

## 1. Atmospheric Environmental Standard - An experience in Japan

Japan government defined the **Environmental Standard** as "The desirable standard to safeguard the human health and to preserve the human living environment, for the environmental elements relating atmospheric pollution, water quality, soil pollution, and noise." It is,

- An **administrative objective** to improve the environmental quality
- The standard **without penal** regulations
- Applicable to the **area of residents living** - not applicable to the industrial area

Atmospheric Environmental Standard of Japan

Pollutant	Environmental Standard Value
SO <sub>2</sub>	< 0.04 ppm ** and < 0.1 ppm *
NO <sub>2</sub>	< 0.06 ppm **
CO	< 10 ppm ** and < 20 ppm ***
Suspended Particulate Matter	< 0.10 mg/m <sup>3</sup> ** and < 0.20 mg/m <sup>3</sup> *
Photochemical Oxidants (O <sub>3</sub> , PAN, etc)	< 0.06 ppm *

\* 1-hour averaged value

\*\* 1-day averaged 1-hour-average-value

\*\*\* 8-hours averaged 1-hour-average-value

NOTE: **ppm** is non-dimensional volume density defined as  $10^{-6} \text{ m}^3/\text{m}^3$ , and is the abbreviation of "parts-per-million." Also, 1 **ppb** denotes  $10^{-9}$ , and 1 **ppt** for  $10^{-12}$ .

## 2. Evaluation of the Atmospheric Environmental Standard

### a. Atmospheric Observation Stations

The first step of the air pollution control is the evaluation of the environmental standard attainment. Atmospheric quality is monitored using the atmospheric pollutants observation stations. The observation stations in Japan and its quality are defined as,

- common observation station: stations based **in common area** such as residential area
- automobile exhaust observation station: stations based **along the roadway**
- roadway observation station: among the automobile exhaust observation stations, the stations which gas inlets are **above the roadway**
- capable observation station: the station which carried out 6000 hours plus effective observation within 1 year = 8760 hours

### b. Long-term Observations and the Evaluation

For the atmospheric environment quality evaluation, long-term (over 20 years in Japan) and sufficient number of the observation points are required. Using the compiled observation results, we can perform followings as,

- to gain the **administrative decision supports**
- to give the **information of air quality** to the power-plants/ factories to ask the cooperation for the air-pollution control
- to find the major source of the pollution and making the **administrative future plan**

### 3. Atmospheric Environment Monitoring Techniques

#### a. SO<sub>2</sub>, NO<sub>x</sub>, and other gases

The measurement methods for the pollutants defined in the atmospheric environmental standard are defined in Japan as follows:

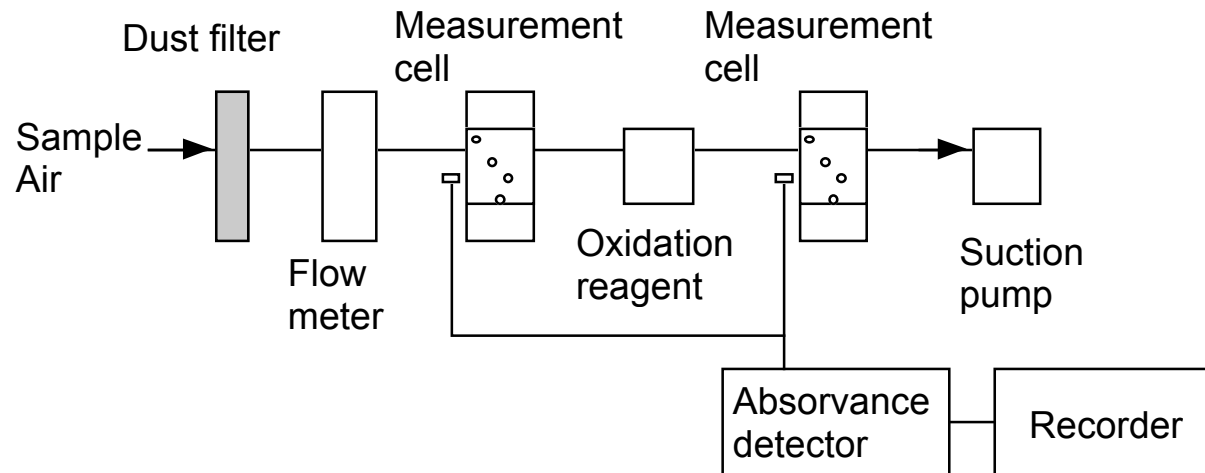
	Measuring Methods defined in the Atmospheric Environmental Standard	Measuring Methods defined in JIS (Japan Industrial Standards)
SO <sub>2</sub>	•Solution electric conductivity	•Solution electric conductivity •Flame photometric detector
CO	•Nondispersive infrared absorption	•Nondispersive infrared absorption
NO <sub>2</sub>	•Absorption spectrophotometry or coulometric analysis using neutral potassium iodide	•Absorption spectrophotometry •Coulometric analysis
Photo-chemical Oxidants	•Absorption spectrophotometry or coulometric analysis using neutral potassium iodide	•Absorption spectrophotometry •Coulometric analysis
Suspended Particulate Matter	•Gravimetry using the gas filtration or comparable light scattering method	

