
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: Encence d'essai pour un véhicule complet — Spécification et
méthode de détermination des composés organiques volatils dans les
habitacles d'automobiles*



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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*.

This second edition cancels and replaces the first edition (ISO 12219-1:2012), which has been technically revised.

The main changes compared to the previous edition are as follows:

- Adaption of temperatures, number of samples to be taken and the pre-conditioning and measuring times to be consistent with the UN mutual resolution concerning the common definitions of vehicle categories, masses and dimensions.

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 everyday 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 obtain 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. Measurements are carried out according to ISO 16000-6 (VOCs) and ISO 16000-3 (carbonyl compounds).

There are several national test methods available for measuring in-vehicle air quality, e.g. References [2] [4]. However, this document requires a fixed heating radiation system whereas the methods of References [2][3] define a fixed temperature programme.

Before setting a fixed radiation density for heating the test vehicle, several validation measurements were performed (Reference [1]).

ISO 16000-3, ISO 16000-5,^[6] ISO 16000-6, ISO 16000-9,^[7] ISO 16000-10,^[8] ISO 16000-11,^[9] ISO 16000-24,^[10] ISO 16000-25,^[11] as well as ISO 16017-1 and ISO 16017-2^[12] also focus on volatile organic compound (VOC) measurements.

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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

1 Scope

This document specifies the whole vehicle test chamber, the vapour sampling assembly and the operating conditions for the determination of volatile organic compounds (VOCs), 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 - 25 °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, 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-micrograms per cubic metre up to several milligrams per cubic metre. Using the principles specified 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.

The method is valid for passenger cars, as defined in ECE-TRANS-WP.29/1045.

This document gives guidelines for:

- 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).

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

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

ECE-TRANS-WP.29/1045, *Special resolution No 1, Concerning the common definitions of vehicle categories, masses and dimensions (S.R. 1)*

3 Terms and definitions

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

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

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

3.1 background concentration

substance concentrations in the whole vehicle test chamber when the test vehicle is inside

3.2 test vehicle

new category 1-1 vehicle (3.12), not older than 28 d ± 5 d after the production date (3.13) to be tested.

Note 1 to entry: Excludes busses used for public transport and trucks only used for the transport of goods

3.3 total volatile organic compounds TVOCs

sum of volatile organic compounds sampled on Tenax TA^{®1} 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(=) determined according to specified procedure

Note 1 to entry: For the purposes of this document. The procedure is that specified in ISO 16000-3.

3.5 ambient mode

mode in which sampling of substances in the interior air of a test vehicle under standardized ambient temperature conditions is performed, defined by 23 °C - 25 °C, as close as possible to 25 °C

3.6 parking mode

mode in which sampling of substances in the interior air of a test vehicle under elevated temperatures resulting from defined external heat radiation is performed

3.7**driving mode**

mode in which sampling of substances in the interior air of a test vehicle, under standardized conditions starting at elevated temperatures and with the engine on using air conditioning

Note 1 to entry: Driving is simulated with an idle test procedure of a vehicle driven after being parked in the sun

3.8**breathing zone**

semi-sphere area with 50 cm radius in front of the drivers face

3.9**sampling train**

apparatus to collect the air sample inside the test vehicle cabin from the breathing zone and to collect the air sample from in the whole vehicle test chamber, trapping the test substances in sorbent tubes under standardized conditions

3.10**volatile organic compound (VOC)**

volatile organic compound, ranging in volatility from $n\text{-C}_6$ to $n\text{-C}_{16}$

EXAMPLE Benzene, toluene, xylene, ethylbenzene and styrene.

3.11**production date**

date a new vehicle leaves the production line

3.12**category 1 vehicle**

power-driven vehicle with four or more wheels designed and constructed primarily for the carriage of (a) person(s)

3.13**category 1-1 vehicle**

category 1 vehicle (3.12) comprising not more than eight seating positions in addition to the driver's seating position

Note 1 to entry: A category 1-1 vehicle cannot have standing passengers.

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 - 25 °C and for a humidity of 50 % RH $\pm$ 10 % RH. A solar radiator system is installed to heat 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 specified in 6.1) (see also Figure 1).

4.2 Heating radiator

Infrared radiator, halogen radiator or other radiators (simulating sunlight) (wavelengths < 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/m² to 450 W/m² (400 W/m² $\pm$ 50 W/m²).

