## 9.15 Meteorological observation measurements

### 9.15.1 Introduction

Air pollution is closely related to the meteorology of lower atmosphere. Here the meteorological measuring methods which are necessary to understand the movements of air pollution and for which no particular special knowledge or technology is needed have been chosen for explanation. Further, an overview of surface and high altitude meteorological observation that is currently taking place is also shown.

### 9.15.2 Surface meteorological observation

(1) Meteorological observation using buildings: Many meteorological observations are made using the rooftops of buildings. When installing a meteorological tower, it is important to select a site that avoids wind currents created by the building itself, and where there are no building obstacles in the vicinity. Further, topographically also, a site must be selected that preserves the regional character. As measurement items, wind direction and wind velocity, temperature, humidity, solar intensity, intensity of the ultraviolet radiation, and air pressure must all be measured automatically.

(2) Meteorological measurements using a tower: Meteorological observation using a tower or chimney are often used as a method of learning the meteorological characteristics of that particular region. Depending on the wind direction, the meteorological tower can be affected, so that ideally, two or three identical measuring systems should be installed at the same height, and depending on the main wind direction, measurement values should be used from the itself can affect the result equipment that remains unaffected. Data on the vertical distribution of the ambient temperature is extremely valuable because it elucidates the frequency of manifestation of the ground surface inversion layer. Further, by installing constant air pollution monitoring equipments meteorological observation using a tower will wake it possible to comprehend in detail the region's composition of air pollution.

### 9.15.3 Upper air meteorological observation

(1) "Pilot balloon" observation: "Pilot balloon" observation is a simple and easy method for learning the wind direction and wind velocity in the upper atmosphere. Because their practicability is also extremely high, they are introduced here in detail. The method is as follows. First a balloon, called a pilot balloon, generally weighing 20 g and filled with helium, is allowed to rise after its buoyancy has been adjusted. Next a balloon theadolite follows the moments of the balloon and measures the azimuth and the angle of evaluation at fixed time intervals. The wind direction and wind velocity in the upper atmosphere are determined from changes in the numerical values.

The buoyancy is adjusted in a site on ground surface with no wind, using a plumb bob. When the speed of elevation is set to 150 m/min., a 57.6 g bob is used. At night, a water battery (13.3 g in weight in its water-laden condition) is used which emits light when being soaked in water and current flows through it. At this time, a 74.9g bob is used. When the speed of elevation is set to 200 m/min., bobs of 136.4 g and 154.8 g are used respectively. Since the speed of elevation is given, when readings are taken 20 seconds apart, if the speed of elevation is 150 m/min., the mean wind speed and wind direction are determined every 50 m in height.

(2) Non-lift balloon observation: This is used to determine the wind currents and the extent of their vertical turbulence at a fixed height. The movements of a non-lift balloon that has been balanced, between its buoyancy and its weight are used. Its movements can be followed by the signals sent from a transmitter fitted to the balloon to the earth, or helicopter can be used for following.

(3) Radio sonde observation: With pilot balloon observation, only the wind velocity and wind direction can be determined. However by using low-level radiosonde, vertical distributions of temperature, humidity, can be determined for up to two to three kilometers. The temperature distribution is indispensable in order to learn the height of the temperature inversion layer and the stability of the air. Further, by learning the vertical distribution of the humidity, it is possible to accurately determine the ceiling height and the history of the air layer above.

(4) Rawinsonde observation: This system can simultaneously measure the wind direction and wind velocity by catching the movements of the radiosonde by an antenna which follows them automatically. In the case of pilot balloon observation, measurements from the upper air above the clouds can obtain data even when visibility is poor or there is cloud cover, by implementing rawinsonde observation for data that otherwise could not be obtained.

(5) Ozonesonde observation: This system can measure vertical ozone distribution up to 30 km high by further attaching ozone measuring equipment to the rawinsonde measuring system. The ozone sensors use a potassium iodide solution. Terrestrial sensor adjustment and calibration is required.

