2-1 Sampling

2-1-1 Collecting an ambient air sample

No. 3 Measurement methods

1 Sampling

(1) Ambient air sample

Sample gas is collected in a sampling container or a sampling bag through one of the following methods, according to the type of sampling equipment in No. 2-1-(1).

a. If using the equipment shown in No. 2-1-(1)-a, open the cock of the sampling container of which the pressure had been reduced to less than 1.3 kPa, and samples are collected within 6 to 30 seconds.

b. If using the equipment shown in No. 2-1-(1)-b, use a suction bottle for sampling to collect a sample of a volume equivalent to that of the sampling bag within 6 to 30 seconds.

c. If using the equipment shown in No. 2-1-(1)-c or No. 2-1-(1)-d, a sample of about 10 L is collected within 6 to 30 seconds.

Samples should be collected if it is recognized that the operating and weather conditions of the target business place are equal or similar to those of when the damage occurred to the living environments of nearby residents. Moreover, the place where the offensive odor discharged from the business place most affects the living environment of residents should be selected, and samples should be collected at a point within 2 m above the ground and within 10 m from the boundary line of the site of that business place. If other sources of odor emission exist around the business place, it is necessary to give extra consideration to the operating and weather conditions, and to carry out the measurement under the circumstances that any offensive odors emitted from other sources will not be of influence. (From the "Enforcement of the law revising a part of the Offensive Odor Control Law," Director's Notice of Air Quality Bureau of the Environment Agency in April 1995.)

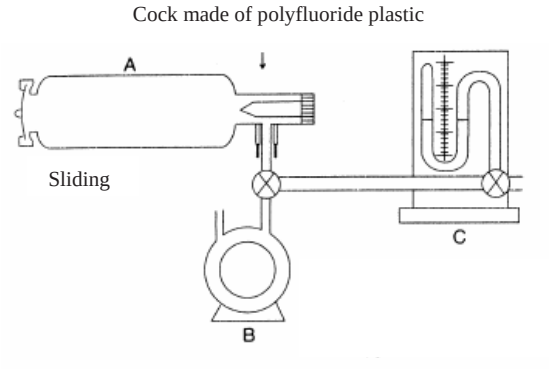
For this reason, the person who collects the samples should remain around the sampling place for a while, to judge the intensity, character and frequency of odor, and decide the sampling place and sampling time. Sampling should be carried out within 6 to 30 seconds. It is preferable to collect the samples properly in less time if the intermittence of odor (the state in which the presence of the odor is not continuous) is significant.

The person collecting the samples should be familiar with these sampling operations, and should fully understand the raw materials, processes, products, qualities, and conditions of discharged odors of the investigated business place, as well as have memorized the odors in each process so that the samples that grasp the daily discharge properties can be collected.

This applies to collecting exhaust port samples, as described in the next section.

1)Vacuum bottle method

Following the method shown in Figure 12, decompress a vacuum bottle to less than 1.3 kPa (10 mmHg), and close the cock made of polyfluoride plastic. Samples are collected when an odor seems to be the strongest, by opening the cock of a vacuum bottle prepared as stated above.



A: Vacuum bottle for sampling
B: Vacuum pump
C: Vacuum pressure gauge
D: 3-way cock

Figure 12: Decompressor of the vacuum bottle for sampling

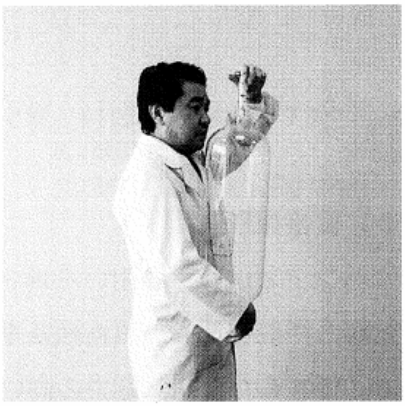


Figure 13: Sampling by using the vacuum bottle method

2) Suction bottle method

Perform the following procedures by using the equipment shown in Figure 14.

1. Connect the sampling bag to the cock made of polyfluoride plastic. Wash and replace the air in sampling bag with odor-free air two or three times on the day or the previous day of sampling, and confirm that it is odor-free.
2. Put the sampling bag in the suction bottle, and secure it with a clamp.
3. After confirming that cock a and cock b are open, decrease the air inside the suction bottle from cock b by using a pump until the sampling bag is almost full with odor-free air, and then close cock b.
4. Under these conditions, decrease the air inside the sampling bag from cock a by using a vacuum pump, and then close cock a. By doing so, the amount of air inside the suction bottle equivalent to the inner volume of the sampling bag can be taken out.
5. Open cock a and collect a sample when the odor feels strongest. Close cock a when sampling is finished.

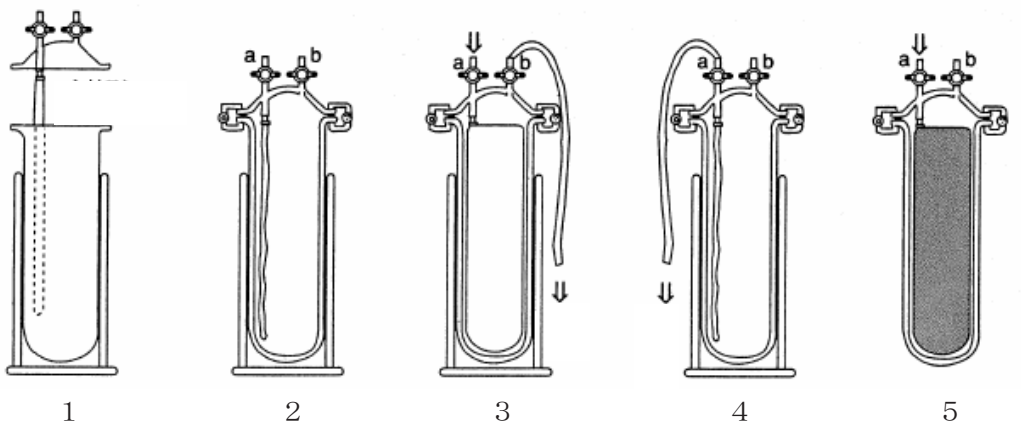
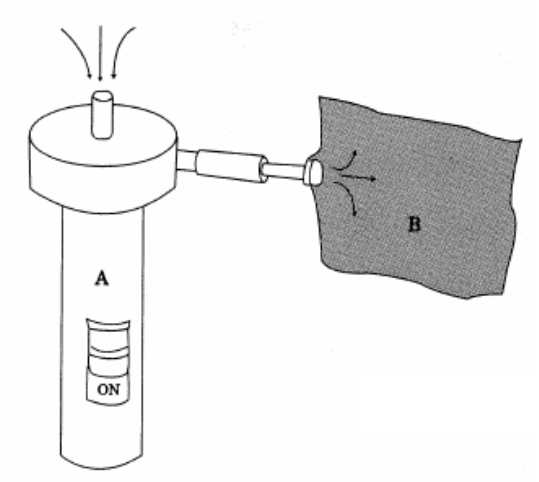


Figure 14: Procedures for sampling using the suction bottle method

3) Direct sampling method

When using a handy pump, collect a sample by connecting the pump and the sampling bag, as shown in Figure 15. Collecting samples in this way takes time in comparison to the odor sampling methods by a vacuum bottle and a suction bottle, so a pump that can supply as much air as possible should be used.



