

CabinAir

Real-driving measurement of in-vehicle air quality and particle filtration

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CabinAir Sweden AB

Outline

1. **Objective**
2. **A mobile test method**
3. **Boundary conditions**
4. **Short-term test**
5. **Long-term test**
6. **Summary**

Objectives

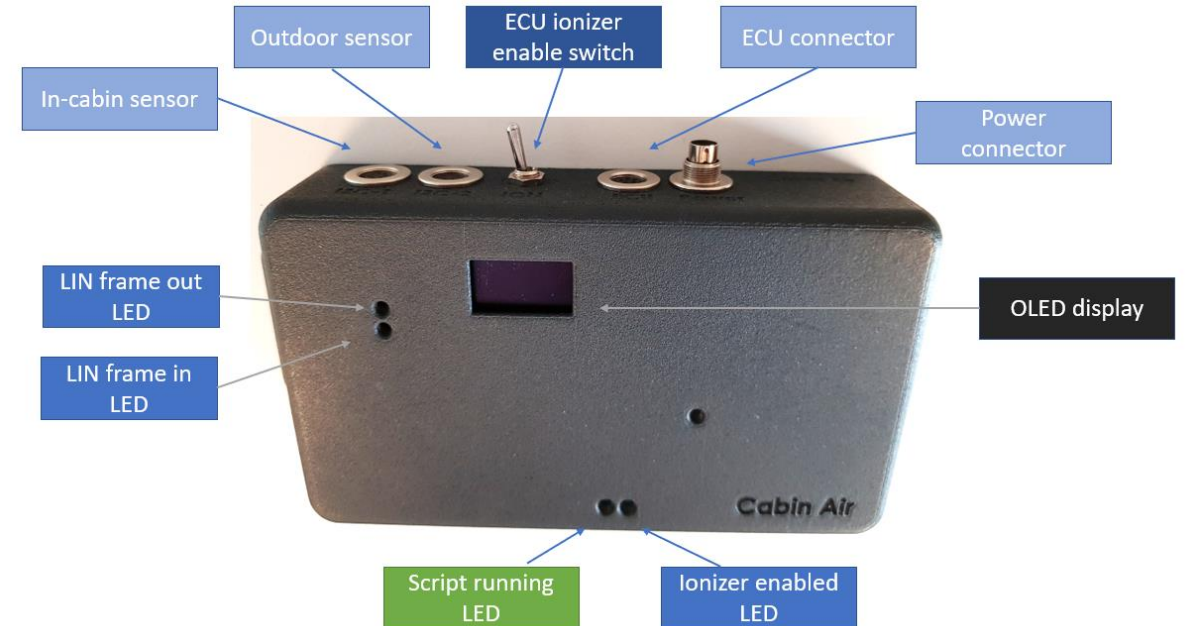
The objectives are:

- To develop a mobile real-driving test method for in-vehicle air quality and cabin air filter's performance, suitable for fleet test, short-term and long-term test
- To evaluate the filtration performance of cabin air filters of different conditions in real-life driving environments

Data logger and sensors

CabinAir Data logger is a device to power and control sensor measurement, to collect, display and upload data

