The necessity of laboratory test in stablized controlled atmosphere for vehicle in-cabin air quality full characterization

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ECOLE D'INGENIEURS
CREATEUR DE NOUVELLES MOBILITES

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SUMMARY

THE MEASUREMENT BUBBLE

Closed chamber (The measurement bubble)

- Closed chamber allowing to introduce the vehicle
- Air extractor, fan and power supply.
- Generate a polluted environment with fine and ultrafine particles

Fig. (1) : The measurement plateform

PARTICLES GENERATION SYSTEMS

Fig. (2): Palas DNP 2000

- Carbon particles
- Particle size : 20 – 2000nm
- Mass flow : 9 mg/h

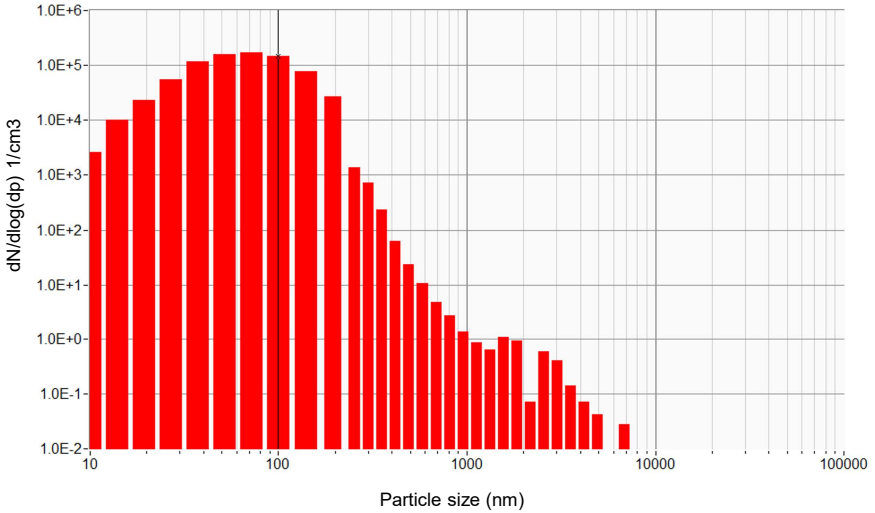
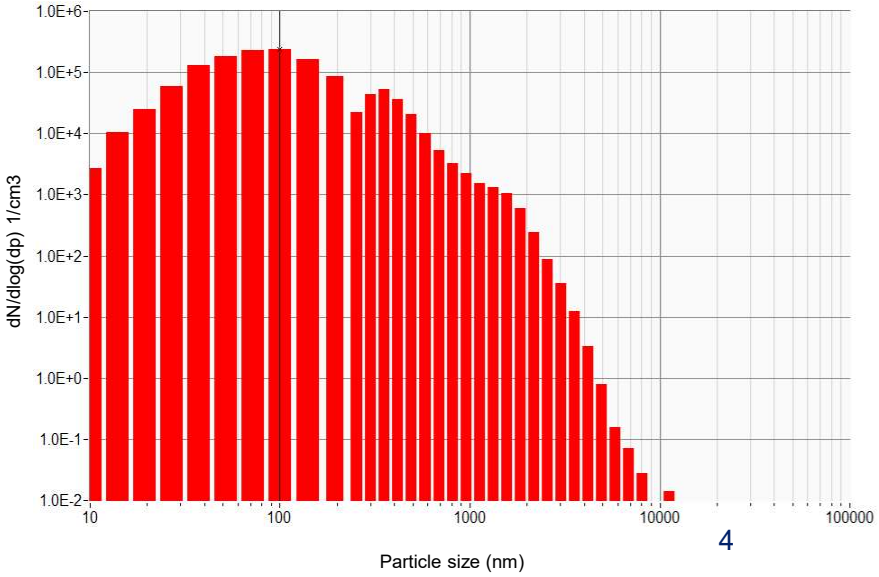


Fig. (3): Palas AGK 2000

- Particles (NaCl ou KCl)
- Particle size : 5nm – 15 µm
- Injection concentration : 10^7 p/cm^3.



HOMOGENEITY OF THE GENERATED POLLUTED ATMOSPHERE

Generation of polluted environment (CFD approach)

- Particles injected 2,5µm, 1µm and 100nm
- Turbulence model used: K-omega (2 equations model) SST
- Forces acting on particles: Gravitational, lift, drag, Brownian