• **SO<sub>2</sub> : Solution electric conductivity method**

Introducing the atmosphere into the **solution of sulfuric acid and hydrogen peroxide**, the sulfur dioxide (SO<sub>2</sub>) in the atmosphere is **converted to sulfuric acid**, and it increase the density. The density of the sulfuric acid can be measured by the **electric conductivity** of the solution.

• **NO<sub>x</sub> : Absorption spectrophotometry (Saltzman method)**

Major components of the atmospheric NO<sub>x</sub> are nitrogen monoxide (NO) and nitrogen dioxide (NO<sub>2</sub>). Introducing **NO<sub>2</sub>** into the **Saltzman reagent** (the solution includes: naphthylethylenediamine dihydrochloride, sulfonyl acid, acetic acid), the reagent become **reddish purple** relating the amount of NO<sub>2</sub>. The density of the reagent color can be measured by the **absorbance of transmitted light** (545 nm). The Saltzman reagent does not react to the NO, then, NO in the atmosphere is usually oxidized before the introduction to the reagent.



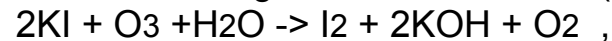
**NO<sub>x</sub> Absorption Spectrophotometry (Saltzman Method)**

- **NO<sub>x</sub> : Chemiluminescent method**

One of the reliable NO<sub>x</sub> measuring methods is the chemiluminescent one. When oxidizing the NO by O<sub>3</sub> to NO<sub>2</sub> occurred, a part of NO<sub>2</sub> become **excited states NO<sub>2</sub>\***. The excited NO<sub>2</sub>\* emits **photons** when transmitting to NO<sub>2</sub>. Then, the density of NO in the atmosphere can be measured by the observation of these photons using a **photo-multiplier**. The NO<sub>2</sub> in the atmosphere is reduced to NO prior to apply the chemiluminescent.

- **Photochemical Oxidant : Absorption spectrophotometry using neutral potassium iodide**

The term of the **photochemical oxidants** such as O<sub>3</sub> and PAN (peroxyacetyl nitrate) is a generic name for the oxidative matters produced by the photochemical reactions in the atmosphere. The major components of the oxidant is estimated as the O<sub>3</sub>. The **total oxidant** is also a generic name for the matter which can have iodine (I) free from the neutral potassium iodide (KI), and the photochemical oxidant is the residue of the total oxidant excluded the NO<sub>2</sub>. The reaction between the neutral potassium iodide and O<sub>3</sub> generates the free I<sub>2</sub> (iodine),



then the density of the oxidant can be made from the absorbance of free I<sub>2</sub>.

• **Other atmospheric constituents: Gas chromatography- mass spectrometry (GC-MS)**

The atmospheric sample including many constituents can be analyzed with combination of the gas chromatography and the mass spectrometry even if the density of the component is very low.

NOTE 1: **Gas chromatography** is a chromatographic technique that can be used to **separate volatile organic compounds**. A gas chromatograph consists of a flowing mobile phase, an injection port, a separation column containing the stationary phase, and a detector. The organic compounds are separated due to differences in their partitioning behavior between the mobile gas phase and the stationary phase in the column.

NOTE 2: **Mass spectrometers** use the difference in mass-to-charge ratio ( $m/e$ ) of ionized atoms or molecules to separate them from each other. Mass spectrometry is therefore useful for quantitation of atoms or molecules and also for **determining chemical and structural information** about molecules. Molecules have distinctive fragmentation patterns that provide structural information to identify structural components. (<http://www.md.huji.ac.il/spectroscopy/gc.htm>).