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). Position the heating radiators on the roof with a shining angle of 90° to the heating area. There shall be no heating radiators shining from the

side. The heating area shall be calibrated in squares of 25 cm × 25 cm with a radiation density of 400 W/m² ± 50 W/m². The required radiation density shall be available directly after the lamps are switched on (within a few minutes).

The irradiation shall be measured in accordance with ISO 9060.

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 (see 4.5).

Prior to sampling, the sampling system shall be checked under sampling load conditions for air tightness. Do not skip this critical step because leaks have a high impact on the test results due to the large backpressure of the tubes and cartridges. To check for leaks, plug the inlet to the sample system. Then use a vacuum pump to bring the sampling system to 71 kPa vacuum, then close a valve between the sample system and the pump. After 30 seconds, the sample system vacuum shall be greater than 68 kPa to proceed. Do not change the sample trains in any way after the leak check procedure is performed. Other equivalent leak checks can be performed.

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 to be:

- a) as short as possible (maximum 5 m) with an internal diameter of 4 mm or more;
- b) of inert, non-emitting and non-absorbing/non-adsorbing material [e.g. stainless steel or polytetrafluoroethylene (PTFE) or glass/quartz (deactivated)];
- c) proven that there are no contaminations or sink effects in the sampling line;
- d) with heating device, if necessary, to prevent condensation/deposition on the inner walls (best practice: temperature controlled to about 20 °C above air temperature inside the test vehicle).

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 a)] 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. This measurement is taken after the 24 h temperature acclimation phase and just prior to opening the vehicle doors for the VOC conditioning phase.

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 to be tested shall have been manufactured by the normal production process. The test data are 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 and carbonyl compound emissions is black. If there is no black test vehicle available, take the darkest 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 at least 24 h before the test.

To establish quality control, it is recommended to measure several vehicles and take multiple air samples of one vehicle for one result. Therefore, it was decided because of cost reasons that measuring one vehicle and taking just one sample of VOC and one sample of aldehydes are sufficient for one result. However, general quality measures shall not be neglected and should be periodically assessed.

5 Principle

A whole vehicle test chamber (see [Annex A](#) for an example) 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 - 25 °C, as close as possible to 25 °C. Subsequently, formaldehyde is determined alone under elevated temperature conditions in the parking mode (see [Table 1](#)). Sunshine is simulated by the use of heating radiators providing a mean fixed irradiation for 4,5 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. Substances to be measured are: formaldehyde, acetaldehyde, benzene, toluene, xylene, ethylbenzene, styrene, and acrolein.

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 the background concentrations. The sampling trains are identical to those of [4.3](#), but the sampling line is shorter and not heated. Altogether a minimum of 24 samples are required (see [Annex D](#)).

The temperature resulting from use of 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 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). The sampling of VOCs is referenced to Tenax TA^{®1}) sorbent tubes; however, other equivalent sorbents may be used if they produce 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

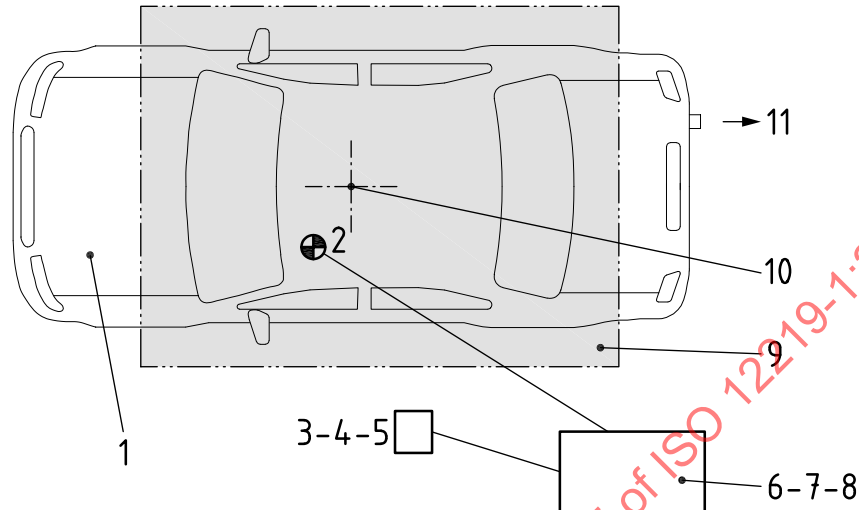
The whole vehicle test chamber with the following requirements is assembled as shown in [Figure 1](#). The following requirements shall be met.

