# I Control Measures Against Offensive Odor


Nagoya International Training Center
(NITC)
Japan International Cooperation Agency
(JICA)
International Center for Environmental Technology Transfer
(ICETT)


(Printed on Recycled Paper)

# CONTENTS

# 1. 'Odor'

## 1.1 Odor and Offensive Odor

We can have the feeling of many kinds of odors around us. It is considered that there are hundred thousands of materials which produce odors. Among them are the sweet smells such as of flowers, fruit and perfume which many people love. On the contrary there are the bad smells such as of the urinous smells of domestic animals and putrid smells of foods, animals and plants which a greater part of the people dislike.

There are reportedly thousands of offensive odors in general. Among them the typical bad smelling materials are represented by the following;

(1) Aldehydes such as acetaldehyde

(2) Ketones such as methyl isobutyl ketone

(3) Lower fatty acids such as isovaleric acid

(4) Nitrogen compounds such as ammonia and trimethylamine

(5) Sulfur compounds such as hydrogen sulfide, methyl mercaptan and methyl sulfide

## 1.2 Adaptability of Smell

As we cannot keep perceiving the smell after continuing to smell the perfume of a flower for a while, it is well-known that the sense of smell is easily adapted (tired). For this reason we can hardly perceive poisonous gases by their smell even if the gas reaches the fatal dose when it gradually leaks out. While not perceiving a specific odor, the sense of smell can have a sufficient sensibility to other odors. In cases that we may feel that there is no smell in the air, there is actually some smell. It is simply because we feel little odor due to a adaptation of smell sense to the environment or own body smell.

## 1.3 Difference in Smell between Individuals

Some people are extremely sensitive to odors while others are not. That is to say, a difference exists in smell between individuals. A sensitive person is not necessarily sensitive to all odors. It is well-known that there are olfactory blindness and incomplete olfactory blindness in the sense of smell just as there are color blindness and incomplete color blindness in the sense of sight. A person is not sensitive to some specific odor or at least less sensitive. For example, it is reported that 2% of the people are not sensible to the smell of sweat (isovaleric acid).

## 1.4 Intensity of Smell

The human sense of smell is a very sensitive gas detector. We call the minimum concentration of material causing odor the threshold of odor material. As shown in Fig. 1.1, the thresholds are distributed in a wide range of concentration depending on the materials.

Regarding the intensity of smell to odor, most people can only make the distinction among three stages such as strong, medium and weak. However, professional perfumers can make the distinction among six stages of odor intensity by using the six-points odor intensity scale as shown in Table 1.1.

In connection with the relationship between concentration of smelling materials and the intensity of the sensibility to odor, it is known that the principle of Weber-Fechner expressed in the following formula is applicable in a wide range of concentration based on the experimental data of many smelling materials.

$$I = k \log C$$

In this formula I indicates the sensible intensity of odor, C the concentration of smelling material and k the constant.

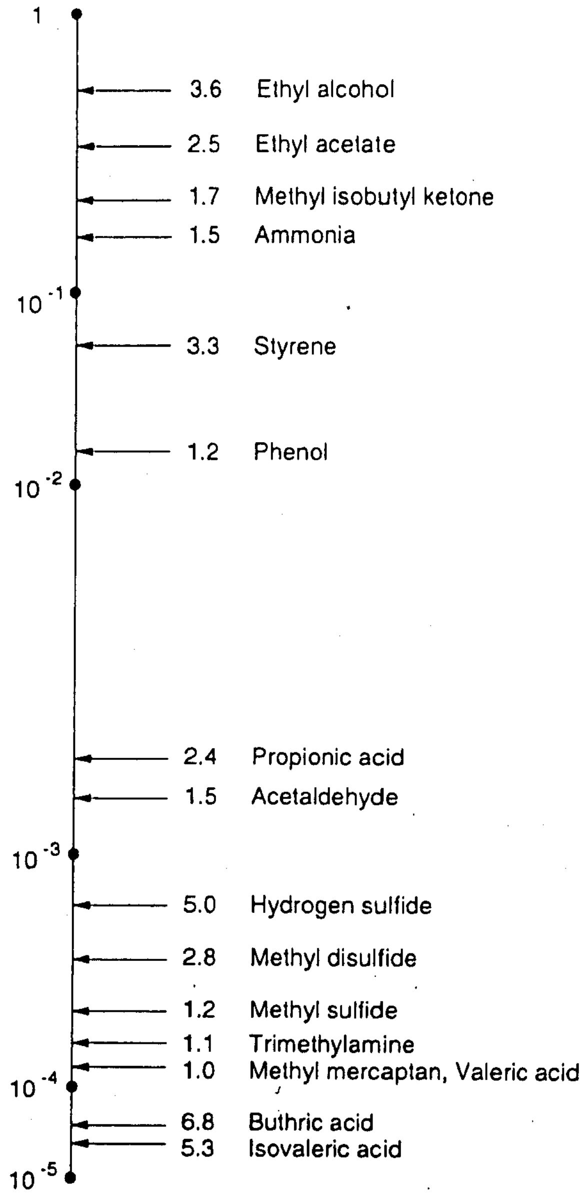



**Fig. 1.1 Threshold of Odor Material (ppm)**

**Table 1.1 Six-points Odor Intensity Scale**

| Odor | Indication |
|---|---|
| 0 | No odor |
| 1 | Barely traceable (Detection threshold concentration) |
| 2 | Faint but identifiable (Recognition threshold concentration) |
| 3 | Easily detectable |
| 4 | Strong |
| 5 | Repulsive |

## 2. Present Situation of Claims against Offensive Odors

### 2.1 Annual Changes in the Number of Offensive Odor Claims

The claims against offensive odors have been on the decline since the Offensive Odor Control Law was enforced in 1972 when the claims showed the peak. In FY 1996 there were still about 10,000 claims against offensive odors (Ref. Fig. 2.1).

The claims against offensive odors occupy about 17% of all pollution-related claims, which is ranked as the third largest percentage following the claims against air pollution and noise (Ref. Fig. 2.2).

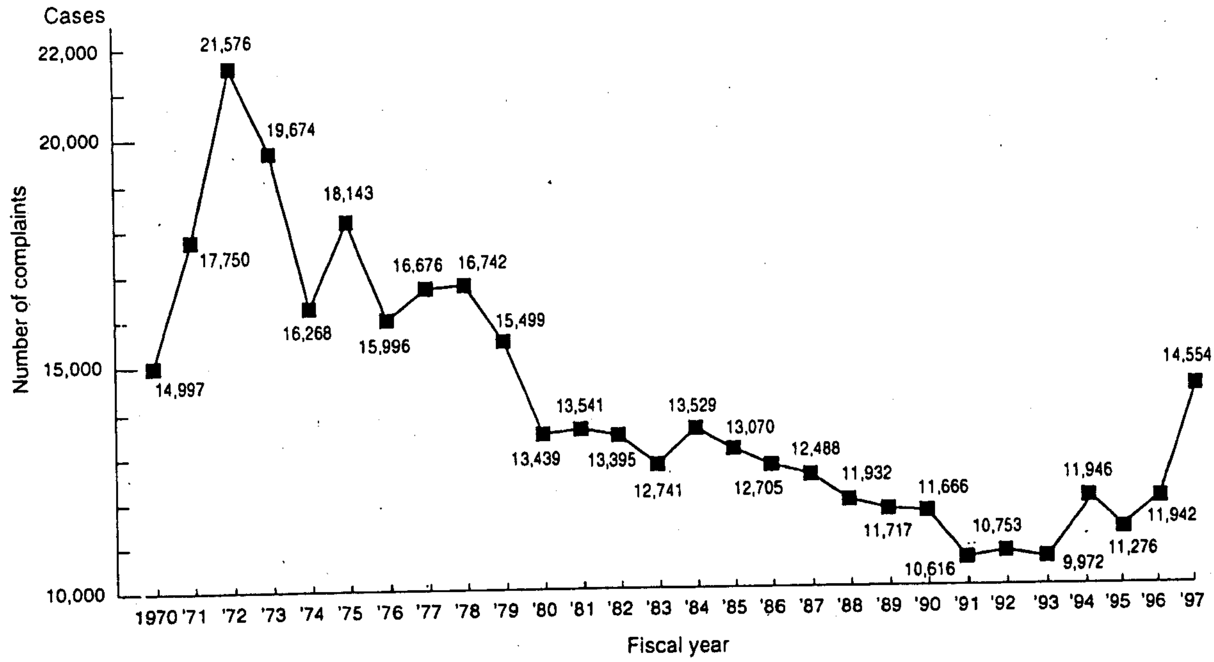
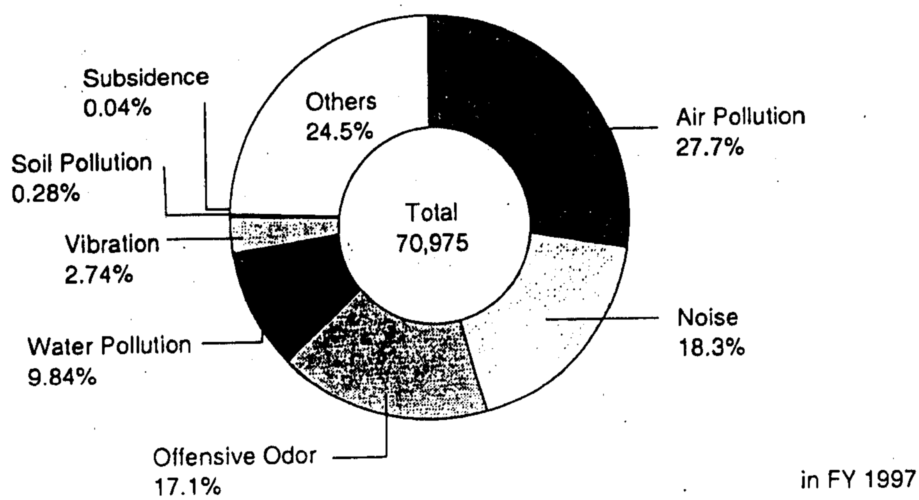



**Fig. 2.1 Annual Change in the Number of Offensive Odor Claims**




(Investigated by Concilation Committee on Environmental Pollution)

**Fig. 2.2 Number of Claims by Type of Pollution**

## 2.2 Claims against Sources (Industries)

In FY 1995, the live stock farms caused 16% claims of all the claims, manufacturing caused 25% claims, and services caused 26% claims.

