

**C-AHI**

# **China-Automobile Health Index**

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**Clean Air Index**

**Vehicle Particulate Matter Testing and Evaluation Protocol**

**(Version 2023)**

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# Vehicle Particulate Matter Testing and Evaluation Protocol

## 1 Scope of Application

This document specifies the testing and evaluation method of vehicle particulate matter in China-Automobile Health Index.

It is applicable to testing and evaluation of the barrier of new passenger cars to external particulate matters and the filtration efficiency for particulate matter in cabin of vehicle.

## 2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute indispensable provisions of this document. For dated references, only the dated edition applies to this document. For undated references, the latest edition (including all amendments) applies to this document.

GB3095-2012 Ambient Air Quality Standards

GB7258-2017 Technical Specifications for Safety of Power-driven Vehicles Operating on Roads

GB/T18801-2015 Air Cleaner

HJ/T400-2007 Determination of Volatile Organic Compounds and Carbonyl Compounds in Cabin of Vehicles

T/CAAMTB54-2021 Test Method for Particulate Matter Filtration in Vehicle Cabin

## 3 Terms and Definitions

For the purposes of this protocol, the following terms and definitions and those defined in GB/T 3095-2012 and GB 7258-2017 apply.

### 3.1 passenger car

a vehicle which is designed and constructed mainly for the carriage of passengers and their baggage and/or temporary articles, with a maximum of 9 seats, including the driver's seat, and which can be equipped with certain special equipment or apparatus and may also tow a center-axle trailer

[Source: GB 7258-2017, 3.2.1.1]

### 3.2 particulate matter 2.5 (PM<sub>2.5</sub>)

particulate matter with an aerodynamic equivalent diameter of less than or equal to 2.5 μm in ambient air

[Source: GB 3095-2012, 3.4]

### 3.3 Vehicle particulate matter barrier (Z)

an index to examine the barrier and protection capacity of the vehicle at rest against external particulate matter, expressed as the incremental PM<sub>2.5</sub> concentration in the vehicle, Z (unit: μg/m<sup>3</sup>)

### 3.4 filtration efficiency for particulate matter in cabin of vehicle (E)

an index to examine the reduction effect of vehicle A/C and related air purification devices on PM<sub>2.5</sub> concentration in the vehicle, which is characterized by purification time t (in min) and

corresponding end-of-purification concentration of  $PM_{2.5}$ ,  $Ct1$  (in  $\mu\text{g}/\text{m}^3$ )

## 4 Technical Requirements for Test

### 4.1 Vehicle PM test chamber

It is a limited space device used to test the protection of the vehicle against external particulate matter and the filtration performance against particulate matter in the air inside the vehicle, and requirements for air tightness and PM mixedness are specified for the device (see Table 1 for detailed technical requirements). Its internal space shall be able to hold a passenger car with doors fully opened.

**Table 1 Requirements for Vehicle PM Test Chamber**

Item	Structural Parameters
Temperature and humidity requirements	Temperature: $25^{\circ}\text{C}\pm 5^{\circ}\text{C}$ ; relative humidity: 50%, control accuracy: 10%
Mixing fan	About 1.5 m in diameter, three-bladed, with a distance of 2.5 m from the centerline on the chamber top
Circulating fan	$500\text{ m}^3/\text{h}\sim 700\text{ m}^3/\text{h}$ , diameter 15 cm, installed 1.2 m~1.5 m from the ground at diagonal positions of inner wall of environmental chamber
Air tightness	Number of air changes not be more than $0.05\text{ h}^{-1}$
Mixedness	More than 80%

### 4.2 Light scattering dust meter

The PM detector includes sample collection unit, sample measurement unit, data acquisition unit, data transmission unit and other auxiliary equipment.

- a) Optical device: built-in  $90^{\circ}$  light scattering photometer.
- b) Measuring range:  $0\text{ }\mu\text{g}/\text{m}^3\sim 20000\text{ }\mu\text{g}/\text{m}^3$ .
- c) Measurement sensitivity: not less than  $1\text{ }\mu\text{g}/\text{m}^3$  for calibration particles.
- d) Test PM particle size:  $0.1\text{ }\mu\text{m}\sim 10\text{ }\mu\text{m}$ .
- e) The instrument shall be equipped with a self-calibration device with optical stability that was calibrated before leaving the factory.

Note: The calibration particles are polystyrene spheres with an average particle size of  $0.6\text{ }\mu\text{m}$ .

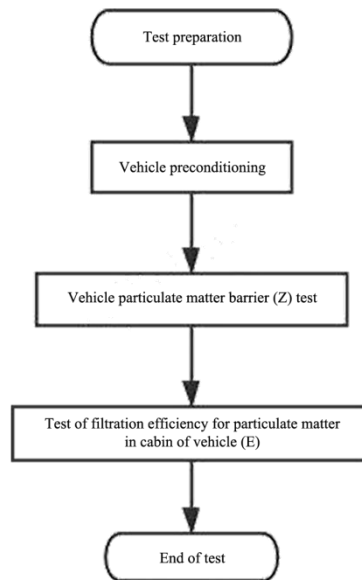
### 4.3 Standard pollutant

Particulate matter: from standard cigarette specified in GB/T 18801 *Air Cleaner*.