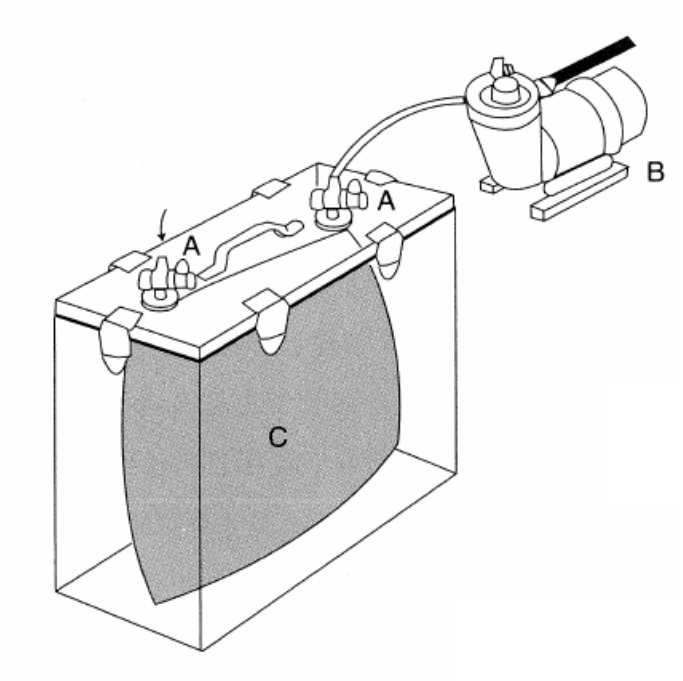
A: Handy pump
B: Sampling bag

Figure 15: Direct sampling (Handy pump)

4) Indirect sampling method

As shown in Figure 16, a sampling bag is put into the vacuum container, and connected to the cock made of polyfluoride plastic.

After confirming that two cocks are open, start operating the sampling pump connected to the cock behind the vacuum container, and collect samples in the sampling bag by reducing the internal pressure of the vacuum container. It is also necessary to be very careful that the vacuum container is airtight.



A: Cock made of polyfluoride plastic
B: Suction pump
C: Sampling bag

Figure 16: Indirect sampling

5) Remark for ambient air sampling

a) When collecting samples, make sure to record the sampling place, time of sample collection, sampling time required, operating conditions, weather conditions, and odor character.

b) Avoid exposing the collected samples to direct sunlight as much as possible, and be careful of the temperature of the samples becoming high during transportation.

c) When using the sampling method of collecting samples directly in a sampling bag, an odor of the measurement place should be taken in and out of the bag before collecting the samples, in order to avoid the influence of adsorption to the inner wall of a bag.

d) Store the collected samples in a dim place under normal temperature until the sensory test.

2-1-2 Collecting a exhaust port sample

No.3 Measurement Methods

1 Sampling

(2) Exhaust port Sample

Method of collecting a 3 to 20 L sample in approximately 1 to 3 minutes, using the sampling equipment in No. 2 – 1 - (2).

The fundamental issues regarding sampling have been stated previously, in "2-1-1 Collecting an ambient air sample."

The sample is collected in about 1 to 3 minutes. The appropriate sampling amount is 3 to 20 L.

Condensate water must be prevented from entering the sampling bag. For this reason, if there is the possibility of water from the exhaust port condensing into the sampling bag, it is necessary to use a condenser between the exhaust pipe and the pump. If the exhaust gas temperature is especially high, or if gas that has passed through exhaust gas cleaning equipment is collected, pay particular attention. Also, if there is the possibility of large amounts of dust being included in the exhaust gas, it is necessary to plug some glass wool into the middle of the sampling tube.

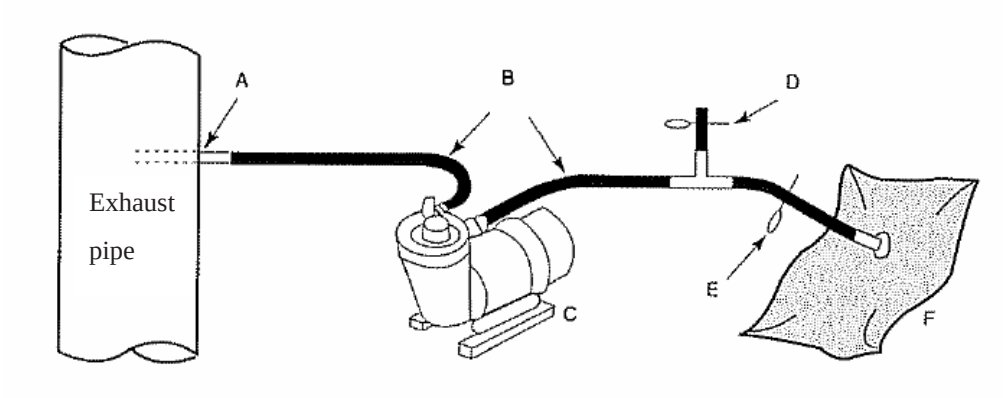
In collecting samples, if the conditions of the sampling site are unfavorable and there is the possibility of danger (i.e. the sampling port is at a high location where there is bad footing, the exhaust gas is of a high temperature, exhaust gas blasts out from the sampling port when the exhaust gas pressure is positive, etc.), take extreme precautions.

1) Direct Sampling Method

As shown in Figure 17, insert the sampling probe (A) into the exhaust pipe, and suck the gas by using the sampling pump (C). When sucking, close the sample screw cock (E), open the bypass screw cock (D), and start operating the sampling pump (C). After clearing out the air in the tube (B), open the sample screw cock (E), and collect the sample in the sampling bag (F). The sampling flow can be adjusted by using the bypass screw cock (D).

To ensure that air other than that wanted for sampling does not mix in, it is necessary to be cautious of leaks. If you are also using a pump that was used to collect samples previously, it is necessary to leave it idle for awhile to clear out the odor. If the presence of odor is recognized even after doing so, dismantle the pump and wash the diaphragm, valve, and pump head thoroughly. Then, air-dry these parts and leave them idle for awhile, and use them after confirming that the odor has been removed.

If the inside of the exhaust pipe is of a positive pressure, and collection of a sample is possible even without using a sampling pump, it is not necessary to use the sampling pump.