The degree and impact of offensive odors emitted from factories and workshops differ depending on the kind of plant, scale of business, working methods and emission methods. For example, the offensive odor emitted from pulp plants mostly comes out of chimneys, and can be felt most strongly at the spot one to two km away from the factories. On the other hand the offensive odor released from the stock farming can be felt most strongly in the neighboring areas because most of offensive odor comes from the cattle sheds.

## 2.3 Feeling of Odor in Daily Life

In order to know potential claim sources, the Environment Agency conducted a survey in 1991, which investigated how people feel offensive odor occurred from outside of their residents (Fig. 2.3).

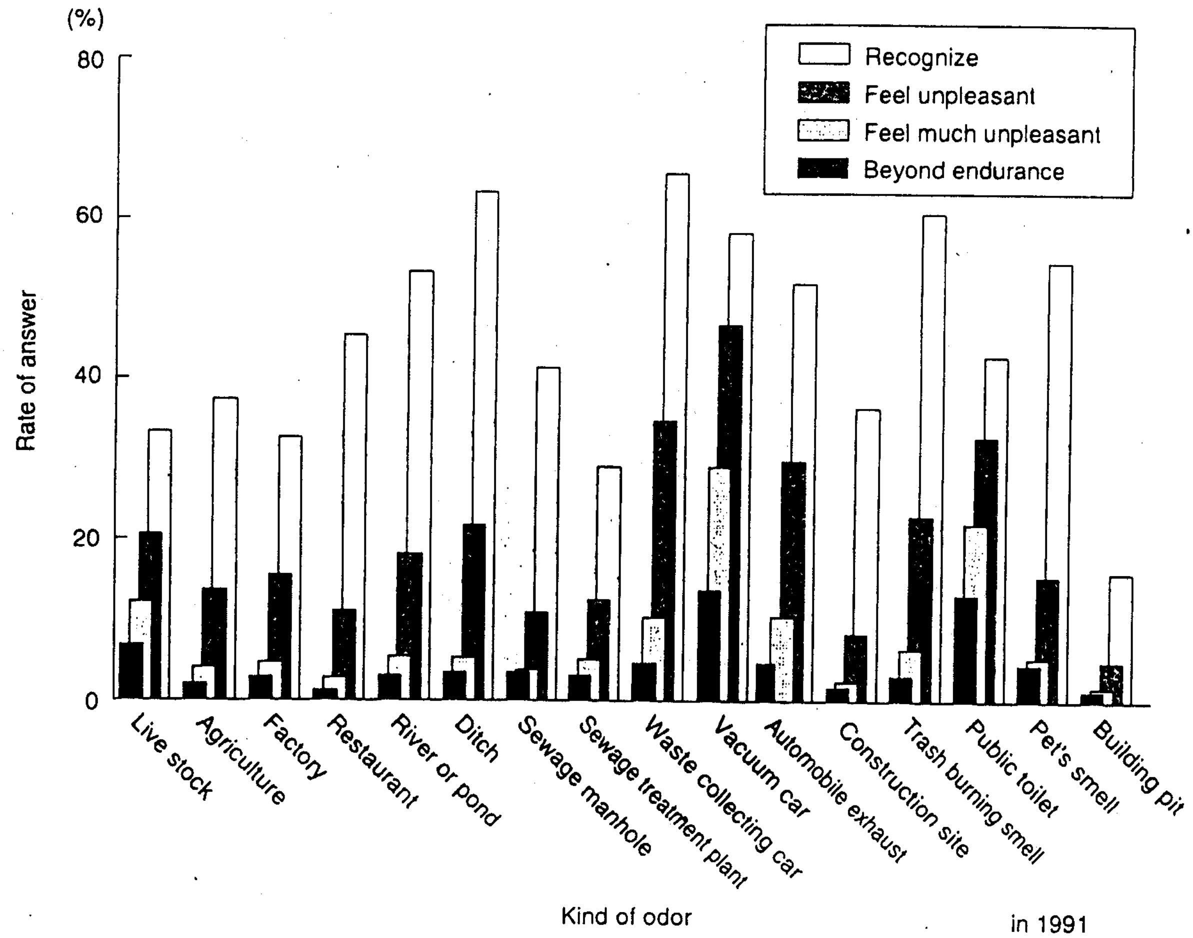



**Fig. 2.3 Feeling of Odor in Daily Life (investigated by Environment Agency)**

# 3. Regulation by Means of the Offensive Odor Control Law

## 3.1 Outline of the Regulation by Means of the Offensive Odor Control Law

The Offensive Odor Control Law is aimed at preserving living environments and contributing to protection of people's health by regulating the emission of smelling substances caused by the business activities of factories and workshops.

Under this Law, concretely speaking, offensive odor substances are defined what cause bad smell by the Government, and it is decided that the designation of regulated areas and set-up of regulation criteria by either concentration of specified offensive odor substances or odor index must be implemented by the governors of prefectures so as to regulate the emission of smelling substances. It is also determined that such governors can recommend/order the factories and workshop whose emission of smelling substances do not meet the criteria of regulation to improve the situations (Figs. 3.1, 3.2).