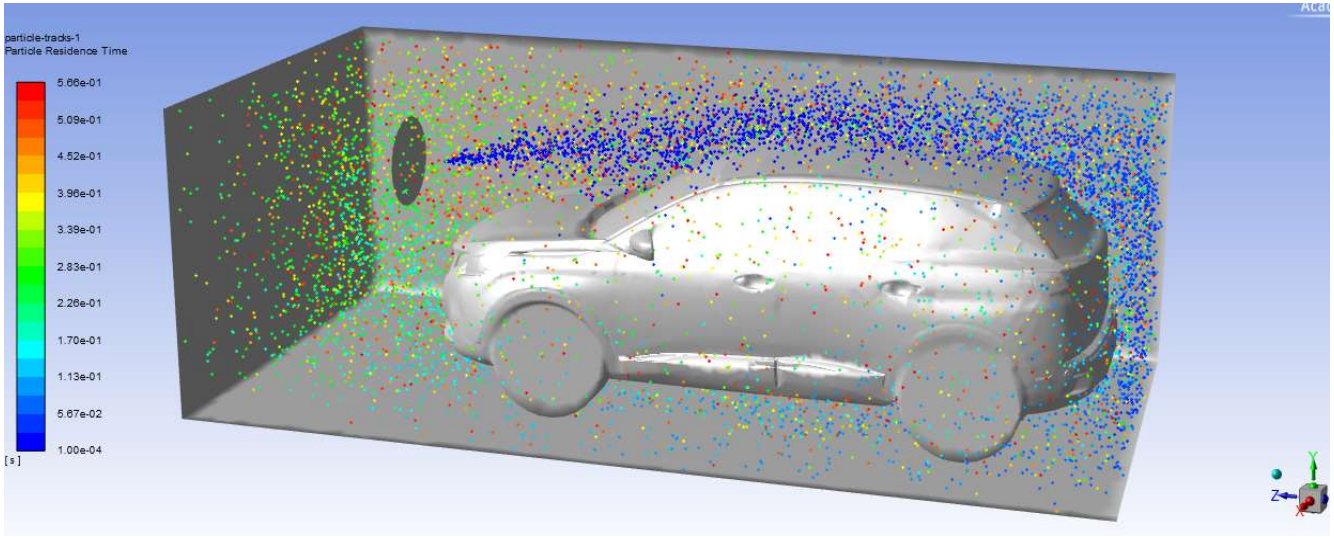


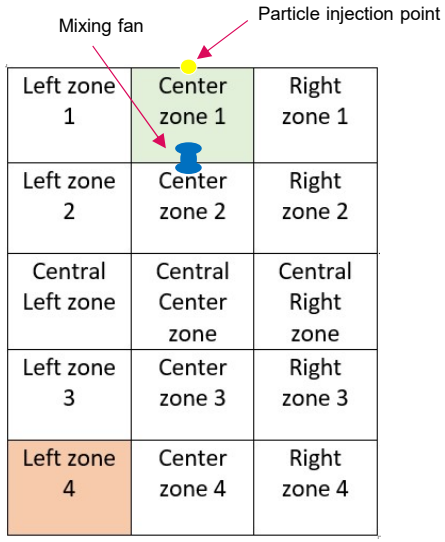
Fig. (4) : Particles distribution in the bubble colored by their residence time (0,5 second)

According to the simulation, after 0.5 second the particles are distributed in the entire volume