The whole vehicle test chamber shall be large enough to accommodate the complete test vehicle. It should include a heating, cooling, humidity, ventilation, and filter system for the air and solar lights if necessary.

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

- a) The whole vehicle test chamber shall be capable of maintaining a temperature of 23 °C -25 °C. 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.
- b) The temperature profile shall be in accordance with [Table 1](#).
- c) Relative humidity (RH) during the ambient mode in the whole vehicle test chamber shall be 50 % RH $\pm$ 10 % RH.
- d) Relative humidity RH during the parking and driving mode in the whole vehicle test chamber shall be documented.
- e) The maximum background concentration for each analyte shall not exceed 20 $\mu\text{g}/\text{m}^3$ for each single component and 200 $\mu\text{g}/\text{m}^3$ for TVOCs or a maximum of 10 % of the respective measured values (whichever is less). If this is not met, the source of the contamination shall be identified and removed or covered to exclude it from the test.
- f) Two duplicate VOCs and two duplicate carbonyl compound background samples (one during ambient mode and one during driving mode) as well as one duplicate formaldehyde background sample (parking mode) are required.
- g) 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.
- h) The air exchange rate of the whole vehicle test chamber during the driving mode should be a minimum of twice per hour.
- i) 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 W/ $\text{m}^2 \pm 50 \text{ W}/\text{m}^2$.
- j) Optional trolley or table to carry sampling devices.
- k) Various measuring instruments and data recording systems for continuous recording of signals measured (e.g. for temperature and humidity measurements).
- l) Door for the entry and exit of the test vehicle.
- m) A hydrocarbon air warning system should be installed (option) to avoid explosive workplace atmospheres; the workplace regulations shall be followed.

- n) A pipe is fixed at the exhaust pipe liner of the test vehicle to remove the waste gas outdoors.
- o) 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.



Key

- 1 test vehicle
- 2 vehicle sampling point location
- 3 chamber sampling point location, 1 m from vehicle, 1 m from floor
- 4 chamber temperature measurement location
- 5 chamber humidity measurement location
- 6 mass flow sample system
- 7 background sample, 2 tubes and 2 cartridges, one is a backup
- 8 field blank
- 9 solar load area, uniform area extending 0,5 m beyond glass of vehicle
- 10 solar load measurement location, top centre of roof
- 11 exhaust dust

Figure 1 — Schematic representation of a whole vehicle test chamber

6.2 Requirements for the test vehicle

6.2.1 General

A new vehicle to be tested shall have been manufactured by the normal production process. The selection of vehicles should be based on a worst-case interior to minimize testing costs. Vehicles with dark exterior and preferably black or dark interior colour are recommended for elevated temperature modes. 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 $28 \text{ d} \pm 5 \text{ d}$ after completion of assembly. The vehicle shall be driven less than 80 km. 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. It should also be ensured, that no external off-gassing materials will be transported in the same cargo area. All transport foils or transit lacquers shall be removed carefully, at least 24 hours before measurement.

6.2.2 Restricting influencing factors

- a) All windows and doors should remain closed. Heating, ventilation and air conditioning system (HVAC) outlets should remain closed to avoid contamination.
- b) Influence of the driver shall be as low as possible. The vehicle driver and handlers shall avoid the following: smoking, eating, transportation of external items, and no perfume inside or near the test vehicle.
- c) Workers should carefully deal with the vehicle to prevent contamination.
- d) Do not use any cleaning agent to remove any residues. Dust wiping, vacuuming, and cleaning with clear water is possible. Clear water cleaning from outside is possible.
- e) No extra fuelling, only the first fuel at production shall be within the fuelling system.
- f) Storage shall be for 24 h of soak time before measurement nearby the test facility. Control the soak storage temperature as close as possible to room temperature between 20 and 30 °C.
- g) Pipe the vehicle exhaust emissions outdoors and away from any air inlets to the test chamber.