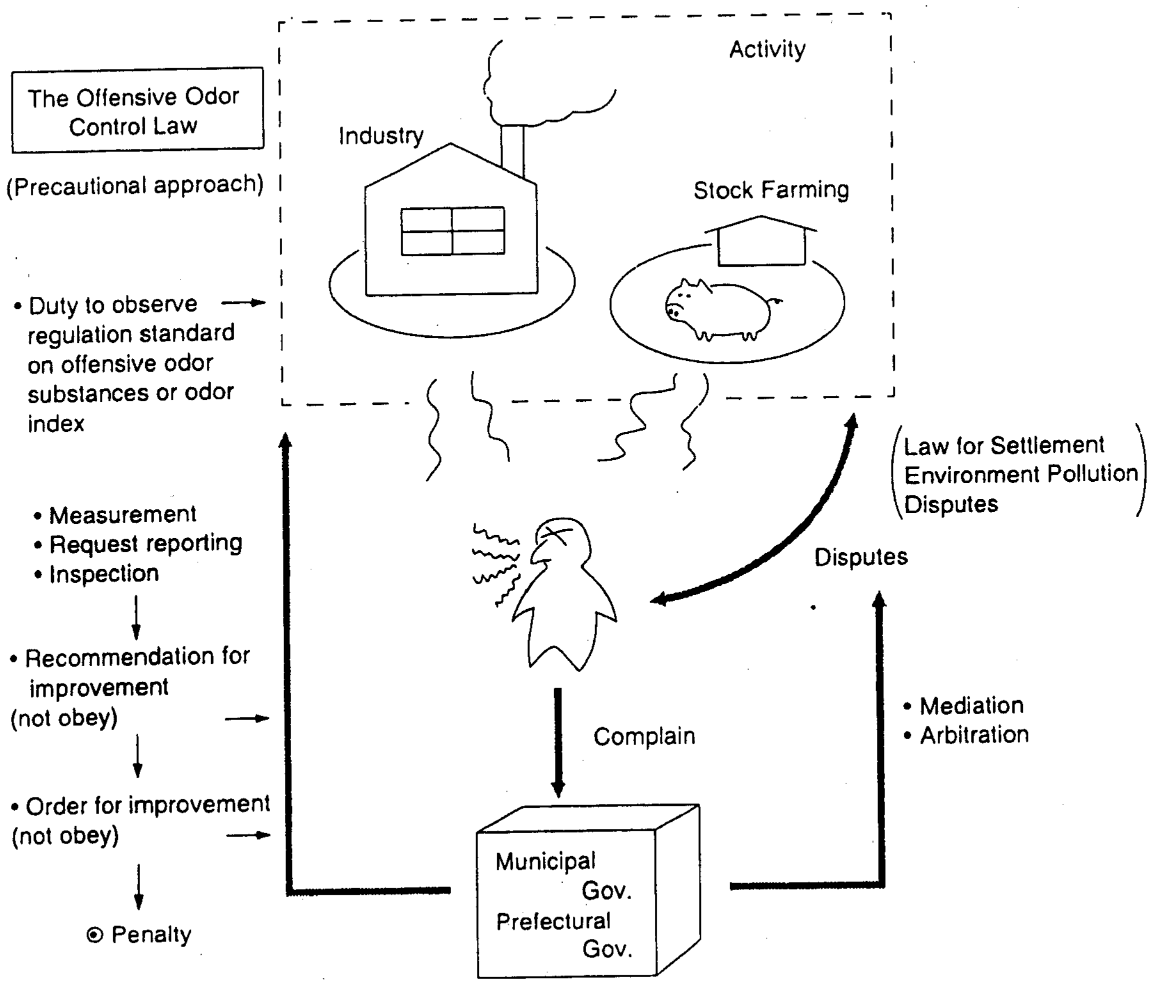



**Fig. 3.1 Control on Offensive Odor**

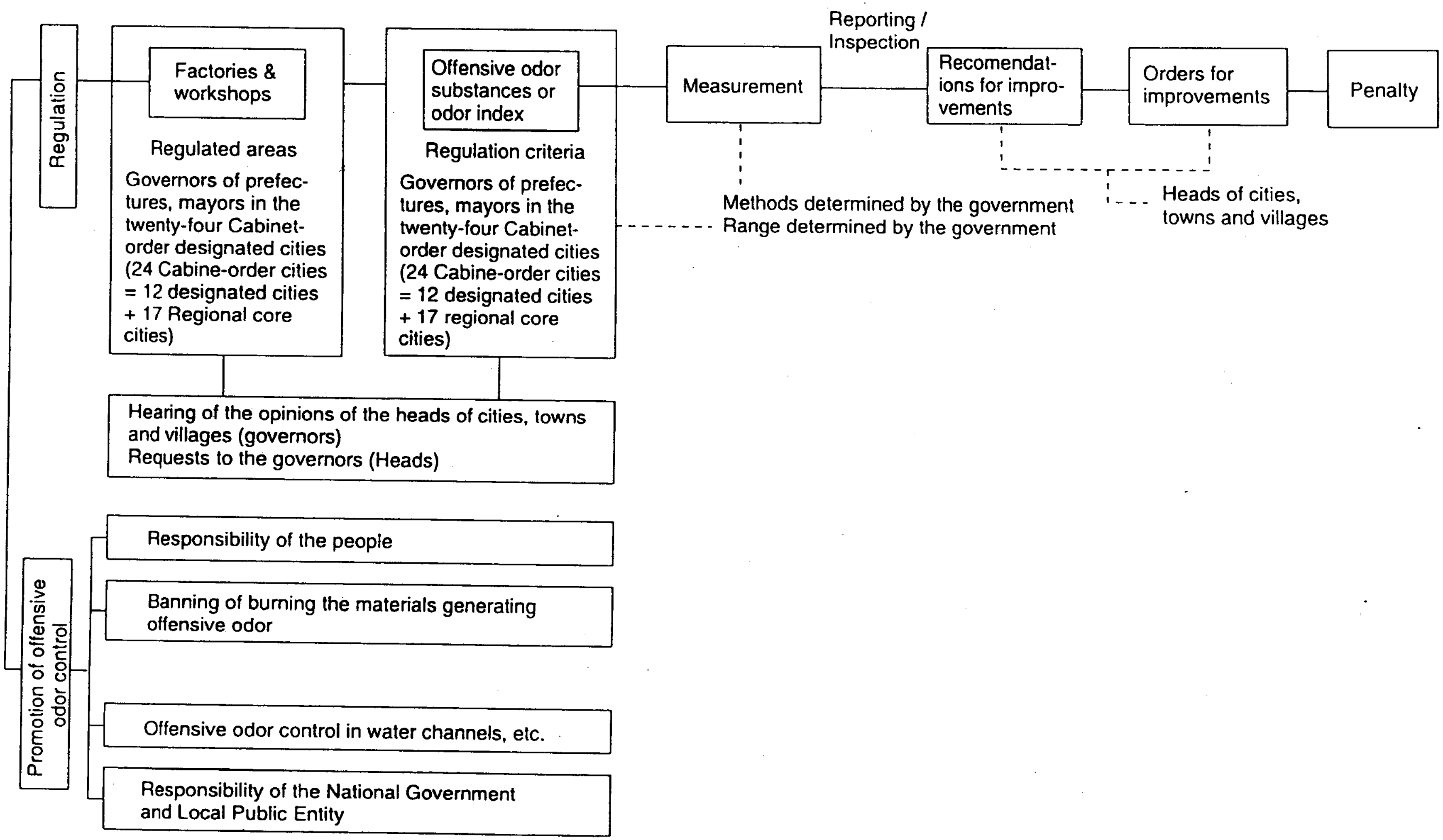



**Fig. 3.2 System of the Offensive Odor Control Law**

## 3.2 Specified Offensive Odor Substances

In the Offensive Odor Control Law it is provided that the specified offensive odor substances must be designated whose concentration must be measured by instrumental analysis method to regulate the offensive odor. The system is based on the idea that the offensive odor can be generally regulated by specifying the substances which are considered to give impacts mostly on the feeling of displeasure out of all the materials composing the offensive odor and also regulating the emission of these substances into the air.

At present 22 substances are designated as specified offensive odor substances as shown in Table 3.1. These substances are considered to be the representative ingredients of offensive odor generated by swineries, poultry farms, fish guts and bones processing plants, oil refineries, pulp plants, chemical products firms, painting plants, etc. to which the claims are made as the sources of offensive odor.

As the main ingredients of offensive odor generated by factories and workshop, some substances are considered as shown in Table 3.2.

**Table 3.1 Specified Offensive Odor Substances**

| | |
|---|---|
| Anmonia | : Smells like raw sewage |
| Methyl mercaptan | : Smells like rotten onions |
| Hydrogen sulfide | : Smells like rotten eggs |
| Dimethyl sulfide | : Smells like rotten cabbage |
| Trimethylamine | : Smells like rotten fish |
| Dimethyl disulfide | : Smells like rotten cabbage |
| Acetaldehyde | : Irritating, smells like green grass |
| Propion aldehyde | : Irritating, sweet-ethereal and burning smell |
| Butyraldehyde | : Irritating, sweet-ethereal and burning smell |
| Isobutyraldehyde | : Irritating, sweet-ethereal and burning smell |
| Valeraldehyde | : Causing cough-reflexes |
| Isovaleraldehyde | : Causing cough-reflexes and slitly fruity smell |
| Isobutyl alcohol | : Irritating, fermented smell |
| Ethyl acetate | : Irritating, smells like thinner |
| Methyl isobutyl keton | : Irritating, smells like thinner |
| Touluene | : Smells like petrol (gasoline) |
| Styrene | : Smells like natural gas (gas stove) |
| Xylene | : Smells like petrol (gasoline) |
| Propionic acid | : Irritating, with a pungent odor |
| Butyric acid | : Smells like sweat |
| Valeric acid | : Smells like dirty socks |
| Isovaleric acid | : Smells like dirty socks |

## Table 3.2 Offensive Odor Substances Coming From Factories Workshops

| Factories and workshops | Offensive odor substances | Ammonia | Methyl mercaptan | Hydrogen sulfide | Dimethyl sulfide | Dimethyl disulfide | Trimethylamine | Acetaldehyde | Pripion aldehyde | Butyraldehyde | Isobutyraldehyde | Valericaldehyde | Isovaleraldehyde | Isobutyl alcohol | Ethyl acetate | Methyl isobutyl keton | Toluene | Styrene | Xylene | Propionic acid | Butyric acid | Valeric acid | Isovaleric acid |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stock farming | Swineries | ○ | ○ | ○ | ○ | | | | | | | | | | | | | | | ○ | ○ | ○ | ○ |
| | Cattle farming | ○ | ○ | ○ | ○ | | | | | | | | | | | | | | | ○ | ○ | ○ | ○ |
| | Poultry farming | ○ | ○ | ○ | ○ | | ○ | | | | | | | | | | | | | ○ | ○ | ○ | ○ |
| Feed and fertilizer manufacturing industies | Complex fertilizer plants | ○ | ○ | ○ | ○ | | | | | | | | | | | | | | | | | | |
| | Fish guts and bones processing plants | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | | | | | | ○ | ○ | ○ |
| | Cattle bones processing plants | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | | | | | | | | |
| | Fowl droppings drying yards | ○ | ○ | ○ | ○ | | | ○ | | | | | | | | | | | | | ○ | ○ | ○ |
| Food processing indutries | Coffee processing plants | | | ○ | ○ | | | ○ | ○ | ○ | ○ | ○ | ○ | | | | | | | | | | |
| | Livestock products plants | ○ | ○ | ○ | | | | | | | | | | | | | | | | | ○ | ○ | ○ |
| | Marine products plants | ○ | ○ | ○ | | | ○ | | | | | | | | | | | | | | | | |
| | Starch plants | | | ○ | ○ | | | | | | | | | | | | | | | ○ | ○ | ○ | ○ |
| Chemical industries | Oil refineries | ○ | ○ | ○ | ○ | ○ | | | | | | | | | | | ○ | | ○ | | | | |
| | Pulp plants | | ○ | ○ | ○ | ○ | | | | | | | | | | | | | | | | | |
| | Rayon plants | | | ○ | | | | | | | | | | | | | | | | | | | |
| | Petrochemical basic plants | | ○ | ○ | ○ | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | | | | |
| | Printing ink plants | | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | | | | |
| | Pharmaceuticals plants | ○ | ○ | ○ | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | | | | |
| | FRP products plants | | | | | | | | | | | | | | | | ○ | ○ | ○ | | | | |
| Other manufacturing industries | Fiber plants | ○ | | ○ | | | | | | | | | | | | | | | | | | | |
| | Leather products plants | ○ | ○ | ○ | | | | | | | | | | | | | | | | | | | |
| | Casting plants | ○ | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | | | | | | | | | | |
| | Iron & steel plants | | | ○ | | | | ○ | ○ | ○ | ○ | ○ | ○ | | | | | | | | | | |
| | Printing | | | | | | | | | | | | | ○ | ○ | ○ | ○ | | ○ | | | | |
| | Painting | | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | | | | |
| | Machine manufacturing | | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | | | | |
| Service and other industries | Wastes disposal plants | ○ | ○ | ○ | ○ | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ |
| | Sewege treatment plants | ○ | ○ | ○ | ○ | | | | | | | | | | | | | | | | | | |
| | Raw sewage treatment plants | ○ | ○ | ○ | ○ | ○ | | | | | | | | | | | | | | | ○ | ○ | ○ |
| | Dead animals treatment center | ○ | ○ | ○ | ○ | | ○ | | | | | | | ○ | | | | | | | | | |
| | Hospitals & clinics | ○ | ○ | ○ | | | | | | | | | | | | | | | | | | | |
| | Restaurants | ○ | | ○ | | | | ○ | ○ | ○ | ○ | ○ | ○ | | | | | | | | | | |
| | Waste collection yards | ○ | ○ | ○ | | | | | | | | | | | | | | | | | | | |

### 3.3 Odor Index

The odor index, which is calculated by the olfactory measurement method is established in the Offensive Odor Control Law, with the purpose of regulating offensive odor.

