

Odor Index Regulation and Triangular Odor Bag Method

2003

1995

1972

Office of Odor, Noise and Vibration
Environmental Management Bureau
Ministry of the Environment
Government of Japan

Outline of the Offensive Odor Control Law

In Japan, the Offensive Odor Control Law was enacted in 1972. The law aims to regulate the emission of offensive odors and preserve the living environment of residents.

Application

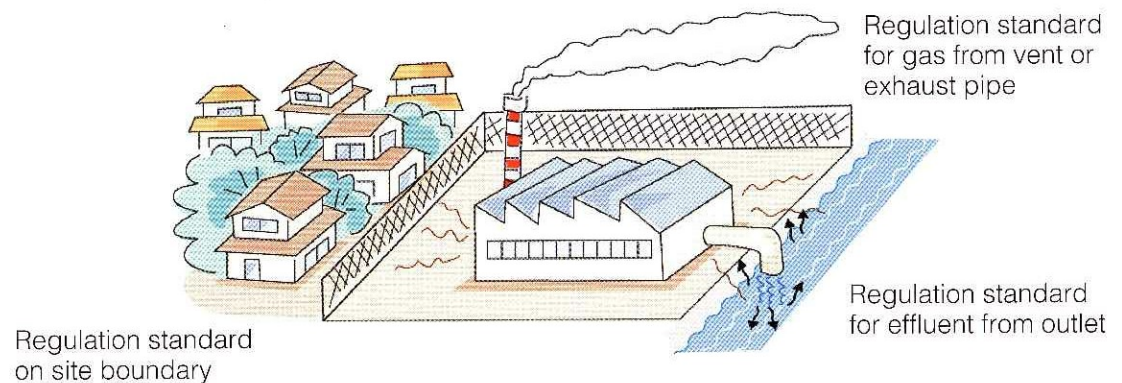
All kinds of factories and workshops within regulated areas designated by local governments based on geographical and demographical conditions are subject to regulation.

Standard

The following 2 systems are used for regulation:

- ▶ Concentration of Offensive Odor Substances
- ▶ Odor Index

Local governments choose either of them and establish 3 applicable regulation standards corresponding to 3 types of odor emissions from factories and workshops.



Implementation

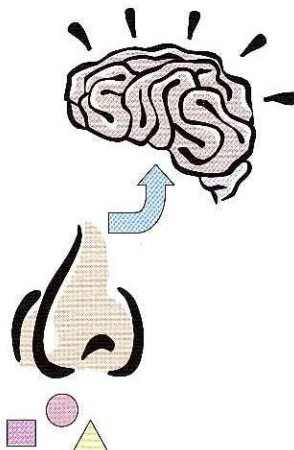
When offensive odor from a factory or workshop exceeds the regulation standard and simultaneously impairs the living environment of residents, local government shall recommend or order the business proprietor to remedy the situation. Penalty shall be imposed on violator



Basic Knowledge

Dose: Offensive Odor Substances

A group of substances that could constitute unpleasant odors and possibly impair the living environment. A total of 22 substances including ammonia and hydrogen sulfide has been designated by the law as Offensive Odor Substances.



Response: Odor Index

An index that quantifies the intensity of odors. Samples are diluted with odor-free air until the odor cannot be detected any longer to determine the dilution rate (odor concentration). The odor index can be calculated by multiplying the common logarithm of the dilution rate by the factor 10.

