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**Interior air of road vehicles — — Part 1: Whole vehicle test chamber —  
Specification and method for the determination of volatile organic  
compounds in cabin interiors**

*Air intérieur des véhicules routiers — — Partie 1: Enceinte d'essai d'un véhicule complet — Spécification et  
méthode de détermination des composés organiques volatils dans les habitacles de voitures*

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 12219-1 was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 6, *Indoor air*, in cooperation with ISO/TC 22, *Road vehicles*.

ISO 12219 consists of the following parts, under the general title *Interior air of road vehicles* — :

- a) *Part 1: Whole vehicle test chamber — Specification and method for the determination of volatile organic compounds in cabin interiors*
- b) *Part 2: Screening method for the determination of the emissions of volatile organic compounds from vehicle interior parts and materials — Bag method*
- c) *Part 3 Screening method for the determination of the emissions of volatile organic compounds from vehicle interior parts and materials — Micro-scale chamber method*
- d) *Part 4: Method for the determination of the emissions of volatile organic compounds from vehicle interior parts and materials — Small chamber method:*
- e) *Part 5: Screening method for the determination of the emissions of volatile organic compounds from vehicle interior parts and materials — Static chamber method (under preparation)*

## Introduction

Volatile organic compounds (VOCs) are widely used in industry and may be emitted by many every-day products and materials. They have attracted attention in recent years because of their impact on indoor 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, if required. Therefore it is necessary to get comprehensive and reliable information about the types of organic compounds in the indoor air of vehicles and also their concentrations.

This part of ISO 12219 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. Measurements are carried out according to ISO 16000-6 (VOCs) and ISO 16000-3 (carbonyls).

There are several national test methods available for measuring in-vehicle air quality e.g. JAMA Report No.98<sup>[3]</sup> and TÜV-Guide<sup>[4]</sup>. However this part of ISO 12219 requires a fixed heating radiation system whereas the methods of References [3] and [4] define a fixed temperature programme.

Before setting a fixed radiation density for heating the test vehicle several validation measurements were performed<sup>[1] to [2]</sup>.

Besides ISO 12219 there are parts of ISO 16000 which are dealing with the measurements of VOCs:

- *Part 3 Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air — Active sampling method*
- *Part 5: Sampling strategy for volatile organic compounds (VOCs)*
- *Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA<sup>®</sup> sorbent, thermal desorption and gas-chromatography using MS or MS/FID*
- *Part 9: Determination of the emission of volatile organic compounds from building products and furnishing — Emission test chamber method*
- *Part 10: Determination of the emission of volatile organic compounds from building products and furnishing — Emission test cell method*
- *Part 11: Determination of the emission of volatile organic compounds from building products and furnishing — Sampling, storage of samples and preparation of test specimens*
- *Part 24: Performance test for evaluating the reduction of volatile organic compounds and carbonyl compounds without formaldehyde concentrations by sorptive building materials*
- *Part 25: Determination of the emission of semi-volatile organic compounds for building products — Micro chamber method*

Furthermore

ISO 16017-1, *Indoor, ambient and workplace air — Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography — Part 1: Pumped sampling and*

ISO 16017-2, *Indoor, ambient and workplace air — Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography — Part 2: Diffusive sampling*

are emphasized dealing with VOC measurements.



# Interior air of road vehicles — — Part 1: Whole vehicle test chamber — Specification and method for the determination of volatile organic compounds in cabin interiors

## 1 Scope

This part of ISO 12219 describes and specifies the whole vehicle test chamber, the vapour sampling assembly and the operating conditions to determine volatile organic compounds (VOCs), and carbonyls in vehicle cabin air. There are three measurements performed; one (for VOCs and carbonyls) 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 carbonyls 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 a 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- $\mu\text{g}/\text{m}^3$  up to several  $\text{mg}/\text{m}^3$ . Using the principles described in this method, some semi-volatile organic compounds (SVOC) can also be analyzed. Compatible compounds are those which can be trapped and released from the Tenax TA<sup>®</sup> sorbent tubes<sup>1)</sup> described in ISO 16000-6, which includes VOCs ranging in volatility from n-C<sub>6</sub> to n-C<sub>16</sub>.

The sampling and analysis procedure for formaldehyde and other carbonyl compounds is performed by collecting air onto 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 concentration range of approximately 1  $\mu\text{g}/\text{m}^3$  to 1  $\text{mg}/\text{m}^3$ .

The method is valid for passenger cars (see 3.2).

This part of ISO 12219 describes:

- a) transport and storage of the test vehicles until the start of the test,
- b) conditioning for 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).

Excluded are busses and motor caravans and trucks in accordance with the description in ISO 3833.

<sup>1)</sup> Tenax TA<sup>®</sup> is the trade name of a product manufactured by Buchem, Inc. It is unique and has a sole manufacturer, however, it is available from many suppliers. This information is given for the convenience of users of this International Standard 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 referenced documents are indispensable for the application 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 3833, *Road vehicles — Types, terms and definitions*

ISO 9059, *Solar energy — Calibration of field pyrhemometers by comparison to reference pyrhemometer*

ISO 9060, *Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation*

ISO 9845-1, *Solar energy — Reference solar spectral irradiance at the ground at different receiving conditions — Part 1: Direct normal and hemispherical solar irradiance for air mass 1,5*

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

*Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA<sup>®</sup> sorbent, thermal desorption and gas-chromatography using MS or MS-FID*

ISO 16017-1, *Indoor, ambient and workplace air — Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography — Part 1: Pumped sampling*

## 3 Terms and definitions

For the purpose of this document, the terms and definitions of ISO 16000-3, ISO 16000-6 and the following apply.

### 3.1

#### **background concentration**

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

### 3.2

#### **test vehicle**

new or used vehicle to be tested (all types of passenger cars, described in [ISO 3833, only in 3.1.1])

NOTE See also 4.5.