The olfactory measurement method consists of measuring the intensity of the offensive odor through the olfaction of the human being, and is capable of an offensive odor evaluation that is closer to the feeling of the human being.

This method can be used in such cases as composite odor, etc., in which the regulation based on the concentration of specified offensive odor substances is not expected to bring about sufficient regulation effect.

### 3.4 Regulated Areas

In the Offensive Odor Control Law, it is provided that the governors of prefectures must designate specific areas where the emission of smelling substances generated by the business activities of factories and workshops is to be regulated after hearing to the opinions of heads of cities, towns and villages.

It is also provided that as the regulated areas they must designate (1) the densely built-up area and (2) the surrounding area with schools and hospitals where it is agreed that there is a need to control the offensive odor for the maintenance of living environment of inhabitants.

The number of cities, towns and villages with regulated areas has increased year by year, and amounted to 1,708 on March 31, 1997. This is equivalent to approximately 53% of the total number of cities, towns and villages in Japan.

### 3.5 Criteria of Regulation

In the Offensive Odor Control Law it is provided that the governors of prefectures must set up the criteria of regulation for specified offensive odor substances or odor index after designating the regulated areas depending on a need and hearing to the opinions of the heads of cities, towns and villages.

There are three kinds of emission type concerning the smelling substances coming from factories and workshops as follow, and a regulation criterion must be established according to emission type respectively by the concentration of specified offensive odor substances or odor index (Fig. 3.3).

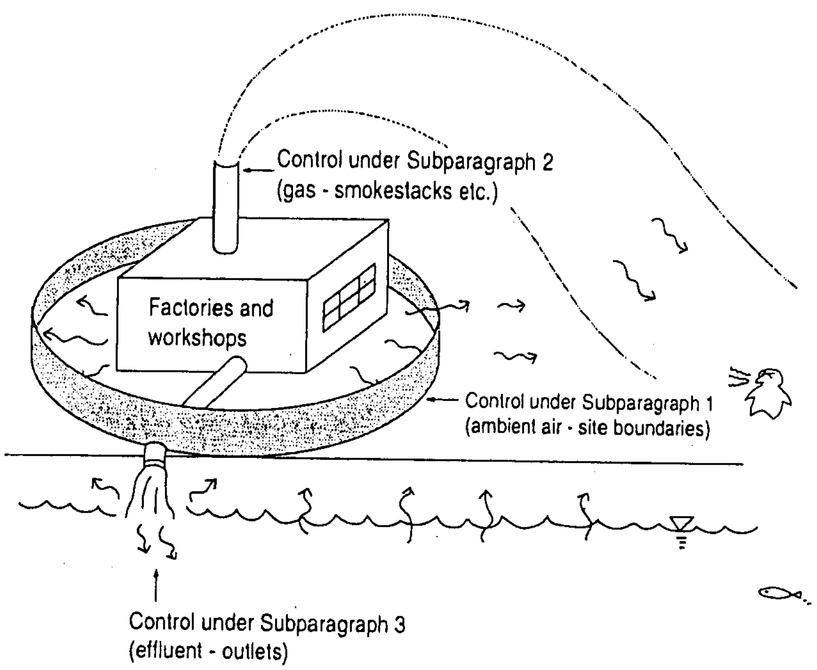



**Fig. 3.3 Three Kinds of Emission Type Concerning the Smelling Substances**

(1) In case the smelling substances are emitted or released from the whole building or site:

The regulation criteria must be established in terms of the allowable concentration measured on the ground surface along the boundary line of the site of such facilities, in consideration of the natural and social conditions of respective regulated areas. Unlike other pollutants, the criteria are not designated as one value but as the ranges of concentration. Among this ranges, the prefectural governors shall establish regulation standards.

(i) The allowable ranges of the regulation criteria for the specified offensive odor substances designated by the Government are obtained as follows.

(a) Certain amount of a specified offensive odor substance is introduced into an odor-free-chamber which was previously washed with hot water and filled with odorless air.

(b) Six panelists (professional perfumers) put their faces into a sniffing window. Each panelist determines a score (0 to 5, shown in Table 1.1) of the intensity of the odor.

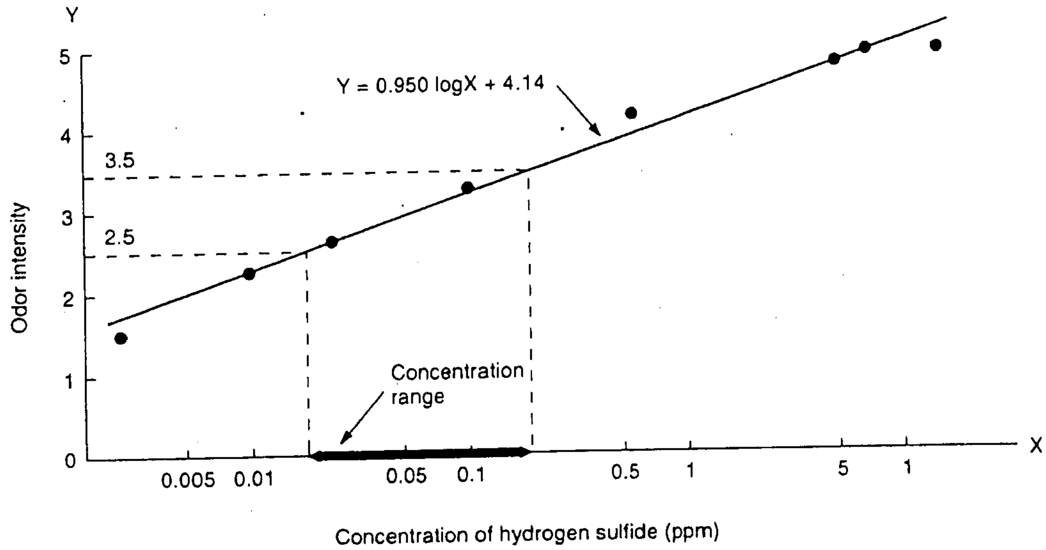
(c) The "odor intensity" is defined as the average of these scores at each concentration.

(d) Six to fifteen concentrations are presented and a relation

$$Y = b \log X + a \qquad \begin{array}{l} Y:\ \text{odor intensity} \\ X:\ \text{concentration} \end{array}$$

is obtained (Fig. 3.4) with the method of least squares. The concentration range corresponds with range of odor intensity 2.5–3.5.

The results are shown in Table 3.3.



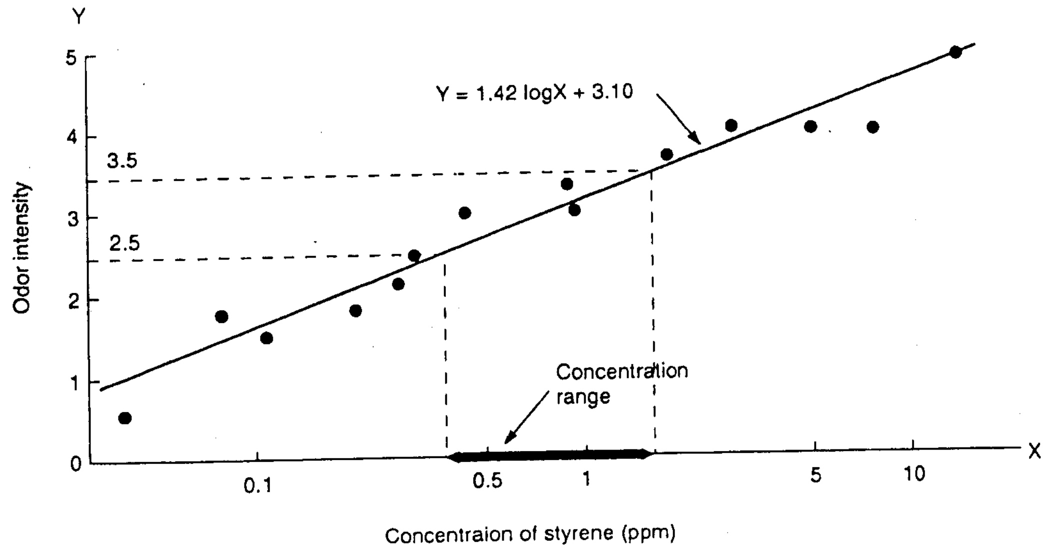




**Fig. 3.4 Relations between Odor Intensity and Concentration of Hydrogen Sulfide and Styrene**

## Table 3.3 Relations between Odor Intensity and Concentration

(Unit: ppm)