HOMOGENEITY OF THE GENERATED POLLUTED ATMOSPHERE

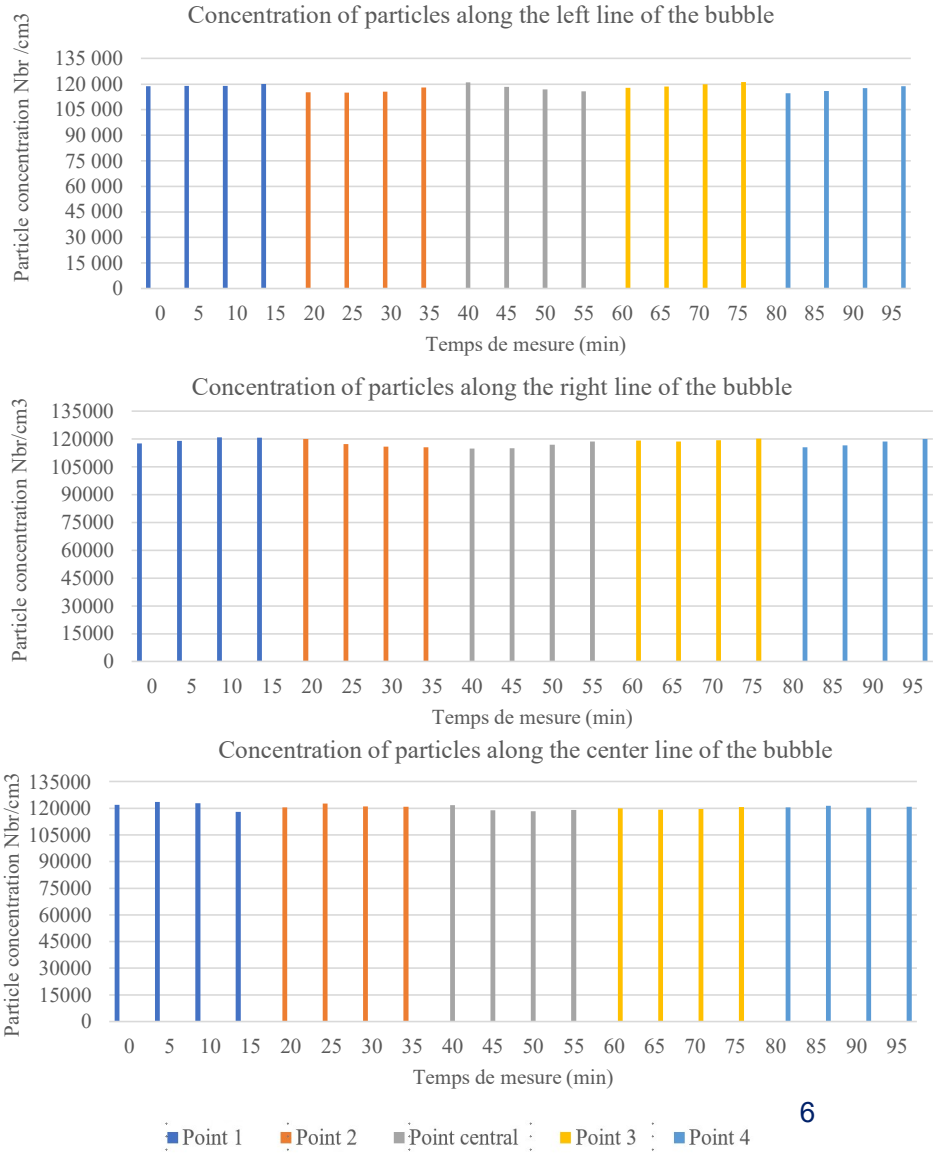
Particle distribution homogeneity

- 15 different zones measured in the bubble.
- Injection of fine and ultra-fine particles into the closed bubble (with the activation of mixing fan)
- Reach a concentration of 120 000 particles/cm^3
- Measurement of the number concentration of particles injected in each localized area.
- Assessing the differences of the concentration between the 15 zones.



Results:

- The maximum difference is between the center zone 1 and the left zone 4: 124000 and 115000 particles/cm^3 respectively . The difference is around 7%.



INTRUMENTATION

Measurements of the mass and number concentrations of fine and ultra-fine particles :

Concentrations of particles in number (Nbr/cm3) and in mass (µg/m3)

Particle size from 0.01 to 35µm

Acquisition rate (1measurement/min)

Fig (5): Grimm Mini Wras

Measurement of particle concentrations by mass (mg/m3)

Size of the particles to be measured 0.1 to 15µm

Acquisition frequency (1 measurement/s)

Fig (6): TSI Dust Track

Measures particle concentration by number (0-500,000 particles/cm3)

Size of particles measured 0.02 to 2 µm

Acquisition rate (1 measurement/s)

Fig (7): PTrack

POLLUTED ATMOSPHERE GENERATION PROTOCOL

- The protocol to generate a polluted and controlled environment :

Preparation

- Preparing the particle generation system
- Introducing the vehicle into the bubble
- positioning the instruments in the in-cabin and in the bubble.

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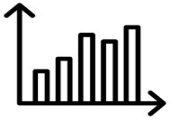
Pre-measurement VIAQ

- Measuring the background pollution before injecting the particles
- Injecting particles into the bubble