### 3.3

#### **volatile organic compound (VOC), very volatile organic compound (VVOC) and semi-volatile organic compound (SVOC)**

organic compounds whose boiling points are in different ranges

NOTE 1 This classification has been defined by the World Health Organization<sup>[5]</sup>.

NOTE 2 Boiling points of some compounds are difficult or impossible to determine because they decompose before they boil at atmospheric pressure. Vapour pressure is another criterion for classification of compound volatility that may be used for classification of organic chemicals<sup>[6]</sup>.

NOTE 3 Definition see Annex D and ISO 16000-6.

### 3.4

#### **total volatile organic compounds (TVOC)**

sum of volatile organic compounds sampled on Tenax TA<sup>®</sup> and eluting between and including n-hexane and n-hexadecane, detected with a flame ionization detector (TVOC<sub>FID</sub>) or mass spectrometric detector



(TVOC<sub>MS</sub>) and quantified converting the total area of the chromatogram in that analytical window to toluene equivalents

[ISO 16000-6]

### 3.5

#### **carbonyl**

compound listed and to be determined according to ISO 16000-3

### 3.6

#### **ambient mode**

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

NOTE Engine off, radiators off, sampling time 30 min.

### 3.7

#### **parking mode**

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

NOTE Sampling time 30 min.

### 3.8

#### **driving mode**

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

NOTE Sampling time 30 min.

### 3.9

#### **sampling train**

apparatus to collect the sample gas inside the test vehicle cabin (indoor) and in the whole vehicle test chamber trapping the VOCs and carbonyls in sorbent tubes under standardized conditions

NOTE See ISO 16000-3 for formaldehyde and ISO 16000-6 for VOCs.

## 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 °C ±2 °C, humidity of 50 % RH ±10 % RH. A solar radiator system is installed for heating the test vehicle cabin with a fixed irradiation. The resulting temperature inside the cabin depends on the insulation and the window glass material (the minimum requirements are laid down in 6.1) (see also Figure 1).

### 4.2 Heating radiator

Infrared radiator, halogen radiator or other radiators (simulating sun light) (wave length <300 nm shall be filtered out). The heating radiators used shall be powered to create a radiation density at the reference measurement point in the middle of the roof surface of the test vehicle of 350 W/m<sup>2</sup> to 450 W/m<sup>2</sup> (400 W/m<sup>2</sup> ±50 W/m<sup>2</sup>).

The heating area shall cover at least the area of the test vehicle cabin and an additional 0,5 m more to each side of the lower part of the glazing (footprint) (see Figure 1). The heating radiators are positioned at

the roof with a shining angle of 90 ° to the heating area. There are no heating radiators shining from the side. The heating area shall be calibrated in squares of 25 cm x 25 cm with a radiation density of 400 W/m<sup>2</sup> ±50 W/m<sup>2</sup>. The required radiation density shall be available directly after the lamps are switched-on (within a few min).

The irradiation shall be measured in accordance with ISO 9060.

NOTE Take care not to have a too short 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 measurements in parallel in the test vehicle (to check the repeatability) (see ISO 16000-3 for carbonyls 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 of 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 2,4-DNPH cartridge for carbonyl sampling respectively, the gas meters and the pumps (see 4.5).

All sampling trains shall be leak checked and shall have a vacuum decay rate of max. 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 vacuum decay rate of max. 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 of the test vehicle, via the manifold outside of the test vehicle to the VOC sorbent tubes or 2,4-DNPH cartridges respectively (see Figure 1).

- a) To be constructed
  - 1) as short as possible (maximum 5 m) with an internal diameter of 4 mm or more;
  - 2) of inert, non-emitting and non-absorbing/non-adsorbing material (e. g. stainless steel or polytetrafluoroethylene (PTFE) or glass/quartz (deactivated));
  - 3) be proven that there are no contaminations or sink effects in the sampling line;
  - 4) with heating device, if necessary, to prevent condensation/deposition on the inner walls (best practise: temperature controlled to about 20 °C above air temperature inside the test vehicle).
- b) 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 near of the test vehicle (see 6.1.b) and the manifold and to the VOC sorbent tubes or 2,4-DNPH cartridges respectively) is identical to that described above but no heating is necessary. This second sampling line is needed for monitoring 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 carbonyls/formaldehyde shall be in accordance with ISO 16000-6 (VOCs) or ISO 16000-3 (carbonyls) 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 analyzed separately (see ISO 16017-1).

#### 4.5 Test vehicle

A new vehicle to be tested (not be operated more than 50 km and with an age of  $28 \text{ d} \pm 5 \text{ d}$  after the completion) shall have been manufactured by the normal production process. The test data will be dependent on the trim level and exterior colour of the selected test vehicle. The colour of the test vehicles for the determination of the official VOC/carbonyl emissions is black. If there is no black test vehicle available the darkest colour shall be taken.

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 over night with open doors/windows before it is transferred into the whole vehicle test chamber. This conditioning shall be undertaken if used vehicles are tested. 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 described in this part of ISO 12219 can also be used for used vehicles. In this case the measurement results may not be identical compared to those of a new test vehicle due to different usages.

### 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 carbonyls is performed for the ambient mode at 23 °C. Subsequently in the parking mode only formaldehyde is determined under elevated temperature conditions (parking mode) (see Figure 3). The sunshine is simulated with heating radiators by a fixed irradiation providing a mean sun irradiation for 4 h and then a third sample is taken (driving mode).

The humidity and temperature of the air inside the whole vehicle test chamber are measured. The VOC and carbonyl vapour samples are taken in the driver breathing zone and collected on VOC sorbent tubes and DNPH cartridges. Later the samples are to be analysed in the laboratory according to ISO 16000-6 or ISO 16000-3 respectively.

