
Interior air of road vehicles —

Part 10:

**Whole vehicle test chamber —
Specification and methods for the
determination of volatile organic
compounds in cabin interiors —
Trucks and buses**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 6, *Indoor air*.

A list of all parts in the ISO 12219 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Volatile organic compounds (VOCs) are widely used in industry and can be emitted by many every-day products and materials. They have attracted much attention in recent years because of their impact on cabin air quality. After homes and workplaces, people spend a lot of time in their vehicles. It is important to determine the material emissions of interior parts and to reduce them to an acceptable level. Therefore, it is important to get comprehensive and reliable information about the types of organic compounds in the interior air of vehicles and also their concentrations.

This document outlines a method of measuring the types and levels of VOCs in vehicle cabin air under controlled conditions. It describes requirements for a whole vehicle test chamber and a test protocol.

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Interior air of road vehicles —

Part 10:

Whole vehicle test chamber — Specification and methods for the determination of volatile organic compounds in cabin interiors — Trucks and buses

1 Scope

This document describes and specifies the whole vehicle test chamber, the vapour sampling assembly and the operating conditions for the determination of volatile organic compounds (VOCs; for more information see [Annex E](#)), and carbonyl compounds in vehicle cabin air. There are three measurements performed: one (for VOCs and carbonyl compounds) during the simulation of ambient conditions (ambient mode) at standard conditions of 23 °C with no air exchange; a second only for the measurement of formaldehyde at elevated temperatures (parking mode); and a third for VOCs and carbonyl compounds simulating driving after the vehicle has been parked in the sun starting at elevated temperatures (driving mode). For the simulation of the mean sun irradiation, fixed irradiation in the whole vehicle test chamber is employed.

The VOC method is valid for measurement of non-polar and slightly polar VOCs in a concentration range of sub-micrograms per cubic metre up to several milligrams per cubic metre. Using the principles described in this method, some semi-volatile organic compounds (SVOC) can also be analysed. Compatible compounds are those which can be trapped and released from the Tenax TA^{®1} sorbent tubes described in ISO 16000-6, which includes VOCs ranging in volatility from *n*-C6 to *n*-C16.

The sampling and analysis procedure for formaldehyde and other carbonyl compounds is performed by collecting air on to cartridges coated with 2,4-dinitrophenylhydrazine (DNPH) and subsequent analysis by high performance liquid chromatography (HPLC) with detection by ultraviolet absorption. Formaldehyde and other carbonyl compounds can be determined in the approximate concentration range 1 µg/m³ to 1 mg/m³.

This method applicable to trucks and buses, as defined in ISO 3833:1977 3.1.1 to 3.1.6.

This document describes:

- a) Transport and storage of the test vehicle until the start of the test.
- b) Conditioning of the surroundings of the test vehicle and the test vehicle itself as well as the whole vehicle test chamber.
- c) Conditioning of the test vehicle prior to measurements.
- d) Simulation of ambient air conditions (ambient mode).
- e) Formaldehyde sampling at elevated temperatures (parking mode).
- f) Simulation of driving after the test vehicle has been parked in the sun (driving mode).

1) Tenax TA[®] is the trade name of a product supplied by Buchem. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12219-1, *Interior air of road vehicles — Part 1: Whole vehicle test chamber — Specification and method for the determination of volatile organic compounds*

ISO 16000-3, *Indoor air — Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air — Active sampling method*

ISO 16000-6, *Indoor Air — Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA[®] sorbent, thermal desorption and gas chromatography using MS or MS-FID*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 background concentration

analyte concentration in the whole vehicle test chamber when the vehicle is inside

3.2 test vehicle

new vehicle to be tested

Note 1 to entry: The test vehicle used can be of any type specified in ISO 3833:1977, 3.1.2 to 3.1.6.

Note 2 to entry: See also [3.5](#)

3.3 total volatile organic compounds (TVOC)

sum of volatile organic compounds sampled on Tenax TA[®] and eluting between and including n-hexane and n-hexadecane, detected with a flame ionization detector (TVOC_{FID}) or mass spectrometric detector (TVOC_{MS}) and quantified converting the total area of the chromatogram in that analytical window to toluene equivalents

3.4 carbonyl compound

compound containing the functional group -C(=O)- determined according to ISO 16000-3

3.5 ambient mode

mode in which sampling of VOCs and carbonyl compounds in the cabin of a test vehicle under standardized ambient temperature conditions is performed, defined as 23 °C

Note 1 to entry: Engine off, radiators off, trucks and buses sampling time 30 min.

3.6**parking mode**

mode in which sampling of formaldehyde in the cabin of a test vehicle under standardized elevated temperature conditions is performed

Note 1 to entry: Engine off, radiators on, trucks and buses sampling time 30 min.