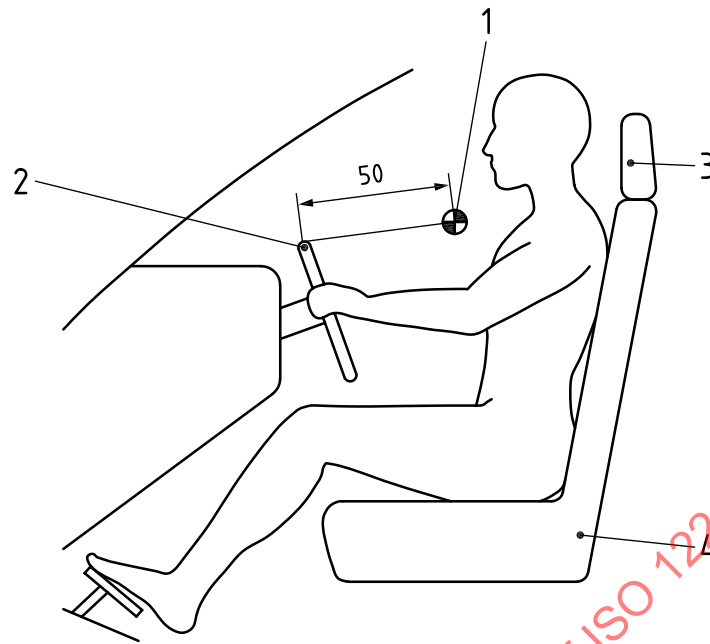
6.2.3 Requirements for sampling train set up

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:

- a) monitoring of the test vehicle cabin in the ambient mode at 23–25 °C [two VOC measurements (duplicate) and two carbonyl compound measurements (duplicate)],
- b) monitoring of the test vehicle cabin in the parking mode at elevated temperatures [two formaldehyde measurements (duplicate); only two sampling trains are needed],
- c) monitoring of the test vehicle cabin in the driving mode [two VOC measurements (duplicate) and two carbonyl compound measurements (duplicate)].

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.

The sampling probe of the sampling trains shall be positioned in the breathing zone of the driver (50 cm from the top of steering wheel in line with the bottom of the headrest). To this end, position the seat as far back as possible and as low as possible and move the steering wheel back to the highest possible position (see [Figure 2](#)).

**Key**

- 1 vehicle sampling point location, 50 cm from top of steering wheel to bottom of headrest
- 2 steering wheel, in up and in most position
- 3 headrest in lowest position
- 4 seat in rearmost and lowest position with seatback at about 90° from seat bottom

Figure 2 — Schematic representation of the sampling position inside the vehicle

6.2.4 Temperature and ventilation

- a) The sensors and cables for the temperature measurements (optional features) are installed according to [Annex B](#).
- b) Set the air conditioner during the driving mode (as defined in [7.3.3.1](#)) in which 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, with engine and air conditioning (auto) on.
- c) Set the air conditioner of the test vehicle in accordance with [Table 1](#)
- d) If no automatic air-conditioning system is available, run the driving mode test 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.

Alternative VOC measurement methods may be used if the method is proven to be equivalent to ISO 16000-3 or ISO 16000-6.

Table 1 — Test schedule

Modes	Preparation mode	Ambient mode				Parking mode		Driving mode
Supplementary phases	Temperature precondition	Sample	VOC precondition	Soak	Sample	Soak	Sample	Sample
Duration	24 h	30 min ^a	30 min to 60 min	16 h ± 1 h	30 min	4 h	30 min	30 min
Start time (hh:mm)	0:00	24:00	24:30	25:00 - 25:30	41:00 - 42:00	41:30	45:30	46:00
Chamber temperature	20 °C to 30 °C	23,0 °C to 25,0 °C, as close as possible to 25,0 °C				As close as possible to 25 °C		
Chamber humidity	50 % RH ± 10 % RH					As close as possible to 50 % RH		
Solar load	OFF					400 W/m ² ± 50 W/m ²		
Vehicle age	28 ± 5 days and less than 80 km							
Vehicle doors	CLOSED		OPEN	CLOSED				OPEN <1 min
Vehicle windows	CLOSED							
Vehicle engine	OFF							ON
Vehicle climate settings auto or manual systems	OFF							Auto or face mode
Air conditioning	OFF							ON
Fan	OFF							Auto or High
Temperature setting	OFF							23 °C or lowest but not MAX AC
Air inlet position	OPEN							Auto
Outlet vents and position	Fully OPEN and Upright							

^a This is a chamber blank sampling.

^a This is a chamber blank sampling.

6.4 Blank measurements

6.4.1 Field blanks

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). Never remove the caps of the field blanks.

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 specified 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 measurements.