## 5 Test Method

### 5.1 Test process

The test process is divided into four stages. The personnel conducting the test shall wear anti-haze protective gear correctly and shall not remove it at will during the test. See Fig. 1 for the test process.



**Fig. 1 Requirements for Vehicle PM Test Chamber**

## 5.2 Test method

The test process shall be as specified in T/CAAMTB54-2021 *Test Method for Particulate Matter Filtration in Vehicle Cabin*. During the test of filtration efficiency for particulate matter in cabin of vehicle (E), the vehicle A/C is set to internal circulation by default, or external circulation as specially required by vehicle manufacturer.

## 6 Evaluation Protocol

### 6.1 Evaluation index

#### 6.1.1 Vehicle particulate matter barrier (Z)

It is used to examine the protection of the stationary vehicle against external particulate matter, expressed as the incremental  $PM_{2.5}$  concentration in the vehicle,  $Z$  (unit:  $\mu g/m^3$ ).

#### 6.1.2 filtration efficiency for particulate matter in cabin of vehicle (E)

It is used to examine the purification effect of A/C in internal circulation mode and related air purification devices on PM pollution in the vehicle, characterized by purification time  $t$  (in min) and corresponding end-of-purification concentration of  $PM_{2.5}$ ,  $Ct1$  (in  $\mu g/m^3$ ).

### 6.2 Scoring Rules

The total score of the vehicle particulate matter barrier (Z) index is 20 points, allocated in different intervals according to the  $Z$  value measured in the test. The total score of the internal circulation purification efficiency (E) index is 80 points, allocated in different intervals according to the purification time  $t$  and the concentration  $Ct1$  at the end of purification measured in the test. The total score is 100 points. See Table 2 for the specific score allocation.

**Table 2 Scoring Rules for Indexes**

Item	Score	Index Range	Score Range
Vehicle particulate matter barrier (Z)	20	$Z \leq 3$	100%
		$3 < Z \leq 5$	(100%, 90%) linear interpolation
		$5 < Z \leq 10$	(90%, 80%) linear interpolation
		$10 < Z \leq 15$	(80%, 70%) linear interpolation
		$15 < Z \leq 20$	(70%, 60%) linear interpolation
		$20 < Z$	50%
Internal circulation purification efficiency (E)	80	$C_{t1} \leq 35 \wedge t \leq 2.5$	100%
		$C_{t1} \leq 35 \wedge 2.5 < t \leq 4$	90%t [4, 2.5) linear interpolation
		$C_{t1} \leq 35 \wedge 4 < t \leq 10$	80%t [10, 5) linear interpolation
		$C_{t1} \leq 35 \wedge 10 < t \leq 15$	70%t [15, 10) linear interpolation
		$35 < C_{t1} \leq 75 \wedge t = 15$	60%
		$75 < C_{t1} \wedge t = 15$	50%

### 6.2.1 Vehicle particulate matter barrier (Z)

The scoring rules for linear interpolation of vehicle particulate matter barrier (Z) are shown in Table 3.

**Table 3 Linear Interpolation of Vehicle Particulate Matter Barrier Index Scoring**

Item	Score	Index Range	Index Value	Scoring rate	Score
Vehicle particulate matter barrier (Z)	20	$3 < Z \leq 5$	5	90%	18.0
			4	95%	19.0
		$5 < Z \leq 10$	10	80%	16.0
			9	82%	16.4
			.....	.....	.....
			6	88%	17.6
			.....	.....	.....
		$10 < Z \leq 15$	15	70%	14.0
			14	72%	14.4
			.....	.....	.....
			11	78%	15.6
		$15 < Z \leq 20$	20	60%	12.0
			19	62%	12.4
			.....	.....	.....
			16	68%	13.6

### 6.2.2 filtration efficiency for particulate matter in cabin of vehicle (E)

The rules for scoring by linear interpolation of filtration efficiency for particulate matter in cabin of vehicle (E) are shown in Table 4.

**Table 4 Linear Interpolation of Filtration Efficiency for Particulate Matter in Cabin of Vehicle (E) Index Scoring**

Item	Score	Index Range	Purification Time t (min)	Scoring rate	Score
Internal circulation purification efficiency (E)	80	$Ct1 \leq 35 \wedge 2.5 < t \leq 4$	$3 < t \leq 4$	90%	72.0
			$2.5 < t \leq 3$	95%	76.0
		$Ct1 \leq 35 \wedge 4 < t \leq 10$	$9 < t \leq 10$	80%	64.0
			$8 < t \leq 9$	82%	65.6
			$7 < t \leq 8$	84%	67.2
			$6 < t \leq 7$	85%	68.0
			$5 < t \leq 6$	86%	68.8
			$4 < t \leq 5$	88%	70.4
			$Ct1 \leq 35 \wedge 10 < t \leq 15$	$14 < t \leq 15$	70%
		$13 < t \leq 14$		72%	57.6
		.....		.....	.....
		$10 < t \leq 11$		78%	62.4

**6.2 Final score**

The final score of the sample vehicle for testing and evaluation is the sum of the score of vehicle particulate matter barrier (Z) and the score of filtration efficiency for particulate matter in cabin of vehicle (E).