3.7**driving mode**

mode in which sampling of VOCs and carbonyl compounds in the cabin of a *test vehicle* (3.2) under standardized conditions starting at elevated temperatures is performed, simulating a vehicle driven after being parked in the sun

Note 1 to entry: Engine on, radiators on, air conditioning on, trucks sampling time 30 min, buses sampling time 120 min.

3.8**sampling train**

apparatus to collect the sample gas inside the *test vehicle* (3.2) cabin (indoor) and the whole vehicle test chamber, trapping the VOCs and carbonyl compounds on sorbent tubes under standardized conditions

Note 1 to entry: See ISO 16000-3 for formaldehyde and ISO 16000-6 the VOCs.

3.9**field blank**

air quality sample taken in an identical manner as the real sample, but without sucking air through the sampling apparatus

[SOURCE: ISO 16000-16; 3.7, modified — Note to entry has been deleted since it does not apply to this document.]

4 Apparatus and materials**4.1 General**

The whole vehicle test chamber is big enough to house the test vehicle completely. An air conditioning system is installed to allow standardized air conditions for a temperature of $23\text{ °C} \pm 2\text{ °C}$, humidity of $50\% \text{ RH} \pm 10\% \text{ RH}$. A solar radiator system is installed to heat the test vehicle cabin to a defined temperature (see also [Figure 1](#)).

4.2 Heating radiator

Infrared radiator, halogen radiator or other radiators (simulating sunlight). The heating radiators used shall be powered to maintain a temperature of $40\text{ °C} \pm 2\text{ °C}$ for trucks and $35\text{ °C} \pm 2\text{ °C}$ for buses.

Position the heating radiators on the roof. There shall be no heating radiators shining from the side.

Take care not to have too short a distance between radiator and surface in order to avoid hot spots.

4.3 Sampling trains**4.3.1 Sampling in the test vehicle**

Four sampling trains are employed: two for the VOC measurements in parallel and two for the carbonyl compound measurements in parallel in the test vehicle (to check the repeatability) (see ISO 16000-3 for carbonyl compounds and ISO 16000-6 or ISO 16017-1 for VOCs).

There is one sampling line with a manifold for the division of the sampling flow outside the test vehicle (see 4.3.3). It consists of the probe, the sampling line (heated, if necessary), the sorbent tube for VOC or the DNPH cartridge for carbonyl compound sampling respectively, the gas meters and the pumps.

All sampling trains shall be checked for leaks and shall have a maximum vacuum decay rate of 30 kPa for an average time of 10 s. For the leak check, the nozzle shall be plugged. Other equivalent leak checks can be employed.

4.3.2 Sampling in the whole vehicle test chamber

Four sampling trains are used to determine the background concentration in the whole vehicle test chamber. The sampling trains are identical to those of 4.3.1, apart from the sampling line, which is much shorter and not heated.

All sampling trains shall have a maximum vacuum decay rate of 30 kPa for an average of 10 s. The nozzle is plugged for the leak check. Other equivalent leak checks can be employed.

4.3.3 Sampling line

Tubing, between the sampling point (probe) inside the test vehicle, via the manifold outside the test vehicle to the VOC sorbent tubes or DNPH cartridges respectively (see Figure 1).

The sampling line shall be constructed so as described in ISO 12219-1.

The tubing should be inserted between the door and the door frame or between the door frame and the glazing and should be sufficiently non-compressible to ensure an unimpeded flow of air.

The second sampling line [tubing, between the sampling point (probe) in the whole vehicle test chamber in the vicinity of the test vehicle (see 6.1 b)) and the manifold and to the VOC sorbent tubes or DNPH cartridges, respectively is identical to that described in the preceding, but no heating is necessary. This second sampling line is needed to monitor the background analyte concentration of the whole vehicle test chamber.

4.4 Analytical equipment and materials

The analytical equipment used for the determination of VOCs and carbonyl compounds or formaldehyde alone shall be in accordance with ISO 16000-6 (VOCs) or ISO 16000-3 (carbonyl compounds), respectively.

It shall be proven for the VOC sorbent tubes and the DNPH cartridges that there is no breakthrough. This can be identified by a back-up sorbent tube which is analysed separately (see ISO 16017-1).

4.5 Test vehicle

A new vehicle (i.e. minimum mileage after vehicle manufacture and within $28 \text{ d} \pm 5 \text{ d}$ after the completion of manufacture) to be tested shall have been manufactured by the normal production process. The preferred colour of the test vehicles for the determination of the official VOC and carbonyl compound emissions is black or a dark colour.

All manual glazing shades shall remain open.