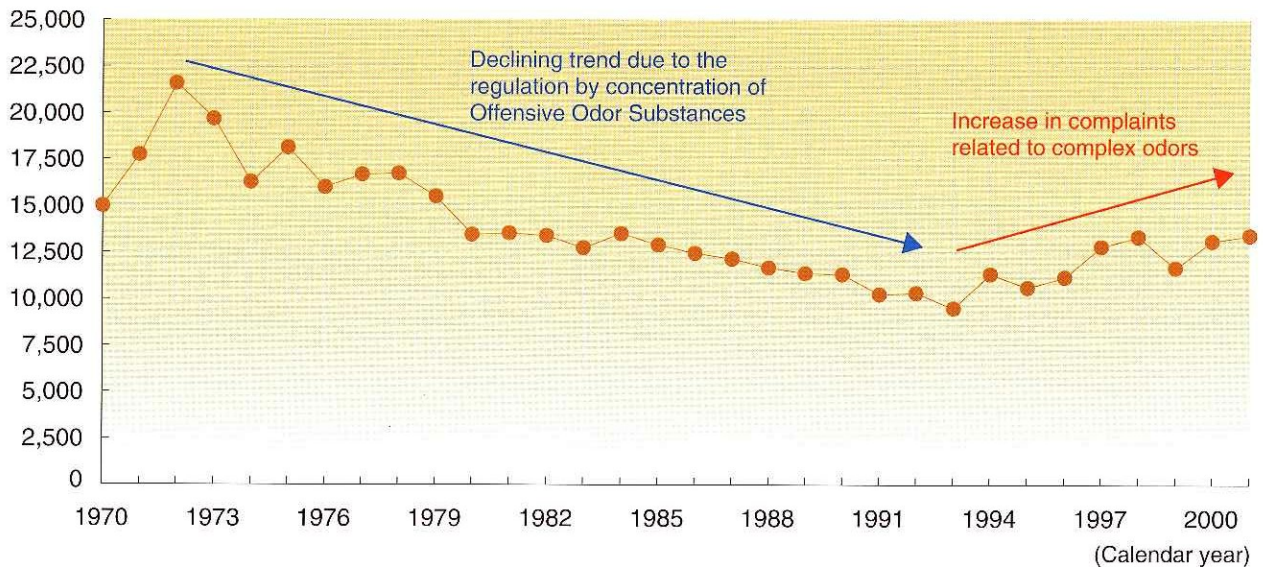
$$\text{odor index} = 10 \times \log (\text{odor concentration})$$



History of Offensive Odor Control in Japan

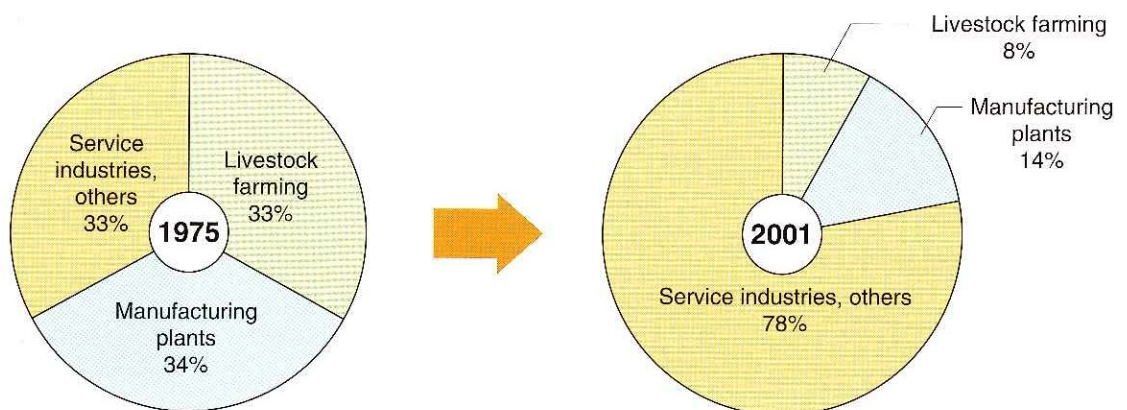
Since the Offensive Odor Control Law took effect in 1972, offensive odor substances have been regulated by their concentrations. Various efforts toward improvement under this law resulted in a decreasing number of complaints. However, the number increased little by little after 1990. One of the causes of this increase is that people have become sensitized to odors generated in daily life. Complaints about livestock farming and manufacturing plants have been decreasing, while those about service industries and private households have been increasing.

(Number of complaints)



Annual changes of complaints about offensive odors (except those related to outdoor incineration)

As the subject of complaints changed in recent years, there was an increasing number of cases that were out of the regulation by concentration of offensive odor substances. To cope with these cases, the Offensive Odor Control Law was revised in 1995 and the odor index regulation was introduced.