7.2 Preparation of the test chamber, vehicle and 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 [6.2.3](#).

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 °C - 25 °C, as close as possible to 25 °C during the ambient mode test. There may be the need for a heating or cooling device. The humidity shall be 50 % RH $\pm$ 10 % 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 [6.4](#) 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 during the driving mode.

7.2.3 Preconditioning of the test vehicle

The essential conditions for the surroundings are as followed.

The temperature during the ambient mode is adjusted to 23 °C - 25 °C, as close as possible to 25 °C via the whole test chamber conditioning system (see [Table 1](#)). The preconditioning is started by opening the door for 30 min to 60 min. After this, the door is closed for 16 h $\pm$ 1 h soak time (see [Table 1](#)).

7.2.4 Field blanks

Prepare the field blanks before the measurements are started (see [6.4.1](#)). Install one Tenax TA^{®1} 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 as well as one Tenax TA^{®1} sorbent tube and one DNPH cartridge in the sampling trains to measure 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 compound 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 ISO 16000-6 and ISO 16000-3.

7.3 Detailed description of the test procedure

7.3.1 Ambient mode

7.3.1.1 Preconditioning

After the conditions of the whole test chamber have been set at 23 °C - 25 °C, as close as possible to 25 °C and 50 % RH $\pm$ 10 % 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 by using two VOC sorbent tubes and two DNPH cartridges. The probe is positioned 1,0 m from the vehicle (see [Figure 1](#)). 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 doors for 30 min to 60 min. Install the sampling train including the two VOC sorbent tubes and the two DNPH cartridges and leak check the sampling train. An overview of the number of samples to be taken is given in [Annex D](#).

7.3.1.2 Time: 24,00 h

Continue by conditioning the whole-vehicle test chamber and close all doors of the test vehicle for at least 16 h $\pm$ 1 h or more (e.g. overnight) at 23 °C to 25 °C, as close as possible to 25 °C and

50 % RH $\pm$ 10 % 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: 41,00 h

Before the sampling starts, purge the dead volume of the sampling line. Turn on the pumps for the sampling trains, two for VOCs and two for carbonyl compounds, each in parallel. Perform the sampling of air samples in the test vehicle cabin at room temperature, 23 °C to 25 °C, as close as possible to 25 °C for 30 min. Adjust the flow rate to maximum 0,2 l/min for VOCs and 1,0 l/min for carbonyl compound measurements. The measurement procedures specified in ISO 16000-6 and ISO 16000-3 shall be followed.

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

7.3.2 Parking mode

7.3.2.1 Time: 41,50 h

Start the 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 400 W/m² $\pm$ 50 W/m² and maintained at that level for 4,5 h. Adjust the air exchange rate to twice per hour or higher (recommended value).

Install the sampling train including the two VOC sorbent tubes and the two DNPH cartridges. An overview of the number of samples to be taken is given in [Annex D](#). Before the sampling begins, check the sampling trains for leaks and purge the dead volume. Turn on the pumps for the sampling trains.

Perform sampling of air samples in the test vehicle cabin at elevated temperatures for 30 min. The flow rate is adjusted to maximum 1,0 l/min for carbonyl compound measurements. The measurement procedures are specified in ISO 16000-3 and ISO 16000-6 and shall be followed.

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

7.3.3 Driving mode

7.3.3.1 Time: 45,30 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 drivers' door, start the engine. 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. Close the drivers' door. Complete these steps of the procedure within 60 s, meaning, that after a maximum of 60 s of engine running the drivers' door shall be closed. The doors and windows of the test vehicle shall remain closed during the entire driving mode. The engine shall be running during the entire mode at the vehicles idling speed with the minimum frequency of idling declared by the manufacturer.

60 s after 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 for 30 min. The flow rate is adjusted to maximum 0,2 l/min for VOCs and 1,0 l/min for carbonyl compound measurements. The measurement procedures specified in ISO 16000-6 (VOCs) and ISO 16000-3 (carbonyl compounds) shall be followed.

7.3.3.2 Time: 46,00 h

Stop the pumps of the sampling trains and switch off the engine and the heating radiators. The sampling volumes are to be 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 Results

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/quality control

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

- a) field blanks are prepared according to [6.4](#);
- b) the field blank level is acceptable if artefact peaks are not greater than 10 % of the typical areas of the analytes of interest;
- c) desorption efficiency of VOCs and carbonyl compounds 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 coefficient of variation ≤ 15 % (ISO 16000-3 and ISO 16000-6) from the duplicate measurements should be reached;
- f) the recovery of C_6 to C_{16} hydrocarbons shall be at least 95 % mass fraction (ISO 16000-6);
- g) documentation to illustrate traceable calibrations for temperature, humidity, and flow measurements.