Furthermore VOC and carbonyl vapour samples are taken in the whole vehicle test chamber to determine the background concentrations. Altogether a total of 8 VOC and 12 carbonyl samples are required (2 duplicate room temperature samplings (ambient mode) and 2 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 2 formaldehyde measurements under the elevated temperature conditions (parking mode).

The temperature caused by the heating radiators inside the test vehicle cabin depends upon the model of the test vehicle and is influenced by the insulation, the window material etc.

The analytical part of the overall measurement procedure is based on 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 (2,4-DNPH) cartridges for the determination of carbonyls (according to ISO 16000-3). The sampling of VOCs is referenced to Tenax TA<sup>®</sup> sorbent tubes, however other equivalent sorbents may be used having the same results (see ISO 16000-6).

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

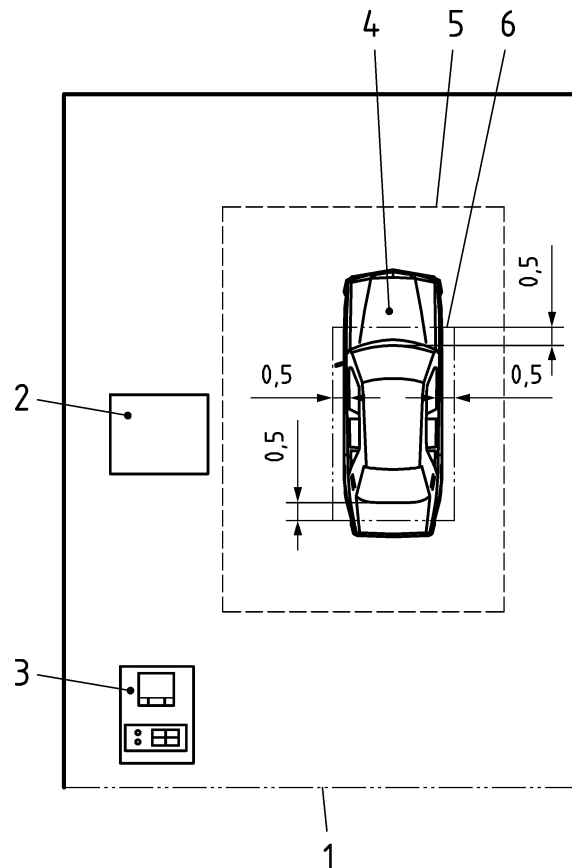
### 6.1 Requirements for the whole vehicle test chamber

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  $23\text{ °C} \pm 2\text{ °C}$ . 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 and at the height of the lower window frame of the front door.

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

- c) Temperature profile (see Figure 3).
- d) Relative humidity (RH) during the ambient mode in the whole vehicle test chamber:  $50\% \text{ RH} \pm 10\% \text{ RH}$ .
- 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  $20\text{ }\mu\text{g}/\text{m}^3$  for each single component and  $200\text{ }\mu\text{g}/\text{m}^3$  for TVOC 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) 2 duplicate VOC and 2 duplicate carbonyl background samples (1 during ambient mode and 1 during driving mode) as well as 1 duplicate formaldehyde background sample (parking mode) are required.  
The VOC sorbent tubes and the 2,4-DNPH cartridges for the VOC and carbonyl 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 2/h.
- h) The heating radiators are fixed above the test vehicle overlapping the footprint of the cabin of the test vehicle by 0,5 m to each side with an irradiation density on the roof surface of  $400\text{ W}/\text{m}^2 \pm 50\text{ W}/\text{m}^2$ .
- i) Optional trolley/table to carry sampling devices (Figure 1, Item 2).
- j) Various measuring instruments and data recording for continuous recording of signals measured (e. g. for temperature measurements and humidity measurements (Figure 1, Item 3)).
- k) Door for the entry and exit of the test vehicle (Figure 1, Item 1).
- l) A hydrocarbon air warning system should be installed (option) to avoid explosive workplace atmospheres; the workplace regulations shall be followed.
- m) A pipe is fixed at the exhaust pipe liner of the test vehicle to remove the waste gas outdoors.



### Key

- |   |                                     |   |               |
|---|-------------------------------------|---|---------------|
| 1 | door test chamber                   | 4 | test vehicle  |
| 2 | sampling device                     | 5 | test area     |
| 3 | controlling and data logging device | 6 | radiator area |

**Figure 1 — Schematic arrangement of whole vehicle test chamber components and the test vehicle**

Care shall be taken to ensure that 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

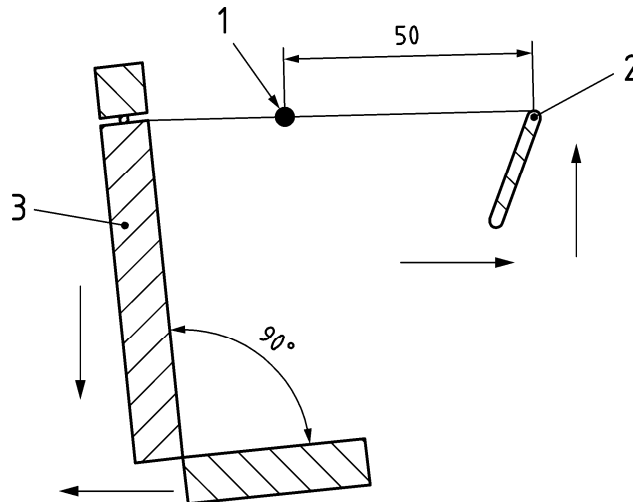
- A new vehicle to be tested shall have been manufactured by the normal production process. The test data depends on the trim level and exterior colour of the selected test car. A detailed specification of the trim level of the test vehicle shall be included in the test report. Any deviation from that specified for the ideal situation shall be noted and the effect of any deviation from the test results shall be explained and reported.
- The test for a new test vehicle shall be carried out within  $28 d \pm 5 d$  after the 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 4.5. All transport foils or transit lacquers shall be removed carefully.
- The sensors and cables for the temperature measurements (optional features) are installed according to Annex B.
- The sampling line (with the probe at one end) for the VOC/carbonyl measurements is installed according to Figures 1 and 2. The sampling line is connected with a manifold situated outside of the

test vehicle. The manifold is connected to four sampling trains which are used for the following consecutive measurements to be performed:

- for monitoring the test vehicle cabin in the ambient mode at  $23\text{ °C} \pm 2\text{ °C}$  [(two VOC measurements (duplicate) and two carbonyl measurements (duplicate))],
- for monitoring the test vehicle cabin in the parking mode at elevated temperatures (two formaldehyde measurements (duplicate); only two sampling trains are needed),
- for monitoring the test vehicle cabin in the driving mode (two VOC measurements (duplicate) and two carbonyl measurements (duplicate)).

