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Clean Air Index
Vehicle Air Quality Testing and Evaluation Protocol

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Vehicle Air Quality Testing and Evaluation Protocol

1 Scope

This document specifies the test and evaluation methods for volatile organic compounds (VOC) in cabin of vehicles and vehicle odor intensity (VOI) in China-Automobile Health Index.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this standard.

HJ/T 400-2007 Determination of Volatile Organic Compounds and Carbonyl Compounds in Cabin of Vehicles

ISO 12219-1-2012 Interior Air of Road Vehicles - Part 1: Whole Vehicle Test Chamber - Specification and Method for the Determination of Volatile Organic Compounds in Cabin Interiors

CQC 9207-2014 Method for Rating and Detection of Odor Inside Passenger Cars

3 Terms and Definitions

For the purposes of this standard, the following terms and definitions apply.

3.1 passenger car

a motor vehicle which, by its design and technical characteristics, is primarily intended for the carriage of passengers and their baggage and/or temporary articles, with a maximum of 9 seats, including the driver's seat, and which may also tow a trailer

3.2 volatile organic compound (VOC)

VOC and aldehyde and ketone components

The term "volatile organic compounds in cabin of vehicles" refers to a collective term of volatile compounds collected using Tenax and other adsorbents and separated using gas chromatographic column with a polarity index of less than 10 and retention time ranging from n-hexane to n-hexadecane. The term "aldehyde and ketone components" refers to a collective term for compounds such as formaldehyde, acetaldehyde, acetone, acrolein, propionaldehyde, crotonaldehyde, butanone, butyraldehyde, methacrolein, benzaldehyde, valeraldehyde, methylbenzaldehyde, cyclohexanone and hexanal that can be detected using the detection methods in this standard.

3.3 vehicle odor intensity (VOI)

odor, the sensory perception of smell detected by the olfactory nerves in the nasal cavity, which results in a sensation in the central nervous system due to the irritation of volatile substances in vehicles

It provides a highly clear indication of the quality of the vehicle interior components and is a subjective evaluation index based on human olfactory perception and comfort.

3.4 total volatile organic compound (TVOC)

sum of volatile organic compounds collected using Tenax and other adsorbents and separated using gas chromatographic column with a polarity index of less than 10 and retention time ranging from n-hexane (inclusive) and n-hexadecane (inclusive)

4 Test Procedures for VOC and Odor in Cabin of Vehicles

4.1 Vehicle preparation stage

Confirm the vehicle appearance and performance, and add 10 L fuel into the vehicle (gasoline vehicle: 95# gasoline; diesel vehicle: 0# diesel; electric vehicle: fully charged). See Tables 1 and 2 for the confirmation form of basic information of sample vehicle and the list of key parts.

Table 1 Confirmation Form of Basic Information of Sample Vehicle

Item	Sample Description
Product name	
Model	
Manufacturer	
Sales model	
Vehicle color	
VIN	
Engine No.	
Displacement (L)	
Fuel type and grade	
Vehicle outline dimensions (L × W × H) (mm)	
Design passenger capacity (person)	
Air filter available or not	
Sunroof available or not	

Table 2 List of Key Parts

Name of Part Assembly	Appearance Color	Material	Thickness	Manufacturer
Front seat				
Rear seat				
Instrument panel				
Door trim				
Carpet				
Roof				
Weather strip				
Shelf panel				
Spare tire cover plate				

After confirmation, place the sample vehicle under evaluation in the vehicle preparation room, keeping it from direct sunlight. Maintain the temperature of the vehicle preparation room at 20°C~30°C. Keep all manual glass sunshades open. After opening the doors/windows, place the vehicle in the room for at least 12 h to equilibrate the temperature of materials in the vehicle with the ambient temperature. Once the vehicle is placed in the vehicle preparation room, do not clean the interior of the vehicle under test (VUT).

4.2 Test stage

The whole test process includes 5 stages. See Fig. 1 for the schematic diagram of the test procedures.

Stage 1: Sample the air in the passenger compartment at normal temperature;

Stage 2: Evaluate the odor intensity in the passenger compartment at normal temperature;

Stage 3: Introduce a sunshine simulation system, and sample the air in the passenger compartment at high temperature;

Stage 4: Evaluate the odor intensity in the passenger compartment at high temperature;

Stage 5: Turn off the sunlight simulation system, enter the driver's seat to start the engine, turn on the A/C, and sample the air in the passenger compartment at high temperature.

The vehicle air sampling and VOI evaluation in the above five stages are carried out in a VOC test environment chamber. In the following sections, Stages 1 and 2 are collectively referred to as normal temperature stage, Stages 3 and 4 as high temperature stage, and Stage 5 is referred to as the ventilation stage.

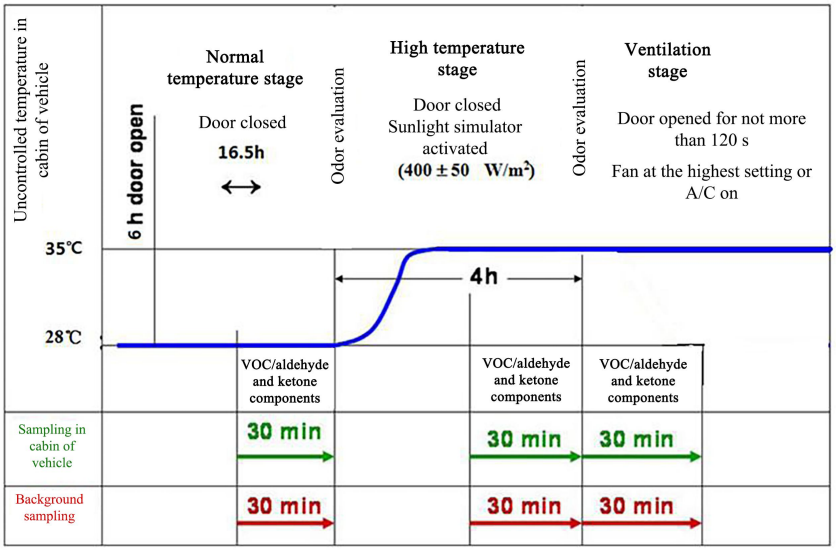


Fig. 1 Schematic Diagram of Test Process

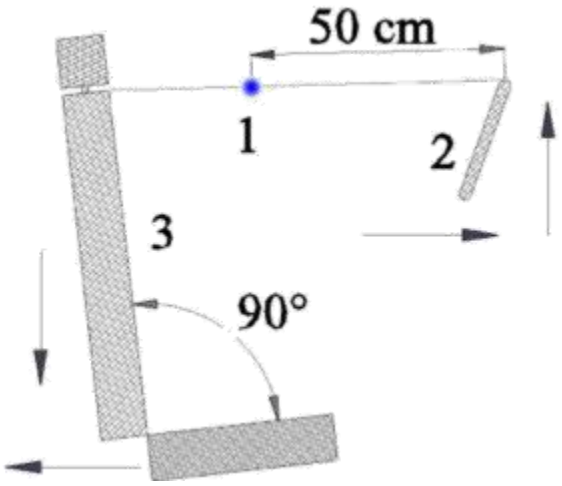
4.2.1 Normal temperature stage - vehicle air sampling and VOI evaluation

Stages 1 and 2 involve sampling aldehyde and ketone components and VOC from the vehicle air at normal temperature and evaluating the VOI.