(6) Kytoon observation: A kytoon is a large balloon shaped like an airship, and possessing buoyancy. By operating a winch on earth and raising and lowering the kytoon sensor, the kytoon can be raised to the target height, and measurements taken. Kytoons come in all different sizes, from small, lightweight models that measure air temperature, humidity, and ozone, to those that measure wind current composition, and wind speed and wind direction. Signal transmission can be either by wireless, or by fiberoptic cable. By using the large model kytoons, an air sampling pipe can be raised, and it is possible to take all types of air pollutant measurements using automatic air pollutant measuring equipment installed on earth, while sampling the air of the upper atmosphere. The measurement height is approximately 1 km, but at times of strong wind or rain, measurements are problematic.

(7) Aircraft observation: In order to understand the layered distribution of air pollution, and the meteorology thereof, the most effective measurements can be taken by using an aircraft. Aircraft used include aircrafts with fixedwings, helicopter with rotary wing, and airships. According to aviation law, generally measurements may not be taken below 300 m. Fixed-wing aircrafts are used for measurements over a wide area, helicopters for measurements centering on vertical distribution, and airships prove to be most effective for measurements at low speed. In any

case, the greatest problem is a stable power source.

### 9.15.4 Continuous remote sensing of upper atmosphere meteorology

(1) Laser radar: If changes over time to the mixed layers of the atmosphere can be understood, it would be useful in monitoring and forecasting air pollution. To this end, a Mie scattering laser radar can be used. Mie scattering is the name given to the diffusion of light due to airborne particulate matter, but this system determines the vertical distribution of particulate matter in the upper atmosphere by receiving and amplifying through a telescope on the ground the Mie scattering intensity following the firing of a laser into the upper atmosphere. The possibility of installing this system in a small van or other such vehicle has already been made practicable, and it is now possible to make continuous measurements to a height of 3 km.

(2) Doppler acoustic radar: Information pertaining to the wind velocity and direction in the upper atmosphere are most useful in elucidating the movements of air pollution. The movements of vertical wind direction are especially important. By using Doppler acoustic radar, it is possible to determine in real time the composition of wind in the upper atmosphere. Doppler acoustic radar emits a sound wave into the upper atmosphere, which is reflected back byairborne particulate matter, and from changes in the sound frequency it is possible to determine both the vertical wind velocity and the horizontal wind velocity. Specifically, with a 2,100 Hz, 30 W output, measurements can be made up to approximately 1,000 m aloft. Measurement accuracy is good, and it is possible to measure up to weak breeze with approximately 0.01 m/s velocity both in the horizontal and vertical directions. By increasing the output, an even higher altitude measurement can be obtained, but it is important to consider the sound disruption to the neighborhood. Further, measurements at a site where major noise is generated in the surroundings are interfered with by that noise.

### 9.15.5 Meteorological network

The regional meteorological measuring system known colloquially as AMeDAS (Automated Meteorological Data Acquisition System) has been developed at approximately 1,300 sites throughout Japan, and the mean distance between stations in a square is 17 km. Of these, approximately 840 sites measure wind velocity and direction, air temperature, duration of sunshine, and amount of precipitation, and the data obtained is useful in analyzing the regional distribution of air pollution. However, because weak breeze cannot be measured, the system is only suitable for measuring the movement of air pollution over a wide area. The mean distance between the statigns with meteorological measuring functions for these four main in a square is 21 km. On the other hand, meteorological elements such as wind speed and direction, air temperature, and humidity are also continuously measured at atmospheric pollution regular measuring stations. Nevertheless, these measuring sites are concentrated in urban areas, and are insufficient for analysis over a wide area, but are extremely useful in the analysis of plane distribution of high concentrations of air pollution in urban areas when the breeze is weak.

In Japan, radiosonde observation is conducted two to four times a day at upper air observations. The measuring times are at 3:00, 9:00, 15:00, and 21:00. The time of the upper air observation is based on midnight and noon of Greenwich mean time, which are 9:00 and 21:00 respectively in Japan.