NOTE The sampling line should be flushed with acetone and dried before each new sampling series with the next test vehicle to avoid contaminations in the sampling line and to avoid memory effects.

- e) The sampling probe of the sampling trains shall be positioned in the breathing zone of the driver (50 cm from top of steering wheel in line with the bottom of the headrest). For this the most moved back position and most bass of the seat and steering wheel moved back with the max and the highest position is chosen (see Figure 2).



**Key**

- 1 sampling point
- 2 steering wheel
- 3 seat with head rest

**Figure 2 — Schematic arrangement of the sampling position in the test vehicle**

- f) Pipe the vehicle exhaust emissions outdoors.
- g) Set the air conditioner during the driving mode (as defined in 7.3.6.2) in which sampling of VOCs and carbonyls is undertaken in the cabin of a test vehicle under standardised conditions starting at elevated temperatures, simulating a vehicle driven after being parked in the sun, engine on and AC (auto) or if no automatic climate system is available ventilation in highest position, recirculation (air) off, radiators on according to Table 1.

Set the air-conditioner of the test vehicle in accordance with Table 1.

Table 1 — Setting of air conditioner

	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	—
Air flow selector	— Automatic — All registers to be upright and fully open	face mode ventilation in highest position, with fresh air ventilation All registers to be upright and fully open	ventilation in highest position, with fresh air ventilation All registers to be upright and fully open
Temperature	23 °C	Lowest (or medium to avoid an automatic air recirculation mode)	Lowest

NOTE These different air conditions are not necessarily equivalent but represent a customer reaction and the specifications of the vehicle.

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

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

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

### 6.4 Blank measurements

#### 6.4.1 Field blanks

The sorbent tubes used as field blanks (for VOC and carbonyls) shall be from the same batch and treated in the same way as that 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.

#### 6.4.2 Analytical blanks

The requirements for analytical and GC/MS blanks are described in ISO 16000-3 and ISO 16000-6.

## 7 Standard test procedure

### 7.1 General

The standard test procedure is divided into three parts:

- a) conditioning of the whole vehicle test chamber,
- b) conditioning of the test vehicle,
- c) performing sampling and analytical measurement.

### 7.2 Pre-arrangements and pre-conditioning of the whole vehicle test chamber and the vehicle and performing the field blanks

#### 7.2.1 Pre-arrangements

Connect the test apparatus with the test vehicle. The cables and sampling lines are attached to the door frame so that when doors are closed there is an (nearly) airtight sealing. Furthermore the sampling line for VOC and carbonyl sampling shall be installed in the test vehicle: The probe is positioned as described in 6.2, Item e).

- Connect the sampling line with the manifold and the manifold with the sampling trains for VOC and carbonyl measurements outside of 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 Pre-conditioning 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  $50\% \text{ RH} \pm 10\% \text{ RH}$  during the ambient mode. The whole vehicle test chamber should be under good ventilation, and the air exchange rate should be 2/h 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 6.4 background concentrations). The heating of the interior of the cabin and the surfaces of the test vehicle is performed by heating radiators from outside the test vehicle.

#### 7.2.3 Pre-conditioning 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 condition (see Figure 3). The pre-conditioning is started by opening of the door for 1 h. After this the door is closed for a minimum of 8 h (see Figure 3).