### b. Suspended Particulate Matter (SPM)

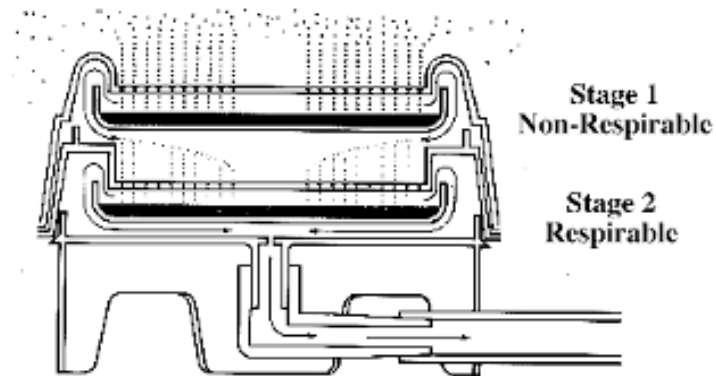
In general, the suspended solid or liquid matter in the atmosphere is called as the **aerosols**. The atmospheric environmental standard defines the **SPM** as the particles having the size less than 10 micrometers, and the **dust** is defined as the matter measured without the size discriminator.

#### •Gravimetric density: Gravimetry using the air filtration

The collection of SPM is performed using a filter and the **high-volume-air-sampler** (flow rate: 1 m<sup>3</sup>/min, sampling duration: some hours ~ 1 day) or the **low-volume-air-sampler** (flow rate: 20 ~ 30 liter/min, sampling duration: some days ~ 1 month). After the air collection, the filter is weighed, and the gravimetric density can be obtained from the weight of the filter and the flowed air mass.

#### •SPM characteristics: size discrimination

The size distribution of the SPM can be obtained using the air samplers such as, multi-stage cascade air sampler (Andersen sampler). The light scattering method (particle counter) can also be used.



NOTE: As the Figure shows, air containing particles is sucked into the top of the sampler. The flow is roughly at a rate of 26.8 liters/minute. The openings in the first stage are relatively large, so the airborne particles are accelerated to a lower extent. Large particles impact onto the culture plate due to their inertia while small particles are swept around the plate by the flow of air. Since the second stage has smaller openings, the acceleration is greater. As a result, smaller particles impact on the culture plate. If there are more stages, smaller particles impact on their respective plates. The very smallest particles are swept around the plate by the air flow and are ultimately lost to the collector.

(<http://www.aerobiology.org/Samplers/Andersen.HTM>)

## 4. Remote Sensing for the Atmospheric Constituents

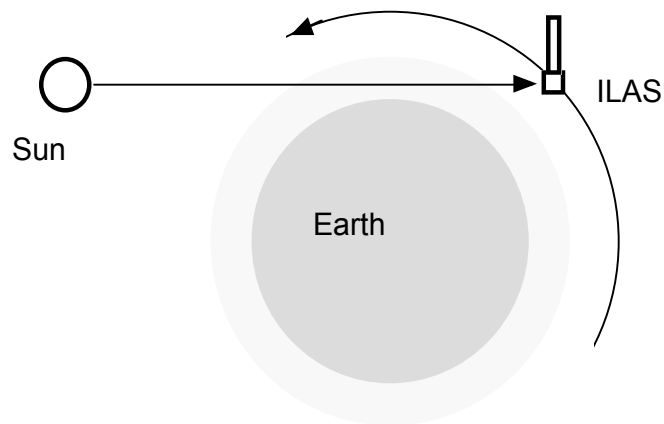
We can measure atmospheric gases concentration without direct air sampling (**in situ measurement**) using electromagnetic waves (micro-wave, milli-wave, ultra violet, visible and infrared light, etc.) remotely. In some case, acoustic wave is used for the remote wind sensor. These method is called **remote sensing**. The **global increase of greenhouse gas** concentration is ongoing, then the remote sensing technique, especially, **satellite borne** remote sensing system is useful because the system can give global view for the gases behavior.

### a. Global ozone measurement

The total ozone mapping spectrometer (**TOMS**) is a satellite borne remote sensor which can measure total ozone in the atmosphere using sun light scatter from the atmosphere. The TOMS is a simple sensor, however, it found the **ozone hole** above the Antarctica.

### b. Stratosphere constituents measurement

The improved limb atmospheric spectrometer (**ILAS/ILAS-II**) is also a satellite borne remote sensor which measures stratospheric constituents using the **solar occultation** method.