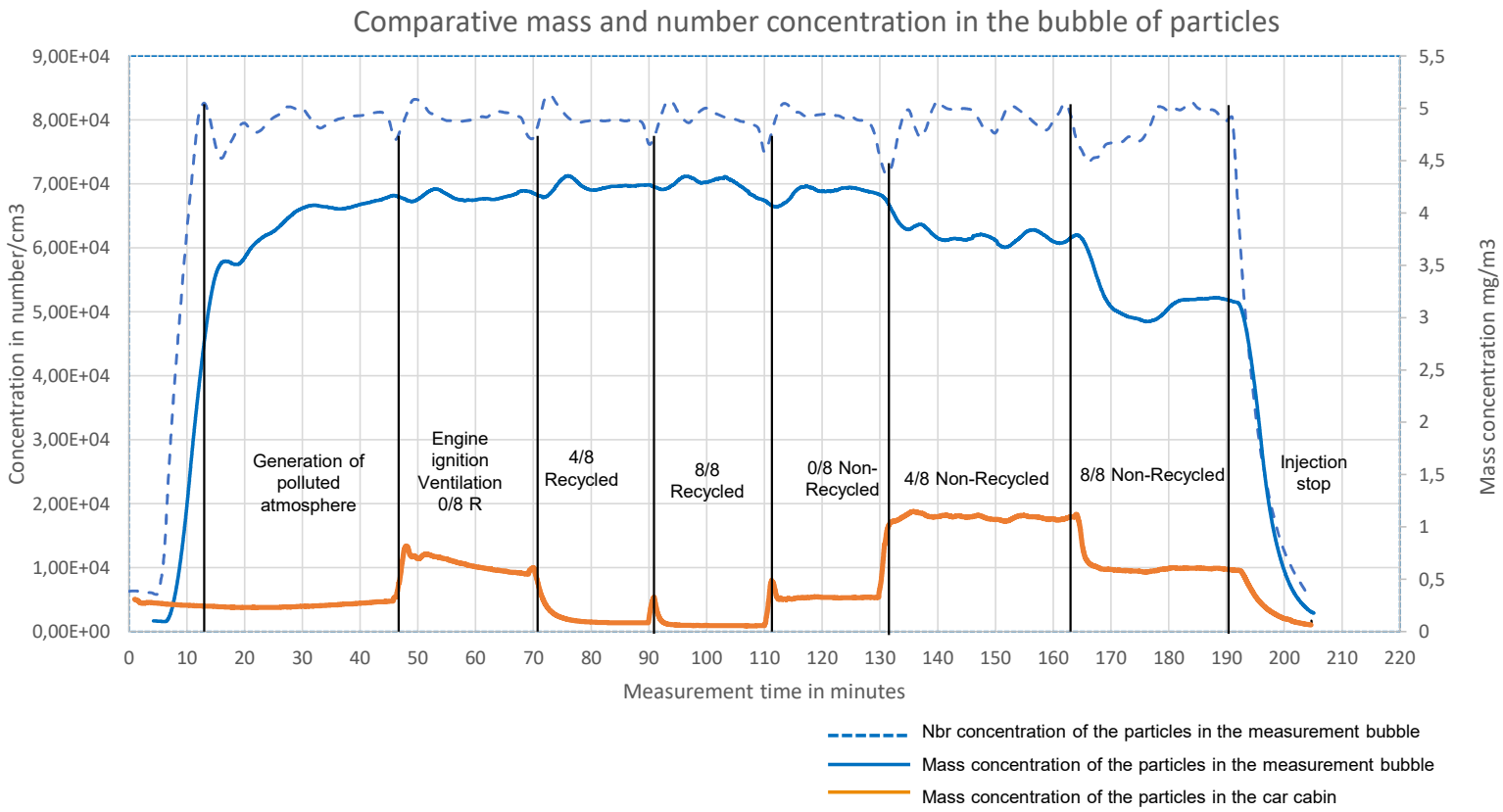


Controling the polluted atmosphere and VIAQ measurement

- Controlling the injection rate of the particles in order to have a stable concentration around 80,000 particles/cm3.
- Measurement of the infiltration rate of particles in the car cabin according to the ventilation mode.

POLLUTED ATMOSPHERE GENERATION PROTOCOL

- Injection of fine and ultra-fine particles into the bubble.
- Generate a polluted atmosphere by controlling the rate of this pollution.
- Average temperature in the measurement bubble : **23°c**
- Average humidity : **40%**

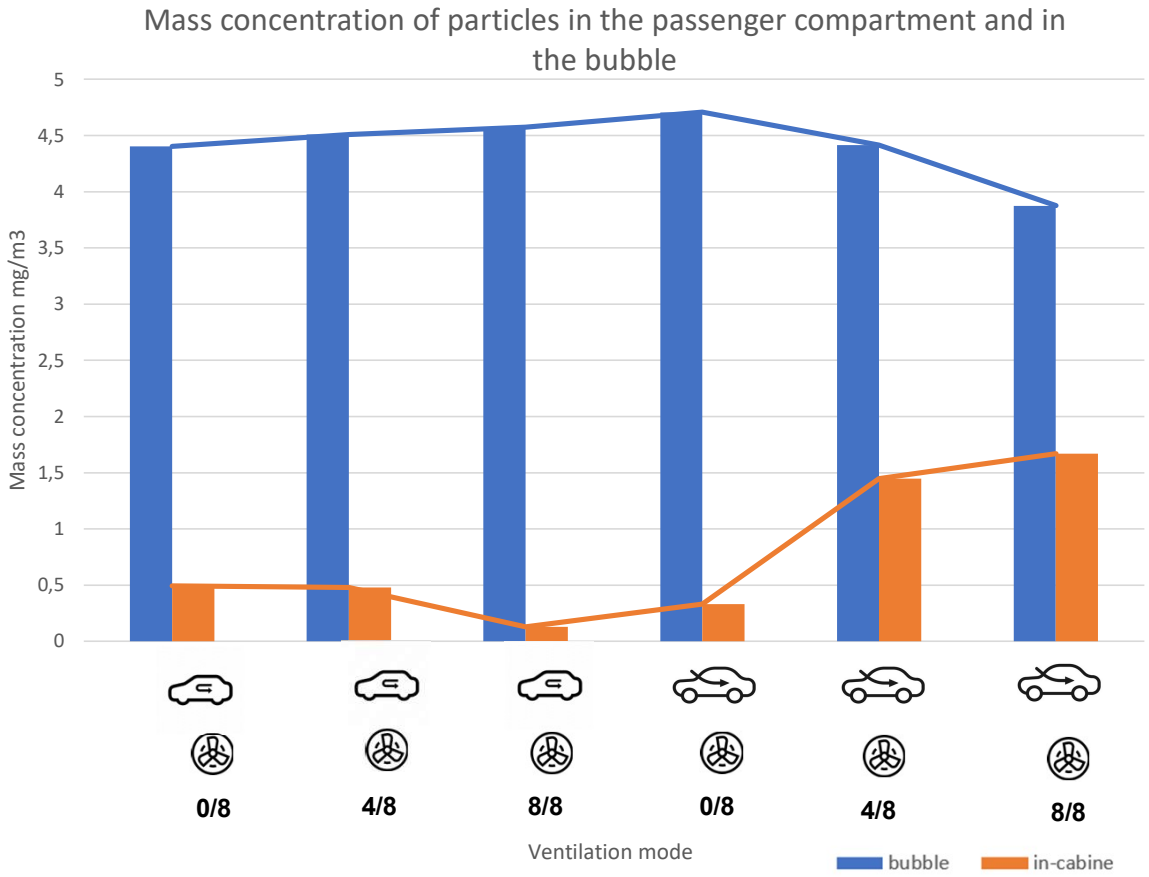


Alignment with the WHO recommendation would amount to lowering it to 10 µg/m3. PM10 is subject to two limit values: 20 µg/m3 as an annual average and 50 µg/m3 as a daily average, not to be exceeded for more than thirty-five days per year. The WHO recommends 15 µg/m3 for the first and 45 µg/m3 for the second. Sept. 23, 2021