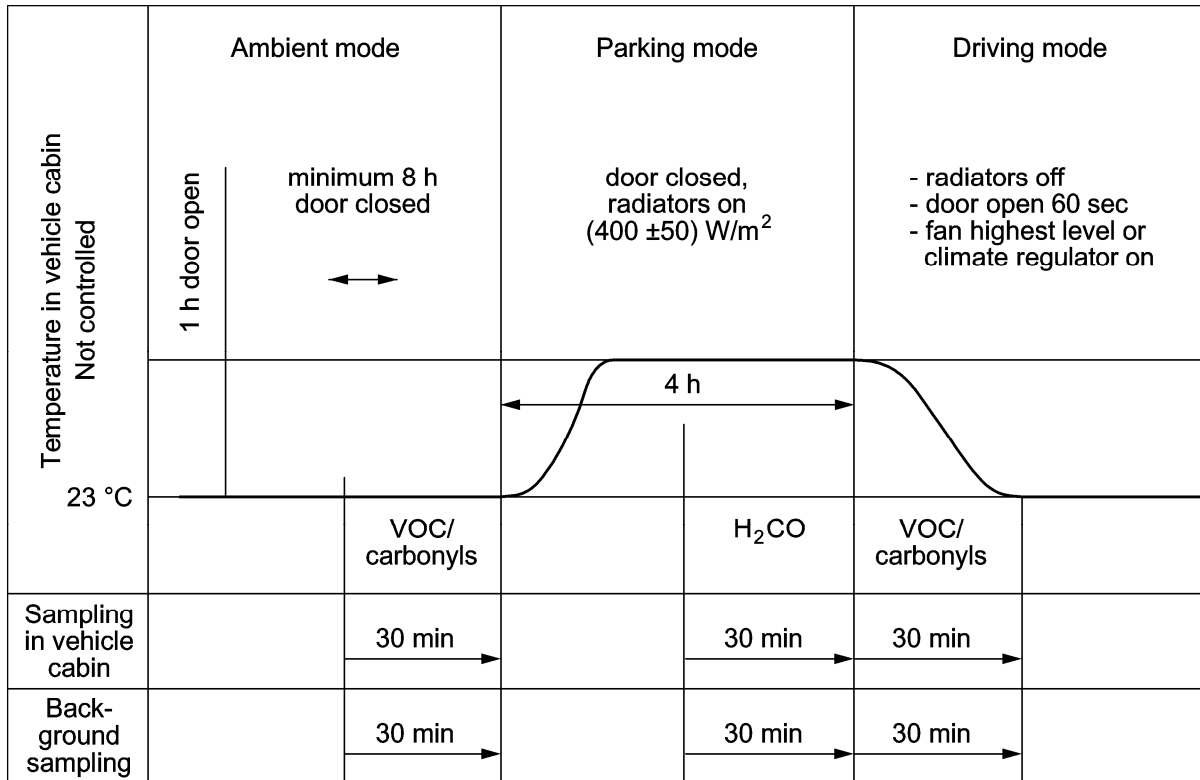


Figure 3 — Schematic temperatures and test schedule

#### 7.2.4 Field blanks

Prepare the field blanks before the measurements are started (see 6.4.1). This is handled in that way that one Tenax TA<sup>®</sup> sorbent tube for VOCs and one 2,4-DNPH cartridge for carbonyls are installed in the sampling trains for measuring the background concentration of the whole vehicle test chamber as well as one Tenax TA<sup>®</sup> sorbent tube and one 2,4-DNPH cartridge are installed in the sampling trains for measuring the background concentration of the test vehicle. The field blank samplers shall be handled in the same way as those used for VOC or carbonyl measurements but without drawing air through the sampling trains. As soon as the samplers have been connected into the sample train, they shall be removed, sealed and retained for analysis with the real samples.

Perform at least one field blank for each measurement series. Analytical GC/MS or HPLC blanks shall be performed according to 6.4

### 7.3 Detailed description of the test procedure

#### 7.3.1 Time: 0 (see schema in Figure 3)

After the conditions of the whole test chamber are set at 23 °C ±2 °C and 50 % RH ±10 % RH and the air exchange rate in the test chamber are adjusted to a recommended value of at least 2/h (described in 7.2.2) the test procedure is started. Start the conditioning of the test vehicle by opening of all doors for 1 h. Install the sampling train including the two VOC sorbent tubes and the two 2,4-DNPH cartridges, and leak check the sampling train (see 4.3.1). An overview of the number of samples to be taken are given in Annex E

**7.3.2 Time: 1:00 h**

Continue with conditioning of the whole vehicle test chamber and close all doors of the test vehicle for min. 8 h or more (e.g. overnight) at 23 °C ±2 °C and 50 % RH ±10 % RH and keep the air exchange rate in the whole vehicle test chamber of at least 2/h (recommended value). There is no dynamic ventilation of the test vehicle.

**7.3.3 Time: 8:30 h**

There is no dynamic ventilation of the test vehicle. Before the sampling starts purge the dead volume of the sampling line. Switch on the pumps of the four sampling trains (two for VOC and two for carbonyls each in parallel). Perform the sampling of gaseous organic compounds in the test vehicle cabin in the ambient mode at room temperature (23 °C ±2 °C) for 30 min. Adjust the flow rate to maximum 0,1 l/min for VOC and 1 l/min for carbonyl measurements. The measurement procedures described in ISO 16000-6 (VOC) and ISO 16000-3 (carbonyls) shall be followed.

At the same time switch on the 4 sampling trains in the whole vehicle test chamber to determine the VOC and carbonyl background concentrations (2 sampling trains for VOCs and 2 for carbonyls each). The probe is positioned 1 m in front of the cabin air intake. The relative humidity and the temperature are measured in the same position.

**7.3.4 Time: 9:00 h**

Switch off the pumps for the VOC and carbonyl measurements, read and register the measurement volumes and take the VOC sorbent tubes and 2,4-DNPH cartridges – which are placed outside the vehicle cabin – out of the sampling train, seal the sorbent tubes/cartridges and analyse according to ISO 16000-6 and ISO 16000-3.

Furthermore start the parking mode with the heating-up procedure (see Figure 3).

The following tasks shall be performed:

Start heating up with heating radiators (see 4.2). The irradiation is adjusted to 400 W/m<sup>2</sup> ±50 W/m<sup>2</sup> and hold the irradiation for 4,5 h.

Adjust an air exchange rate of 2/h or higher (recommended value) in the whole vehicle test chamber.

**7.3.5 Time: 12:30 h**

Install the two 2,4-DNPH cartridges in the two sampling trains for the test vehicle measurement and two for the whole vehicle test chamber. Before the sampling begins, leak check the sampling train (see 4.3.1) and purge the dead volume. Switch 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 measurements. The measurement procedure described in ISO 16000-3 (carbonyls) shall be followed.

**7.3.6 Time: 13:00 h**

**7.3.6.1 Parking mode**

Switch off the pumps for the formaldehyde measurements and take the 2,4-DNPH cartridges out of the sampling train to be analysed according to ISO 16000-3. Read and register the measurement volumes.

**7.3.6.2 Driving mode**

Before the sampling in the driving mode begins, install the two VOC sorbent tubes and the two 2,4-DNPH cartridges, and purge the dead volume.

Open the driver's door, start the engine, and turn on the air conditioning in less than 60 sec (23 °C in case of automatic conditioning or lowest operation for semi-automatic and manual conditioning systems; for test vehicles without automatic climate systems the fan is in highest performance mode with fresh air ventilation) (see Table 1).