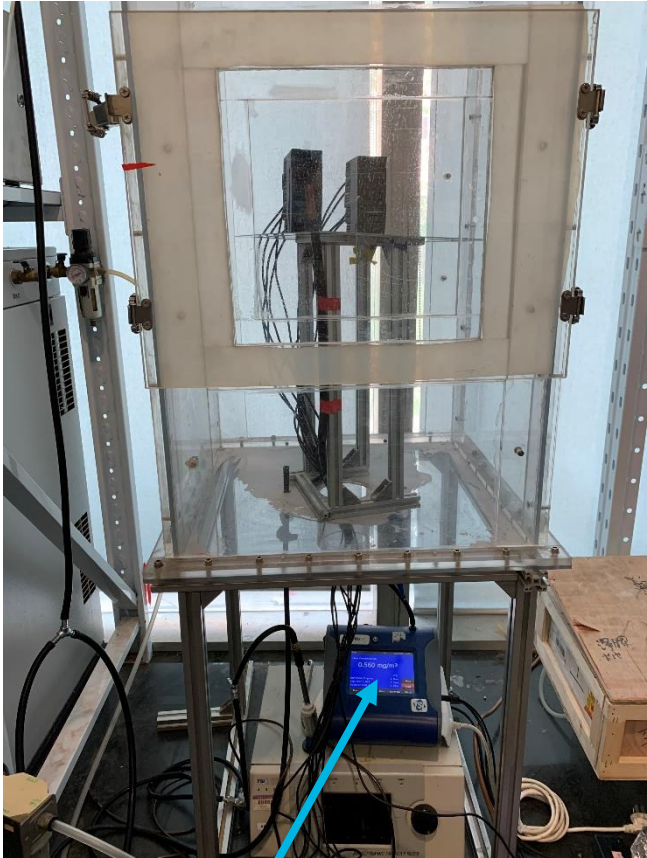
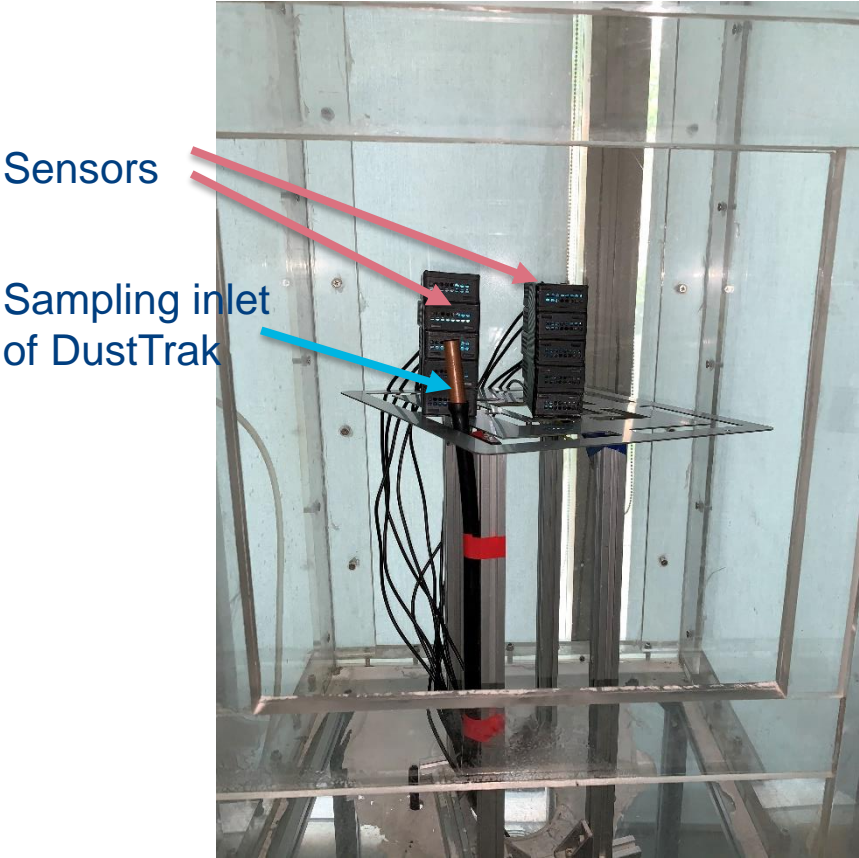
- Internal sensor module (PM, CO₂, tVOC, temperature & humidity)
- External sensor module (PM, temperature & humidity)