The test vehicle shall be stored and transported under conditions preventing direct solar heating, otherwise the vehicle shall be conditioned after arrival overnight with open doors and windows before it is transferred into the whole vehicle test chamber. No transport waxes for protection should be used. All transport foils or transit lacquers shall be removed carefully before the test. The test vehicle shall not be cleaned (inside) for at least 24 h before starting the measurements.

The method specified in this document can also be employed for used vehicles. In this case, it is possible that the measurement results are not identical to those obtained on a new test vehicle due to different usage.

5 Principle

A whole vehicle test chamber (see [Annex A](#)) reserved for this purpose is assembled. The air in the test vehicle cabin is measured according to a uniform standardized programme (see [Figure 1](#)). Sampling of VOCs and carbonyl compounds is performed for the ambient mode at 23 °C. Subsequently, formaldehyde is determined alone under elevated temperature conditions in the parking mode (see [Figure 3](#)). Sunshine is simulated by the use of heating radiators providing fixed irradiation for 3,5 h, after which a third sample is taken in the driving mode. The humidity and temperature of the air inside the whole vehicle test chamber are measured.

The VOC and carbonyl compound vapour samples are taken in the driver breathing zone and collected on VOC sorbent tubes and DNPH cartridges. Later the samples shall be analysed in the laboratory according to ISO 16000-6 or ISO 16000-3, respectively.

Furthermore, VOC and carbonyl compound vapour samples are taken in the whole vehicle test chamber to determine background concentrations. Altogether, a total of eight VOC and 12 carbonyl compound samples are required: two duplicate room temperature samplings (ambient mode) and two duplicate elevated temperature samplings (driving mode), and the same duplicate background samples in the whole test chamber in each of the modes as well as the two formaldehyde measurements under the elevated temperature conditions (parking mode).

The analytical part of the overall measurement procedure is based on the use of sorbent tubes with subsequent thermal desorption and gas chromatographic analysis for VOCs (according to ISO 16000-6) and the use of 2,4-dinitrophenylhydrazine (DNPH) cartridges for the determination of carbonyl compounds (according to ISO 16000-3).

6 Requirements of the whole vehicle test chamber, test vehicle and measurement procedures

6.1 Requirements for the whole vehicle test chamber

The whole vehicle test chamber with the following requirements is assembled as shown in [Figure 1](#). The following requirements shall be met:

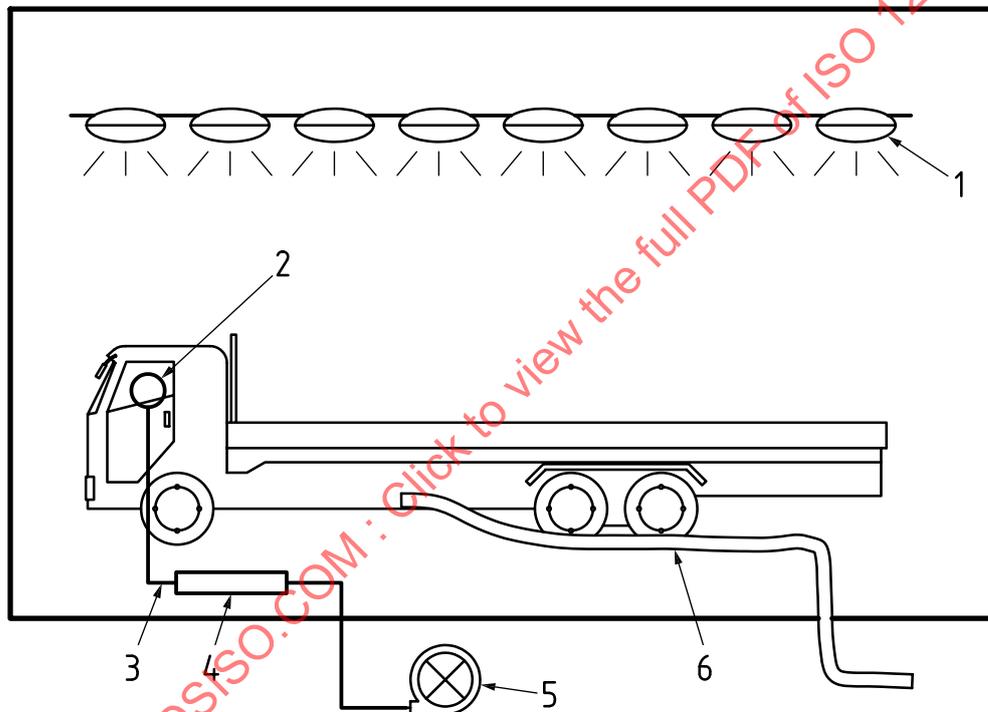
- a) The whole vehicle test chamber shall be large enough to accommodate the complete test vehicle.
- b) The whole vehicle test chamber shall be capable of maintaining a temperature of 23 °C ± 2 °C. A heating and ventilation system (including the adjustment of the humidity) and, if necessary, a cooling system is necessary. The sampling point for the background concentrations in the whole test chamber shall be more than 1 m from the side of the test vehicle passenger seat door for trucks or passenger entrance door closer to the front for buses and at the height of 1m from the chamber floor.