After removing the surface coverings (such as plastic film used to protect seats and carpets) from interior components of the vehicle outside the VOC test environment chamber, push the vehicle into the environment chamber. Maintain the vehicle stationary in the chamber, with doors, windows, passenger compartment air inlet damper, engine and all other equipment (e.g., A/C) closed. Additionally, turn the A/C to internal circulation position.

Select the midpoint of the connection line of front seat headrest connection line (for adjustable front seat, slide it to the rearmost point of the slide rail) as the sampling point, ensuring the height of the sampling point is aligned with that of the breathing zone of driver and passengers. The schematic diagram of sampling points is shown in Fig. 2. Then install the sampling device assembly, which consists of metal fixture, sampling conduit, sampling tube, etc. The metal fixture is used to fix the sampling conduit at the headrest of the front seat. The sampling conduit is made of PTFE, and its ends are sealed (such as, with used DNPH tube and used Tenax tube). Then, the sampling device assembly is checked for leakage. When the sampling device assembly is installed, at least one temperature transfer and sensing device shall be used to measure the air temperature at the sampling point, and a hygrometer shall be placed in the vehicle to record the relative humidity.

The Tenax tube, used for air sampling in the vehicle, is a commercially available stainless steel tube filled with about 200 mg of solid adsorbent material and marked with the serial number and the air flow direction. The adsorbent bed is entirely within the thermal desorption area of the sampling tube. The adsorbent medium of DNPH sampling tube is 2,4-dinitrophenylhydrazine, which can generate stable colored hydrazone derivatives when coming into contact with carbonyl compounds.



1 - Sample point 2 - Steering wheel3 - Seats with head restraints

Fig. 2 Sampling Points

Start the vehicle VOC test environment chamber, set the temperature to 28°C and the relative humidity to 50%RH. At this stage, the VOC test environment chamber shall meet the following conditions: a) ambient temperature: 28°C±2°C; b) relative humidity: 50%RH±10%RH; c) air speed: ≤0.3 m/s; d) background concentration of pollutants in the chamber: benzene and formaldehyde ≤0.02 mg/m^3.

Fully open all doors and windows, trunk and openable storage compartments inside the vehicle for 6 h. In the last 4 h, ensure that the environmental conditions in the environment chamber meet the above-mentioned requirements.

After the 6 h, close all doors and windows, trunk and storage compartments inside the vehicle. Begin the enclosure stage, which shall last for at least 16 h. In this stage, ensure that there is no air exchange between the vehicle and the chamber. In the enclosure stage, the environment chamber still shall meet the following conditions: a) ambient temperature: 28°C±2°C; b) relative humidity: 50%RH±10%RH; c) air speed: ≤0.3 m/s; d) background concentration of pollutants in the chamber: benzene and formaldehyde ≤0.02 mg/m^3. Perform a flow rate calibration for the gas sampling pump with a first-class soap film flowmeter. The flow rate range for the Tenax sampling tube used for collecting the VOC is 100 ml/min~200 ml/min, and that for the DNPH sampling tube used for collecting aldehyde and ketone components is 100 ml/min~500 ml/min.

Once the enclosure time is sufficient, install an aged Tenax tube and a new DNPH tube. Then, start the sampling pump in the vehicle VOC test environment chamber to collect VOC and aldehyde and ketone components in cabin of vehicle (parallel sampling of air in the vehicle). During the collection of air in the vehicle, air samples shall be taken from the sampling environment chamber as blank samples. The sampling point for the chamber air shall be located within a space not more than 0.5 m away from the outer surface of the VUT, and at a height equivalent to that of the sampling point in the vehicle. One background sample, each for VOC and aldehyde and ketone components, shall be taken from the chamber. All sampling duration shall be 30 min.

After sampling, stop the sampling pumps used for collecting VOC and aldehyde and ketone components both inside and outside the vehicle, remove the Tenax tube and DNPH sampling tube, seal the sampling tube opening with a sealing cap, wrap the sampling tube tightly with tin foil or aluminum foil, and store and transport it at low temperature (< 4°C) for a maximum duration of 30 days.

After sampling at the normal temperature stage, the VOI at normal temperature shall be evaluated. In the evaluation system, the intensity of odor irritation to human olfactory organs is classified into 6 levels (Level 1 ~ Level 6) from low to high, allowing for the quantification of the

odor evaluation results. The higher the VOI level, the intenser the irritation.

Three odor evaluators sequentially enter the vehicle, sitting in the driver's seat, front passenger's seat and rear seat respectively, to conduct the sensory evaluation of the odor in cabin of vehicle. Any two doors cannot be opened at the same time during olfactory evaluation. For example, the first odor evaluator enters the vehicle from the left front door and closes it; then the second odor evaluator enters the vehicle from the right front door and closes it; then the third odor evaluator enters the vehicle from the left rear door and closes it. After the evaluation is completed, the 3 odor evaluators get off the vehicle one by one, but the doors cannot be opened at the same time. In order to prevent airflow disturbance during the evaluation process, the doors shall be controlled to open as minimally as possible. The odor evaluators shall give their evaluation within 30 s upon entering the vehicle. To ensure the independence, impartiality and fairness of the whole evaluation process, the odor evaluators shall not communicate with each other, such as speaking or making gesture suggestions, during the odor evaluation process. The total duration of the evaluation shall not exceed 2 min. The odor evaluators shall provide a sensory evaluation of the odor intensity based on their perception, and independently and objectively rate the odor intensity from Level 1 to Level 6, with a gradient of 0.5 level. During the odor evaluation, the odor evaluators shall first determine whether the odor is interfering. If there is no interference, they shall assign a rating between Level 1 and Level 3; if there is interference, they shall assign a rating between Level 4 and Level 6. When the odor evaluators have a clear determination of the VOI level, they shall give an integer rating. In situations where they are unsure whether to rate a higher or lower level, they can assign a rating with a gradient of 0.5 level. The rating criteria are shown in Table 3 below.

Table 3 Evaluation Criteria of VOI Level

VOI Level	Description of VOI Scoring Criteria
Level 1	There is no odor or the odor is imperceptible.
Level 2	There is odor, and it is perceptible, but not irritating, with light intensity.
Level 3	There is distinct odor, and it is perceptible, but not irritating, with medium intensity.
Level 4	There is pungent odor, with relatively strong intensity.
Level 5	There is intense, pungent odor, with strong intensity.
Level 6	There is insufferable offensive odor.