IN-CABIN AIR QUALITY CHARACTERIZATION

Vehicle feature:

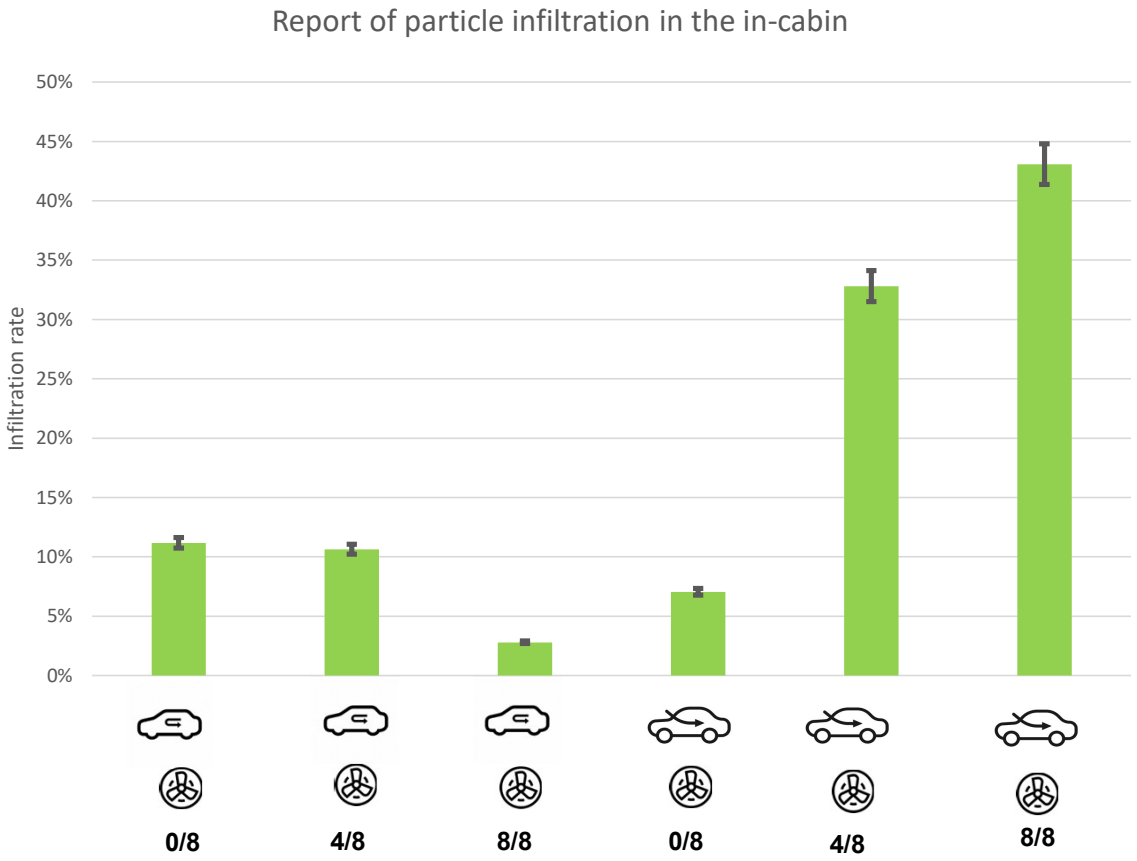
- Thermal engine (Diesel)
- Model year 2021, mileage 2000 Km.
- In- cabin filter Original HE type.



- The concentration of particles infiltrated into the car cabin during the non-recycled (OA) mode is the highest.
- For the global ventilation modes the lowest in-cabin concentration (127 µg/m^3) is higher than the WHO concentration guidlines (45µg/m3)

IN-CABIN AIR QUALITY CHARACTERIZATION

- Particles infiltrate at highest rates for non-recycled ventilation.