At the same time switch on the pumps of the four sampling trains (two for VOC and two for carbonyls each in parallel). The sampling of gaseous organic compounds in the test vehicle cabin is performed at elevated temperature for 30 min. The flow rate is adjusted to maximum 0,1 l/min for VOC and 1 l/min for carbonyl measurements. The measurement procedures described in ISO 16000-6 (VOC) and ISO 16000-3 (carbonyls) shall be followed.

At the same time switch on the 4 sampling trains in the whole vehicle test chamber to determine the VOC and carbonyl background concentrations (2 sampling trains for VOCs and 2 for carbonyls each).

### **7.3.7 Time: 13:30 h**

Stop the pumps of the sampling trains and switched off the engine. The sampling volumes are read and registered. The VOC sorbent tubes and 2,4-DNPH cartridges are taken out of the sampling train for the analysis as described in ISO 16000-6 and ISO 16000-3.

Stop the continuous measurements for temperature and humidity.

### **End of 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 described in the two International Standards mentioned above. There is an informative test report (see Annex B) which should be agreed on between client and laboratory.

## **9 Performance characteristics**

The detection limits and standard deviations for VOCs given in ISO 16000-6 and for carbonyls 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/quality control (QA/QC)**

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

- a) Field blanks are prepared according to 6.4.
- b) The field blank level is acceptable if artefact peaks are no greater than 10 % of the typical areas of the analytes of interest.
- c) Desorption efficiency of VOCs/carbonyls should be checked according to ISO 16000-3 and ISO 16000-6.
- d) The collection efficiency can be assessed by using back-up tubes or taking samples of different sampling volumes less than the safe sampling volume.

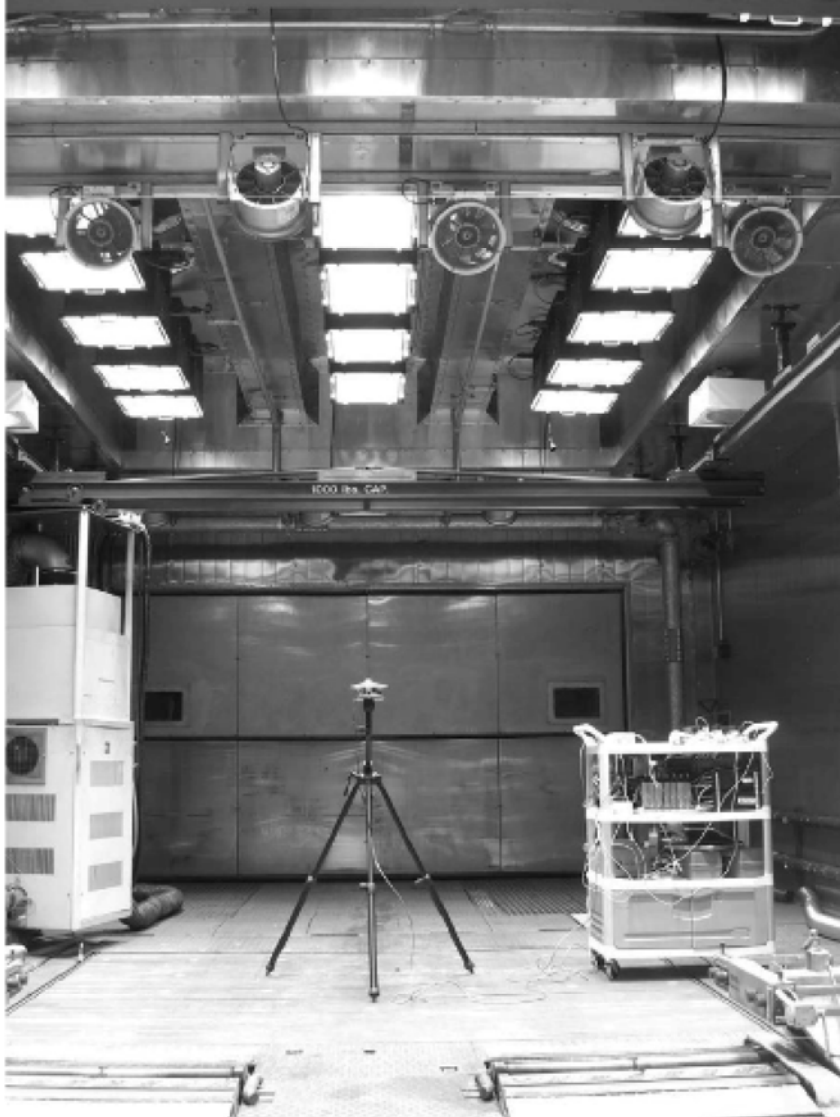
- e) Repeatability of the measuring method shall be determined e. g. using collection and analysis of duplicate samples. A relative standard deviation  $\leq 15\%$  (ISO 16000-3 and ISO 16000-6) from the duplicate measurements should be reached.
- f) The recovery of C<sub>6</sub> to C<sub>16</sub> hydrocarbons shall be 95 % (ISO 16000 Part 6).
- g) Documentation illustrating traceable calibrations for temperature, humidity, and flow measurements.

## **11 Safety measures**

It is the responsibility of the user of this part of ISO 12219 to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. National regulations for precautions shall be followed.

**Annex A**  
(informative)

**Whole vehicle test chamber**



**Figure A.1 — Example of the illustration of a whole vehicle test chamber<sup>2)</sup>**

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<sup>2)</sup> Printed with the kind permission of the Ford Motor Company (USA)

## Annex B (informative)

### Temperature measuring points for the parking mode

The temperature can be measured at the sampling point (inside of the test vehicle).

Other temperature measurements at other points may be of possible interest, depending on the particular problem e. g. instrument panel, top of the test vehicle, rear parcel shelf (see Figure B.1) (measured with e. g. standard PT 100 air thermometers).