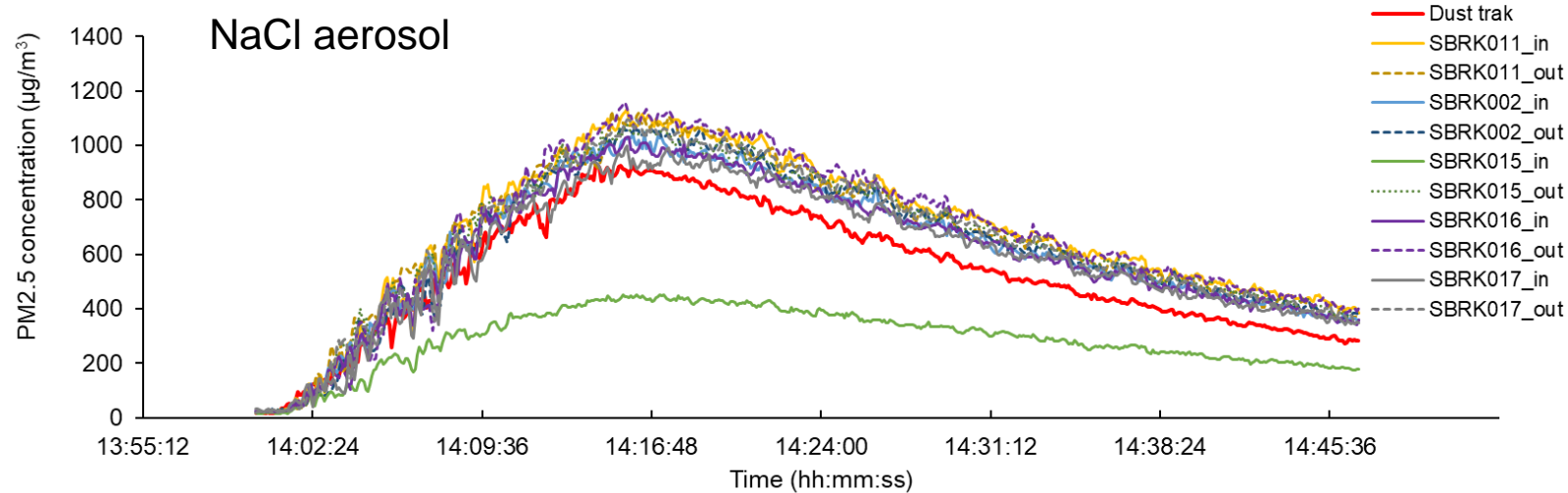
- Linux based embedded system
- Single Core 1GHz CPU
- 1GB RAM
- 2 Channel I2C
- 1 Channel LIN
- WIFI
- Bluetooth 4.1 & BLE
- 4G modem
- GPS (USB, optional)
- Amazon web services

Verification of PM sensors

Aerosol generator: Designed by Tsinghua University: Patent No. CN201210153212.4

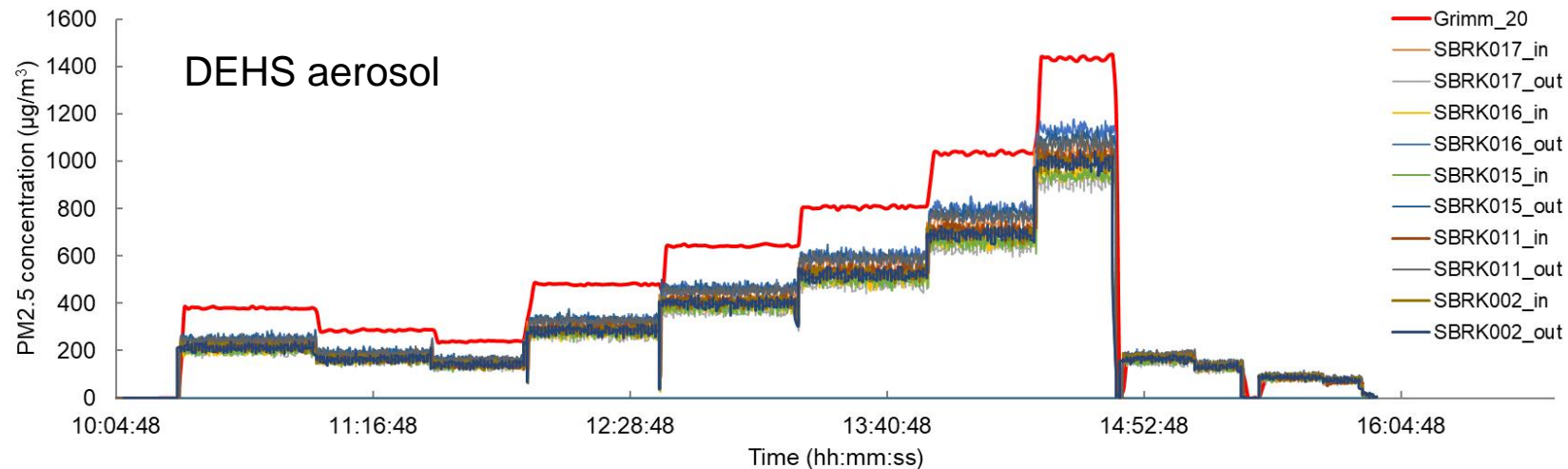


Verification of PM sensors



Reference instrument
Dust Trak model 8357
(0.3 – 2.5 μm)