4.2.2 Sunlight stage - vehicle air sampling and VOI evaluation

After the odor intensity evaluation at normal temperature stage is completed, close the doors, perform a leak detection on the sampling device assembly, and activate the sunlight simulator to begin the sunlight stage. Set the environment chamber temperature to 35°C and the relative humidity to 50%RH. After 2 h exposure to light, the environmental conditions in the chamber shall meet the temperature of 35°C±2°C, the relative humidity of 50%±10%RH, and the air speed and background pollutant concentration in the chamber shall be the same as those at normal temperature stage. Activate the sunlight simulator, place the radiation density sensor on the vehicle roof, set the radiation density to 400 W/m2, and ensure that the indicated radiation density is within the range of 400 W/m2±50 W/m2. The radiation coverage shall extend at least 0.5 m on each side of the vehicle body, and the sunlight simulator shall have a 90° irradiation angle towards the heating area. There shall be no solar radiation from the side. To avoid hot spots on the vehicle roof, the distance between the sunlight simulator and the vehicle roof shall be above 1.0 m.

In the process of heating up the air in the vehicle by the infrared radiation on the roof, vehicle body and windows, the tester needs to perform flow rate calibration for the gas sampling pump again with a first-class soap film flowmeter. The flow rate setting range of the Tenax sampling tube used for collecting the VOC is 100 ml/min~200 ml/min, and that for the DNPH sampling tube used for collecting aldehyde and ketone components is 100 ml/min~500 ml/min.

The whole sunlight simulator shall be activated for 4 h, and the sampling shall be performed in

the last 0.5 h. Replace an aged Tenax tube and a new DNPH tube, and perform parallel sampling for VOC and aldehyde and ketone components in the vehicle. During the collection of air in the vehicle, air samples shall be taken from the sampling environment chamber as blank samples. The sampling point for the chamber air shall be located within a space not more than 0.5 m away from the outer surface of the VUT, and at a height equivalent to that of the sampling point in the vehicle. One background sample, each for VOC and aldehyde and ketone components, shall be taken from the chamber. All sampling duration shall be 30 min. The difference between the temperature in the vehicle and the ambient temperature in the chamber possibly affects the volume of sampled air. If necessary, a heating device can be added to the sampling conduit. After 30 min of sampling, turn off all sampling pumps and remove the DNPH tube and Tenax tube from the sampling device assembly. Seal the sampling tube opening with a sealing cap, wrap the sampling tubes tightly with tin foils or aluminum foils, and store and transport them at low temperature (<4°C). The storage duration shall not exceed 30 days.

After sampling at the sunlight stage, the VOI at sunlight stage shall be evaluated, and the sunlight simulation system shall be turned off after the VOI evaluation. Three odor evaluators sequentially enter the vehicle, sitting in the driver's seat, front passenger's seat and rear seat respectively, to conduct the sensory evaluation of the odor in cabin of vehicle. Any two doors cannot be opened at the same time during olfactory evaluation. For example, the first odor evaluator enters the vehicle from the left front door and closes it; then the second odor evaluator enters the vehicle from the right front door and closes it; then the third odor evaluator enters the vehicle from the left rear door and closes it. After the evaluation is completed, the odor evaluators get off the vehicle one by one, and the doors cannot be opened at the same time. In order to prevent airflow disturbance during the evaluation process, the doors shall be controlled to open as minimally as possible. The odor evaluators shall give their independent evaluation within 30 s upon entering the vehicle, and the total duration of the whole odor evaluation process shall not exceed 2 min. The odor evaluators shall provide a sensory evaluation of the odor intensity based on their perception, and independently and objectively rate the odor intensity from Level 1 to Level 6, with a gradient of 0.5 level. When the odor evaluators determine the VOI level, they shall give an integer rating. In situations where they are unsure whether to rate a higher or lower level, they can assign a rating with a gradient of 0.5 level. See Table 3 for rating criteria.

4.2.3 Ventilation stage - vehicle air sampling

After finishing the olfactory evaluation in the sunlight stage, the odor evaluator sitting in the front seat ignites the engine and turns on the A/C (see Table 4 for A/C settings of vehicles under evaluation with manual A/C, automatic A/C, and without A/C) to enable the external circulation mode. Before the test starts, the tester shall manually confirm the A/C state of the vehicle. At the same time, the tester in the environment chamber connects the exhaust pipe of the vehicle under evaluation to the fan, starts the exhaust extraction system, and discharges the exhaust generated by engine ignition outside the chamber to ensure that the environmental conditions in the chamber still meet the following: a) ambient temperature: 35°C±2°C; b) relative humidity: 50%RH±10%RH; c) air speed: ≤0.3 m/s; d) background concentration of pollutants in the chamber: benzene and formaldehyde ≤0.02 mg/m^3.

After closing the doors, perform a leak detection on the sampling device assembly. After confirming that there is no leakage, start parallel sampling of aldehyde and ketone components and VOC in the air inside the vehicle. During the collection of air in the vehicle, air samples shall be taken from the sampling environment chamber as blank samples. The sampling point for the chamber air shall be located within a space not more than 0.5 m away from the outer surface of the VUT, and at a height equivalent to that of the sampling point in the vehicle. One sample, each for VOC and aldehyde and ketone components, shall be taken from the chamber. All sampling duration shall be 30 min.

After 30 min of sampling, turn off all sampling pumps and remove the DNPH tube and Tenax

tube from the sampling device assembly. Seal the sampling tube opening with a sealing cap, wrap the sampling tubes tightly with tin foils or aluminum foils, and store and transport them at low temperature (<4°C). The storage duration shall not exceed 30 days.

Table 4 A/C Setting

	Automatic A/C	Semi-automatic or Manual A/C	Without A/C
A/C ON/OFF	ON	ON	--
Indoor/outdoor air switching	External circulation	Fresh air circulation	--
Air flow switch	Automatic All air regulators Up and fully opened	Face mode All air regulators Up and fully opened	At the maximum ventilation position; fresh air circulation
Temperature	23°C	Lowest	Lowest

4.3 Analysis stage

4.3.1 TD-GC/MS analysis of VOC

The basic principle of VOC analysis is as follows. After the Tenax sampling tube is heated, organic components are desorbed from the adsorbent, and the carrier gas brings the organic compounds into the trapping device inside the instrument for re-adsorption. Subsequently, rapid heating is applied to desorb the compounds, then the carrier gas brings them into the chromatographic column of the gas chromatograph-mass spectrometer (GC-MS) for separation and determination. The capillary gas chromatographic column used in the test room is 60 m long, which allows the effective separation of benzene, toluene, ethylbenzene, xylene and styrene, and the calculation of the peak area of all volatile organic compounds ranging from n-hexane to n-hexadecane in the chromatographic analysis window. The mass spectrometric detector generates a reconstructed ion spectrum in full-scan mode, and the peak area of characteristic mass ions is selected for compound quantification.