Annex A (informative)

Whole vehicle test chamber

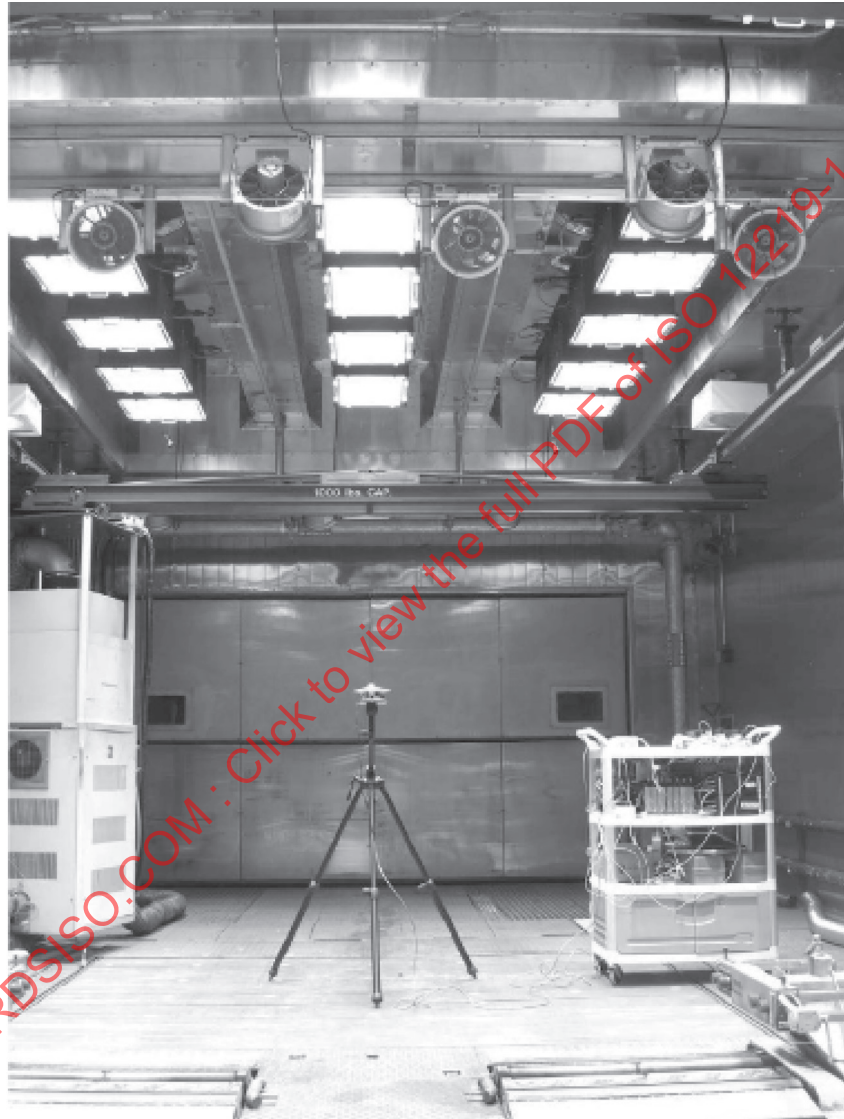


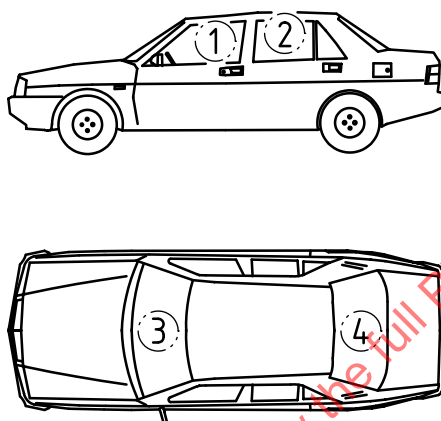
Figure A.1 — Example of the illustration of a whole vehicle test chamber reproduced by permission of the Ford Motor Company (USA)

Annex B (informative)

Temperature measuring points for parking mode

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

Other temperature measurements at other points may be of interest, depending on the particular problem, i.e. instrument panel, top of the test vehicle, rear parcel shelf (e.g. measured with standard Pt_{100} air thermometers).