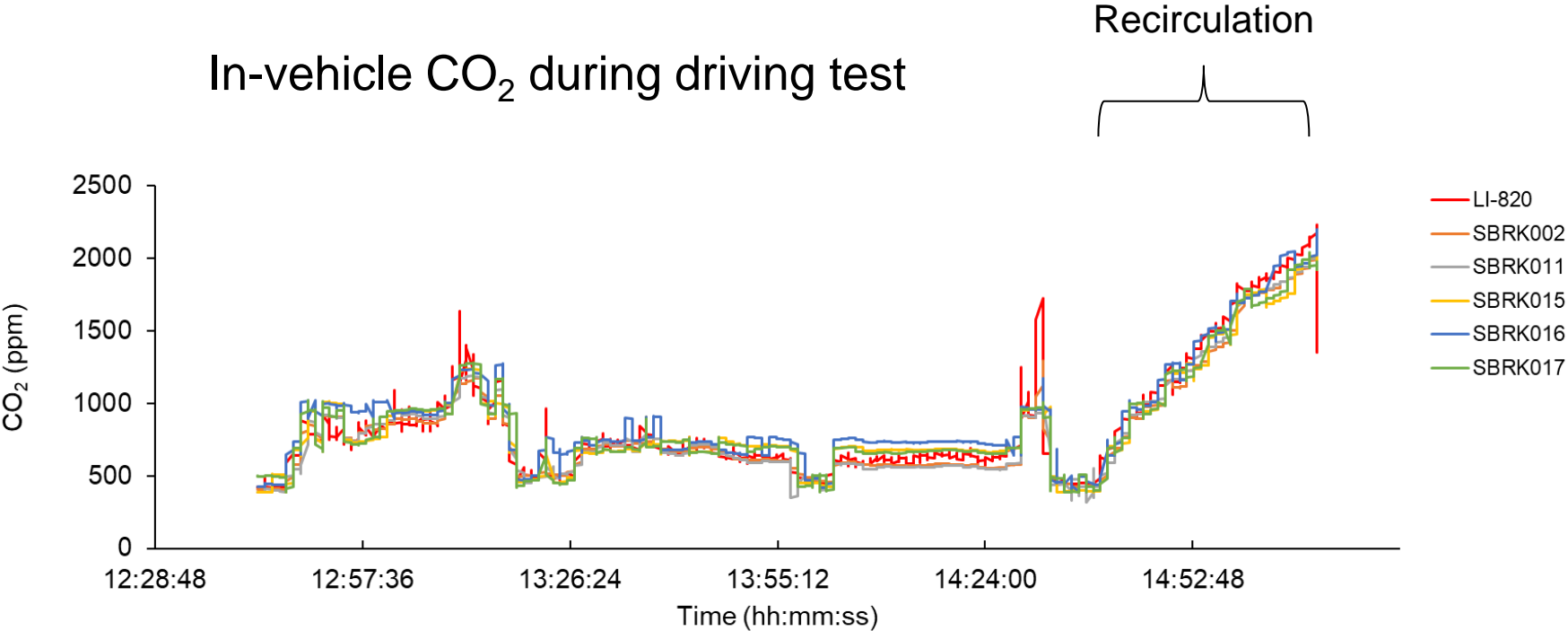
Big deviation for the
SBRK015 indoor sensor,
acceptable performance for
the rest sensors (intra-
model variability <10%)



Reference instrument
Grimm MiniWRAS 1.371
(10 nm – 35 μm)

Compare sensors'
performance to each other,
intra-model variability
<10%)

Verification of CO₂ sensors



Good consistency of CO₂ sensors' readings, compared to the reference instrument LI-820

Boundary conditions

- Average outdoor PM2.5 concentration greater than 20 $\mu\text{g}/\text{m}^3$
- Windows and doors are closed during the whole test
- HVAC ventilation: totally fresh air (CO_2 concentration less than 1000 ppm with less than 2 passengers)
- HVAC fan speed: Low or medium
- Continuous driving for at least 20 minutes
- No interior PM sources, e.g. smoking

Short-term test – overview

- Organizations: CabinAir, Tsinghua University
- Test time and location: May-July 2020, Beijing China
- Test vehicles: 5 recruited volunteer drivers (2 GM, 3 VW)
- Existing cabin air filters, 3 -12 months since installed
- Test method: city-road driving
- Driving routes: Usually between the drivers' home and office in Beijing city
- Parameters measured: PM2.5 and CO₂
- Reference instrument: Dust trak II model 8357, LI-820