NOTE An air filter system can be used to keep the whole vehicle test chamber clean.

- c) The temperature profile shall be in accordance with [Figure 3](#).
- d) Relative humidity (RH) during the ambient mode in the whole vehicle test chamber shall be 50 % RH ± 10 % RH.
- e) Relative humidity RH during the parking and driving mode in the whole vehicle test chamber shall be documented.
- f) The maximum background concentration for each analyte shall not exceed 20 µg/m³ for each single component and 200 µg/m³ for TVOCs or a maximum of 10 % of the respective measured values (whichever is greater). If this is not met, the source of the contamination shall be identified and removed or covered to exclude it from the test.
- g) Two duplicate VOCs and two duplicate carbonyl background samples (one during parking mode and one during driving mode) as well as one duplicate formaldehyde background sample (parking

mode) are required. The VOC sorbent tubes and the DNPH cartridges for the VOC and carbonyl compound sampling in the test vehicle as well as the pumps and the other sampling devices are positioned in the whole vehicle test chamber. The air exchange rate of the whole vehicle test chamber during the driving mode should be a minimum of twice per hour.

- h) The heating radiators are fixed above the test vehicle overlapping the footprint of the cabin of the test vehicle. The heating radiators used shall be powered to maintain a temperature of $40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ for trucks and $35\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ for buses.
- i) Various measuring instruments and data recording for continuous recording of signals measured (e.g. for temperature and humidity measurements).
- j) Door for the entry and exit of the test vehicle.
- k) A hydrocarbon air warning system should be installed (option) to avoid explosive workplace atmospheres; workplace regulations shall be followed.
- l) A pipe at the exhaust pipe liner of the test vehicle to remove the waste gas outdoors.



Key

- | | |
|------------------------------------|----------------|
| 1 irradiation lamp | 4 sorbent tube |
| 2 about the level of driver's nose | 5 pump |
| 3 sampling line | 6 exhaust duct |

Figure 1 — Overview of test chamber

Care shall be taken to ensure that the sampling train components remain at or near ambient temperature and are protected from the direct effects of the heating radiators of the whole vehicle test chamber.

6.2 Requirements for the test vehicle

- a) A new vehicle to be tested shall have been manufactured by the normal production process. The test data depends on the trim level of the selected test vehicle. A detailed specification of the trim level of the test vehicle shall be included in the test report. Any deviation from that specified for the

ideal situation shall be noted and the effect of any deviation from the test results shall be explained and reported.

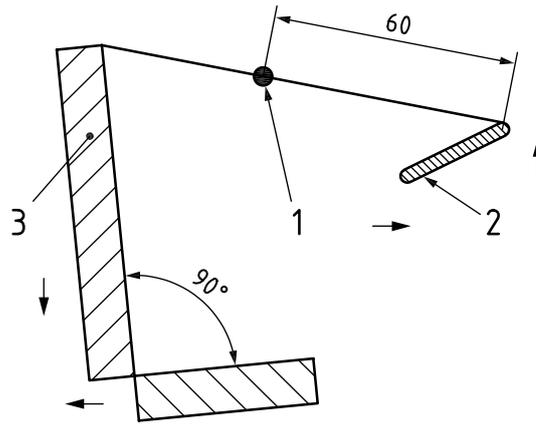
NOTE Trim level denotes the version of a vehicle model and the combination of features it is required with. Higher trim levels come with more features while an entry-level trim comes with less features.

