing steps when required. It is preferable that it is located close to a power source in order to operate any necessary equipment, such as a suction pump. (See note 1)

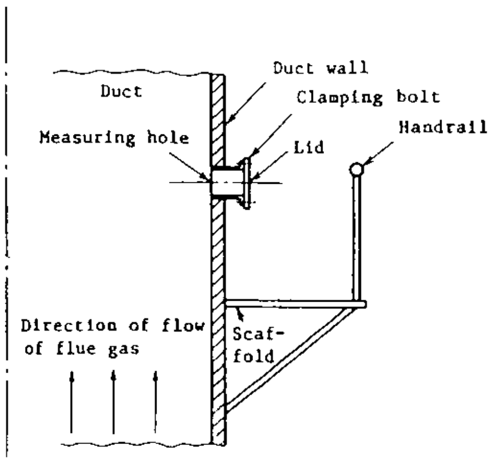


Figure 4.1 Example of sampling hole structure

Note 1: If the sampling position is high up, a suction pump or suchlike may be placed at ground level, and operations carried out at ground and higher levels by connecting long rubber suction tubes.