CHARACTERIZATION OF THE IN-CABIN FILTER

In-cabin filter

- Activated carbon filter.
- Length [mm]: 290, width [mm]: 95, thickness [mm]: 30.
- Filter fine dust
  The exhaust gas
  Bacteria and respirable particles

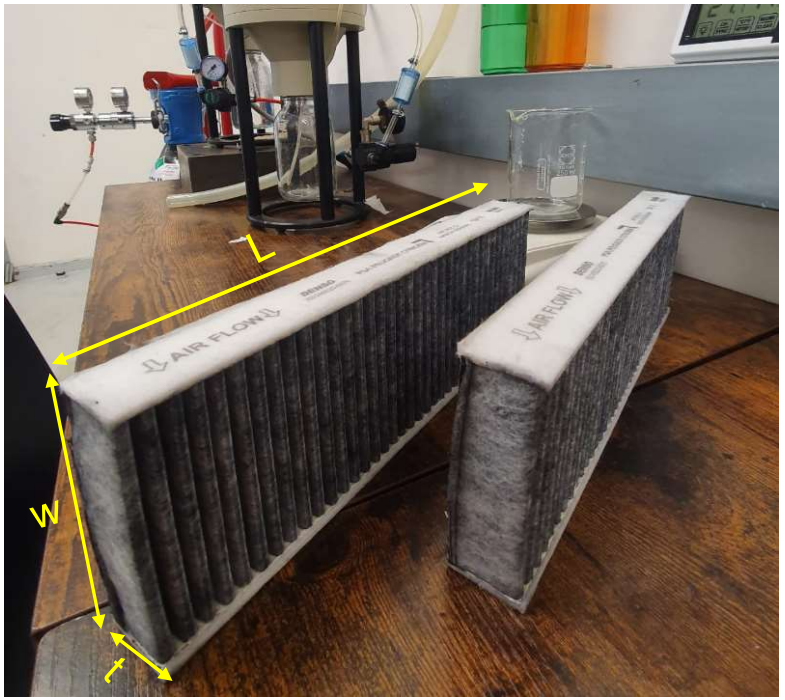
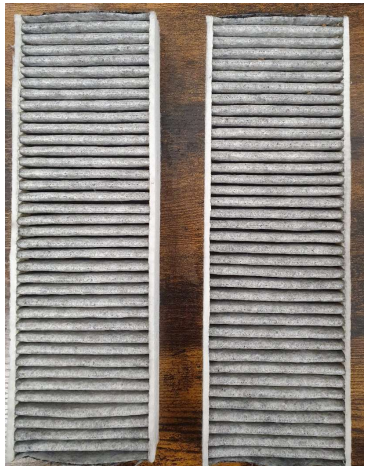
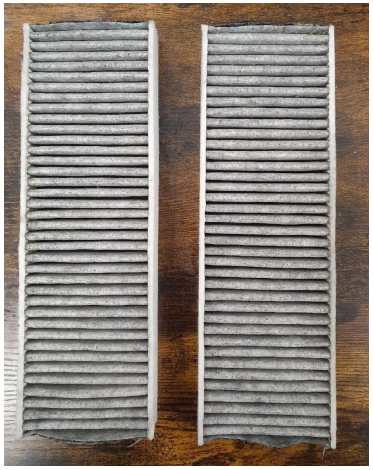