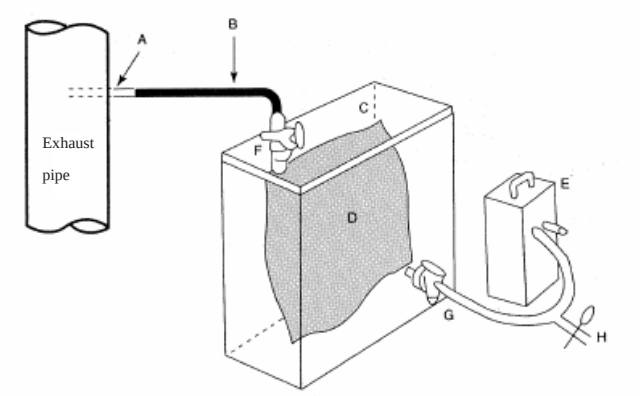


A: Sampling probe
B: Tube
C: Sampling pump
D: Bypass screw cock
E: Sample screw cock
F: Sampling bag

Figure 17 Direct Sampling of a exhaust port Sample (Diaphragm Pump)

2) Indirect Sampling Method

As shown in Figure 18, put the sampling bag (D) into the vacuum container (C), and connect it to the polyfluoride plastic cock (F). Insert the sampling probe (A) into the exhaust pipe, and after confirming that the two cocks (F, G) are open, operate the sampling pump (E) connected to the cock (G) behind the vacuum container (C), and collect a sample in the sampling bag (D) by depressurizing the inside of the vacuum container. It is necessary to be particularly cautious of air leakages from the vacuum container (C) and gas leakages from the tube.



A: Sampling probe
B: Tube
C: Vacuum container
D: Sampling bag
E: Sampling pump
F: Polyfluoride plastic cock
G: Cock
H: Screw cock

Figure 18 Indirect Sampling of a exhaust port Sample

3) Measuring the Flow Rate of the exhaust port

The flow rate of the exhaust gas is measured by the method established by the Japanese Industrial Standard (JIS) Z8808, “Method of measuring dust concentration in exhaust gas.”

4) Remark for exhaust port sampling

a) When collecting samples, do not forget to record the sampling place, time of sample collection, sampling time required, and the operating conditions.

b) Avoid exposing collected samples to direct sunlight as much as possible, and be careful of the temperature of the samples becoming high during transportation.

c) To prevent the influence of adsorption on the bag’s inner wall, when collecting a sample, clear out what was collected once and collect a sample again.

d) Store the collected samples in a dim place under normal temperature until the sensory test.

e) In principle, do not use a sampling bag after it has been used once. However, when collecting a sample with a higher odor concentration after collecting one with a low odor concentration first, it is possible to reuse a sampling bag if it is washed well.

f) Because the polyfluoride plastic tube will melt if the temperature of the sample is above 250°C, it is necessary to be resourceful, such as by using tubes that are highly resistant to heat (made from glass, metal, etc.), or make the sampling tube long enough so that the sample can cool down while passing through it.

2-2 Sensory Test

No. 3 Measurement Methods

2 Sensory Test

(1) Timing for Sensory Test

A sensory test (a test in which a panel uses olfaction to judge the presence of odor in an odor bag; called the same hereinafter) is to be conducted as soon as possible, on the same day or the day after the sample is collected.

1) Timing for sensory test

Depending on the type of sample, there are some in which the quality of the sample changes or the odor becomes weaker in a short period of time after it is collected. For this reason, it is a general rule that the sensory test is performed on the same day the sample is collected. Or, if there was no alternative but to collect the sample in the afternoon or night, the sensory test is to be conducted in the morning of the following day.

No. 3 Measurement Methods

2 Sensory Test

(2) Number of Panel Members

Appoint at least six persons selected according to the panel selection method established previously in No. 1 - 2.

2) Panel Selection

a) Panel selection

It is necessary to select panel members by randomly extracting people other than those who are inappropriate for the sensory test, such as those who have direct vested interests in the place where the sample was collected, or those who do not feel physically well on the day of the test, from among the many people recruited previously by open recruitments. It is also necessary to ensure fairness of judgment by not telling the panel members where the samples to be tested were collected. (From the Enforcement of the Revised Offensive Odor Control Law," Director's Notice of Air Quality Bureau of the Environment Agency in September 1995.)

In accordance, it is necessary to secure about 10 to 20 successful candidates who passed the olfactory test, and to make considerations such as a) avoiding people whose olfaction is affected due to a cold, etc., who do not feel physically well, or who are unable to be mentally calm on the day of the test, and b) avoiding people who have vested interests towards the place where the sample was collected.

b) Number of panel members

The panel must be comprised of at least six persons, and in general, testing is conducted by six persons.

c) Cautions regarding the panel

1) On the day of the sensory test, panel members are advised against wearing makeup with strong fragrance and to refrain from eating meals with strong odors.
2) The process of the sensory test is fully explained to the panel in advance. It is also explained that the correct number is not necessarily the same as that of the adjacent person.
3) The panel is instructed to arrive at the waiting room 30 minutes before the sensory test, to make sure that they do not begin the test without being calm enough, due to tardiness.

d) The panel and fatigue

Taking the fatigue of the panel into account, the maximum number of samples which can be measured in one day is 10 to 14 (4 to 6 samples in the morning, 6 to 8 samples in the afternoon). Measuring more than the maximum number of samples will induce a lot of fatigue on the panel and therefore should be avoided by all means. Figure 19 indicates the regular course of time. The time required to measure one sample is approximately 20 to 40 minutes for an ambient air sample, and approximately 15 to 25 minutes for a exhaust port sample.

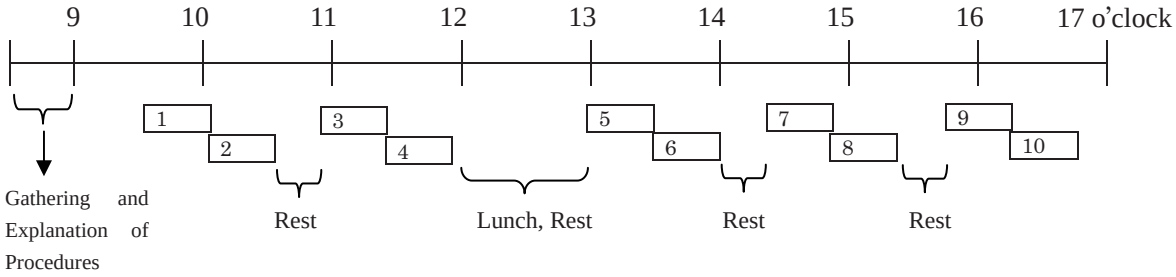


Figure 19 Standard Course of Time for Sensory Test

[Reference]　The Reason Why the Panel Must Consist of at least 6 persons

If the olfactory acuity of human beings did not differ much from person to person, it would not matter if the panel consisted of a small number of people, but if this acuity varies widely, then the number of people would have to be larger, otherwise reliable values with high reproducibility will not be obtained. Figure 20 is an example of a research conducted on the variability of olfactory acuity of human beings in relation to methyl-cyclopentenolone. As can be seen from this graph, there is a wide range even among persons with normal olfaction. Therefore, if the panel consists of only one person, the data varies widely, but if the number of panel members increases and the mean is calculated, then the variation becomes small. In other words, when the panel is made up of *n* persons, the standard deviation of the mean is. This is $1/\sqrt{n}$ demonstrated in Figure 21.