| Odor intensity → | | | 1 | 2 | 2.5 | 3 | 3.5 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| Substances | | Y (Score) = b*logX (ppm) + a | | | | | | | |
| Ammonia | $NH_3$ | Y = 1.67*logX + 2.38 | 0.1 | 0.6 | 1 | 2 | 5 | 10 | 40 |
| Methyl mercaptan | $CH_3SH$ | Y = 1.25*logX + 5.99 | 0.0001 | 0.0007 | 0.002 | 0.004 | 0.01 | 0.03 | 0.2 |
| Hydrogen sulfide | $H_2S$ | Y = 0.95*logX + 4.14 | 0.0005 | 0.006 | 0.02 | 0.06 | 0.2 | 0.7 | 8 |
| Dimethyl sulfide | $(CH_3)_2S$ | Y = 0.78*logX + 4.06 | 0.0001 | 0.002 | 0.01 | 0.05 | 0.2 | 0.8 | 2 |
| Dimethy disulfide | $CH_3SSCH_3$ | Y = 0.99*logX + 4.51 | 0.0003 | 0.003 | 0.009 | 0.03 | 0.1 | 0.3 | 3 |
| Trimethylamine | $(CH_3)_3N$ | Y = 0.90*logX + 4.56 | 0.0001 | 0.001 | 0.005 | 0.02 | 0.07 | 0.2 | 3 |
| Acetaldehyde | $CH_3CHO$ | Y = 1.01*logX + 3.85 | 0.002 | 0.01 | 0.05 | 0.1 | 0.5 | 1 | 1 × 10 |
| Propion aldehyde | $CH_3CH_2CHO$ | Y = 1.01*logX + 3.86 | 0.002 | 0.02 | 0.05 | 0.1 | 0.5 | 1 | 1 × 10 |
| Butyraldehyde | $CH_3(CH_2)_2CHO$ | Y = 1.03*logX + 4.61 | 0.0003 | 0.003 | 0.009 | 0.03 | 0.08 | 0.3 | 2 |
| Isobutyraldehyde | $(CH_3)_2CHCHO$ | Y = 1.06*logX + 4.23 | 0.0009 | 0.008 | 0.02 | 0.07 | 0.2 | 0.6 | 5 |
| Valericaldehyde | $CH_3(CH_2)_3CHO$ | Y = 1.36*logX + 5.28 | 0.0007 | 0.004 | 0.009 | 0.02 | 0.05 | 0.1 | 0.6 |
| Isovaleraldehyde | $(CH_3)_2CHCH_2CHO$ | Y = 1.35*logX + 6.01 | 0.0002 | 0.001 | 0.003 | 0.006 | 0.01 | 0.03 | 0.2 |
| Isobutyl alcohol | $(CH_3)_2CHCH_2OH$ | Y = 0.79*logX + 2.53 | 0.01 | 0.2 | 0.9 | 4 | 2 × 10 | 7 × 10 | $1 \times 10^3$ |
| Ethyl acetate | $CH_3CO_2C_2H_5$ | Y = 1.36*logX + 1.82 | 0.3 | 1 | 3 | 7 | 2 × 10 | 4 × 10 | $2 \times 10^2$ |
| Methyl isobutyl ketone | $CH_3COCH_2CH(CH_3)_2$ | Y = 1.65*logX + 2.27 | 0.2 | 0.7 | 1 | 3 | 6 | 1 × 10 | 5 × 10 |
| Toluene | $C_6H_5CH_3$ | Y = 1.40*logX + 1.05 | 0.9 | 5 | 1 × 10 | 3 × 10 | 6 × 10 | $1 \times 10^2$ | $7 \times 10^2$ |
| Styrene | $C_6H_5CH=CH_2$ | Y = 1.42*logX + 3.10 | 0.03 | 0.2 | 0.4 | 0.8 | 2 | 4 | 2 × 10 |
| Xylene | $C_6H_4(CH_3)_2$ | Y = 1.53*logX + 2.44 | 0.1 | 0.5 | 1 | 2 | 5 | 1 × 10 | 5× 10 |
| Propionic acid | $CH_3CH_2COOH$ | Y = 1.38*logX + 4.60 | 0.002 | 0.01 | 0.03 | 0.07 | 0.2 | 0.4 | 2 |
| Butyric acid | $CH_3(CH_2)_2COOH$ | Y = 1.29*logX + 6.37 | 0.00007 | 0.0004 | 0.001 | 0.002 | 0.006 | 0.02 | 0.009 |
| Veleric acid | $CH_3(CH_2)_3COOH$ | Y = 1.58*logX + 7.29 | 0.0001 | 0.0005 | 0.0009 | 0.002 | 0.004 | 0.008 | 0.04 |
| Isovaleric acid | $(CH_3)_2CHCH_2COOH$ | Y = 1.09*logX + 5.65 | 0.00005 | 0.0004 | 0.001 | 0.004 | 0.01 | 0.03 | 0.3 |

(ii) The allowable ranges of the regulation criteria for odor index designated by the Government are obtained the range of odor index which corresponds with range of odor intensity 2.5–3.5 (levels at which the majority of local residents do not feel uncomfortable), the same as the regulation criteria for the specified offensive odor substances.

It is obtained as the range of odor index 10–21 through the survey of the relation between odor intensity and odor index for almost every types of industry (Table 3.4).

**Table 3.4 The Relation between Odor Intensity and Odor Index**

| Odor intensity | Range of odor index |
|---|---|
| 2.5 | 10–15 |
| 3.0 | 12–18 |
| 3.5 | 14–21 |

(2) In case that the smelling substances may be emitted through an exhaust port such as a chimney:

We sometimes have the experience of being sensible to the offensive odor far away from the site even if we are not sensible to it on the surface of the site boundary depending on the height of a chimney.

(i) In such a case the regulation criteria must be determined as the allowable limit of flux as the maximum ground level concentration of specified offensive odor substances becomes equivalent to the allowable concentration on the site boundary. By the way, the regulations standards referring to the odor index have not been established yet.

(a) The method of setting regulation standards for smoke stacks shall be that of calculating the flow rate with the following equation for each kind of specified offensive odor substances (excluding 9 substances).

$$q = 0.108 \times He^2 \cdot Cm$$

Where

q = Flow rate of specified offensive odor substance (unit: $m^3$/hour calculated at 0°C and at 1 atmospheric pressure)

He = Height of stack adjusted using the method described in the next Paragraph (unit: meters)

Cm = Value set as regulation standard by the prefectural governor in case of (1) (unit: parts per million [ppm])

Provided however that this formula shall not apply if the height of the stack adjusted using the method described in the next Paragraph is less than 5 meters.

(b) The adjustment of height of the stack shall be done in accordance with the following equation.

$$He = Ho + 0.65\,(Hm + Ht)$$

$$Hm = \frac{0.795\sqrt{Q \cdot V}}{1 + \dfrac{2.58}{V}}$$

$$Ht = 2.01 \times 10^{-3} \cdot Q \cdot (T - 288) \cdot \left(0.30 \log J + \frac{1}{J} - 1\right)$$

$$J = \frac{1}{\sqrt{Q \cdot V}}\left(1{,}460 - 296 \times \frac{V}{T - 288}\right) + 1$$

Where

He = Adjusted height of stack (unit: meters)

Ho = Actual height of stack (unit: meters)

Q = Flow rate of exhaust gas at 15°C (unit: $m^3$/second)

V = Exhaust velocity of exhaust gas (unit: meters/second)

T = Temperature of exhaust gas (unit: absolute temperature)

It is known that some of specified offensive odor substances have chemical exchange in the process to landing. The regulation criteria for these substances has not yet been determined.

(ii) Odor control standards as applicable to gas discharge outlets are set in terms of odor emission rate or odor index depending on whether the height of the outlet is 15 m or more or less than that.

1) Height of gas discharge outlet 15 m or more

- Indicator: Odor emission rate
- Atmospheric dispersion formula: One that takes into account the disturbances in the discharged gas stream (downdraft) caused by the presence of buildings

As offensive odor emission facilities are usually small scale, the impact of buildings on their odor dissipation characteristics tends to be significant. For this reason, regulatory control is provided using the following formula, which takes into account the presence of buildings and other factors, to calculate the rate of odor emission from the gas discharge outlet (odor emission rate) based on the building conditions, exhaust gas flow rate, etc.:

$$q_t = \frac{60 \times 10^A}{F_{max}}$$

$$A = \frac{L}{10} - 0.2255$$

where $q_t$, $F_{max}$ and L stand for the following:

$q_t$: Odor emission rate of the exhaust gas (expressed in cubic meters per minute as adjusted to the conditions of 0°C and 1 atm.)

$F_{max}$: Maximum value (expressed in cubic meters per second as adjusted to the conditions of 0°C and 1 atm.) of F (x) as shown in the table below, which gives the odor concentration at ground level at a point x m downwind of the discharge outlet when the odor emission rate at the discharge outlet is one cubic meter per second as adjusted to the conditions of 0°C and 1 atm. However, it is replaced by one divided by the exhaust gas flow rate (expressed in cubic meters per second as adjusted to the conditions of 0°C and 1 atm.), if the maximum value of F (x) exceeds this value.

L: Control standard applicable to the site boundary

**Table**

$$F(x) = \frac{1}{3.14\sigma_y\sigma_z} \exp\left(\frac{-(H_e(x))^2}{2\sigma_z^2}\right)$$

Note:

In the above formula, x, $\sigma_y$, $\sigma_z$ and $H_e$ stand for the following:

x: Downwind distance measured from the discharge outlet (expressed in meters)

$\sigma_y$: Horizontal spread of the discharged gas stream (expressed in meters) for a given downwind distance from the discharge outlet as calculated using a method specified by the Director General of the Environment Agency by taking into consideration the effects of the highest building in the neighborhood

$\sigma_z$: Vertical spread of discharged gas stream (expressed in meters) for a given downwind distance from the discharge outlet as calculated using a method specified by the Director General of the Environment Agency by taking into consideration the effects of the tallest building in the neighborhood

$H_e(x)$: Height of the axis of the discharged gas stream (expressed in meters) for a given downwind distance from the discharge outlet as calculated using the formula below. However, it is regarded as zero meters, if the sum of $H_i$ and $\Delta H_i$ in the formula is less than half the height of the tallest building in the neighborhood.

$$H_e(x) = H_i + \Delta H + \Delta H_i$$

where $H_i$, $\Delta H$ and $\Delta H_i$ stand for the following:

$H_i$: Initial discharge height (expressed in meters) as given by the formula below. However, the calculated value is replaced by the actual height of the discharge outlet (expressed in meters), if the former exceeds the latter.

$$H_i = H_o + 2\,(V - 1.5)\,D$$

where $H_i$, $H_o$, V and D stand for the following:

$H_i$: Initial discharge height (expressed in meters)

$H_o$: Actual height of discharge outlet (expressed in meters)

V: Velocity of exhaust gas at discharge outlet (expressed in meters per second)

D: Diameter of discharge outlet (expressed in meters). However, if the discharge outlet is not circular in shape, an equivalent diameter as obtained from its cross-sectional area by assuming it to be circular applies.