- b) The test for a new test vehicle shall be carried out within $28 \text{ d} \pm 5 \text{ d}$ after completion of assembly. The test vehicle shall be stored and transported under conditions with no direct heating such as in the shadow or sales rooms which are described in 3.5. All transport foils or transit lacquers shall be removed carefully. In cases where a vehicle cannot be transported it may have to be driven to the test chamber. If this is the case all relevant data shall be reported (mileage, temperatures, etc.).
 - c) The sensors and cables for the temperature measurements shall be installed at the driver's nose position. Additional sensors and cables can be installed according to Annex B.
 - d) The sampling line (with the probe at one end) for the VOC and carbonyl compound measurements is installed according to Figures 1 and 2. The sampling line is connected with a manifold situated outside the test vehicle. The manifold is connected to four sampling trains which are used to perform the following consecutive measurements:
 - 1) Monitoring of the test vehicle cabin in the ambient mode at $23^\circ\text{C} \pm 2^\circ\text{C}$ (two VOC measurements (duplicate) and two carbonyl compound measurements (duplicate)).
 - 2) Monitoring of the test vehicle cabin in the parking mode at elevated temperatures (two formaldehyde measurements (duplicate); only two sampling trains are needed).
 - 3) Monitoring of the test vehicle cabin in the driving mode (two VOC measurements (duplicate) and two carbonyl compound measurements (duplicate)).
 - e) The sampling probe of the sampling trains shall be positioned in the breathing zone of the driver (60 cm from the top of steering wheel in line with the top of the headrest). Position the seat as far back as possible and as low as possible and move the steering wheel back to the highest position (see Figure 2).
- NOTE On the bus, the VOC concentration in the vehicle is constant and the ride time of the driver is the longest, so sampling is performed in the driver breathing zone (nose position). See Annex B.
- f) Pipe the vehicle exhaust emissions outdoors.
 - g) Set the air conditioner during the driving mode (as defined in 7.3.3.1). Sampling of VOCs and carbonyl compounds is undertaken in the cabin of a test vehicle under standardized conditions starting at elevated temperatures to simulate a vehicle driven after being parked in the sun. Engine and air conditioning (auto) are set to on, or, if no automatic air-conditioning system is available, with the ventilation set to its highest position, (air) recirculation off, and radiators on, according to Table 1.

6.3 Requirements for VOC and carbonyl compound air sampling and measurement methods

For VOC and carbonyl compound sampling and measurement of the air in the cabin of the test vehicle and in the whole vehicle test chamber, the following procedures shall be followed [see also 6.1 g)]:

- a) Carbonyl compounds including formaldehyde: ISO 16000-3
- b) VOCs: ISO 16000-6



- Key**
- 1 sampling point
 - 2 steering wheel
 - 3 headrest integrated seat

Figure 2 — Schematic arrangement of the sampling position in the test vehicle; dimensions in cm

Table 1 — Air conditioner settings

	Automatic air conditioner	Semi-automatic or manual air conditioner	No air conditioner
Air-conditioning ON/OFF	ON	ON	—
Indoor/outdoor air change-over	Automatic	Fresh air circulation	—
Fan speed	Automatic	Halfway between minimum and maximum levels	—
Air flow selector	Automatic All registers pointed straight ahead and fully open	Face mode Ventilation in highest position, with fresh-air ventilation All registers pointed straight ahead and fully open	Ventilation in highest position, with fresh-air ventilation All registers pointed straight ahead and fully open
Temperature	23 °C	Lowest (or medium to avoid an automatic air recirculation mode)	Lowest

6.4 Field blank measurement

The sorbent tubes used as field blanks (for VOC and carbonyl compounds) shall be from the same batch and treated in the same way as those used for sampling and analysis (including all devices and handlings), except that no gas is drawn through the sampling trains (see 7.2.4).

A field blank procedure shall be performed at least before each measurement series (series of consecutive measurements of several vehicles).

The field blank shall not be deducted from the measured value.

All field blanks shall be reported with the corresponding measured values.

NOTE Field blank tubes needed to be recapped moments after uncapping.

7 Standard test procedure

7.1 General

The standard test procedure is divided into three parts:

- conditioning of the whole vehicle test chamber;
- conditioning of the test vehicle;
- performing sampling and analytical measurement.

7.2 Pre-arrangements and preconditioning of the whole vehicle test chamber and the vehicle performing field blanks

7.2.1 Pre-arrangements

Connect the test apparatus with the test vehicle. Attach the cables and sampling lines to the door frame so that, when the doors are closed, there is a (nearly) airtight sealing. Furthermore, the sampling line for VOC and carbonyl compound sampling shall be installed in the test vehicle. The probe is positioned as specified in [6.2.e](#)).

- Connect the sampling line with the manifold and the manifold with the sampling trains for VOC and carbonyl compound measurements outside the test vehicle.
- Connect the test apparatus within the whole vehicle test chamber.
- Install the heating radiators and the other installations listed in [6.1](#).

7.2.2 Preconditioning of the whole vehicle test chamber

Adjust the temperature of the whole vehicle test chamber to $23\text{ °C} \pm 2\text{ °C}$ during the ambient mode test. There may be the need for a heating or cooling device. The humidity shall be $50\% \text{ RH} \pm 10\% \text{ RH}$ in the ambient mode. The whole vehicle test chamber should be under good ventilation, and the air exchange rate should be twice per hour or higher. The interior materials of the whole vehicle test chamber shall have no appreciable emissions regarding the indoor air inside the test vehicle (see [6.1](#) and [6.1 f](#))) background concentrations. The heating of the interior of the cabin and the surfaces of the test vehicle is performed by heating radiators from above the test vehicle.