As a specific example, according to the results of the test using the three standard odors of methyl-cyclopentenolone, isovaleric acid, and skatole, there is a 94% probability that the mean of the six panel members will fall within the upper 10% range of the logarithmic value, centered around the estimated population mean value. Also, when excluding the top and bottom panel members and taking only the middle 4 persons into consideration, there is a 91% probability that their mean will fall within the abovementioned range.

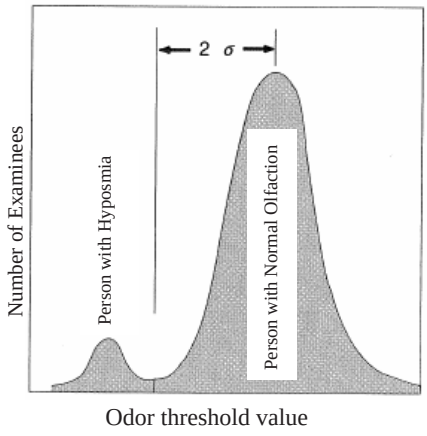


Figure 20　Distribution of Odor Threshold Values for a Group

Odorant: Methyl-cyclopentenolone
Number of People Studied: 300

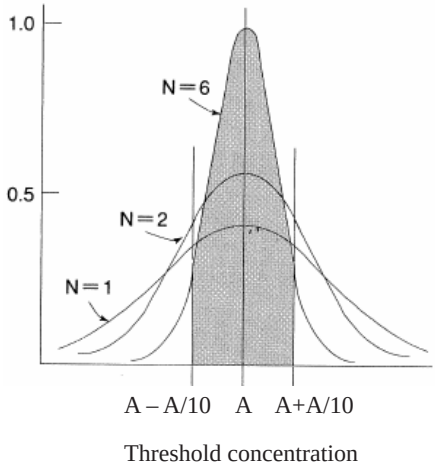


Figure 21　Distribution of Mean threshold value for a Panel of *n* persons

No. 3 Measurement Methods

2 Sensory Test

(3) Location of Sensory Test

The location where the sensory test is to be held should have a ventilation system or a ventilation window, and should not be a location that has odors which would affect the sensory test. It should also be a location where the panel can remain calm.

3) Location and environment of sensory test room

a) Conditions for sensory test room

The sensory test should be conducted in a place which fulfills the following conditions. If such a place is separate from the waiting room, it is necessary that the waiting room fulfills the following conditions as well.

a. A room where there is no odor

A room where there is a ventilation system or a ventilation window. In particular, rooms which have the odor of floor wax, new *tatami* mats, or new construction materials are unsuitable. It is also necessary that the test room should be a non-smoking room at all times, even when testing is not conducted.

b. A quiet location with little human traffic.

c. A place where the sample source cannot be seen

d. A place where the sample preparation cannot be seen

e. A place where the panel can keep calm, etc.

In addition, it is also preferable that the temperature and humidity of the test room be adequately maintained. The temperature should be maintained at below 25 °C during the summer, and above 17 °C during the winter. It would also be preferable to maintain the relative humidity of the room at a range between 40 to 70%.

b) The layout of the room

An example of the recommended layout for the test room is indicated in Figure 22. In this figure, the “sensory test room” is the location where the panel sniffs odor, and the “waiting room” is a lounge where the panel can rid themselves of olfactory fatigue and psychological worries. The “sample preparation room” is the location where operators prepare the odor.

It is necessary that the waiting room be large enough for 6 persons to relax comfortably. If the room's circumstances do not allow for a sensory test room to be set up separately, divide one room with a screen or partition, and use the sensory test room and waiting room separately.

It would also be favorable if people can easily come and go between the sensory test room and waiting room. The sample preparation room and sensory test room are not to be separated by a partition, and it is better to set them up as separate rooms.

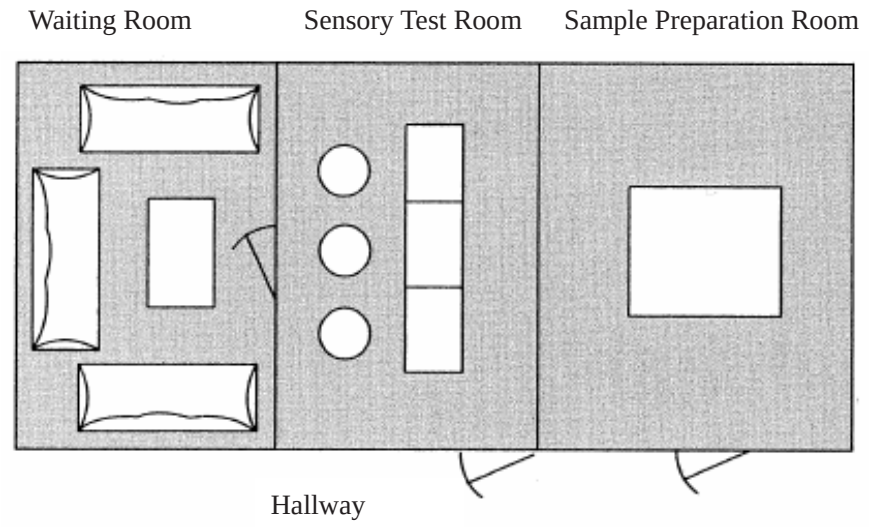


Figure 22 Example of Sensory Test Room

c) Environment of the room

Although there is no harm in some whispered talking in the waiting room, it is necessary to refrain from talking in the sensory test room by all means. However, because it is fundamental that the test is to be conducted on the conditions that the panel is mentally at ease, the operator should take precautions in making sure that the atmosphere in the sensory test room (as well as the waiting room) is not too tense.

2-2-1 Sensory Test for an ambient air Sample

2-2-1 (A) Procedures of Sensory Test for an ambient air Sample

No. 3 Measurement Methods

2 Sensory Test

(4) Procedures for the Sensory Test

a. Ambient air Sample

Pour odor free air into each of the three odor bags and seal the bags with silicone rubber stoppers, and using a syringe, inject some of the collected sample into one of these bags, to prepare the dilution ratio (hereinafter called “first dilution ratio” (*1)) with which the sensory test is first conducted. Give one prepared odor bag (hereinafter called “odor bag with odor”) and two odor bags which were injected only with odor-free air (hereinafter called “odor bag without odor”) to the panel, as one set. Each panel member, using sniffing masks, selects one bag out of the three that they think is the bag with the injected sample (This operation is called “selection operation,” and is hereinafter called the same.). This selection operation is repeated three times for each panel member.

For each selection operation conducted by each panel member, as a rate of correct answers, give 1.00 to a panel member who correctly selects the odor bag with odor, 0.00 to a panel member who selects an odor bag without odor, and 0.33 to a panel member who is unable to select an odor bag. After adding all the rates of correct answers together, divide this value by the cumulative number of times of selection operations performed by all of the panel members. By doing so, the average rate of correct answers is obtained.

The sensory test is complete if the average rate of correct answers is under 0.58. If the average rate of correct answers is over 0.58, increase the dilution ratio by 10-fold, conduct the aforementioned operations again, and complete the sensory test.