$\Delta H$: Rise of the axis of the discharged gas stream (expressed in meters) for a given downwind distance from the discharge outlet as calculated using a method specified by the Director General of the Environment Agency

$\Delta H_i$: Fall of the axis of the discharged gas stream caused by the tallest building in the neighborhood (expressed in meters) as given by one of the formulas given in the table below (right column) as chosen on the basis of the applicable initial discharge height category (left column)

| | |
|---|---|
| $H_i < H_b$ | $-1.5\,H_b$ |
| $H_b < H_i < 2.5\,H_b$ | $H_i - 2.5\,H_b$ |
| $H_i > 2.5\,H_b$ | 0 |

In the above table, $H_i$ and $H_b$ stand for the initial discharge height (expressed in meters) and the height of the tallest building in the neighborhood (expressed in meters)

2) Height of gas discharge outlet less than 15 m

- Indicator: Odor index
- Atmospheric dispersion formula: Simple formula that does not require the measurement of the exhaust gas flow rate

With facilities which have low gas discharge outlets, regulatory control is provided using odor indexes based on the formula below, in light of the fact that, with such facilities, the use of a simple formula that does not require the measurement of the exhaust gas flow rate is considered acceptable in terms of accuracy and that it is practically impossible to conduct a flow rate measurement on all facilities including very small-scale ones.

$$I = 10 \times \log C$$

$$C = K \times H_b^{\,2} \times 10^B$$

$$B = \frac{L}{10}$$

where I, K, $H_b$ and L stand for the following:

I: Odor index of the discharged gas

K: One of the values given in the table below (right column) as chosen on the basis of the applicable discharge outlet diameter category (left column). Where the discharge outlet is not circular in shape, an equivalent diameter as obtained from its cross-sectional area by assuming it to be circular applies.

| | |
|---|---|
| Diameter of discharge outlet less than 0.6 m | 0.69 |
| Diameter of discharge outlet 0.6 m or more but less than 0.9 m | 0.20 |
| Diameter of discharge outlet 0.9 m or more | 0.10 |

$H_b$: Height of the tallest building in the neighborhood (expressed in meters). However, this is replaced by one of the values shown in the third column of the table below (expressed in meters) as chosen on the basis of the calculated value (first column) and actual height of the discharge outlet (second column), if the calculated value is less than 10 or if the calculated value is 10 or more and at least 1.5 times the actual height of the discharge outlet (expressed in meters).

| | | |
|---|---|---|
| Less than 10 | 6.7 m or more | 10 m |
| | Less than 6.7 m | 1.5 times actual height of discharge outlet |
| 10 or more and at least 1.5 times actual height of discharge outlet (expressed in meters) | | 1.5 times actual height of discharge outlet |

L: Control standard applicable to the site boundary

(3) In case the smelling substances in the waste water may be discharged out of the site of factories and workshops and then evaporate into the air:

In cases where wastewater containing smelling substances is released from factories and workshop into the environment through effluent outlets, even when offensive odors are not present at the outlets or on site boundaries (i.e. conforming to control standards on the site boundaries), odor generation sometimes occurs with the passing of time through the evaporation and dissipation of smelling substances.

To prevent offensive odors, therefore, controlling the concentrations of smelling substances in the ambient air alone is not enough, and it is necessary to control the concentrations of dissolved smelling substances in factory effluents etc. as well.

The regulation criteria must be also set up as the allowable limit of concentration in exhausted water based on the allowable concentration on the site boundary.

At present, only four substances containing sulfur are specified as targets for the control of concentrations in effluents, based on their typicalness as odorous substances, and characteristics such as the ease of transition from liquid to gaseous state. By the way, the regulations standards referring to the odor index have not been established yet (as things now stand). Their regulation standards are calculated separately, using the following formula (for four sulfur compounds only):

$$C_{Lm} = k \times C_m$$

Where

$C_{Lm}$: Regulation standard on the concentration of an odorous substance in an effluent (mg/ℓ)

k: Constant (chosen from Table 3.4 according to the volume of the effluent discharged from the industrial site into the environment (mg/ℓ)

$C_m$: Regulation standard for the concentration of the same substance in the ambient air, as specified in (1) above (ppm)

**Table 3.5 Values of Constant k** Unit of Q: $m^3/s$

| Substance | k | | |
|---|---|---|---|
| | $Q=\leq 10^{-3}$ | $10^{-3}<Q\leq 10^{-1}$ | $10^{-1}<Q$ |
| Hydrogen sulfide ($H_2S$) | 5.6 | 1.2 | 0.26 |
| Methyl mercaptan (MM) | 16 | 3.4 | 0.71 |
| Dimethyl sulfide (DMS) | 32 | 6.9 | 1.4 |
| Dimethyl disulfide (DMDS) | 63 | 14 | 2.9 |

Table 3.6 shows the regulation standards on the concentrations of four sulfur-containing odorous substances in the effluent of an industrial site on its boundaries, as calculated with the above conversion formula for each effluent volume class assuming odor intensity ratings of 2.5, 3.0 and 3.5.

**Table 3.6 Allowable Limits on Odorous Substance Concentrations in Effluents as Calculated from the Conversion Formula** (Unit: mg/ℓ)

| Effluent volume ($m^3/s$) | Q≤0.001 | | | 0.001<Q<0.1 | | | 0.1<Q | | |
|---|---|---|---|---|---|---|---|---|---|
| Odor intensity | 2.5 | 3.0 | 3.5 | 2.5 | 3.0 | 3.5 | 2.5 | 3.0 | 3.5 |
| Hydrogen sulfide | 0.1 | 0.3 | 1 | 0.02 | 0.07 | 0.2 | 0.005 | 0.02 | 0.05 |
| Methyl mercaptan | 0.03 | 0.06 | 0.2 | 0.007 | 0.01 | 0.03 | 0.001* | 0.003 | 0.007 |
| Dimethyl sulfide | 0.3 | 2 | 6 | 0.07 | 0.3 | 1 | 0.01 | 0.07 | 0.3 |
| Dimethyl disulfide | 0.6 | 2 | 6 | 0.1 | 0.4 | 1 | 0.03 | 0.09 | 0.3 |

Note *: The regulation standard should be set at 0.002 mg/ℓ due to certain measurement conditions.

## 3.6 Measuring Methods

When the regulation criteria are applied to the emission of the smelling substances in factories and workshops, the measuring methods determined by the Director General of Environment Agency must be utilized.

In the areas regulated by specified offensive odor substances, as shown in Table 3.6, specified offensive odor substances are sampled in plastic bags or taken in solution, and after changing them into the substances easy to measure by chemical reaction or condensing them, their concentrations are measured by gas chromatograph, etc. Since the regulation criteria are applied at the exhaust port, as the allowable limit of flux of the specified offensive odor substance, the quantity of exhaust gas must be measured as well as the concentration.

In the areas regulated by the odor index, the intensity of the offensive odor is to be evaluated by means of the olfactory measurement method.

This method is one of olfactory sensory tests. Under this system a set of three plastic bags are filled with non-smelling air, and the an odor is poured into one of three bags until a prescribed rate of dilution is achieved. Six or more panelists, who are citizens selected with five standard odorants (T & T olfactmeter), sniff to determine a rate of diffusion at which they cannot distinguish the air in the bag from air in the two other bags (Fig. 3.7).

As for the samples collected on the site borderline, the selection operations mentioned above are carried out three times each for each panel, by using samples diluted to 10 times or another appropriate dilution degree larger than 10 times, with attention paid to use always the same dilution degree.

## Table 3.7 Outline of Odorous Substance Measurement Methods

| Odorous substance | Attached table | Classification | Sampling method | Concentration method | Sampling volume (Minimum limit of determination) | Measurement method | Instruments used |
|---|---|---|---|---|---|---|---|
| Ammonia | 1 | Site boundaries | Boric acid solution absorption | | 50 1 (0.05 ppm) | Absorptiometry (indophenol method) | Absorptiometer or photoelectric photometer |
| | | Effluent outlet | JIS K0099 | | | | |
| Methyl mercaptan<br>Hydrogen sulfide<br>Dimethyl sulfide<br>Dimethyl disulfide | 2 | Site boundaries<br>Effluent outlet<br>(Dimethyl sulfide only) | Odor bag | Low temperature concentration | 5 l1<br>(Note 1) | Gas chromatography | Gas chromatography with a flame photometric detector (FPD) |
| | | Effluent | Sampling bottle | — | — | Headspace method + gas chromatography | Gas chromatography with a flame photometric detector (FPD) |
| Trimethylamine | 3 | Site boundaries<br>Effluent outlet | Sulfuric acid solution absorption | Low temperature concentration | 50 1<br>(0.0005 ppm) | Gas chromatography | Gas chromatography with a flame ionization detector (FID) |
| Acetaldehyde<br>Propionaldehyde<br>n-butyl aldehyde<br>isobutyl aldehyde<br>n-valeric aldehyde<br>isovaleric aldehyde | 4 | Site boundaries<br>Effluent outlet<br>(excluding acetaldehyde) | Odor bag | DNPH scavenging | 30 1<br>(Note 2) | Gas chromatography | Gas chromatography with an alkali thermionic detector (FTD) |
| | | | | Absorption at normal temperature | 5 1<br>(0.0005 ppm) | Gas chromatograph-mass spectrometer | Gas chromatograph-mass spectrometer with an electron ionization detector (EID) (selective ion detection method) |
| isobutanol | 5 | Site boundaries<br>Effluent outlet | Odor bag | Low temperature concentration | 51<br>(0.01 ppm) | Gas chromatography | Gas chromatography with a flame ionization detector (FID) |
| Ethyl acetate<br>Methyl isobutyl ketone | 6 | Site boundaries<br>Effluent outlet | Odor bag | Low temperature concentration<br>Absorption at normal temperature | 5 1<br>(0.01 ppm) | Gas chromatography | Gas chromatography with a flame ionization detector (FID) |
| Toluene<br>Styrene<br>Xylene | 7 | Site boundaries<br>Effluent outlet<br>(excluding styrene) | Odor bag | Low temperature concentration<br>Absorption at normal temperature | 5 1<br>(0.01 ppm) | Gas chromatography | Gas chromatography with a flame ionization detector (FID) |
| Propionic acid<br>n-butyric acid<br>n-valeric acid<br>isovaleric acid | 8 | Site boundaries | Absorption at normal temperature (direct sampling)<br>(glass beads) | | 25 1<br>(0.0005 ppm) | Gas chromatography | Gas chromatography with a flame ionization detector (FID) |