Odor index regulation has the following advantages:

- can deal with diverse (more than 400,000) odorants
- can evaluate additive and multiplicative effects of odorants
- can help us imagine the intensity of odor through measurement results
- can meet residents' sense of suffering from offensive odors

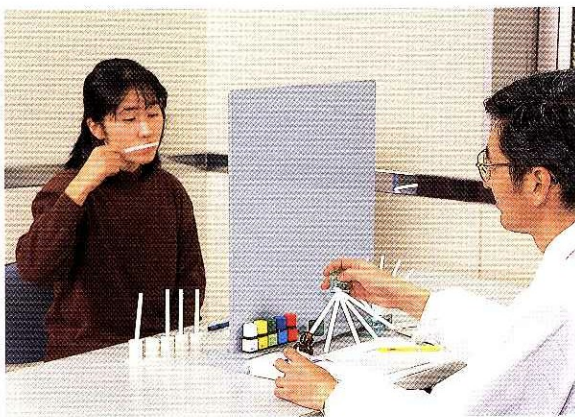


Triangular Odor Bag Method

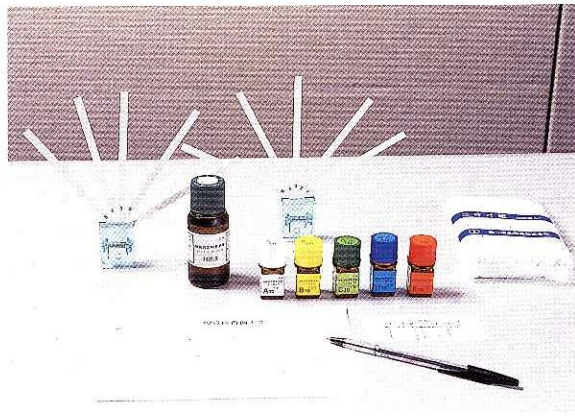
Odor intensity is measured with olfactory measurement methods. In Japan, the "Triangular Odor Bag Method" has officially been adopted for measuring the odor index.

(1) Selection of panel (group of persons who judge the presence of odor with their olfaction)

An aptitude test is conducted using five standard odorants to choose a group of persons without olfaction abnormalities as the panel. To measure the odor intensity precisely and fairly, the panel must be in good health, both physically and mentally. It is important to take panel members' health condition into account and confirm that their olfactory sense is not affected by cold or other illness.



Aptitude Test using Five Standard Odorants: testees identify two test strips with odor out of five strips of test papers.



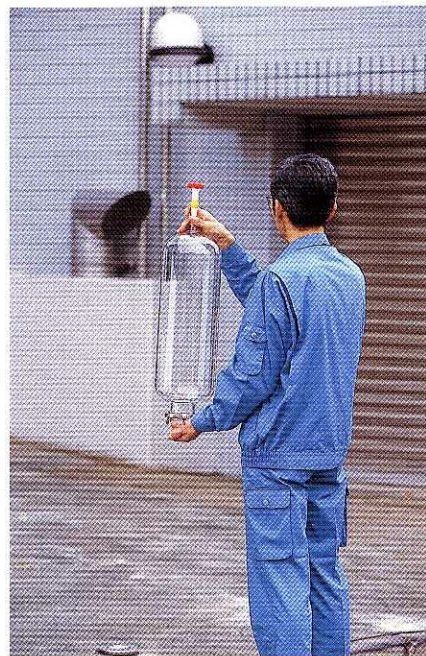
Standard Odorants for Aptitude Test: There are five standard odors used in the aptitude test including odor "smells like flowers" and odor "smells like sweaty socks."

(2) Sampling

The measurement of the odor index is conducted indoors, using samples from the site in question. It is important that operators of olfactory measurement are sufficiently familiar with the situation at the sampling site and take samples from the location where the smell is most intense.



Since the odor intensity is always changing, the operator has to take samples instantaneously from the location of the most intensive smell, identifying the intensity with his/her own olfaction.



Olfactory Measurement Operator

An olfactory measurement operator is a person in charge of management and organization of the entire series of olfactory measurement from panel selection, sampling, performance of tests and summarizing the results based on the Triangular Odor Bag Method.