The reagents used in the analysis shall be chromatographically pure. A standard curve is established in the test room using mixed reference materials of certified VOC, with the mass number of target components plotted on x-axis and the peak area of characteristic mass ions on y-axis. The linear correlation coefficient of each component shall be at least 0.995. If the calibration curve does not pass through the zero point, the curve equation shall include the intercept.

Remove the tin foil from the Tenax sampling tube and install the sampling tube on a thermal desorption device, with the airflow direction opposite to that during sampling. The instrument will automatically perform strict leakage detection on all parts of the sample gas path. In case of any leakage in the sample gas path, the instrument will automatically stop the desorption of the sampling tube. After the leakage detection, the sampling tube, sample gas path and cold trap shall be purged with carrier gas at room temperature. The VOC is desorbed from the adsorbent by heating, and then brought into the cold trap by the carrier gas for pre-concentration. Then after the secondary thermal desorption, the VOC enters the gas chromatography - mass spectrometer through the transmission line for content analysis.

4.3.2 Calculation method of VOC concentration

1) The calculation method of sampling volume (V_1) is shown in Formula 4.1:

$$V_1 = \frac{Q_1 \times t_1}{1000} \quad \text{(Formula 4.1)}$$

Where, Q_1- calibrated sampling flow rate of gas sampling pump (mL/min)

t_1- sampling time (min)

V_1- sampling volume (L)

2) The calculation method of corrected sampling volume (V_2) is shown in Formula 4.2:

$$V_2 = V_1 \cdot \frac{T0}{T_2} \cdot \frac{P}{P_0} \quad \text{(Formula 4.2)}$$

Where, V_2- corrected sampling volume (L)

V_1- sampling volume (L)

T_0- absolute temperature in standard state, 273 K (K)

T_2- sum of sampling temperature (t_2, °C) and absolute temperature in standard state, (t_2+273) K

P- atmospheric pressure (kPa)

P_0- atmospheric pressure in standard state, 101.3 kPa (kPa);

3) The calculation method of VOC concentration is shown in Formulas 4.3~4.5:

$$C_0 = \frac{m_0}{V_2} \times 10^{-3} \times 10^{-3} \times 10^3 \quad \text{(Formula 4.3)}$$

Where, C_0- background concentration of each VOC in chamber (mg/m^3)

m_0- measured result of environment chamber air at GC-MS workstation (ng)

V_2- corrected sampling volume (L)

$$C_1 = \frac{m_1}{V_2} \times 10^{-3} \times 10^{-3} \times 10^3 \quad \text{(Formula 4.3)}$$

Where, C_1- concentration of each VOC in the vehicle (mg/m^3)

m_1- measured result of vehicle air at GC-MS workstation (ng)

V_2- corrected sampling volume (L)

$$C_{VOC}=C_1—C_0 \quad \text{(Formula 4.5)}$$

Where, C_{voc}- concentration of each VOC in the vehicle under evaluation (mg/m^3)

C_1- concentration of each VOC in the vehicle (mg/m^3)

C_0- background concentration of each VOC in chamber (mg/m^3)

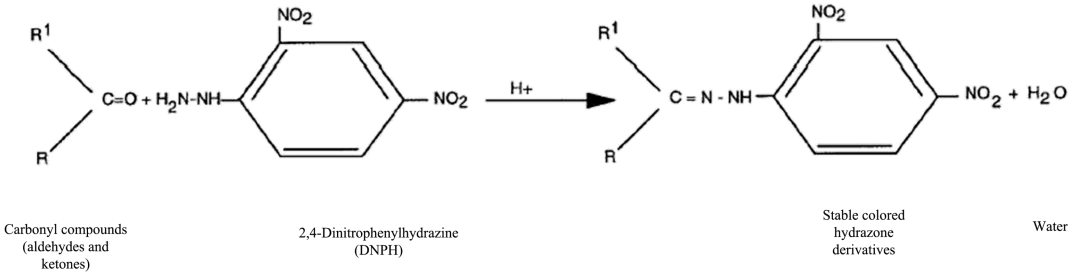
4) Calculation method of TVOC

TVOC includes the amount of all compounds from n-hexane (inclusive) to n-hexadecane (inclusive) in the total ion current diagram (TIC). Calculate the concentration (S_{id}) of the identified and quantified VOC in the standard curve, and calculate the concentration (Sun) of the unidentified VOC regarding the first 25 maximum peaks using the response factor of toluene. The sum of S_{id} and S_{un} is the concentration of TVOC.

4.3.3 HPLC analysis of aldehyde and ketone components

The aldehyde and ketone components react with DNPH coated on silica gel under the catalytic conditions of a strong acid, generating stable and colored hydrazone derivatives, as shown in the

reaction formula below (see Fig. 3). According to the "like dissolves like" principle, acetonitrile can be used as the eluent for hydrazone derivatives. After the eluent is diluted to an appropriate concentration, the concentrations of formaldehyde, acetaldehyde, and acrolein are determined using a high-performance liquid chromatograph with a UV detector. Qualitative analysis can be done based on retention time, while quantification can be done based on peak area.



R and R^1 represent alkyl or aromatic groups (ketones) or hydrogen atoms (aldehydes).

Fig. 3 Principle Description

Place the DNPH sampling tube on the solid phase extraction device for sample elution (if applicable, use a needle tube to elute the DNPH sampling tube). The flow direction of eluent shall be opposite to that during sampling. Accurately add 5 ml of acetonitrile for reverse elution of the sampling tube, and collect the eluent into a 5 ml volumetric flask. Filter the eluent with a 0.45 μm microporous membrane and treat it with an ultrasonic cleaner for 1-2 min. Fill the volumetric flask with acetonitrile up to the 5 ml mark, label it and store it in a refrigerator at 4°C for 30 d.

The acetonitrile used in the analysis shall be chromatographically pure. A standard curve is established in the test room by diluting a certified mixed reference solution of aldehydes and ketones to an appropriate concentration, and a calibration curve is drawn with the concentration of the target components plotted on x-axis and the peak area on y-axis. The linear correlation coefficient of each component shall be at least 0.995. If the calibration curve does not pass through the zero point, the curve equation shall include the intercept.

Transfer the solution after ultrasonication to a dedicated sample bottle of liquid chromatograph, and analyze the aldehyde and ketone components in the air in the vehicle and chamber background in the same way as when establishing the standard curve.