Cooperation partner: School of Environment, Tsinghua University

Test vehicles

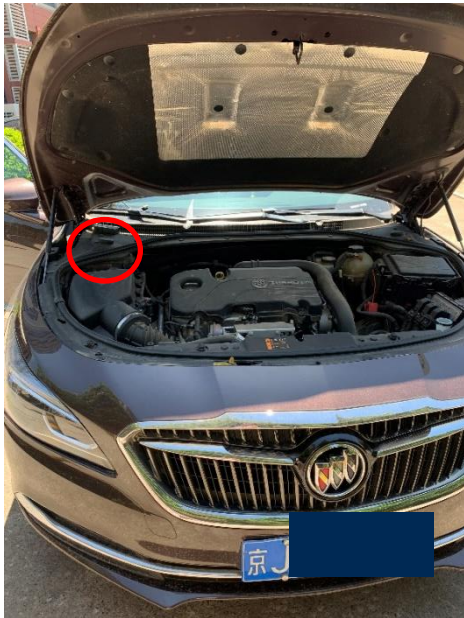
Institute: CabinAir + Tsinghua University

Test method: real-driving tests

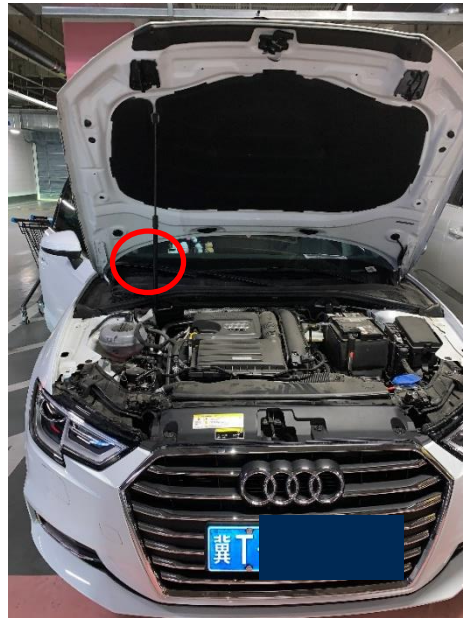
Test vehicles: 5 recruited vehicles (model year 2014-2020)

HVAC ventilation: fresh air

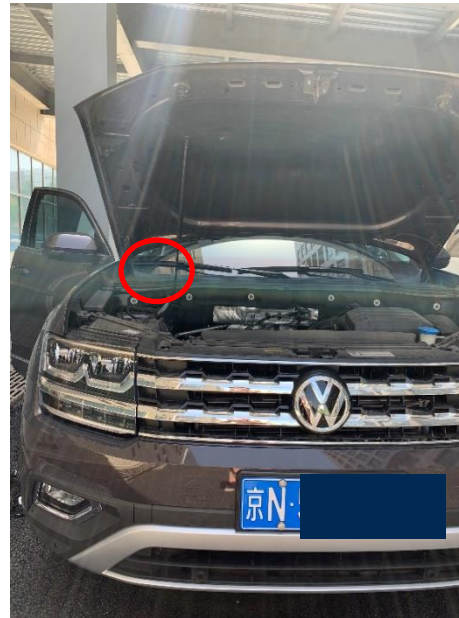
- 5 sets of Data logger units
- 5 indoor sensor modules (PM, CO₂, temp & humidity)
- 5 outdoor sensor modules (PM, temp & humidity)
- Similar location of sensors on different cars