(*1) In principle, the first dilution ratio for an ambient air sample is 10. However, if it can be anticipated that the average rate of correct answers will be over 0.58 when conducting a selection operation again after a 10-fold dilution, decide on an appropriate value for the dilution ratio of over 10 so that the average rate of correct answers is under 0.58.

1) Procedures of Sensory Test for an ambient air Sample

A sensory test for an ambient air sample is performed in the procedures shown in Figure 23. In general, because the concentration of ambient air samples is relatively low, the method of having the panel test multi-level samples diluted in multiple stages (ex. threefold, 10-fold, 30-fold, 100-fold, etc.) does not provide highly accurate measured values.

For this reason, in the sensory test for ambient air samples, a method, called an assay, was devised. The procedures for this method are as follows.

Sampling	→	Sensory Test in Test Room			→	Numeric Conversion
		1. Prepare three times worth of three sets consisting of one odor bag with the diluted sample odor and two odor bags with no odor for 6 persons.	2. Have the 6 panel members select the odor bag with odor from the set of three bags (Repeat three times with the same concentration)	3. If the average rate of correct answers is above 0.58, perform the procedure again after diluting it 10-fold		Arrange the measured results, and calculate the measured value.

Figure 23 Flow of a Sensory Test for an ambient air Sample

a) The operator sets up the first dilution ratio

The first dilution ratio is, by principle, set at 10, but this ratio can be set at above 10 as appropriate to the odor's strength when the operator actually sniffs the odor of the sample in the sampling bag. In addition, the extent of offensive odors at the sampling site and results from past sensory tests can be informative as well. The extent of the "appropriate ratio" will be described hereinafter.

b) Next, the operator prepares one set of three odor bags with the first dilution ratio, and makes the panel perform the selection operation. At this point, in regards to the set of odor bags prepared with the first dilution ratio, each panel member performs the test three times. Selection results for a total of 18 times (when the panel consists of 6 persons, hereinafter the same) are obtained with the first dilution ratio.

c) For each of the 18 selection results, give a point value as shown below.

1) Correct (If the odor bag with odor was able to be selected) → 1.00

2) Incorrect (If the odor bag without odor was selected) → 0.00

3) Unable to select (If the odor was unable to be identified) → 0.33

The average rate of correct answers for the panel as a group is determined by totaling these points for the 18 times worth, and dividing this total value by 18.

d) If this average rate of correct answers is under 0.58, the sensory test is finished at this point.

If the average rate of correct answers is over 0.58, prepare the odor bags so that dilution ratio is 10-fold of the first dilution ratio (ex. If the first dilution ratio is 10-fold, prepare the odor bags so that the dilution ratio is 100-fold), and perform the selection operation with the entire panel three times each again. Using the 18 times worth of results obtained from the selection operation in such a way, calculate the ratio of correct answers in the method mentioned above in c). Then the sensory test is finished.

2) Selection Operation

For both an ambient air sample and exhaust port sample, the following steps from (1) to (5) are counted as one selection operation, and a sensory test is conducted as a combination of this selection operations.

(1) Using the pump for supplying odor-free air, inject odor-free air into the odor bag until it is almost full, and seal the bag by using a silicone rubber stopper (No. 03). At this point, there is approximately 3 L of air in the bag. It is also necessary to thoroughly replace air that has lingered in the bag previously with the odor-free air.

For example, as shown in Figure 24, the method of filling the odor bag with odor-free air by letting the odor-free air overflow is efficient.

When the temperature of the odor-free air becomes high because of the heat from the pump, put a cooling tube between the pump and the activated carbon tank.

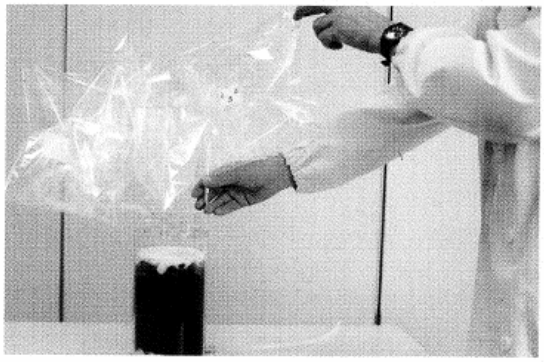


Figure 24 Method of Filling an Odor Bag with Odor-free Air

(2) To make one of the odor bags be of the fixed dilution ratio, take one of the odor bags filled with odor-free air (three bags per person), and use a syringe to inject a fixed amount of the undiluted odor from the sampling bag through the top of the label. If a syringe with a large-holed needle is used for the injection, seal off the hole of the injection needle with adhesive tape to prevent the sample air from escaping.

To take out the sample from the sampling bag, structure the opening of the sampling bag as shown in Figure 25. The process of taking out a sample from the vacuum bottle is displayed in Figure 26. Table 3 shows the relationship between the dilution ratio and the injected amount. If injecting 300 mL of a sample with a dilution ratio of 10 times, 300 mL of odor-free air must already be taken out by using the syringe.

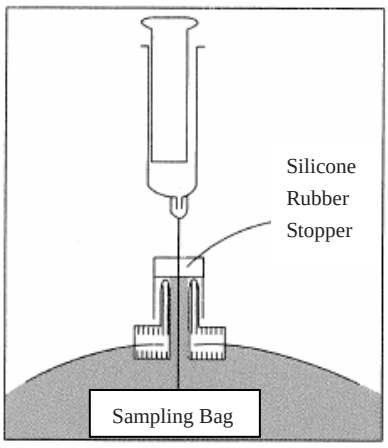
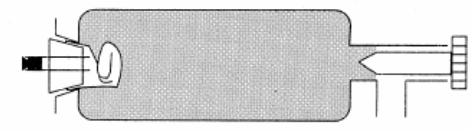


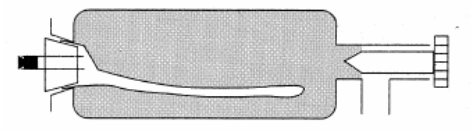
Figure 25 Taking out a Sample from the Sampling Bag

Table 3 Dilution Ratio to be Made and the Amount of Sample to Inject (ambient air Sample and exhaust port Sample)

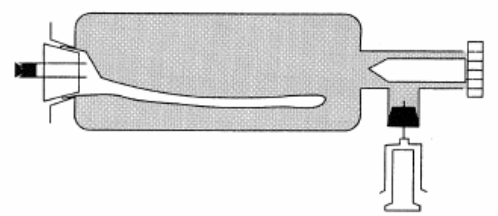
Dilution Ratio	Injected Amount	
10		300 mL
30		100 mL
100		30 mL
300		10 mL
1000		3 mL
3000		1 mL
10000		300 μL
30000		100 μL
100000	One that is diluted	30 mL
300000	1,000-fold	10 mL



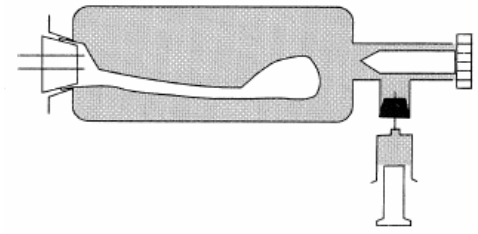
a. Insert a glass tube in the silicone stopper (No. 30). Attach a bag for the vacuum bottle to this, and secure it with adhesive tape. At this time, gather the bag so that it is as small as possible. Next, take out the air from inside the bag through the glass tube with a pump, then remove the pump and seal off the glass tube with a silicone stopper (No. 03) so that air does not come in. Replace the vacuum bottle's sliding lid with a stopper prepared in this way.



b. Tilt the vacuum bottle lengthways and stretch out its bag lengthways as well.



c. Attach a silicone rubber stopper (No. 03) to the opening of the polyfluoride vinyl cock, and set the syringe. Open the polyfluoride vinyl cock and remove the silicone stopper (No. 03) attached to the glass tube.



d. In this condition, take out the necessary amount of sample using the syringe.