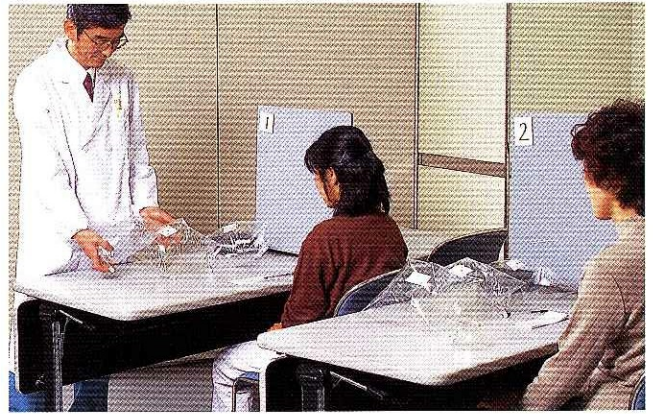
This is a National Certification granted to those who passed both the written examination and an aptitude test using five standard odorants. Currently, there are 2,081 certified operators nationwide (as of March 2003). Olfactory measurement operators are allowed to measure the odor index based on the Offensive Odor Control Law when commissioned by local governments.

(3) Performance of sensory test

The sensory test is conducted by at least 6 members of the panel. Each panel is given 3 bags; 1 with a sample in it and 2 without sample (odor-free air) and asked to choose the odorous bag.

If the panel can tell the correct bag, the odor is then diluted and the test is continued until it becomes impossible to identify the bag with odor.

In order to ensure the accuracy of the measurement, it is important to take psychological influences of panel members and olfactory fatigue into account.



Panel members are to identify the bag with odor among 3 bags in a composed environment without odor where they can concentrate on the test.



Fill a bag with odor-free air (filtered through activated charcoal).



When panel members detect intensive odors, their olfaction weakens (olfactory fatigue). Therefore, the test is started with a moderately diluted concentration.

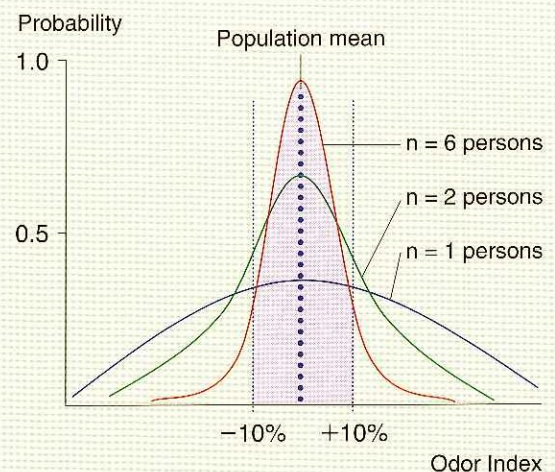
(4) Calculation

Test results should be calculated according to stipulated methods to determine the odor index.

Why are at least 6 members necessary for the panel ?

The individual sensitivity to smell differs even among those who passed the aptitude test. To examine the variation of test results, a series of sensory tests was conducted by changing the number of panel members. Sensory tests performed by 6 panel members yielded test results (odor index) which ranged within $\pm 10\%$ of the population mean with a probability of 94%. When calculated with 4 members excluding maximum and minimum values, the probability of results being in a $\pm 10\%$ range of the population mean was 91%, revealing a high reliability of results.

Therefore, the panel for the olfactory measurement should include 6 or more members. Moreover, in order to eliminate the influence of outliers, maximum and minimum values should be excluded.



Probability distribution of test results



Calculation of Odor Index

- 1) First, calculate the threshold of each panel member as follows;

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

X_i : Threshold of panel i (expressed as common logarithm)

M_{1i} : Maximum dilution rate at which the answer of panel i is correct.

M_{0i} : Minimum dilution rate at which the answer of panel i is incorrect or indistinct.