4.3.4 Calculation method of concentration of aldehyde and ketone components

1) The calculation method of sampling volume (V_1) is shown in Formula 4.11:

$$V_1 = \frac{Q_1 \times t_1}{1000} \qquad \text{(Formula 4.11)}$$

Where, Q_1- calibrated sampling flow rate of gas sampling pump (mL/min)

t_1- sampling time (min)

V_1- sampling volume (L)

2) The calculation method of corrected sampling volume (V_2) is shown in Formula 4.12:

$$V_2 = V_1 \cdot \frac{T0}{T_2} \cdot \frac{P}{P_0} \qquad \text{(Formula 4.12)}$$

Where, V_2- corrected sampling volume (L)

V_1- sampling volume (L)

T_0- absolute temperature in standard state, 273 K (K)

T_2- sum of sampling temperature (t_2, °C) and absolute temperature in standard state, (t_2+273) K

P- atmospheric pressure (kPa)

P_0- atmospheric pressure in standard state, 101.3 kPa (kPa);

3) The calculation method of concentration of aldehyde and ketone components is shown in Formulas 4.13~4.15

$$C_0 = \frac{V_d}{V_2} \times C_c \times 10^3 \quad \text{(Formula 4.13)}$$

Where, C_0- concentration of each aldehyde and ketone component in the chamber background (mg/m^3)

V_d- constant volume for solid phase extraction (L)

V_2- corrected sampling volume (L)

C_c- measured results of each aldehyde and ketone component in the chamber background at the liquid chromatograph workstation (mg/L)

$$C_1 = \frac{V_d}{V_2} \times C_c \times 10^3 \quad \text{(Formula 4.14)}$$

Where, C_1- concentration of each aldehyde and ketone component in the vehicle (mg/m^3)

V_d- constant volume for solid phase extraction (L)

V_2- corrected sampling volume (L)

C_c- measured results of each aldehyde and ketone component in the air in the vehicle at the liquid chromatograph workstation (mg/L)

$$C_c = C_1 — C_0 \quad \text{(Formula 4.15)}$$

Where, C_c- concentration of each aldehyde and ketone component in the vehicle under evaluation (mg/m^3)

5 Evaluation Procedures for VOC and Odor in Cabin of Vehicles

5.1 Evaluation principle

To ensure the scientific, fair and impartial evaluation of VOC and Odor in cabin of vehicles in "China-Automobile Health Index", the following principles shall be followed:

1) Focuses

The evaluation shall focus on the health indexes (health hazards) of occupants during vehicle usage, involve the evaluation of VOI (odor in cabin of vehicle) which is a highly valued comfort index for consumers, and also take into account the integrated pollution indexes (integrated pollution) of organic compounds in vehicles. The purpose is to promote the development and application of environmentally friendly materials, configurations and processes, drive automobile enterprises to develop vehicles with excellent air quality, and guide the automobile industry to a healthy development path.

2) Objectivity

Evaluation indexes, methods and modes shall objectively and fully reflect the essential characteristics of products under different environmental conditions, ensuring the objective and fair evaluation results.

3) Comprehensiveness

Comprehensive evaluations shall be performed from multiple aspects and perspectives. The evaluation indexes shall not be limited to the requirements of current domestic standards, and shall incorporate factors such as sunlight simulation, idling ventilation conditions and sensory evaluation

of odor in cabin of vehicle.

4) Operability

The evaluation indexes shall not only fully reflect the quality of the air in vehicles, but also be operable. The evaluation mode shall be concise and reasonable, and there shall be clear levels for evaluation indexes.

5.2 Evaluation index

The VOC part in the "China-Automobile Health Index" has a full score of 70 points, consisting of health hazard (V_1), integrated pollution (V_2) and TVOC (V_4). The part of odor in cabin of vehicle (V_3) has a full score of 30 points, consisting of the VOI level at normal temperature and that at high temperature.

5.2.1 Health hazards

The United States Environmental Protection Agency (US EPA) has promulgated the Guidelines for Carcinogen Risk Assessment, which outlines the methods and procedures of health risk assessment. The risk of potential harm to the health of individuals exposed to carcinogens is assessed by estimating the probability of adverse effects on human health caused by carcinogenic factors.

Exposure assessment is one of the commonly used means in carcinogen risk assessment. Measuring, estimating or predicting the intensity, frequency and duration of exposure to carcinogenic factors in environmental media for a population can provide a quantitative basis for carcinogen risk assessment. The identification of characteristics of exposed population and the determination of concentration and distribution of substances with carcinogen risks in environmental media are two integral and interrelated components of the assessment.

In this evaluation system, health hazards are used to evaluate substances classified by US EPA as Class I carcinogens (such as benzene and formaldehyde) with sufficient evidence of carcinogenicity.

The average daily absorption dose of harmful substances is calculated according to Formula 5.1.

$$C_{xr} = 0.9 \times C_{bx} \times E_{bn} \times E_{bp} \times E_{bs} \times I_{hx}/(365 \times A_{sm} \times B_{tz}) \quad \text{(Formula 5.1)}$$

Where, C_{xr} - average daily absorption dose of harmful substances, mg/(kg·d)

C_{bx} - measured concentration of benzene and formaldehyde in the air in vehicle, mg/m^3

E_{bn} - year of exposure, taken as 50 a

E_{bp} - exposure frequency, taken as 250 d/a

E_{bs} - exposure duration, taken as 3.5 h/d

I_{hx} - average air respiration rate, taken as 1.01 m^3/h

A_{sm} - average life, taken as 76.1 a

B_{tz} - average body weight, taken as 65 kg

The US EPA specifies that the P_f of benzene in air is 0.029 (kg·d)/mg, and that of formaldehyde is 0.045 (kg·d)/mg. Carcinogenic factors are introduced to calculate the health hazard index according to Formula 5.2.

$$H_{za} = C_{xr} \times P_f \quad \text{(Formula 5.2)}$$

Where, H_{za} - health hazard value, dimensionless

P_f- carcinogenic factor, (kg·d)/mg

5.2.2 Integrated pollution

As one of the commonly used methods for environmental quality assessment, the comprehensive index method provides a simple and clear description of the integrated intensity of air pollution caused by various pollutants with the relative value between pollutant concentration and assessment criteria. It is suitable for comprehensively assessing the air quality under the interaction of several pollutants, taking into account both the highest and average indexes.

The calculation method of this index is as follows: First, divide the average concentration (C_i) of benzene, toluene, xylene, ethylbenzene, styrene, formaldehyde, acetaldehyde and acrolein by the assessment criteria (S_i) of this pollutant to obtain the individual air quality index (I_i), then select the maximum value (I_{max}) of individual air quality index and calculate the average (I_{av}) of the individual air quality index of i pollutants. The geometric mean of I_{max} and I_{av} is the pollution index (I). The larger the value of I,

the more serious the integrated pollution. The calculation method of integrated pollution value is shown in Formula 5.3.

$$\mathrm{I} = \sqrt{I_{max} \cdot I_{av}} = \sqrt{(max\left|\frac{C_1}{S_1}, \frac{C_2}{S_2} \lambda \frac{C_n}{S_n}\right|) \times (\frac{1}{n}\sum_{i=1}^{n}\frac{C_i}{S_i})} \qquad \text{(Formula 5.3)}$$

Where, I- integrated pollution value

I_{av}- average of individual air quality index of each pollutant

I_{max}- maximum value of individual air quality index of each pollutant

C_i- average concentration of the i^{th} pollutant

S_i- assessment criteria for the i^{th} pollutant

5.2.3 Odor in cabin of vehicle

The leader of the odor evaluation team shall collect the evaluation results from each odor evaluator and summarize the results. The leader shall first calculate the range (the difference between the highest and the lowest rating) of the evaluation results of three odor evaluators. If the range is greater than 1.5, odor evaluation shall be performed again; if the range is less than or equal to 1.5, the arithmetic average of the three evaluation results shall be calculated as the VOI level. If the calculated average has decimal places, it shall be rounded according to the following method: [0,0.25) is taken as 0, [0.25,0.75) as 0.5, and [0.75,1.0] as 1.0.