(9.1) References

1) S. Butcher and R. Charlson (Takashi Araki et al, trans.); The Chemistry of Air Pollution (1975)
2) Japan Society of Air Pollution (now the Japan Society for Atmospheric Environment) ed.; Revised Air Pollution Handbook, Volume 1, Measurement (1975)
3) Hori, Masahiro: Measurement method of harmful factors Japan Society for Safety Engineering ed.; Safety Engineering Lecture 4, Health Damage in Workshop p.149 (1982)
4) Kawaguchi, Hiroshi; Detection Limits and Sensitivity, Bunseki, 1982, No.1, pp.36 to 42
5) Sugimae, Akiyoshi; Bunseki Kagaku 28, p.559 (1979)

(9.3) Literature cited

Air Quality Bureau, Environment Agency; Ambient Air Continuous Monitoring Manual (1980)

(9.4) Literature cited

1) British Standards Institution: Deposit Gauges for Atmospheric Pollution, British Standard 1747 (1951)
2) Department of Scientific and Industrial Research: Measurement of Air Pollution, Her Majesty's Stationery Office (1957)
3) Terabu, Motoji; The Chemistry of Air Pollution, Gihakudo (1951)
4) Air Pollution Measurements Committees: Recommended Standard Method for Continuing Dust Fall Survey (APM-I. Revision 1), J. Air Poll. Control Assoc., 16 (7), (1966)
5) Japan Environmental Measurement and Analysis Association; Commentary of Environmental Measurement and Analysis Methods, Volume 1, Maruzen (1984)
6) National Air Pollution Research Council; Revised Air Pollution Handbook (r), Measurements, Corona Ltd. (1975)
7) Terabu, Motoji (trans.), British Science and Engineering Association (ed.); Methods of Measuring Air Pollution, Gihakudo (1958)

(9.6) Literature cited

1) Japan Environmental Measurement and Analysis Association; Notes on Environmental Measurement and Analysis, Volume 1 (Air Pollutant Sample Collection Methods), Volume 2 (Air Pollutant Measurement and Analysis Methods), Maruzen (1984)
2) Air Quality Bureau, Environment Agency; Air Pollutants Measuring Methods Indication (1987)
3) Air Quality Bureau, Environment Agency, Air Regulation Section; Hazardous Air Pollutants Measuring Manual (1997)
4) Japan Environmental Sanitation Center; Analysis and Forecasts of Suspended Particulate Pollutants (1987)
5) Environment Agency Commission Results Report; "National Air Surveillance Network, Analysis of Suspended Dust and Suspended Particulate Matter", 1975 to 1996, Japan Environmental Sanitation Center

(9.7) Literature cited

1) Gotoh, Sumio, Matsushita, Hidetsuru, Shiozaki, Takuya, Kato, Yukihiko; Aroutin analysis of benzo (a) pyrene in airborne particulates by high performance liquid chromatography, *Bunseki Kagaku*, vol.30, 362 (1981)

2) Air Pollution Control Division, Air Quality Bureau, Environment Agency; Hazardous Air Pollutants Measuring Manual (1997)

(9.8) Literature cited

1) Japan Environmental Analysis Measurement Committee; Interpreting Environmental Measurement and Analysis Methods, Volume 2 (Methods of Measuring and Analyzing Air Pollutants), Maruzen (1984)

2) Air Quality Bureau, Environment Agency; Indicators in Air Pollutant Measurement Methods (1987)

3) Air Pollution Control Division, Air Quality Bureau, Environment Agency; Toxic Air Pollutants Measurements Manual (1997)

4) Kanagawa Prefecture Coastal Areas Air Pollution Survey Association; Survey of Atmospheric Concentrations of Fluorine and Organic Chlorides, Kanagawa Prefecture Coastal Areas Air Pollution Survey Report, pp.4 to 58 (1990)

(9.9) Literature cited

1) Air Quality Bureau, Environment Agency, Air Pollution Control Division; Hazardous Air Pollutants Measuring Methods Manual (October 1997)

2) Ministry of Health and Welfare, Hygiene Bureau Aqueduct Environmental Regulation Section; Standard Dioxin Measuring Methods in Waste Substance Disposal, (February 1997)