Key

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

Figure B.1 — Example for temperature measuring points

Annex C
(informative)

Test report

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

Reporting format and data exchange

The data exchange file shall be constructed as follows. VOC and SVOC concentrations as well as any other relevant parameters shall be reported and exchanged as a csv-formatted data file. Parameter values shall be separated by a comma, ASCII-Code #h2C. The decimal marker of numerical values shall be a comma, ASCII-Code #h2C. Lines shall be terminated by carriage return, ASCII-Code #h0D. No thousands separators shall be used.

Headers of the Reporting and Data Exchange File

Table C.1 — Test vehicle data

Line #	Parameter	Basic Data Type [A= Alpha or N= Numeric (max length, fractional digits)]	Data Type [Enumeration String, Decimal Integer]	Total Digits	Fractional Digits	Minimum Value	Maximum Value	Allowed Values for: Enumeration or Description or Units
1	Process Code	N(2)	Integer			0	99	Version of Test Report. 1st dataset is N=0, highest value is the latest correction of existing dataset
2	Name of Witness	A(250)	String					Only if applicable. Full name of witness, company name and contact information for certification of test. Use "Self Certified" if no witness is required
3	Test ID Code	A(50)	String					Serial Test Identification
4	Name of Vehicle Test Operator(s)	A(50)	String					Given and Last Names
5	Name of Analytical Test Operator(s)	A(50)	String					Given and Last name of test operator(s)
6	Vehicle Laboratory and Address	A(200)	String					Name of Vehicle Test Laboratory, Street, City, State, Country, ZIP Code

Table C.1 (continued)

Line #	Parameter	Basic Data Type [A= Alpha or N= Numeric (max length, fractional digits)]	Data Type [Enumeration String, Decimal Integer]	Total Digits	Fractional Digits	Minimum Value	Maximum Value	Allowed Values for: Enumeration or Description or Units
7	Analytical Laboratory and Address	A(200)	String					Name of Sample Laboratory, Street, City, State, Country, ZIP Code
8	Valid or Void	A(5)	String					Enter if the test value is valid or void
9	Test Comments	A(1000)	String					Test report comments
10	Production Date	A(10)	String					Ref. ISO 8601-1 (e.g. YYYY-MM-DD)
11	Transportation Date	A(10)	String					Ref. ISO 8601-1 (e.g. YYYY-MM-DD)
12	Storage Date	A(10)	String					Ref. ISO 8601-1 (e.g. YYYY-MM-DD)
13	Preconditioning Date	A(10)	String					Ref. ISO 8601-1 (e.g. YYYY-MM-DD)
14	Vehicle Test Date	A(10)	String					Ref. ISO 8601-1 (e.g. YYYY-MM-DD)
15	Analytical Test Date	A(10)	String					Ref. ISO 8601-1 (e.g. YYYY-MM-DD)
16	Elapsed days from the production date	N(3)	Integer					Time in days from production to end of sampling
17-20(1)	...	...	...					...
21	Manufacturer Name	A(50)	String					Original Equipment Manufacturer (OEM)
22	Factory Name	A(50)	String					Place of production
23	Vehicle Identification Number	A(17)	String					17-character vehicle identification number (VIN)

Table C.1 (continued)

Line #	Parameter	Basic Data Type [A= Alpha or N= Numeric (max length, fractional digits)]	Data Type [Enumeration String, Decimal Integer]	Total Digits	Fractional Digits	Minimum Value	Maximum Value	Allowed Values for: Enumeration or Description or Units
24	Vehicle Class (Category 1-1 Vehicle only)	A(1)	Enumeration					A= Mini Vehicle, B= Small Vehicle, C= Medium Vehicle, D= Large Vehicle, E= Executive Vehicle, F= Luxury Vehicle, J= Sport Utility Vehicle (incl. off-road vehicle), M= Multi-Purpose Vehicle, S= Sports Vehicle, P= Small Pickup Truck, T= Standard Pickup Truck
25	Model Name	A(50)	String					Manufacturer's model name
26	Exterior Colour	A(50)	String					Paint Colour
27	Interior Colour	A(50)	String					Seat Trim Colour
28	Interior Seat Material Type	A(50)	String					Description of Seat Cover Material (e.g. Leather, Cloth, colour, etc.)
29	Odometer Reading	N(5)	Integer					Distance travelled [km], should be <80 km
30	Vehicle History	A(50)	String					Optional Description of Test Vehicle
31	Climate Control System Type/ Characteristics	A(20)	String					Description of Climate Control System
32	AC Operator Control	A(1)	Enumeration					M= Manual, A= Automatic
33-49 (1)	...	...	...					...
50	Chamber - Formaldehyde	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 55-00-0 [µg/m ³]