Note 1: Methyl mercaptan 0.0002 ppm
Hydrogen sulfide
Dimethyl sulfide 0.0005 ppm
Dimethyl disulfide

Note 2: Acetaldehyde 0.0005 ppm
Propionaldehyde
n-butyl aldehyde
isobutyl aldehyde
n-valeric aldehyde 0.002 ppm
isovaleric aldehyde

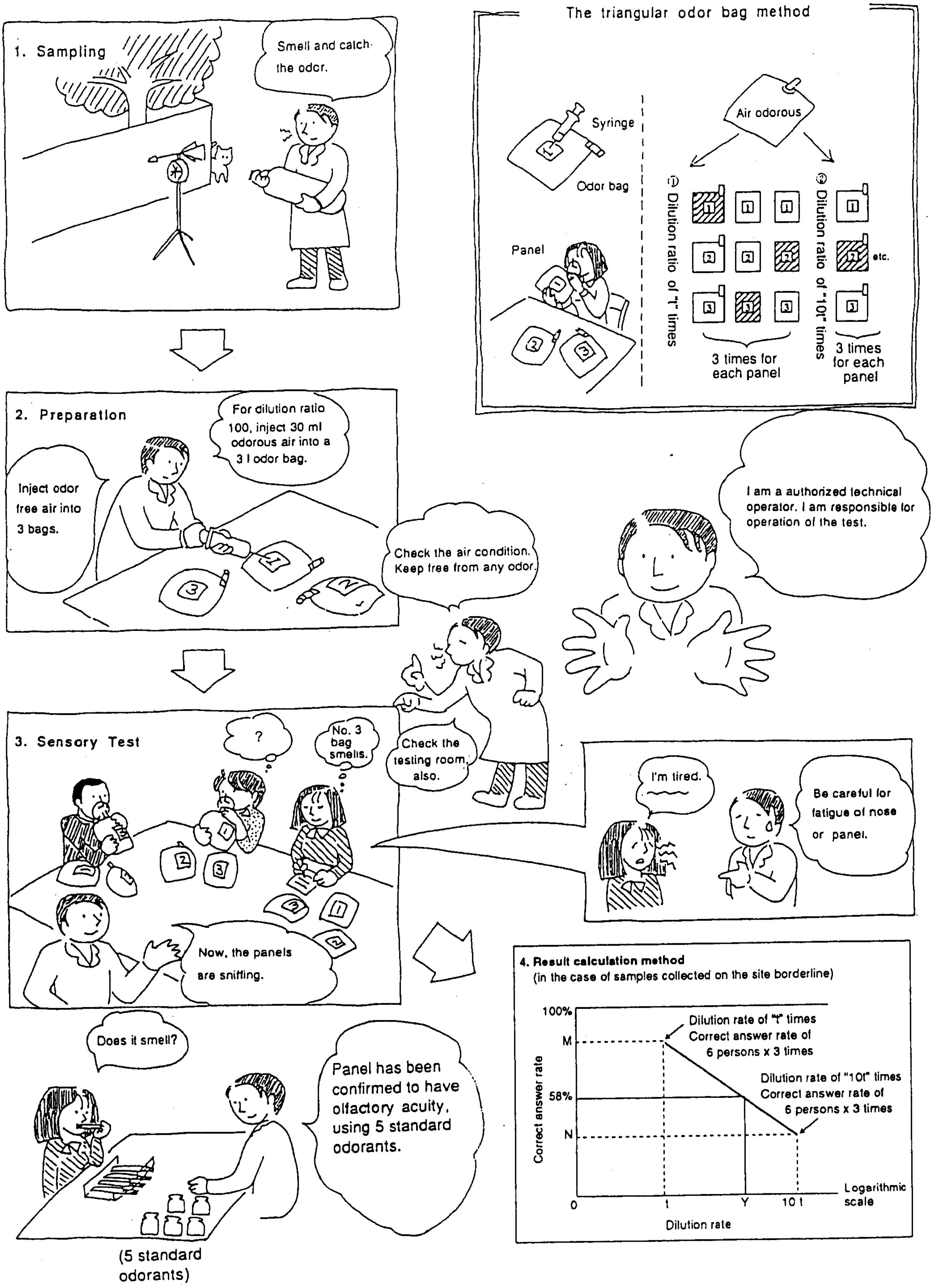



**Fig. 3.7 Outline of the Triangle Bag Method for Odor Sensory Measurement**

The scores "correct answer = 1.00," "incorrect answer = 0.00" and "unknown = 0.33" to the various results, and the average correct answer rate is obtained for the totality of the answers. When the average correct answer rate falls below 0.58 the identification test shall be ended, and when the result is larger than 0.58 the selection operation shall be repeated for further diluted samples.

When the average correct answer rate (M) falls below 0.58 with the initial dilution rate, the odor index of the odor in question is regarded to be less than 10 times the normal logarithm of the initial dilution rate.

When the average correct answer rate (M) becomes larger than 0.58 with the initial dilution rate, the odor index of the odor in question is calculated with the following mathematical expression:

$$\text{Odor index } Y = 10\log\left(M \times 10^{\frac{r_1 - 0.58}{r_1 - r_0}}\right)$$

where

M: Dilution rate used in the first judgement operation (= initial dilution rate)

$r_1$: Average correct answer rate obtained at the first judgement operation

$r_0$: Average correct answer rate obtained at the second judgement operation (dilution rate = $10 \times$ initial dilution rate)

As for samples collected at gaseous substance exhaust ports, the selection operations described above shall be carried out with samples that are concentrated enough to allow odor judgement by the panel but diluted enough not to cause fatigue of nose influence and the like on the panel, and the tests shall be repeated until the answers become incorrect or unknown in the various panels.

a) In the first place, obtain the threshold value as follows for each panel:

$$X_i = \frac{(\log M_{1i} + \log M_{0i})}{2}$$

where

$X_i$: Threshold value of the panel "i" (expressed in normal logarithm)

$M_{1i}$: Maximum dilution rate at which the answers of the panel "i" are correct

$M_{0i}$: Dilution rate at which the answers of the panel are either incorrect or unknown

b) Out of the various values of $X_i$, exclude the maximum value and the minimum value, respectively, and the value X obtained by averaging the results of the remaining 4 members of the panel shall be regarded as the threshold value of the panels as a whole (expressed in normal logarithm).

$$X = \frac{X_1 + X_2 + X_3 + X_4}{4}$$

where:

X: Threshold value of the panels as a whole (expressed in normal logarithm)

$X_i$: Threshold value of the panel "i"

c) The value of X multiplied by 10 shall be regarded as the odor index.

$$Y = 10X$$

where

Y: Odor index

X: Threshold value of the panels as a whole (expressed in normal logarithm)

### 3.7 Recommendations/Orders for Improvements

When the heads of cities, towns and villages approve that the living environments of inhabitants are spoiled because the emission of smelling substances caused by the business activities of factories and workshops in regulated areas does not conform to the regulation criteria, they may recommend to improve the operation of the facility causing the smelling substances, to improve the equipments for the control of emission of smelling substances, or to take other measures for reducing the emission of smelling substances within a reasonable period to be set.

The mayors of cities, towns and villages may order them to take the measures in the recommendation within a reasonable period to be set if anyone so recommended is not obedient to such recommendation.

Unless they are obedient to the orders for improvements, imprisonment of less than one year or a fine of less than five hundred thousands yen will be imposed on them.

### 3.8 Entrustment of the Measurement

Under this Law, the measurements required for issuing improvement recommendations and orders, as well as the monitoring and measurement of the environment and atmosphere shall either be carried out by servants of the National Government or regional public organizations, or, as for the measurement of offensive odor substances, entrusted to persons authorized to carry out environmental measurement and certification duties based on the Measurement Law. As for the measurement of the odor index, it may be entrusted to Odor Judgement Technicians, that are experts possessing National Certification, or juridical persons whose employee in charge of the measurement duties is an Odor Judgement Technician.

Moreover, this Law provides for the method of entrustment of the measurement, the responsibilities of the Odor Judgement Technician, the issuance of the Certificate of Odor Judgement Technician and other regulations related to the Odor Judgement Technician.