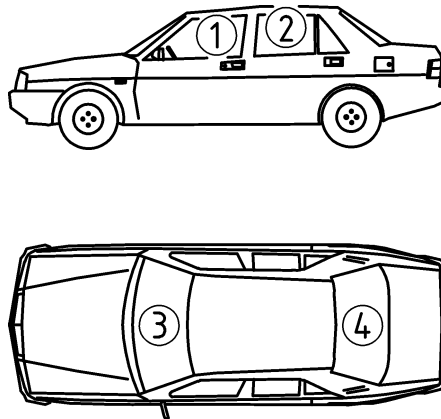


Figure B.1 — Example for temperature measurement points

#### Key

- 1 temperature of the test vehicle cabin air (near sampling probe)
- 2 surface temperature, top of the test vehicle (inside)
- 3 surface temperature, instrument panel
- 4 surface temperature, rear shelf (alternative if there is no rear shelf: rear luggage cover)

**Annex C**  
(informative)

**Test report**

NOTE ISO grants the user of this part of ISO 12219 the right to reproduce or otherwise use the sampling protocol on this page solely for the purpose of implementing this part of ISO 16000.

**C.1 General**

Client:

Experts:

Telephone:

Fax:

E-Mail:

Date of report:

Pages:

Order number:

**Name of Laboratory**

Address

**C.2 Sampling records and continually recorded measured data**

**C.2.1 Protocol for test vehicle data**

**Table C.1 — Test vehicle data**

Sample cover sheet number:

Vehicle type:	
VIN:	
Number of km/miles upon delivery:	
Vehicle colour	
Interior specification :	
<b>Glazing:</b>	
Shade and type of the window glass:	
Tank capacity:	
Sliding sun-roof/glass roof:	
Airbag in the steering wheel on the left and on the right:	
Central locking system:	
ABS und ASC:	
Fire extinguisher:	
<b>Volume of interior:</b>	
Passenger compartment: in m <sup>3</sup>	
Trunk: in m <sup>3</sup>	
Total volume: in m <sup>3</sup>	
Method of determination:	
The adjustment of the control elements for the ventilation system is done:	
History	
Preservation of outer skin:	



Table C.1 (continued)

De-preservation:	
<b>Conditioning phase</b>	
Location outdoors:	
Location under sales room conditions:	
Have doors and windows been closed tight all the time?	
Test vehicle delivered on (date):	
Test vehicle pushed or driven into test garage by:	

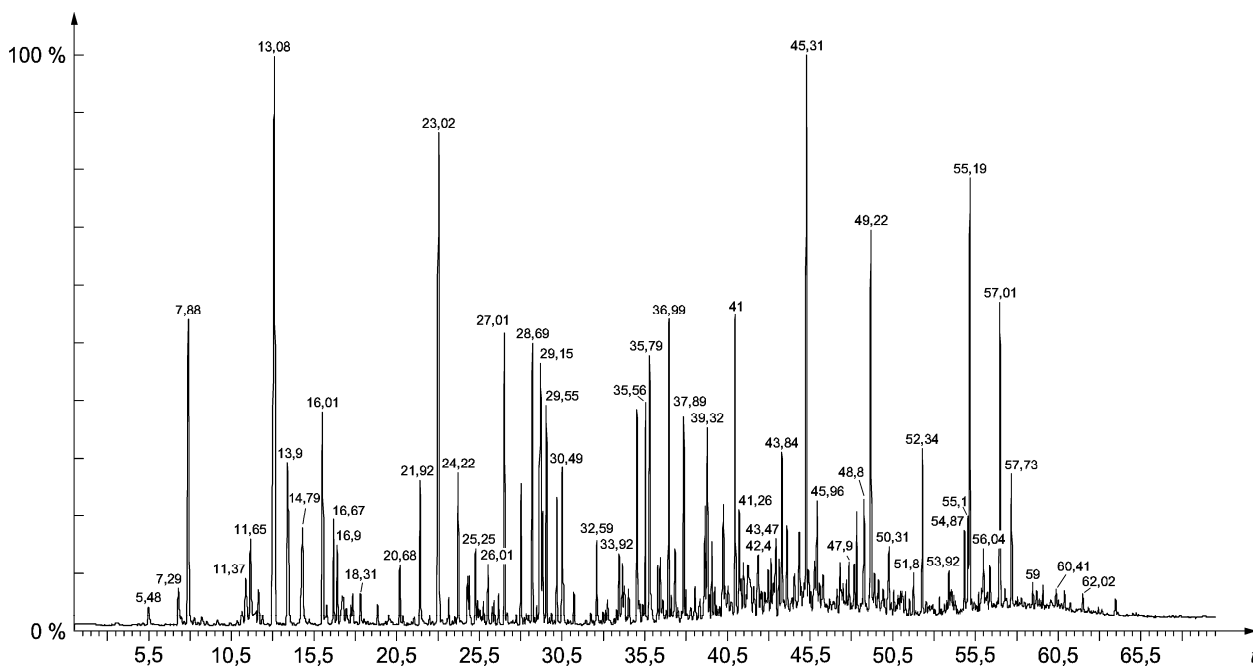
## C.2.2 Example of sampling records of volatile carbonyles and ketones (ambient mode)

Table C.2 — Concentrations of volatile aldehydes and ketones

Sample: Sampling condition: Test vehicle cabin air 23 °C (ambient mode)		
Compound	CAS number	Concentration $\mu\text{g}/\text{m}^3$
formaldehyde		
acetaldehyde		
acetone		
acrolein		
2-furaldehyde		
propionaldehyde		
crotonaldehyde		
2-butanone		
n-butyraldehyde		
benzaldehyde		
cyclohexanone		
valeraldehyde		
4-methyl-2-pentanone		
hexaldehyde		
heptaldehyde		

NOTE Table C.2 according to 3.5 and ISO 16000-3.