3) U.S. EPA: Method 0010, Modified method 5 sampling train (1986)

4) U.S. EPA: Method 0023A, Sampling method for polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofuran emissions from stationary sources (1996)

5) Shiozaki; Dioxins Analysis, *Bunseki* 1997 (1), pp.32 to 38

(9.10) Literature cited

1) A. C. Barton and H. G. McAdie; A cumulative survey technique for atmospheric nitrogen dioxide. In : 67th annual Meeting of the Air Pollution Control Association. Denver, Colorado, June 9-13, pp.1-20 (1974)

2) Sato, Shizuo, et. al., Methods of Measuring Relative Airborne Concentrations of $NO_2$, Pollution and its *Countermeasures*, 13 (3), 52-57 (1997)

3) Simple Nitrous Oxides Measuring Methods Research Society; Research Concerning Methods of Measuring Relative Concentrations of nitrogen dioxide, Environment Agency-sponsored research paper (1977)

4) Nishimura, Hajime, Yanagizawa, Yukio; $NO_2$ Personal Samplers for Use in Measuring Concentrations in the Living Environment, *Journal of the Japan Society of Air Pollution* 8, 316-323 (1980)

5) Hirano, Koichiro, et. al; Simple Methods of Measuring NO and $NO_2$, *Environment and Measuring Technology* 12, 32-39 (1985)

### (9.11) Literature cited


1) Nagata, Yoshio, Takeuchi, Norifumi; Threshold Measurement Values for Offensive Odor Substances using TheTriangle Odor Bag Method, Lecture Essays from the Japan Society for Atmospheric Environment, p. 528 (1988)

2) Kato, Tatsuo; Air Pollution Gas Chromatograph Technology, Sanyo Publishing (1975)

3) Ishikuro, Tomohiko, Kato, Tatsuo, Shigeta, Yoshihiro; Offensive Odor Equipment Measuring, Kodansha (1984)

4) Furukawa, Osamu, Hasegawa, Takashi, Namiki, Sho; Revisions to Measuring Methods of Offensive Odor Substances, Offensive Odor Research 24, pp.351-364 (1993)

5) Air Quality Bureau, Environment Agency, Special Pollution Section; Easy Offensive Odor Substances Measuring Manual (1990)

6) Ishikuro, Tatsuyoshi; Basic Odor Countermeasures and their Application, Ohm Co. (1997)

7) New Environment Management Facilities Dictionary Editorial Board; Anti-Air Pollution Equipment, Industrial Survey Council (1996)

8) Otaki, Toshikazu, Yamagata, Noboru,; Environmental Pollution Analysis Methods 12, Dainihon Tosho (1973)


### (9.13) Literature cited


1) Totsuka, T.; Effects of sulfur dioxide on the growth of plants. Res, Rep, Natl. Inst. Environ. Stud. No.10, pp. 317-332 (1979)

2) Aihara, K., Omichi, S., Sinozaki, M., Totsuka, T., Yajima, I.; Small Open Top Chambers (OTC) for Evaluating the Impact of Air Pollution on Plants, Bulletin of Kanagawa Prefectural Environ. Center 10, 12-21 (1988)

3) Horie, H., Izuta, T., M. Takigawa, K., Miyake, T., Totsuka, T.; Evaluation of the Atmospheric Environment Using a Small Open Trop Chamber (OTC) as an indicator of Radish Growth, *Japan Society for Air Quality* 23, pp.284-289 (1988)

4) Ushijima, T.; Phytometer, Rep.of Jap. Environment Agency 1980, Manual of Environmental Impact Assessment through the Impact of Air on Plants (proposed), Separate volume, pp.64-70, Japan Public Hygiene Association (1981)

5) Matsunaka, S.:Bioindicator, Kodansha Scientific, p.182 (1975)


### (9.14) Literature cited


1) Air Quality Bureau, Environment Agency, Guideline on Measuring Corrosion of Metallic Substances Due to Air Pollution, 1988


### (9.15) Reference


1) Meteorological Handbook Compilation Committee; Meteorological Handbook, Asakura Shoten (1979)