Figure 26 Taking out a Sample from the Vacuum Bottle

(3) For the other two odor bags filled with only odor-free air, open a hole from the top of the label in the same way, using only a needle. If a large-holed needle is used, seal off the hole of the injection needle with adhesive tape. This is to avoid the panel from realizing that only the odor bag injected with the undiluted odor has a needle hole, and thus, being able to identify the bag with odor.

(4) Give one set, consisting of a total of three bags—one odor bag with odor, and two odor bags without odor—as prepared in this way, to the panel. In the sample preparation room, the operator must correctly record the numbers of the odor bags with odor that is given to the panel.

(5) The panel puts a sniffing mask on the odor bags given to them in (4), removes the silicone rubber stoppers, sniffs the odor, and gives the number of one bag out of the three that has an odor. Answers are not submitted verbally but are always written down on the answer sheet. The proper way of sniffing an odor is shown in Figure 27. The fundamentals of sniffing is to press one's face against the sniffing mask tightly so that there is no space, and sniff the odor inside the bag in line with one's own breathing. The panel must fully understand that air that has been inhaled is not to be exhaled into the bag again. The panel is also warned to remain in their seats until the last panel member finishes sniffing, even if they have finished sniffing already.

(6) An example of the answer sheet and tabulation sheet used by the operator is shown in Table 4 and Table 5, respectively.

Table 4 Example of Answer Sheet for Panel
(Same for exhaust port Sample)

Answer Sheet

No. of Times Name
(or Number)

From among the three bags, write down the number of the bag which has a different odor.

Answer

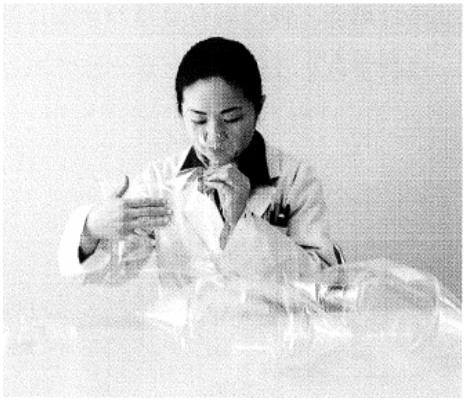


Figure 27 How to Sniff the Odor

3) Remark for the Sensory Test

(1) When the panel consists of 6 persons, it is more effective to divide the panel into two groups of three rather than conduct the test with 6 persons simultaneously. In other words, while one group of 3 persons sniffs odors, the other group of 3 persons can rest in the waiting room. When it is time for the 3 persons who had been resting to sniff odors, the 3 persons who had previously been sniffing odors are to rest. The test is to be conducted in such an alternating way. With this method, there is the advantage that the panel will not be continually tense, and will be able to concentrate only when sniffing odors. Also, in terms of preparation, while one group is sniffing odors, samples for the other group can be prepared, thus resulting in higher efficiency. This factor is applicable to sensory tests for both ambient air samples and exhaust port samples.

(2) If the panel is inexperienced, it is necessary to practice sniffing one or two times, in combination with teaching the test methods and practicing the actual operations.

(3) There may be some cases in which there are some inherent odors remaining on the odor bag even after washing it fully. In such cases, make the panel aware of these inherent odors and prompt them to select one bag with a different odor.

Table 5 Tabulation Sheet (Ambient air Sample)

Name of investigated business			
Odor character		Odor index	
Sampling location		Location of sensory test	
Sampling date	Year Month Day	Testing date	Year Month Day

Panel																				
	Number of Times	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	Amount of sample injected	mL			mL			mL			mL			mL			mL		
	Dilution Ratio																		
A	Number of odor bag with odor																		
	Answer																		
	Judgment																		
B	Number of odor bag with odor																		
	Answer																		
	Judgment																		
C	Number of odor bag with odor																		
	Answer																		
	Judgment																		
D	Number of odor bag with odor																		
	Answer																		
	Judgment																		
E	Number of odor bag with odor																		
	Answer																		
	Judgment																		
F	Number of odor bag with odor																		
	Answer																		
	Judgment																		
Number of correct answers																			
Number of incorrect answers																			
Number of unclear answers																			
Average rate of correct answers																			

2-2-1 (B) Calculation Method for Sensory Test of an ambient air Sample

3 Calculation of Odor Index

(1) Ambient air samples

The odor index is calculated using the following equation.

However, when the average rate of correct answers for the first dilution ratio is under 0.58, the value of the odor index is indicated as under 10 log M.

$$Y = 10 \log \left(M \times 10^{\frac{r1-0.58}{r1-r0}}\right)$$

In this equation, Y represents the odor index, M represents the original dilution ratio, r_1 represents the average rate of correct answers for the first dilution ratio, and r_0 represents the average rate of correct answers when the dilution ratio is 10-fold.

1) Calculating the Odor Index for an ambient air Sample

If the average rate of correct answers for the first dilution ratio (r_1) is under 0.58, it is determined that the odor index is under 10-fold the common logarithm of the first dilution ratio.

If the average rate of correct answers for the first dilution ratio (r_1) is above 0.58, the odor index is calculated using the following equation.