Fig. (8) : in-cabin filter

CHARACTERIZATION OF THE IN-CABIN FILTER



In-cabin filter
0 km

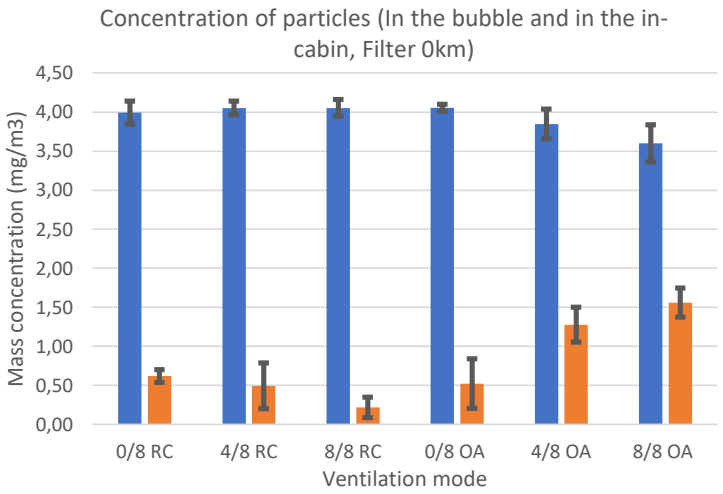


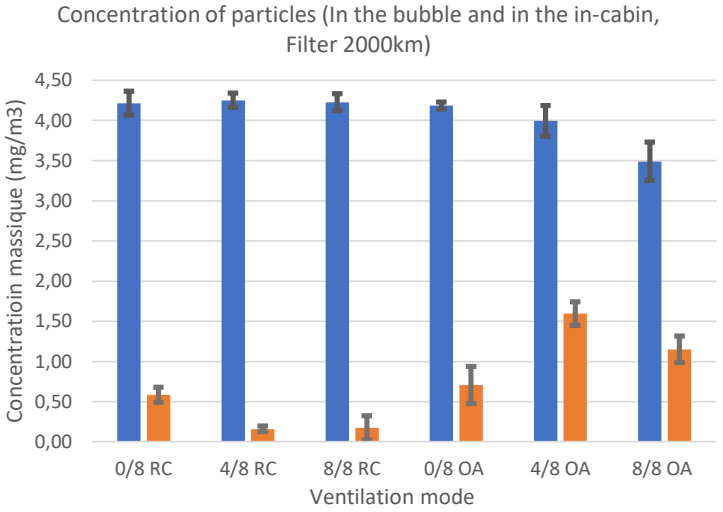
In-cabin filter
2480 km

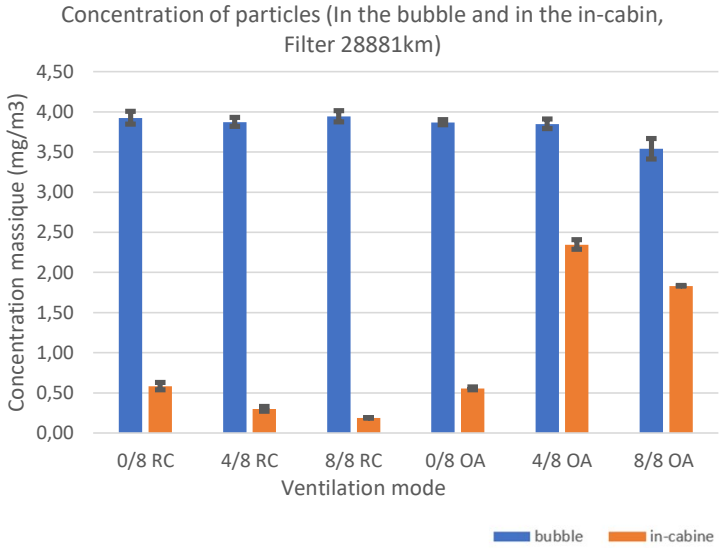
In-cabin filter
28881 km

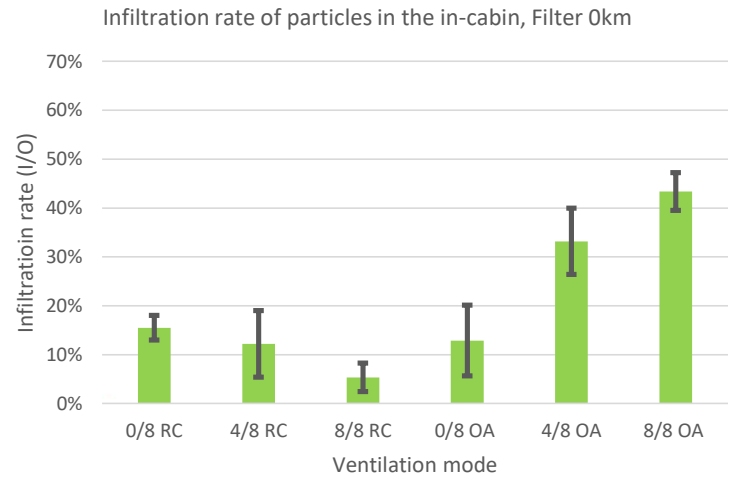
- On average, the cabin filter is changed every year or every 15 000 kilometers.
- Traffic in the city where the air is often more polluted, rather plan to change it every 6 to 8 months or every 10 000 kilometers.
- (Recommended by manufacturers)