## C.2.3 Identification of volatile hydrocarbons (VOC (volatile organic compounds))



RT	RI	compound	CAS number	$\mu\text{g}/\text{m}^3$
N	.....	X	.....	.....
23,0	767	Toluene	108-88-3	162
28,7	863	Ethylbenzene	100-41-4	49
29,2	871	m, p-Xylene	108-38-3 / 106-42-3	67
30,2	891	Styrene	100-42-5	24
30,5	894	o-Xylene	95-47-6	29
33,2	1021	1,4-Dichlorobenzene	104-46-7	<5
43,8	1400	Tetradecane	629-59-4	15
54,5	1983	Di-n-butyl phthalate	84-74-2	<5
68,4	2565	Di(2-ethylhexyl) phthalate	117-81-7	<5

N is retention time of compound X

Figure C.1 — Chromatogram of vapour phase organic substances with some examples listed – Test vehicle cabin air measurement at 23°C room temperature (ambient mode)

## C.3 Report on results

The results of the quantitative measurements are concentrations of substances expressed in mass per volume unit (e.g.  $\mu\text{g}/\text{m}^3$ , standardized for gas in the following conditions: temperature of 20 °C (or according to the national regulations), pressure of 1013 hPa, dry). As a rule these measured values relate only to the time span of the sampling, and the circumstances of the conditioning of the vehicle's interior present at that time. A proposal for a presentation of the results is given in Table C.3.

**Table C.3 — Results of TVOC value and selected compounds in the different modes**

Sampling condition	1. Sample	2. Sample	3. Sample	4. Sample	5. Sample	6. Sample
	Test vehicle: ambient mode  23 °C	Whole vehicle test chamber: ambient mode  23 °C	Test vehicle: parking mode  sampling point X °C (optional)	Whole vehicle test chamber: parking mode  sampling point Y °C (optional)	Test vehicle: driving mode  sampling point X °C (optional)	Whole vehicle test chamber: driving mode  sampling point Y °C (optional)
	<b>Concentration</b> µg/m <sup>3</sup>					
Sample	xxx	xxx	xxx	xxx		
Compound 1						
Compound 2						
TVOC value						

## Annex D (informative)

### Very volatile organic compounds, volatile organic compounds, and semi-volatile organic compounds

Volatile organic compounds may be classified as volatile, very volatile or semi-volatile. World Health Organisation (WHO) has classified VVOCs, VOCs and SVOCs based on ranges of boiling points <sup>[5]</sup>:

**Table D.1 — Classification of VVOCs, VOCs, and SVOCs**

Description	Abbreviation	Boiling point range	
		from °C	to °C
Very volatile organic compounds	VVOC	<0	50 – 100
Volatile organic compounds	VOC	50 – 100	240 – 260
Semi-volatile organic compounds	SVOC	240 – 260	380 – 400

NOTE Boiling points of some compounds are difficult or impossible to determine because they decompose before they boil at atmospheric pressure. Vapour pressure is another criterion for classification of compound volatility that may be used for classification of organic chemicals<sup>[5]</sup>. VOCs generally have saturation vapour pressures at 25 °C greater than 10<sup>-2</sup> kPa. SVOCs have vapour pressures between 10<sup>-2</sup> to 10<sup>-8</sup> kPa, respectively. VVOCs typically have vapour pressures greater than 15 kPa.

## Annex E (normative)

### Overview about the number of samples to be taken

According to the description in this part of ISO 12219, a minimum of 24 samples shall be taken.

Samples are always taken in duplicate. The field blank should be taken in duplicate (one is placed temporarily in the background sample train and one in the vehicle sample train) before the ambient mode samples are taken. There are three sampling modes: ambient, parking and driving.

There are three sampling locations, field blank, background and vehicle.

**Table E.1 — Number of samples to be taken**

Sampling mode per ISO 12219-1	Ambient mode	Ambient mode	Parking mode	Driving mode	Driving mode
<b>Sample media</b>	<b>Tenax TA<sup>®</sup></b>	<b>DNPH</b>	<b>DNPH</b>	<b>Tenax TA<sup>®</sup></b>	<b>DNPH</b>
Measured compounds	VOCs	Carbonyls	Carbonyls	VOCs	Carbonyls
<b>Sampling location:</b>					
• Whole vehicle test chamber and vehicle for field blank	2 <sup>a</sup>	2 <sup>a</sup>			
• Whole vehicle test chamber for background	2	2	2	2	2
• Vehicle	2	2	2	2	2
<b>Totals</b>	<b>6</b>	<b>6</b>	<b>4</b>	<b>4</b>	<b>4</b>

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

NOTE Extra samples for specific compounds may be taken as appropriate.

The requirements for analytical and GC/MS blanks are described in ISO 16000-3 and ISO 16000-6.

## Bibliography

- [1] POLSTER, M., HARRIS, A., QUINN, J., *Test Results for Resolution of ISO CD 12219-1*, publication in preparation<sup>3)</sup>
- [2] KIM, M.-G., *Car cabin interior air quality*, publication in preparation<sup>3)</sup>
- [3] JAMA Report No.98 & JASO Z125-09 *Road vehicles – Interior – Measurement methods of diffused volatile organic compounds (VOC)*
- [4] BMBF Project Fkz: 07INR27A8 / 07INR27B0: *Entwicklung und Erprobung von Standard-Messverfahren für die Bewertung des Fahrzeugeigenen Beitrages zu organischen Luftverunreinigungen in Fahrgasträumen von Personenkraftwagen*
- [5] World Health Organization (WHO) *Indoor air quality : organic pollutants*. EURO Reports and Studies No. 111. Copenhagen
- [6] LEWIS, R. G., GORDON, S. M. Sampling of organic chemicals in air. In: KEITH, L. H., editor. *Principles of environmental sampling*, 2nd edition, pp, 401-470. Washington DC: American Chemical Society, 1996

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<sup>3)</sup> In case that this document is not published officially after closure of the FDIS ballot on ISO 12219-1, this reference will be removed in the final version of this International Standard.