During the evaluation of odor in cabin of vehicle, if it is necessary to perform odor evaluation again due to too large range, the VOC sampling results remain valid, but the test needs to be rearranged according to the test and evaluation standard for the second odor evaluation.

5.3 Evaluation items and weights

The evaluation items and weights of VOC and VOI are shown in Table 5. According to the test stage, the weight at constant temperature and humidity stage is 50 points, that of sunlight simulation stage is 30 points, and that of idling ventilation conditions is 20 points. According to the evaluation items, the weight of TVOC is 10 points, that of health hazard is 30 points, that of integrated pollution is 30 points, and that of VOI is 30 points.

Table 5 Evaluation Items and Weights

Test Stage		Evaluation Item		Evaluation Index	
Name	Weight	Name	Weight	Name	Weight
Normal temperature	50	Aldehyde and ketone components and VOC in cabin	20	Health hazard (formaldehyde)	5
				Health hazard (benzene)	5

stage		of vehicle		Integrated pollution	10
		VOI	20	Intensity level	20
		total volatile organic compound (TVOC)	10	TVOC concentration	10
Sunlight stage	30	Aldehyde and ketone components and VOC in cabin of vehicle	20	Health hazard (formaldehyde)	5
				Health hazard (benzene)	5
				Integrated pollution	10
		VOI	10	Intensity level	10
Ventilation stage	20	Aldehyde and ketone components and VOC in cabin of vehicle	20	Health hazard (formaldehyde)	5
				Health hazard (benzene)	5
				Integrated pollution	10

5.4 Scoring criteria

5.4.1 Health hazards

According to the method recommended by US EPA, the health hazard value H_{za} is used to determine the carcinogenic risk posed by benzene and formaldehyde in the air in cabin of vehicle. If $H_{za} < 1\times10^{-6}$, then there is no carcinogenic risk; if $1\times10^{-6} \le H_{za} < 1\times10^{-4}$, then the carcinogenic risk is within an acceptable range; if $H_{za} \ge 1\times10^{-4}$, then the carcinogenic risk is high.

The scoring criteria for health hazard indexes of benzene under normal temperature and ventilation conditions are shown in Table 6. When $H_{za} < 4\times10^{-6}$, a score of 100% of weight is assigned; when $4\times10^{-6} \le H_{za} < 1\times10^{-5}$, a score of 90% of weight is assigned; when $1\times10^{-5} \le H_{za} < 2\times10^{-5}$, a score of 80% of the weight is assigned; when $2\times10^{-5} \le H_{za} < 4\times10^{-5}$, a score of 70% of the weight is assigned; when $4\times10^{-5} \le H_{za} < 6\times10^{-5}$, a score of 60% of the weight is assigned; when $6\times10^{-5} \le H_{za} < 8\times10^{-5}$, a score of 50% of the weight is assigned; when $8\times10^{-5} \le H_{za} < 1\times10^{-4}$, a score of 40% of the weight is assigned; when $H_{za} \ge 1\times10^{-4}$, no score is assigned.

Table 6 Scoring Criteria for Health Hazards under Normal Temperature and Ventilation Conditions (Benzene)

Health Hazards	Scoring
$H_{za}<4\times10^{-6}$	Score of 100% of the weight
$4\times10^{-6}\le H_{za}<1\times10^{-5}$	Score of 90% of the weight
$1\times10^{-5}\le H_{za}<2\times10^{-5}$	Score of 80% of the weight
$2\times10^{-5}\le H_{za}<4\times10^{-5}$	Score of 70% of weight
$4\times10^{-5}\le H_{za}<6\times10^{-5}$	Score of 60% of the weight
$6\times10^{-5}\le H_{za}<8\times10^{-5}$	Score of 50% of the weight
$8\times10^{-5}\le H_{za}<1\times10^{-4}$	Score of 40% of the weight
$H_{za}\ge1\times10^{-4}$	Zero

The scoring criteria for health hazards of formaldehyde under normal temperature and ventilation conditions are shown in Table 7. When $H_{za} < 1\times10^{-5}$, a score of 100% of weight is assigned; when $1\times10^{-5} \le H_{za} < 2\times10^{-5}$, a score of 90% of weight is assigned; when $2\times10^{-5} \le H_{za} < 3\times10^{-5}$, a score of 80% of weight is assigned; when $3\times10^{-5} \le H_{za} < 5\times10^{-5}$, a score of 70% of weight is assigned; when $5\times10^{-5} \le H_{za} < 7\times10^{-5}$, a score of 60% of weight is assigned; when $7\times10^{-5} \le H_{za} < 9\times10^{-5}$, a score of 50% of weight is assigned; when $9\times10^{-5} \le H_{za} < 1\times10^{-4}$, a score of 40% of weight is assigned; when $H_{za} \ge 1\times10^{-4}$, no score is assigned.

Table 7 Scoring Criteria for Health Hazards under Normal Temperature and Ventilation Conditions (Formaldehyde)

Health Hazards	Scoring

$H_{za}<1\times10^{-5}$	Score of 100% of the weight
$1\times10^{-5}\leq H_{za}<2\times10^{-5}$	Score of 90% of the weight
$2\times10^{-5}\leq H_{za}<3\times10^{-5}$	Score of 80% of the weight
$3\times10^{-5}\leq H_{za}<5\times10^{-5}$	Score of 70% of weight
$5\times10^{-5}\leq H_{za}<7\times10^{-5}$	Score of 60% of the weight
$7\times10^{-5}\leq H_{za}<9\times10^{-5}$	Score of 50% of the weight
$9\times10^{-5}\leq H_{za}<1\times10^{-4}$	Score of 40% of the weight
$H_{za}\geq1\times10^{-4}$	Zero

The scoring criteria for health hazards of benzene under sunlight conditions are shown in Table 8. When $H_{za}<2\times10^{-5}$, a score of 100% of weight is assigned; when $2\times10^{-5} \leq H_{za} < 6\times10^{-5}$, a score of 90% of weight is assigned; when $6\times10^{-5} \leq H_{za} < 1\times10^{-4}$, a score of 80% of weight is assigned; when $1\times10^{-4} \leq H_{za} < 2\times10^{-4}$, a score of 60% of weight is assigned; when $2\times10^{-4} \leq H_{za} < 3\times10^{-4}$, a score of 40% of weight is assigned; when $3\times10^{-4} \leq H_{za} < 4\times10^{-4}$, a score of 20% of weight is assigned; when $H_{za} \geq 4\times10^{-4}$, no score is assigned.