Table C.1 (continued)

Line #	Parameter	Basic Data Type [A= Alpha or N= Numeric (max length, fractional digits)]	Data Type [Enumeration String, Decimal Integer]	Total Digits	Fractional Digits	Minimum Value	Maximum Value	Allowed Values for: Enumeration or Description or Units
51	Chamber - Acetaldehyde	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 75-07-0 [µg/m ³]
52	Chamber - Acrolein	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 107-02-8 [µg/m ³]
53	Chamber - Benzene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 71-43-2 [µg/m ³]
54	Chamber - Toluene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 108-88-3 [µg/m ³]
55	Chamber - Xylene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 1330-20-7 [µg/m ³]
56	Chamber - Ethylbenzene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 100-41-4 [µg/m ³]
57	Chamber - Styrene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 100-42-5 [µg/m ³]
58-69(1)	...	...	...	5	1	0	9999,9	...
70	Blank - Formaldehyde	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 55-00-0 [µg/m ³]
71	Blank - Acetaldehyde	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 75-07-0 [µg/m ³]
72	Blank - Acrolein	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 107-02-8 [µg/m ³]
73	Blank - Benzene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 71-43-2 [µg/m ³]
74	Blank - Toluene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 108-88-3 [µg/m ³]
75	Blank - Xylene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 1330-20-7 [µg/m ³]
76	Blank - Ethylbenzene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 100-41-4 [µg/m ³]
77	Blank - Styrene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 100-42-5 [µg/m ³]
78-89(1)	...	...	Decimal	5	1	0	9999,9	...
90	Ambient Mode Vehicle - Formaldehyde	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 55-00-0 [µg/m ³]
91	Ambient Mode Vehicle - Acetaldehyde	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 75-07-0 [µg/m ³]

Table C.1 (continued)

Line #	Parameter	Basic Data Type [A= Alpha or N= Numeric (max length, fractional digits)]	Data Type [Enumeration String, Decimal Integer]	Total Digits	Fractional Digits	Minimum Value	Maximum Value	Allowed Values for: Enumeration or Description or Units
92	Ambient Mode Vehicle - Acrolein	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 107-02-8 [$\mu\text{g}/\text{m}^3$]
93	Ambient Mode Vehicle - Benzene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 71-43-2 [$\mu\text{g}/\text{m}^3$]
94	Ambient Mode Vehicle - Toluene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 108-88-3 [$\mu\text{g}/\text{m}^3$]
95	Ambient Mode Vehicle - Xylene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 1330-20-7 [$\mu\text{g}/\text{m}^3$]
96	Ambient Mode Vehicle - Ethylbenzene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 100-41-4 [$\mu\text{g}/\text{m}^3$]
97	Ambient Mode Vehicle - Styrene	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 100-42-5 [$\mu\text{g}/\text{m}^3$]
98-109(1)	...	...	Decimal	5	1	0	9999,9	...
110	Parking Mode Vehicle - Formaldehyde	(N4,1)	Decimal	5	1	0	9999,9	CAS#: 55-00-0 [$\mu\text{g}/\text{m}^3$]
111-129(1)	...	...	Decimal	5	1	0	9999,9	...
130	Driving Mode Vehicle - Formaldehyde		Decimal	5	1	0	9999,9	CAS#: 55-00-0 [$\mu\text{g}/\text{m}^3$]
131	Driving Mode Vehicle - Acetaldehyde		Decimal	5	1	0	9999,9	CAS#: 75-07-0 [$\mu\text{g}/\text{m}^3$]
132	Driving Mode Vehicle - Acrolein		Decimal	5	1	0	9999,9	CAS#: 107-02-8 [$\mu\text{g}/\text{m}^3$]
133	Driving Mode Vehicle - Benzene		Decimal	5	1	0	9999,9	CAS#: 71-43-2 [$\mu\text{g}/\text{m}^3$]