Odor index $Y = 10 \log \left(M \times 10^{\frac{r1-0.58}{r1-r0}}\right)$

M: Dilution ratio used for the first judgment operation (= first dilution ratio)

r_1: Average rate of correct answers for the first judgment operation

r_0: Average rate of correct answers for the second judgment operation (dilution ratio: 10 x first dilution ratio)

The following describes an example of a calculation for measuring an ambient air sample.

a) First, conduct a selection operation with a 10-fold dilution. If the results are like those displayed in Table 6, the average rate of correct answers r_1 for the panel is:

$$r1 = \frac{(1.00\times7 + 0.00\times9 + 0.33\times2)}{18} = 0.43$$

As this is under 0.58, this odor is assessed as having an odor index of under 10 (odor concentration of 10).

b) Next, if the results of the selection operation are those displayed in Table 7, the average rate of correct answers r_1 for the entire panel is:

$$r1 = \frac{(1.00\times12 + 0.00\times4 + 0.33\times2)}{18} = 0.70$$

As this is above 0.58, a selection operation with a dilution ratio that is 10-fold this dilution ratio, or in other words, a 100-fold dilution, is to be conducted again. If the results are those displayed in Table 8, the average rate of correct answers r_0 for the entire panel is:

$$r0 = \frac{(1.00\times7 + 0.00\times10 + 0.33\times1)}{18} = 0.41$$

Since the dilution ratio M with which the first selection operation was performed is 10-fold, the odor index Y is:

$$Y = 10 \log (10\times10^{\frac{0.70-0.58}{0.70-0.41}}) = 14$$

Table 6
First Judgment Operation
(M < 0.58)

Panel	10-fold dilution		
A	O	O	X
B	X	X	X
C	X	△	X
D	O	O	O
E	X	X	O
F	O	X	△

Table 7
First Judgment Operation
(M > 0.58)

Panel	10-fold dilution		
A	O	O	X
B	O	O	△
C	X	O	X
D	O	O	O
E	O	X	O
F	△	O	O

Table 8
Second Judgment Operation

Panel	100-fold dilution		
A	O	X	X
B	O	O	X
C	X	△	X
D	O	X	O
E	X	O	X
F	X	X	O

[Reference] Remark for the Sensory Test of ambient air Samples

(1) How to think about the odor index

It is known that the intensity of the stimulation to a person's olfaction is proportionate to the logarithm of the concentration of the odor substance (Weber-Fechner's Law). This is a law for a single odor within a constant concentration range, but it has been inferred that this way of thinking is applicable to concentrations of complex odors as well, and consequently, expresses the odor index, a value 10 times the common logarithm of the odor concentration, based on the evaluation of measurement results by the triangular odor bag method.

(2) About the rate of correct answers expressing the threshold value when measuring an ambient air sample

With human olfaction, an odor is no longer detected after the level of the odor is under a certain level. This level, at which the odor can no longer be detected, is the threshold value, and the fundamental way of thinking about the measurement of the odor index is to dilute a sample with odor and measure the dilution ratio (equivalent to odor concentration) until it reaches the threshold value.

In the sensory test for an ambient air sample, the value of 0.58 is prescribed as the rate of correct answers that signifies the threshold value of that odor. When assuming that the relationship between the odor's dilution ratio and the rate of correct answers in the sensory test for an ambient air sample by the triangular odor bag method is

$$Y = \frac{2}{3} \exp(-ax)^n) + \frac{1}{3}$$

x: Dilution ratio Y: Rate of correct answers a, n: constants,

As Y is not dependent on n when x = 1/a in the above formula,

$2/3 \exp(-(ax)n) + 1/3 = 2/3 \times 1/2.718 + 1/3 = 0.58$

is stipulated from the advantages of calculation.

2-2-2 Sensory Test for a exhaust port Sample

2-2-2 (A) Procedures of Sensory Test for a exhaust port Sample

No. 3 Measurement Methods

2 Sensory Test

(4) Procedures of the sensory test

b Exhaust port sample

Selection operation is conducted by giving each panel member one odor bag, prepared with the first dilution ratio (*2) in the same procedure as in No. 3 - 2 –4-a (* The procedure shown in “(2-2) (1) selection operation procedures” of this manual) and two odor-free bags, as one set. In this selection operation, for the panel member who selects an odor-free bag or is unable to select a bag, the selection operation is complete. For a panel member who selects the odor bag, repeat the selection operation with a dilution ratio of about threefold until the panel member selects an odor-free bag or is unable to select a bag, upon which the selection operation is complete.

(*2) The first dilution ratio of the exhaust port sample should be one with which it is possible that the panel can easily judge the presence of odor, and does not cause an influence of olfactory fatigue, etc., on the panel.

1) Sensory test for a exhaust port sample

The sensory test for a exhaust port sample is to be conducted in the procedures given in Figure 28.

In the sensory test for a exhaust port sample, a method of making the panel sequentially judge multi-stage samples diluted at different levels (ex. 30-fold, 100-fold, 300-fold, etc.) (called “descending method”) is used.

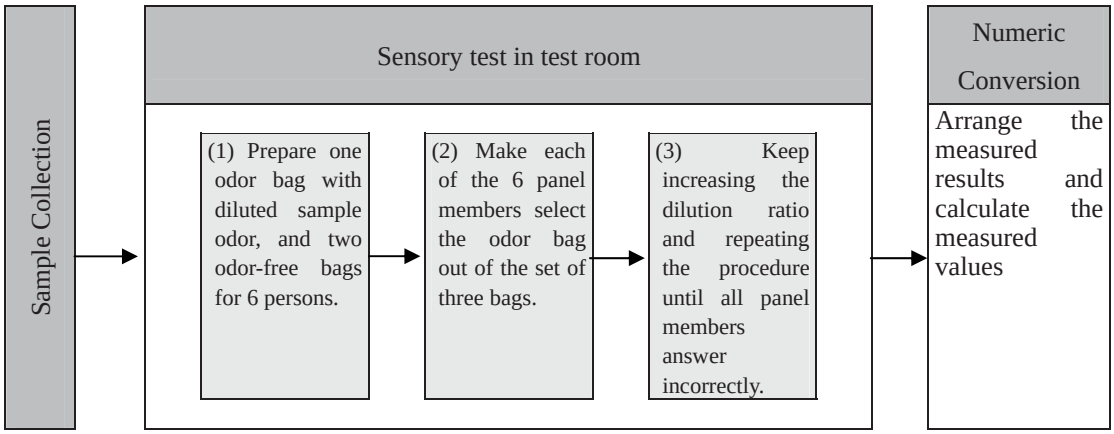


Figure 28 Flow of a sensory test for a exhaust port sample

a) First, the operator sets the first dilution ratio.

The first dilution ratio of the exhaust port sample should be high enough so that the panel can adequately determine the presence of odor (which means that all panel members can answer correctly in the first selection operation), and should be prepared so that it does not induce olfactory fatigue, etc., on the panel. In addition, as stated previously in 2-2-1(A), in the section for the calculation method for sensory test of an ambient air sample, the first dilution ratio for an ambient air sample is, in principle, set at 10-fold, but the first dilution ratio for a exhaust port sample is established separately for each sensory test, in accordance with the concentration of the original sample to be measured.

b) Next, the operator prepares one set of three odor bags, with the first dilution ratio, and makes all the panel members perform the selection operation. In this selection operation, for the panel members who are able to correctly select the odor bag with odor, another selection operation is conducted, with the dilution ratio at about threefold the first dilution ratio (30-fold → 100-fold, 1,000-fold → 3,000-fold, etc.). For the panel members who are successful in this selection operation, another selection operation is conducted, with a set of odor bags further diluted about threefold. In this manner, selection is performed with odor bags gradually diluted approximately threefold. The dilution ratio at which an individual panel member's answer is incorrect or unclear is the point at which the sensory test is complete for that person.

The test is conducted in this manner until all of the panel member answer incorrectly (or answer "unclear"). In addition, if the test is continuing when only one panel member has answered correctly, it is acceptable to finish testing at this point.

c) An example of the tabulation sheet used by the operator is shown in Figure 9, for reference.