Table 8 Scoring Criteria for Health Hazards under Sunlight Conditions (Benzene)

Health Hazards	Scoring
$H_{za}<2\times10^{-5}$	Score of 100% of the weight
$2\times10^{-5}\leq H_{za}<6\times10^{-5}$	Score of 90% of the weight
$6\times10^{-5}\leq H_{za}<1\times10^{-4}$	Score of 80% of the weight
$1\times10^{-4}\leq H_{za}<2\times10^{-4}$	Score of 60% of the weight
$2\times10^{-4}\leq H_{za}<3\times10^{-4}$	Score of 40% of the weight
$3\times10^{-4}\leq H_{za}<4\times10^{-4}$	Score of 20% of the weight
$H_{za}\geq4\times10^{-4}$	Zero

The scoring criteria for health hazards of formaldehyde under sunlight conditions are shown in Table 9. When $H_{za} < 1\times10^{-4}$, a score of 100% of weight is assigned; when $1\times10^{-4} \leq H_{za} < 3\times10^{-4}$, a score of 90% of weight is assigned; when $3\times10^{-4} \leq H_{za} < 5\times10^{-4}$, a score of 80% of weight is assigned; when $5\times10^{-4} \leq H_{za} < 7\times10^{-4}$, a score of 60% of weight is assigned; when $7\times10^{-4} \leq H_{za} < 9\times10^{-4}$, a score of 40% of weight is assigned; when $9\times10^{-4} \leq H_{za} < 1\times10^{-3}$, a score of 20% of weight is assigned; when $H_{za} \geq 1\times10^{-3}$, no score is assigned.

Table 9 Scoring Criteria for Health Hazards under Sunlight Conditions (Formaldehyde)

Health Hazards	Scoring
$H_{za}<1\times10^{-4}$	Score of 100% of the weight
$1\times10^{-4}\leq H_{za}<3\times10^{-4}$	Score of 90% of the weight
$3\times10^{-4}\leq H_{za}<5\times10^{-4}$	Score of 80% of the weight
$5\times10^{-4}\leq H_{za}<7\times10^{-4}$	Score of 60% of the weight
$7\times10^{-4}\leq H_{za}<9\times10^{-4}$	Score of 40% of the weight
$9\times10^{-4}\leq H_{za}<1\times10^{-3}$	Score of 20% of the weight
$H_{za}\geq1\times10^{-3}$	Zero

5.4.2 Integrated pollution

Si values (evaluation criteria) are shown in Table 10. The criteria for the integrated pollution evaluation of VOC are shown in Table 11.

The Si values are referenced from the draft for comments for the revision of GB 27630 *Guideline for Air Quality Assessment in Passenger Car*.

Table 10 Evaluation Criteria (Si Values)

	Benzene	Toluene	Ethylbenzene	Xylene	Styrene	Formaldehyde	Acetaldehyde	Acrolein
Normal temperature conditions	0.06	1.00	1.00	1.00	0.26	0.10	0.20	0.05
Sunlight conditions	0.12	2.00	2.00	2.00	0.52	0.80	0.40	0.10
Ventilation conditions	0.06	1.00	1.00	1.00	0.26	0.10	0.20	0.05

Table 11 Criteria for Integrated Pollution Evaluation of VOC

For any test condition, the scoring criteria of integrated pollution index of VOC are as follows: Level I, a score of 100% of weight is assigned;

Integrated Pollution Level of VOC	Integrated Pollution Value Range of VOC	Scoring
Level I	I≤0.20	Score of 100% of the weight
Level II	0.20＜I≤0.40	Score of 90% of the weight
Level III	0.40＜I≤0.60	Score of 80% of the weight
Level IV	0.60＜I≤0.80	Score of 70% of weight
Level V	0.80＜I≤1.00	Score of 60% of the weight
Level VI	1.00＜I≤1.50	Score of 40% of the weight
Level VII	1.50＜I≤2.00	Score of 20% of the weight
Level VIII	I＞2.00	Zero

Level II, a score of 90% of weight is assigned; Level III, a score of 80% of weight is assigned; Level IV, a score of 70% of weight is assigned; Level V, a score of 60% of weight is assigned; Level VI, a score of 40% of weight is assigned; Level VII, a score of 20% of weight is assigned; Level VII, no score is assigned.

5.4.3 TVOC in cabin of vehicle

At normal temperature, the total score of TVOC in cabin of vehicle is 10 points, and the scores are assigned according to the TVOC concentration in different intervals. The specific scores are assigned as per Table 12 and Table 13.

Table 12 Scoring Criteria for TVOC under Normal Temperature Conditions

TVOC Concentration (mg/m^3)	Scoring
C_{TVOC}≤1	Score of 100% of the weight
1＜C_{TVOC}≤2	(100%, 90%] linear interpolation
2＜C_{TVOC}≤3	(90%, 80%] linear interpolation
3＜C_{TVOC}≤4	(80%, 70%] linear interpolation
4＜C_{TVOC}≤5	(70%, 60%] linear interpolation
5＜C_{TVOC}≤6	(60%, 50%] linear interpolation
C_{TVOC}＞6	Score of 40% of the weight

Table 13 Linear Interpolation for Scoring for TVOC under Normal Temperature Conditions

Score/Points	TVOC Concentration Range (mg/m^3)	TVOC concentration	Scoring rate
10	1＜C_{TVOC}≤2	1.1	99%
		1.2	98%
		1.3	97%
		...	...
	2＜C_{TVOC}≤3	2.1	89%
		2.2	88%
		2.3	87%
		...	...
	3＜C_{TVOC}≤4	3.1	79%
		3.2	78%
		3.3	77%
		...	...
	4＜C_{TVOC}≤5	4.1	69%
		4.2	68%
		4.3	67%
		...	...
	5＜C_{TVOC}≤6	5.1	59%
		5.2	58%
		5.3	57%
		...	...

5.4.4 Odor in cabin of vehicle

The scoring criteria for VOI under normal temperature conditions are shown in Table 14. For VOI not higher than Level 1.5, a score of 100% of weight is assigned; for Level 2, a score of 95% of weight is assigned; for Level 2.5, a score of 90% of weight is assigned; for Level 3, a score of 80% of weight is assigned; for Level 3.5, a score of 70% of weight is assigned; for Level 4, a score of 60% of weight is assigned; for Level 4.5, a score of 40% of weight is assigned; for Level 5, a score 20% of weight is assigned; for VOI greater than or equal to Level 5.5, no score is assigned.