## 4. Promotion of Offensive Odor Prevention Measures by the Citizens, Business Corporations, National Government and Other Entities

### 4.1 Generation and Prevention of Offensive Odor Accompanying Daily Life

The offensive odor occurs not only from factories and workshops, but also from "the cooking of food and beverage at homes, rearing of pets and other kinds of daily life activities." "Since the latter ones are not necessarily compatible with remedial measures based on regulatory methods, it is presumed that the most effective method for coping with them is to improve the level of consciousness of each citizen in particular. Such being the case, the Offensive Odor Control Law provides for the responsibilities for preventing offensive odor caused by the said daily life activities." (Although these stipulations are out of the regulatory area of the Law, they are applicable to all areas in which there is concentration of residences.)

### 4.2 Banning of Burning the Materials Generating Offensive Odor

The offensive odor occurs from burning rubber, leather, plastics and waste oil, etc. In the Offensive Odor Control Law it is forbidden that they burn the materials to generate offensive odor in the open air. (This provision is applied to anyone as well as to the entrepreneurs.)

### 4.3 Control of Offensive Odor in Water Channels

It is often reported that in the sewers, rivers, ponds, lakes and ports the offensive odor occurs due to the in-flow of waste water from factories and houses and the decomposition of wastes thrown away and spoils the living environment of inhabitants living in the surrounding areas. For this reason it is provided in the Offensive Odor Control Law that the administrators of sewers and rivers, etc. must take proper care of these places not to be spoiled by the offensive odor.

### 4.4 Responsibility of the National Government and Regional Public Organizations

The Offensive Odor Control Law stipulates that the National Government and the regional public organizations have the obligation of carrying out the enlightenment and the diffusion of knowledge through the environmental education and the like, supporting the efforts of the citizens for preventing offensive odor (refer to section 4.2), as well as carrying out other measures such as the supply data and information deemed to be necessary, etc.

# 5. Offensive Odor Control Measures

## 5.1 Control Measures in Factories and Workshops

When they produce and process the goods and treat the liquid-waste in factories, specific odor occurs respectively. In the case that such specific odor may be felt offensive, they must take the measures to control the offensive odor.

It is considered that in order to control the offensive odor we must choose the raw materials causing less smelling substances and also reduce the quantity of smelling substances occurred by improving the producing and processing process and treatment methods.

The smelling substances must be eliminated by the use of deodorization equipments to such a degree that the inhabitants living near the factories and workshops will not have uncomfortable feeling with them.

## 5.2 Technologies for Controlling Offensive Odor

The technologies to be used for the control of offensive odor are introduced as follows (Table 5.1):

(1) Offensive odor materials are washed away with water or are converted into weak odor materials using the acid and alkali liquid. (A liquid should be chosen depending on the kind of offensive odor materials).

(2) Offensive odor materials are absorbed with the absorbents such as activated carbon (charcoal), silica gel and ion-exchange resion. (Absorbents should be chosen depending on the kind of offensive odor materials.)

(3) Offensive odor materials are burnt directly in a burning furnace. (There is a need to completely burn the offensive odor materials by improving the conditions for burning.)

(4) By the use of catalysts such as platinum, palladium, etc. the offensive odor materials are oxidated and decomposed. (In this case we must take much care against the catalyst poison in the waste gas spoiling the effect of catalysts.)

(5) By spraying good smelling materials the offensive odor can be masked.

(6) The offensive odor materials are decomposed by the activated sludge and the microorganism living in the soil.

(7) The offensive odor materials are condensed and eliminated.

Depending on the type of industry and working process of factories and workshops, the offensive odor causing the claims varies in terms of materials caused, their concentration, quantity of emission and characters. At the same time meteorological conditions of the location of factories and workshops will give impacts on the offensive odor causing the claims. Therefore, it is difficult to decide as a rule about which technology must be applied for controlling the offensive odor.

## Table 5.1 Summary of Offensive Odor Control Measures (Deodorization Methods)

| | | Applicable industries/sites | Principles | Advantages | Disadvantages |
|---|---|---|---|---|---|
| Water scrubbing methods | Water scrubber | Animal husbandry, agricultural and forestry industries, night soil treatment plants, sewage treatment plants, leather processing plants, etc. | Of odor generating substances, water-soluble components (such as ammonia, lower amines and lower fatty acids) are removed by scrubbing them with water) | Simultaneous removal of mist, fumes, particles is possible; chemicals are not used so maintenance and management is easy. | Not expected to be effective for substances with a low water-solubility (e.g. hydrogen sulfide, mercaptans, higher amines and fatty acids) |
| | Chemical water scrubber | | Odor generating components are removed by scrubbing them with acidic (e.g. sulfuric acid and hydrochloric acid) and basic (e.g. sodium hydroxide) solutions. | Acid scrubbing is effective for the removal of ammonia, amines, etc., and base scrubbing for hydrogen sulfide, lower fatty acids, etc.; simultaneous removal of mist, fumes and particles is possible. | High running costs; care required for maintenance and management. |
| Absorption methods | Activated charcoal absorption | Painting workshops, printing factories, plastic processing plants, textile processing plants, acrylate resin manufacturing plants, plating factories, rubber manufacturing plants, dry cleaners, etc. | Odor generating substances are absorbed and removed by utilizing molecular attraction exerted by activated charcoal, silica gel, and zeolite, etc. | Effective for alcohol, benzene, fatty acids, mercaptans, and other organic compounds.<br>Easy maintenance and management | Limited effectiveness for ammonia, amines and aldehyde |
| | Ion exchange method | | Odor generating substances are electrically captured and removed utilizing the positive or negative electric polarity that ion-exchange resins possess. | Effective for a wide range of odorous gases | Ion-exchange resins are expensive |
| Combustion methods | Direct combustion | Chemical plants, food factories, pulp mills, printing factories, feed manufacturing plants, fertilizer manufacturing plants, etc. | Odor generating gases are mixed with air in a combustion furnace, and oxidized and decomposed through combustion (at 600–800°C). | 99.9% or more odor removal effect<br>Easy maintenance and management | The effectiveness is reduced in the case of incomplete combustion.<br>The removal of humidity is required via a pretreatment.<br>High fuel costs |
| | Indirect combustion | | A method to obtain the same effectiveness as the direct combustion method at lower temperatures by utilizing catalysts | Savings can be made on fuel costs. | The removal of humidity is required via a pretreatment.<br>Maintenance and management is difficult. |
| Oxidation methods | Ozone oxidation | Oil refineries, sewage treatment plants, night soil treatment plants, feed manufacturing plants, meat processing plants, etc. | Odors are removed or neutralized by taking advantage of the oxidation and masking effects of ozone. | Effective for hydrogen sulfide, methyl mercaptan, dimethyl disulfide, amines and aldehydes<br>Easy system operation and management | Limited effectiveness for ammonia etc.<br>Need to adjust the amount of oxidizing agent added<br>Maintenance and management is difficult. |
| | Chlorine oxidation | | Odors are removed by utilizing the oxidation power of chloric acid and hypochlorous acid. | Effective for hydrogen sulfide, methyl mercaptan, dimethyl disulfide, etc. | Limited effectiveness for ammonia etc.<br>Need to adjust the amount of oxidizing agent added<br>Maintenance and management is difficult. |
| Neutralization method | | Sewage treatment plants, chemical plants, food factories, etc. | Deodorization through the mutual cancellation of odors by mixing odors from odorous gases with those of neutralizing agents | Handling is very easy<br>Low system installation costs | Neutralizing agents are relatively expensive.<br>Limited application range |
| Biological deodorization<br>Soil deodorization | | Agricultural and animal husbandry industries, night soil treatment plants, sewage treatment plants, animal carcass processing plants, food factories, etc. | Deodorization through the oxidation and decomposition of odorous gases by microorganisms living in the soil, as they pass through soil layers | Effective for ammonia, amines, hydrogen sulfide, etc.<br>Low maintenance and management costs<br>No need for wastewater treatment | A large site area is required.<br>Maintaining and controlling soil microorganisms is difficult. |
| Masking method | | Fat and oil processing plants, leather processing plants, textile processing plants, restaurants and bars, etc. | Odors from odorous gases are masked by stronger smells emanating by fragrant substances | Easy handling<br>Low system installation costs | Limited application range<br>High deodorant costs<br>High odor concentration |

Any single type of method will not be sufficient usually for the control of offensive odor, but a combination of several methods will be required.

### 5.3 Transfer and Centralization of Factories and Workshops

When the offensive odor problem occurs due to factories/workshops densely neighboring houses, it should be considered that they transfer and centralize the factories and workshops scattered in densely built-up areas by creating the industrial parks in the coastal region or inland areas in order to make the houses separate from the factories and workshops causing offensive odor. As such factories and workshops are small and medium-sized generally, they often face financial problems which make the transfer difficult. Therefore, the Environment Corporation, etc. render services for such transfer by constructing the factory buildings for joint use and creating the factory complexes.

## 6. Problems for the Present

### 6.1 Additional Designation of Specified Offensive Odor Substances

As the specified offensive odor substance 22 substances are designated at the present time. Because the claims against the emission of the other substances are considerably made excluding these 22 substances, there is a need to designate the additional substances which are considered to cause claims often among these substances.

### 6.2 Additional Determination of Regulation Standards and Measurement Methods Referring to Odor Index

As things now stand, the regulation standards and the calculation methods applicable to the gaseous substance exhaust parts and the discharged waters are not determined, due to the insufficient scientific knowledge about the matter. Such being the case, they shall be determined as soon as possible, through the required studies and investigations.

### 6.3 Study of the Automatic Measurement

The degree of offensive odor coming from sources changes from time to time depending on such meteorological conditions as direction and speed of wind. However, measurement takes a lot of time because this measuring method is to analyze by hands. Since such an analysis can not get hold of the changing situations of offensive odor, we are studying about the introduction of automatic measurement.