Table 9 Example of Tabulation Sheet (for exhaust port Sample)

Name of investigated business			
Odor character		Odor index	
Sampling location		Location of sensory test	
Sampling date	Year Month Day	Testing date	Year Month Day

Panel	Number of times	1	2	3	4	5	6	7	8	Individual threshold value of panel (logarithmic value) Xwi
	Amount of original sample injected	100 mL	30 mL	10 mL	3 mL	1 mL	300 μL	100 μL	30 μL	
	Dilution ratio	30	100	300	1,000	3,000	10,000	30,000	100,000	
	Logarithm of dilution ratio	1.48	2.00	2.48	3.00	3.48	4.00	4.48	5.00	
A	Number of odor bag									
	Answer									
	Judgment									
B	Number of odor bag									
	Answer									
	Judgment									
C	Number of odor bag									
	Answer									
	Judgment									
D	Number of odor bag									
	Answer									
	Judgment									
E	Number of odor bag									
	Answer									
	Judgment									
F	Number of odor bag									
	Answer									
	Judgment									
Threshold value of overall panel (mean after eliminating largest and smallest values)										

2-2-2 (B) Calculation Method for Sensory Test of a exhaust port Sample

3 Calculation of Odor Index

(2) Exhaust port Sample

a Calculate each panel member's threshold value, which is related to the dilution ratio of the sample odor, by using the following equation.

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

In this equation, X_i is the threshold value of a panel member, which is related to the dilution ratio of the sample odor; M_{1i} is the largest value among the dilution ratios of the odor bags that the same panel member selected correctly; and M_{0i} is the value of the dilution ratio of the odor bag in the case when the same panel member selected an odor-free bag or was unable to select the odor bag correctly.

b Eliminate the largest and smallest values among X_i as calculated per panel member, add together all the rest of the values, and divide the obtained value by the number of panel members minus 2.

c Calculate using the following equation.

$Y = 10X$

In this equation, Y represents the odor index, and X represents the value calculated above in b.

1) Calculating the odor index of a exhaust port sample.

a) First, calculate the threshold value of each panel member in the following way.

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

X_i : Threshold value of panel member i (common logarithm indication)
M_{1i}: The largest dilution ratio at which panel member i answered correctly
M_{0i}: The dilution ratio at which panel member i answered incorrectly, or was not able to give a clear answer.

b) From X_i, eliminate the largest and smallest values, and the mean of the values for the other 4 persons is the threshold value X (common logarithm indication) of the overall panel.

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

X: Threshold value of the overall panel (common logarithm indication)
X_i: Threshold value of panel member i

c) Multiply X by 10 to obtain the odor index.
Y = 10X
Y: Odor index
X: Threshold value of the overall panel (common logarithm indication)

Here, Figure 10 is used as an example to calculate the odor index.
First, when calculating each individual panel member's threshold value, because panel member A answered correctly at a dilution ratio of 100 and incorrectly at a dilution ratio of 300, 2.24, which is the mean value of the dilution ratio's logarithmic value, is the threshold value (common logarithm indication). In the same manner, as panel member B answered correctly at a dilution ratio of 300 and incorrectly at a dilution ratio of 1000, the threshold value (common logarithm indication) for panel member B is 2.74. This is expressed in the following Table 10.

Table 10 Example of Results of Sensory Test for a exhaust port Sample

Dilution Ratio		30	100	300	1000	3000	10000	Threshold value of each panel member	Eliminate largest and smallest values
Logarithmic Value		1.48	2.00	2.48	3.00	3.48	4.00		
Panel	A	/	o	x				2.24	Eliminated
	B	/	o	o	x			2.74	
	C	/	o	o	o	o	o		Eliminated
	D	/	o	o	x			2.74	
	E	/	o	x				2.24	
	F	/	o	o	o	x		3.24	

After calculating the threshold value for each panel member, eliminate the largest and smallest values, and calculate the mean value for the rest of the values. In other words, in this figure, panel member C has the largest value, and panel members A and E have the smallest value. When these values are eliminated, the mean value of the 4 remaining panel members is calculated as

$$X = \frac{(2.74 + 2.74 + 2.24 + 3.24)}{4} = 2.74$$

This is the threshold value (common logarithm indication) of the overall panel.
Therefore, the odor index is
Y = 10 x 2.74 = 27.4 After rounding off to the nearest whole number, the odor index is 27.

2) Remark for the Sensory Test for exhaust port Samples

a) For every level of the dilution ratio with which the test is conducted, increase the dilution ratio by about threefold, for example 30, 100, 300, 1000, 3000, etc. The reason for diluting in a series of approximately threefold is to make the amount injected an easily understandable value, since the volume of the odor bags is 3 L. It is also believed that a value of threefold is appropriate for the sensitivity of human olfaction.

b) In the case of measuring an exhaust port sample, for the dilution ratio of the sample with which the sensory test is to begin, the operator should make a sample with the appropriate dilution ratio beforehand and sniff it himself/herself, to make sure that it is not too strong but that all the panel members can detect it easily. Be careful, however, for olfactory fatigue is induced easily if the odor of the first sample given to the panel is too strong.

c) If the dilution ratio exceeds 100000-fold, prepare the sample using a 2-stage dilution. That is, prepare beforehand a 3 L odor bag with the sample diluted at 1000-fold, and inject an appropriate amount of this sample into a second odor bag to prepare a sample with the intended dilution ratio. In this case, wait for approximately one minute so that the sample diffuses uniformly inside the bag.

d) In particular, if the panel does not have much experience, and all panel members with the exception of one or two people answer correctly at a certain dilution ratio during the sensory test, it is necessary to consider continuing the sensory test at the next dilution ratio with all panel members, without excluding those who answered incorrectly. This is so that one person does not feel psychological pressure of being excluded. Naturally, do not use the extra data.

e) The reason for eliminating the highest and lowest values in the calculation process for the odor index

If there are 6 panel members, the reason why the threshold value (common logarithm indication) of all the 6 members is calculated by eliminating the top and bottom 2 persons out of the 6 and averaging the values of the 4 remaining persons, and not by averaging the values of all the 6 persons is as follows.

a) There are cases in which, even for people with normal olfaction, feel ill on the day of the sensory test due to bad psychological or physiological conditions, and there is no way for the operator to confirm this.

b) To avoid abnormal values, due to a panel entering a wrong number by mistake, from influencing the measurement results.

c) To shorten the testing time, as the test can be completed even when only one panel member answers correctly.

f) Quantification limit of odor index for a exhaust port sample

Threshold values for individual panel members are indispensable in order to calculate the odor index of a exhaust port sample. The lowest individual threshold value obtained in the sensory test is 1.24 which is obtained if a panel member answers correctly at the dilution ratio of 10 and incorrectly at 30. Therefore, the quantification limit of odor index for a exhaust port sample is 12. (Odor index is indicated as “under 12” when two or more panel members answer incorrectly at the dilution ratio of 10.)