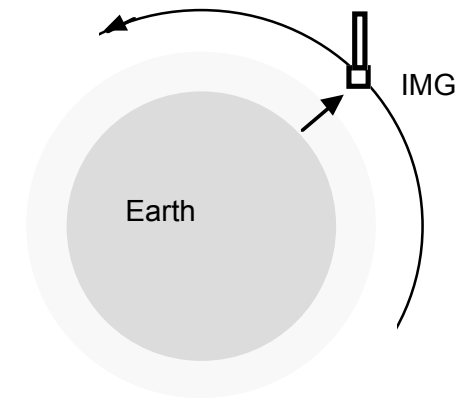
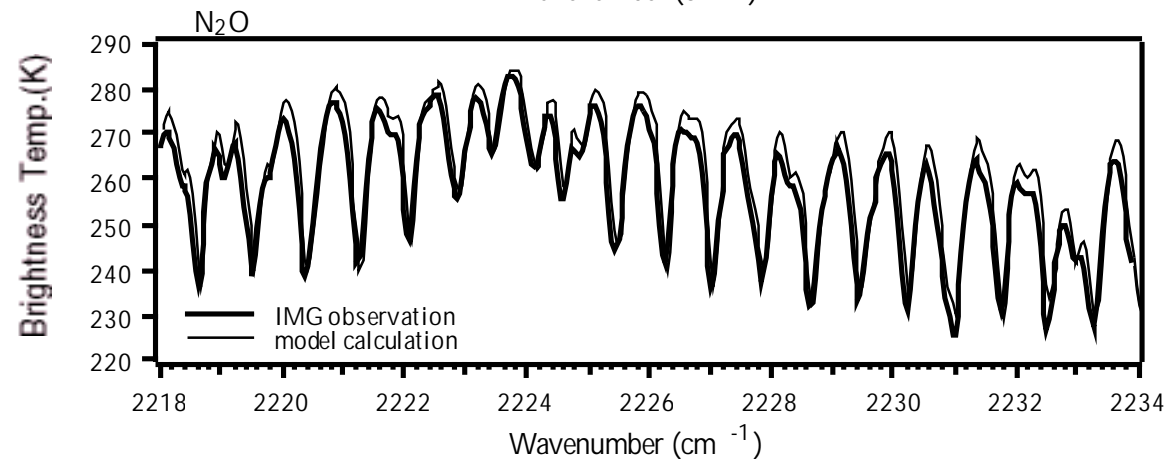
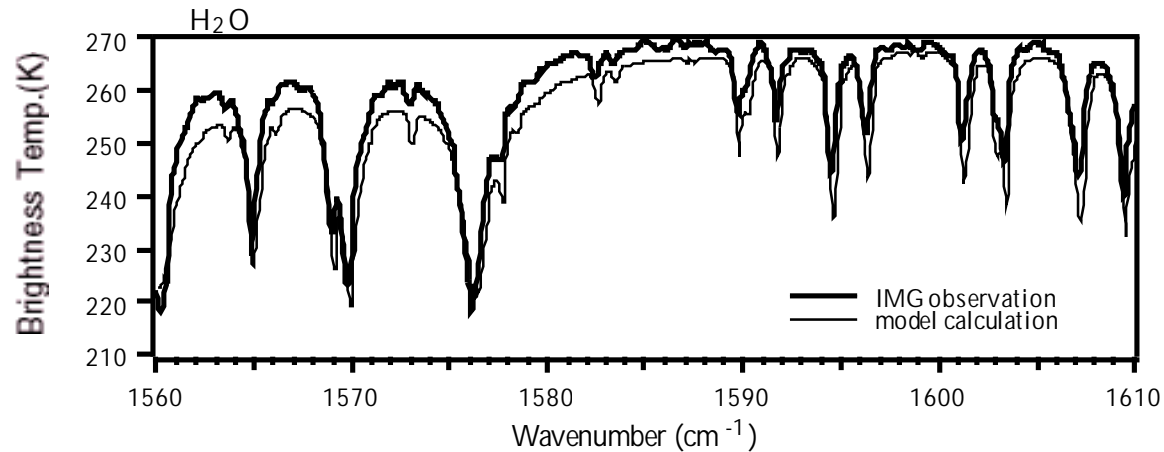


**ILAS and solar occultation method**



### c. Troposphere constituents measurement

The interferometric monitor for greenhouse gases (**IMG**) is a satellite borne remote sensor which measures the spectrum of infrared radiation from the earth/atmosphere. From the spectra, profiles of temperature, humidity, and greenhouse gases concentration can be retrieved.



**IMG and atmospheric radiation observation**

NOTE: TOMS, ILAS, and IMG are boarded on the ADEOS satellite launched Aug.17, 1996, however, end of June 1997, satellite failure occurred.