7.2.3 Preconditioning of the test vehicle

The essential conditions for the surroundings are as follows:

The temperature during the ambient mode is adjusted to $23\text{ °C} \pm 2\text{ °C}$ via the whole test chamber conditioning system (see [Figure 3](#)). The preconditioning is started by opening the door for 1 h. After this, the door is closed for a minimum of 8 h (see [Figure 3](#)).

7.2.4 Field blanks

Prepare the field blanks before the measurements are started (see [6.4](#)). Install one sorbent tube for VOCs and one DNPH cartridge for carbonyl compounds in the sampling trains to measure the background concentration of the whole vehicle test chamber. Also install one sorbent tube and one DNPH cartridge in the sampling trains to measure the background concentration of the test vehicle. The field blank samples shall be handled in the same way as those used for VOC or carbonyl compound

measurements, but without drawing air through the sampling trains. As soon as the samples have been connected into the sample train, they shall be removed, sealed and retained for analysis with the real samples.

7.3 Detailed description of the test procedure

7.3.1 Ambient mode

7.3.1.1 Preconditioning time 0 (see scheme in Figure 3)

After the conditions of the whole test chamber have been set at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \text{ RH} \pm 10\% \text{ RH}$ and the air exchange rate in the test chamber has been adjusted to a recommended value of at least twice per hour (see 7.2.2), the test procedure is started.

At this time, turn on the sampling trains in the whole vehicle test chamber to determine the VOCs and carbonyl compounds background concentrations, two VOC sorbent tubes and two DNP cartridges. The probe is positioned 1,0 m from the vehicle. The relative humidity and temperature are measured in the same position. After the chamber sample is finished, start the conditioning of the test vehicle by opening all door for 1 h. Install the sampling train including two VOC sorbent tubes and two DNP cartridges and leak check the sampling train.

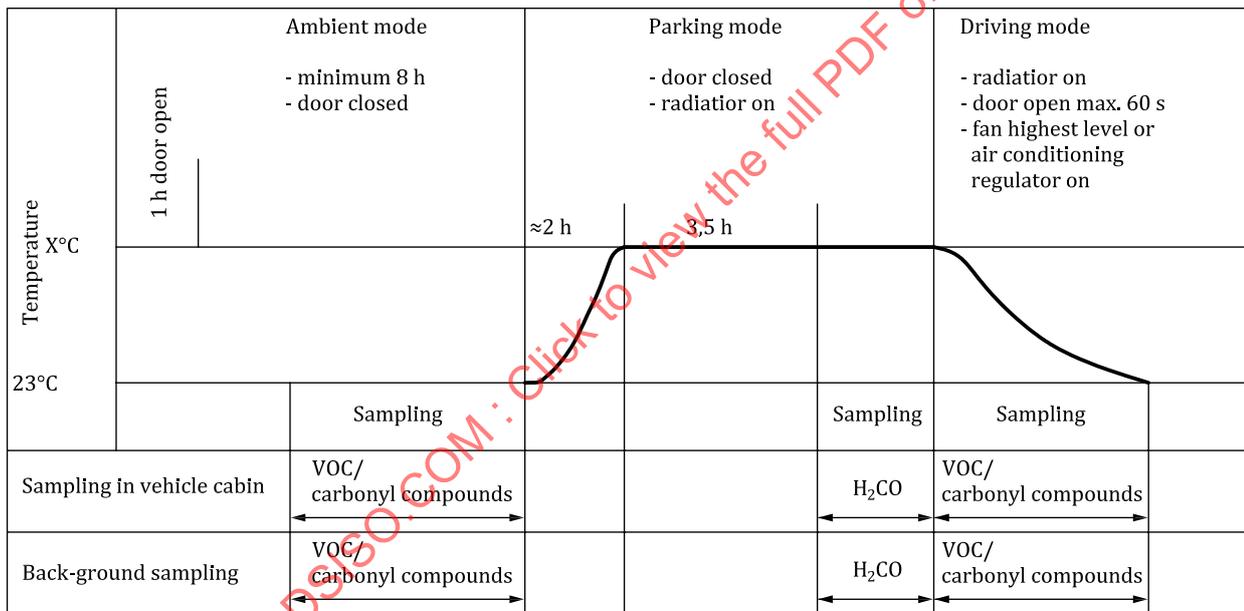


Figure 3 — Schematic temperatures and test schedule

7.3.1.2 Time: 1,00 h

Continue by conditioning the whole-vehicle test chamber and close all doors of the test vehicle for at least 8 h or more (e.g. overnight) at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \text{ RH} \pm 10\% \text{ RH}$ and keep the air exchange rate in the whole vehicle test chamber at a minimum of twice per hour (recommended value). There is no dynamic ventilation of the test vehicle.