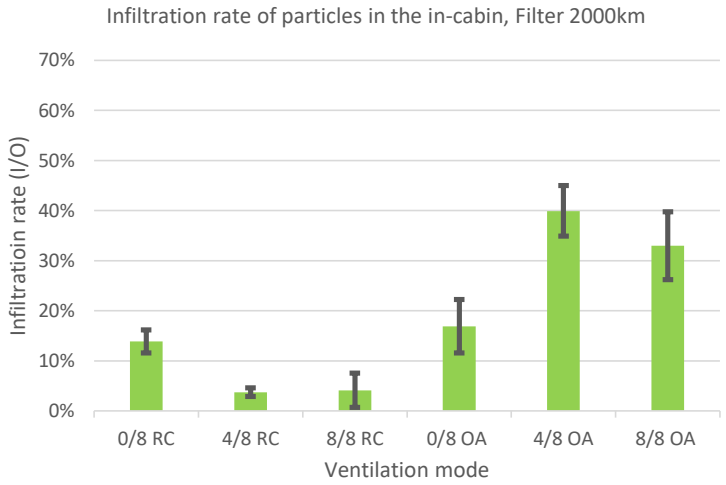
CHARACTERIZATION OF THE IN-CABIN FILTER

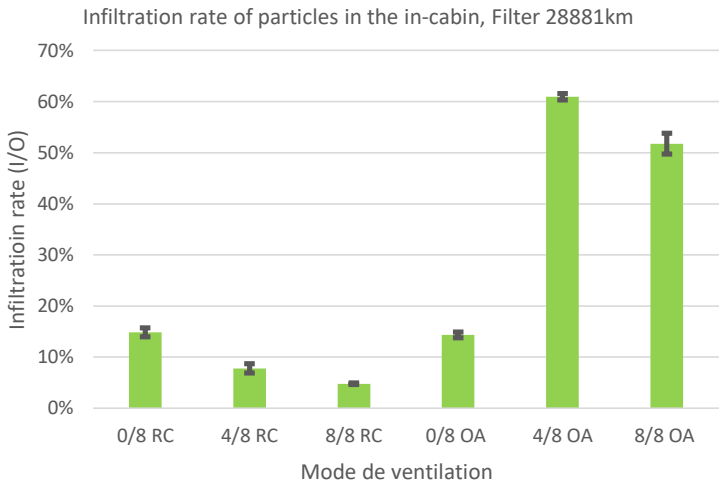




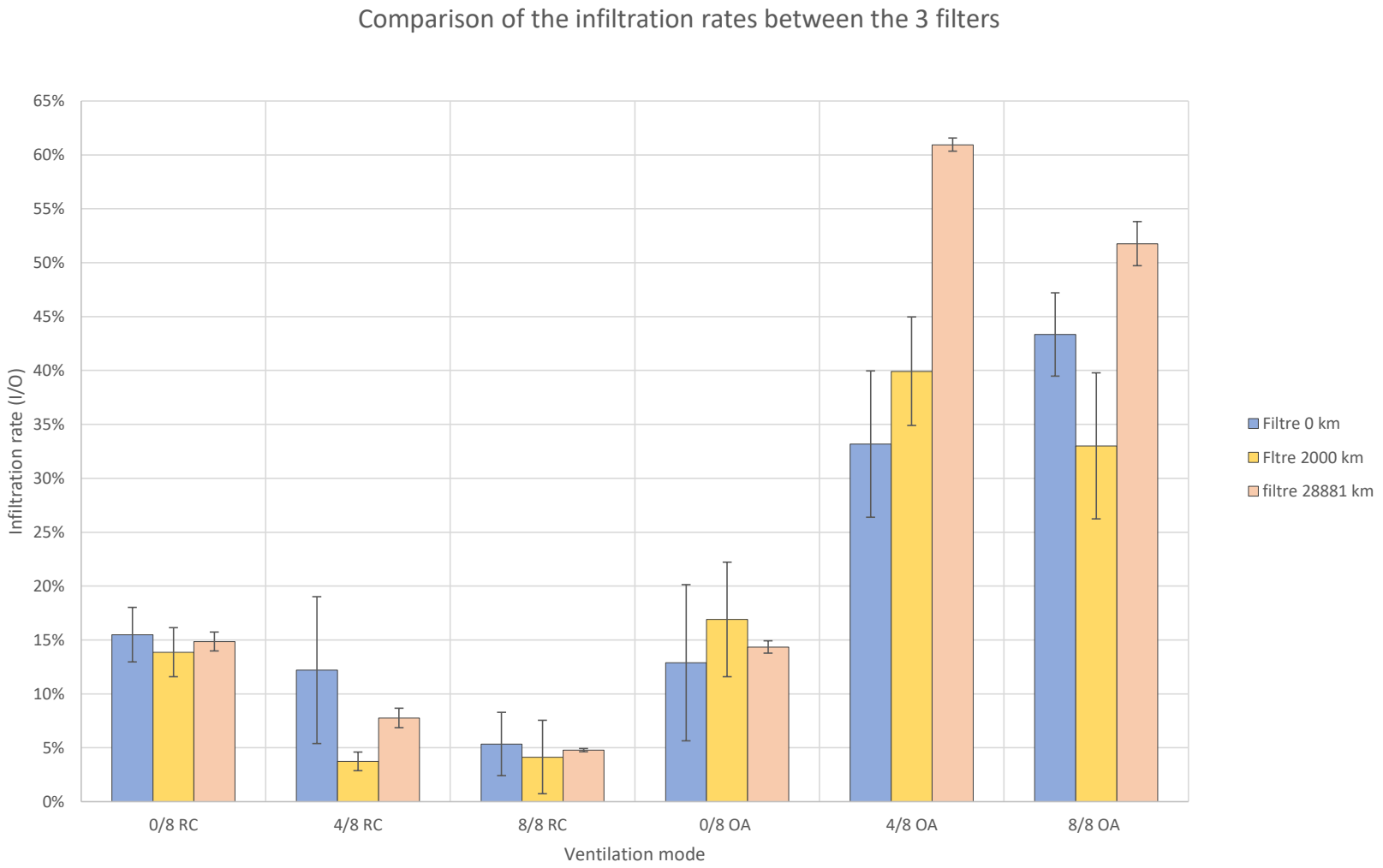








CHARACTERIZATION OF THE IN-CABIN FILTER



STATIC VIAQ MEASUREMENTS VS ON-ROAD MEASUREMENTS

- Non recycled ventilation mode with medium flow rate ventilation
- Same vehicle model
- Same cabin filter

	On-road			Static (measurments bubble)		
	Indoor concentration (mg/m3)	Outdoor concentration (mg/m3)	Infiltration rate (I/O)	Indoor concentration (mg/m3)	Outdoor concentration (mg/m3)	Infiltration rate (I/O)
PM_{10}	0,009	0,010	92%	1,447	4,433	33%
$PM_{2,5}$	0,008	0,008	96%	1,439	4,256	34%
PM_{1}	0,008	0,008	96%	1,436	4,039	36%

-On-road measurements make it difficult to control external conditions: weather, inter-vehicle distances, road infrastructure types, **pollution level (table above)**

-Static laboratory measurements inconvenient: influence of vehicle speed, less representative of realistic conditions during driving

Necessity of static laboratory measurements complementary to the on-road measurements

THE END

Thank you