Table 14 Scoring Criteria for VOI under Normal Temperature Conditions

Odor in cabin of vehicle	Scoring
≤ Level 1.5	Score of 100% of the weight
Level 2	Score of 95% of the weight
Level 2.5	Score of 90% of the weight
Level 3	Score of 80% of the weight
Level 3.5	Score of 70% of weight
Level 4	Score of 60% of the weight
Level 4.5	Score of 40% of the weight
Level 5	Score of 20% of the weight
≥ Level 5.5	No score

The scoring criteria for VOI under high temperature conditions are shown in Table 15. For VOI not higher than Level 1.5, a score of 100% of weight is assigned; for Level 2 or 2.5, a score of 95% of weight is assigned; for Level 3, a score of 90% of weight is assigned; for Level 3.5, a score of 80% of weight is assigned; for Level 4, a score of 70% of weight is assigned; for Level 4.5, a score of 60% of weight is assigned; for Level 5, a score of 40% of weight is assigned; for Level 5.5, a score of 20% of weight is assigned; for Level 6, no score is assigned.

Table 15 Scoring Criteria for VOI under High Temperature Conditions

Odor in cabin of vehicle	Scoring
≤ Level 1.5	Score of 100% of the weight
Level 2 or 2.5	Score of 95% of the weight
Level 3	Score of 90% of the weight
Level 3.5	Score of 80% of the weight
Level 4	Score of 70% of weight
Level 4.5	Score of 60% of the weight
Level 5	Score of 40% of the weight
Level 5.5	Score of 20% of the weight
Level 6	Zero

5.5 Result evaluation and release

The total score of "China-Automobile Health Index - VOC and Odor in Cabin of Vehicles" is calculated as the sum of the scores of health hazard, integrated pollution and VOI, as shown in Formula 5.4.

$$V=V_1+V_2+V_3+V_4 \quad \text{(Formula 5.4)}$$

Where, V- total score of China-Automobile Health Index (VOC and Odor in Cabin of Vehicles);

V_1- score of health hazard;

V_2- score of integrated pollution;

V_3- score of VOI;

V_4- score of TVOC in cabin of vehicle;

Appendix A Selection of Odor Evaluators

In order to reduce the impact of subjectivity of evaluators and random environmental factors on evaluation results, odor assessors shall undergo a rigorous selection process to ensure their sensitivity to odor. To select the odor evaluators, standard odorant solution and n-butanol are used to evaluate their capabilities. The odor evaluators are required to accurately distinguish standard odors of different concentrations and properties before performing the odor evaluation.

The odor evaluators shall meet the following basic requirements: a) no olfactory recognition disorders; b) good personal hygiene, no obvious personal smell and no smoking habits; c) interested in odor sensory evaluation; d) high sensitivity and consistent determination of specific odor intensity among evaluators and within individual evaluators; e) impartiality towards the products being evaluated, and relevant professional backgrounds in chemistry, environmental science, materials science or related fields; f) under 45 years old.

The first round of selection takes place in a well-ventilated room. The examiner provides 5 white paper strips. Prior to the test, the examiner immerses 3 of the stripes into the odorless liquid by 1 cm, and the other 2 strips into the standard odorous liquid by 1 cm. Then 5 immersed strips are placed parallel at a certain distance, allowing the examinees to distinguish them by odor. If the first odor identification is correct, proceed to the next odor identification. Generally, the examinee shall have the ability to distinguish among floral fragrance, body odor, sweet pot smell, ripe fruit aroma and fecal odor. If there is an incorrect identification, the examinee will not pass the examination. Table A.1 shows the composition and odor properties of standard odorant solution.

Table A.1 Composition and Odor Properties of Standard Odorant Solution

No.	Standard Odorant Solution	Concentration (w/w)	Odor Property
A	β-Phenylethanol	$10^{-4.0}$	Floral fragrance
B	Isovaleric acid	$10^{-5.0}$	Body odor
C	Methylcyclopentanone	$10^{-4.5}$	Sweet pot smell
D	γ-Undecanolactone	$10^{-4.5}$	Ripe fruit aroma
E	β-Methylindole	$10^{-5.0}$	Fecal odor

The examinees who pass the first round of selection proceed to the second round of selection, which mainly involves identifying different concentrations of n-butanol

and ranking them from low to high concentrations. Fill 6 odor bottles of 500 mL with 150 mL of solution respectively, for which the composition, concentration grade and odor description are shown in Table A.2. Cap the odor bottles, and keep them standstill at room temperature for 2 h. After that, the examinees smell the 6 odor bottles, and rank them in order of increasing concentration. Those who rank the bottles correctly will be qualified for odor evaluation.

Table A.2 Description of N-butanol Solution with Different Concentrations and Odor

Intensity level	Odor Description	Concentration
Level 1	There is no odor or the odor is imperceptible.	Deionized water
Level 2	There is odor, and it is perceptible, but not irritating, with light intensity.	2ml/L
Level 3	There is distinct odor, and it is perceptible, but not irritating, with medium intensity.	8ml/L
Level 4	There is pungent odor, with relatively strong intensity.	18ml/L
Level 5	There is intense, pungent odor, with strong intensity.	30ml/L
Level 6	There is insufferable offensive odor.	Pure n-butanol

Appendix B Evaluation of Continuous Ability of Odor Evaluator

In order to maintain the long-term confidence of evaluation results provided by odor evaluators, it is necessary to regularly evaluate the continuous ability of odor evaluators. Such evaluation will improve the confidence in the evaluation results provided by odor evaluators.

B.1 Continuous ability evaluation method - single odor evaluator

The examiner prepares a standard n-butanol odor solution of Level 2~6 according to Table A.2, and gives a random bottle to the odor evaluator, who shall first determine whether the odor is pungent (i.e., whether the VOI level is greater than or equal to 4), and submit the results to the examiner.

The examiner gives two random bottles of standard n-butanol odor liquid to the odor evaluator, who shall determine the VOI level of odor liquid in the two bottles, and submit the number of the bottle with higher odor intensity to the examiner.

The odor evaluator who gives the correct answer in both evaluations passes the continuous ability evaluation. If there is a wrong answer in the two evaluations, the odor evaluator needs to be familiar with the n-butanol solutions of different odor intensity levels again and then re-evaluate the odor on another day.

An odor evaluator shall participate in a quarterly continuous ability evaluation.

B.2 Continuous ability evaluation method - team

The examiner prepares a standard n-butanol odor solution of Level 2~6 according to Table A.2, and gives a random bottle to 3 members in the odor evaluation team in turn, who shall independently give their own odor evaluation results. After collecting the evaluation results of 3 odor evaluators, the examiner first calculates the range. If the range is less than or equal to 1, and the absolute value of the difference between the average of the 3 evaluation results and the theoretical odor intensity value is also less than or equal to 1, the odor evaluation team passes the continuous ability evaluation.

The odor evaluation team shall participate in a quarterly continuous ability evaluation, and each team has two opportunities for each continuous ability evaluation.