7.3.1.3 Time 8,50 h

Before the sampling starts, purge the dead volume of the sampling line. Turn on the pumps for the sampling trains (two for VOC and two for carbonyl compounds, each in parallel). Perform the sampling of gaseous organic compounds in the test vehicle cabin at room temperature $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 30 min. Adjust the flow rate to maximum 0,2 l/min for VOC and 1 l/min for carbonyl compound measurements.

The measurement procedures specified in ISO 16000-6 (VOCs) and ISO 16000-3 (carbonyl compounds) shall be followed.

Switch off the pumps for the VOC and carbonyl compound measurements, read and record the measurement volumes and take the VOC sorbent tubes and DNPH cartridges, which are placed outside the vehicle cabin, out of the sampling train. Seal the sorbent tubes or cartridges and analyse according to ISO 16000-6 and ISO 16000-3.

7.3.2 Parking mode

7.3.2.1 Time 9,00 h

Start parking mode with the heating-up procedure. The following tasks shall be performed. Start heating with the heating radiators (see 4.2). The irradiation is adjusted to reference measurement point in the cabin driver's nose position at $40\text{ °C} \pm 2\text{ °C}$ for Trucks and $35\text{ °C} \pm 2\text{ °C}$ for Buses maintained at that level for 3,5 h. Adjust the air exchange rate to twice per hour or higher (recommended value) in the whole vehicle test chamber.

7.3.2.2 Time 12,50 h

Install the two DNPH cartridges in the two sampling trains for the test vehicle measurement and two for the whole vehicle test chamber. Before the sampling begins, check the sampling train for leaks (see 4.3.1) and purge the dead volume. Turn on the pumps of the four sampling trains. Perform formaldehyde sampling in the test vehicle cabin at elevated temperatures for 30 min. The flow rate is adjusted to maximum 1 l/min for carbonyl compound measurements. The measurement procedure specified in ISO 16000-3 (carbonyl compounds) shall be followed.

Turn off the pumps for the formaldehyde measurements and take the DNPH cartridges out of the sampling train to be analysed according to ISO 16000-3. Read and register the measurement volumes.

7.3.3 Driving mode

7.3.3.1 Time 13,00 h

Before the sampling in the driving mode begins, install the two VOC sorbent tubes and the two DNPH cartridges, and purge the dead volume. Connect the exhaust pipe of the test vehicle with the ventilation system of the test chamber to remove the exhaust gases outdoors.

Open the driver's door, start the engine, and turn on the air conditioning. Set vehicle temperature at 23 °C in case of an automatic conditioning system or the lowest operation for semi-automatic and manual conditioning systems. For test vehicles without automatic air-conditioning systems, the fan is in highest performance mode with fresh-air ventilation (see Table 1).

Close the driver's door. Complete these steps of the procedure within 60 s, meaning that after 60 s of engine running the driver's door shall be closed. The doors and windows of the test vehicle shall remain closed during the entire driving mode. Engine shall be running during the entire mode at the vehicles idling speed with the minimum frequency of idling declared by the manufacturer.

After 60 s of closing the doors, switch on the pumps of the four sampling trains (two for VOCs and two for carbonyl compounds, each in parallel). The sampling of gaseous organic compounds in the test vehicle cabin is performed at elevated temperature of 30 min for trucks and 120 min for buses. The measurement procedures specified in ISO 16000-6 (VOCs) and ISO 16000-3 (carbonyl compounds) shall be followed.

7.3.3.2 Time 13,5 h for trucks, 15 h for buses

Stop the pumps of the sampling trains and switch off the engine and the heating radiators. The sampling volumes are read and registered. The VOC sorbent tubes and DNPH cartridges are taken out of the sampling train for the analysis as specified in ISO 16000-6 and ISO 16000-3.

Stop the continuous measurements for temperature and humidity. This is the end of the test cycle.

8 Calculation, presentation of results, and precision and uncertainty

Calculation and presentation of results are performed according to ISO 16000-6 and ISO 16000-3. The precision and uncertainty shall also be followed as specified in ISO 16000-6 and ISO 16000-3. There is an informative test report (see [Annex C](#)) which should be agreed on between the client and the laboratory.

9 Performance characteristics

The detection limits and standard deviations for VOCs given in ISO 16000-6 and for carbonyl compounds in ISO 16000-3 are met in this measurement procedure. The condition to meet these performance characteristics is that there are no contaminations or sink effects in the sampling lines. This shall be proven before the measurements and shall be documented.