- 2) Then, calculate the average threshold of panel, which is the average of X_i excluding maximum and minimum values.

$$X = \frac{X_1 + X_2 + \dots + X_{n-2}}{n-2}$$

X : Average threshold of panel (expressed as common logarithm)

n : Number of panel members

- 3) Calculate the odor index by multiplying X by the factor 10.

$$Y = 10X$$

Y : Odor index

Example

An example of the test result is shown on the table below. Threshold of panel i (X_i) ranges from 2.24 to 3.74. Among these values, excluding the maximum (3.74) and minimum (2.24) values, average threshold of the panel (X) is determined by averaging X_i for the remaining 4 panel members. This value (X) multiplied by the factor 10 is the odor index (Y).

$$X = \frac{2.74 + 2.74 + 2.24 + 3.24}{4} = 2.74 \text{ (expressed as common logarithm)}$$

$$Y = 10 \times 2.74 = 27.4 \rightarrow 27 \text{ (round digits after decimal point)}$$

Example of sensory test for sample collected at exhaust port

Dilution rate	30	100	300	1000	3000	10000	Threshold of each panel (X_i)	Exclude maximum/minimum values
Logarithm	1.48	2.00	2.48	3.00	3.48	4.00		
Panel	A	/	○	×			2.24	Excluded
	B	/	○	○	×		2.74	
	C	/	○	○	○	×	3.74	Excluded
	D	/	○	○	×		2.74	
	E	/	○	×			2.24	
	F	/	○	○	○	×	3.24	

Sensory tests for samples collected on site boundary

There is an established method that is suitable for measuring odors with low concentration. This method is applied to measure samples collected on site boundary of factories and workshops. First, when panel members select a bag with odor, the answers "correct," "incorrect" and "indistinct" are given a score of 1.00, 0.00 and 0.33, respectively. Then, the average correct answer rate is determined by averaging the scores of panel members. The odor index is calculated according to the following equation.

$$Y = 10 \log \left(M \times 10^{\frac{r_1 - 0.58}{r_1 - r_2}} \right)$$

Y : Odor Index

M : Initial dilution rate

r_1 : Average correct answer rate at the first operation

r_2 : Average correct answer rate at the second operation

Triangular Odor Flask Method

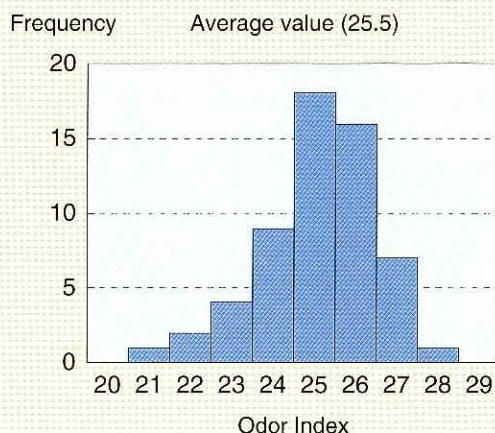
This is one of the methods to measure odors emitted from wastewater. This method is applied to measure samples collected at outlet of factories and workshops. Flasks are used instead of bags and at least 6 members of the panel identify the flask with odor among 3 flasks, repeatedly to determine the odor index. The procedures for the sensory test and the calculation of test results are almost the same as those in the triangular odor bag method.

Quality control

The quality control for the triangular odor bag method consists of two parts: external accuracy control and internal accuracy control.

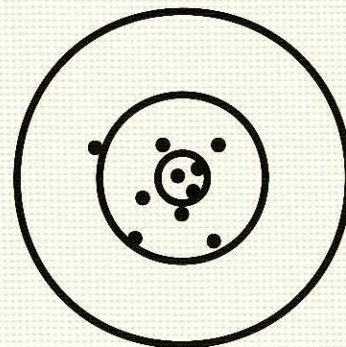
External accuracy control

In order to determine inter-laboratory errors, samples of unknown concentrations are distributed and measured simultaneously at multiple laboratories. The measurement accuracy of each laboratory is evaluated in comparison with the overall distribution of results.



Internal accuracy control

For intra-laboratory control, samples of known concentration are measured periodically at each laboratory and results are then compared with a standard value to evaluate the intra-laboratory errors.



Precision and trueness are evaluated for test results using ethyl acetate with a concentration of 2,000 ppm.

Contact address for inquiries or comments regarding this brochure

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