10 Quality assurance

An appropriate level of quality control shall be employed following ISO 16000-3 and ISO 16000-6, namely:

- field blanks are prepared according to [6.4](#);
- the field blank level is acceptable if artefact peaks are no greater than 10 % of the typical areas of the analytes of interest;
- desorption efficiency of VOCs and carbonyl compounds should be checked according to ISO 16000-3 and ISO 16000-6;
- the collection efficiency can be controlled by always taking sample volumes below the safe sampling volume, see ISO 16000-6 - breakthrough can be checked using back-up tubes or by collecting samples at a range of different sampling volumes below the safe sampling volume;
- repeatability of the measuring method shall be determined, e.g. using collection and analysis of duplicate samples - a coefficient of variation ≤ 15 % (ISO 16000-3 and ISO 16000-6) from the duplicate measurements should be reached;
- the recovery of C6 to C16 hydrocarbons shall be 95 % mass fraction (ISO 16000-6);
- documentation (see [Annex D](#)) illustrating traceable calibrations for temperature, humidity, and flow measurements.

Annex A (informative)

Whole vehicle test chamber and the ambient mode chamber condition



Figure A.1 — Example of the illustration of a whole vehicle test chamber

The ambient mode chamber condition will be set at 23 ± 2 °C in consideration of the existing equipment capacity. Buses and trucks have large bodies. A large body becomes a load and the chamber temperature is not stable.

Annex B (informative)

VOC concentration distribution in the bus cabin

Figure B.1 indicates the VOC concentration ratio between the passenger area and driver area in the bus cabin. The passenger area means the central part of the bus cabin.

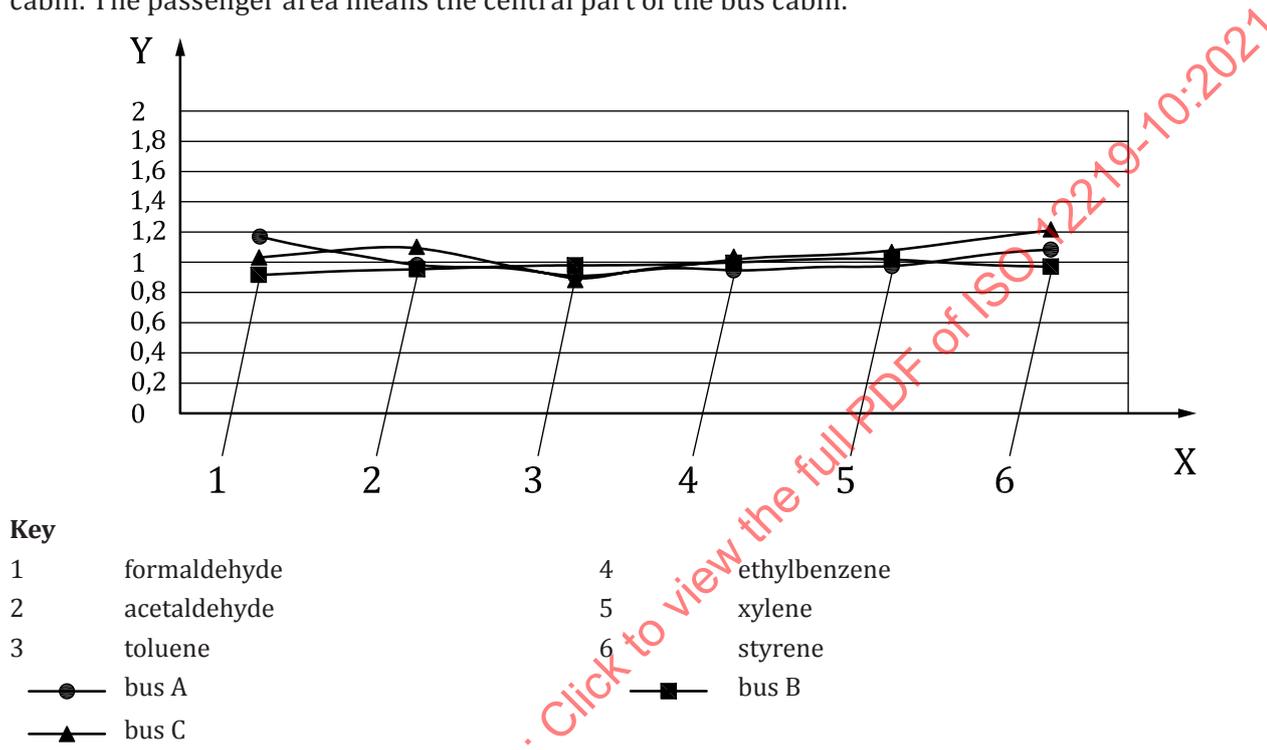


Figure B.1 — Example for VOC concentration distribution in the bus cabin