GM Lacrosse



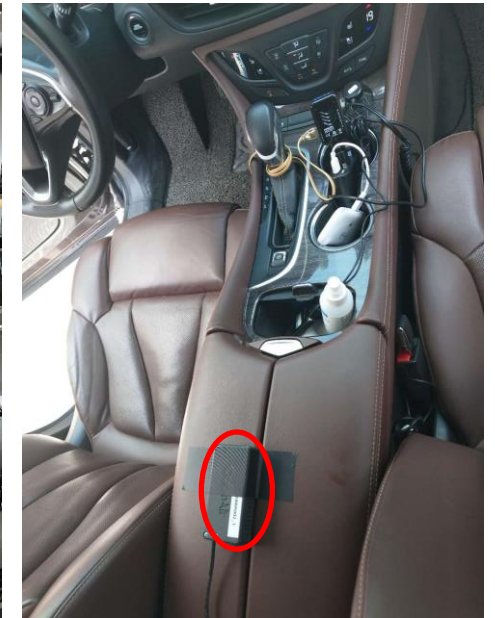
VW Audi



VW Teramont

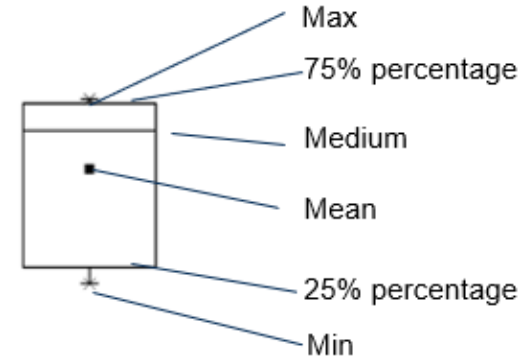
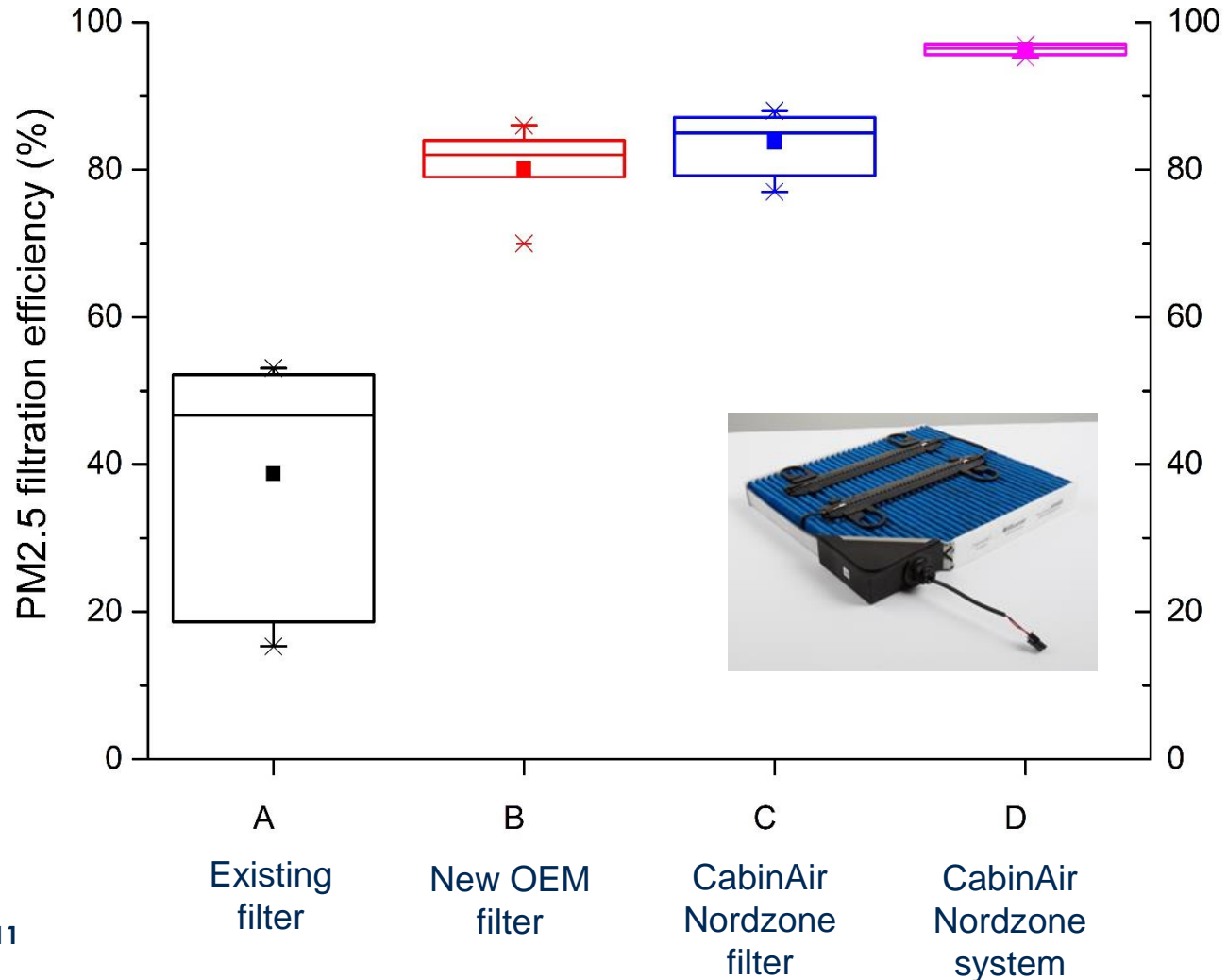


VW Golf



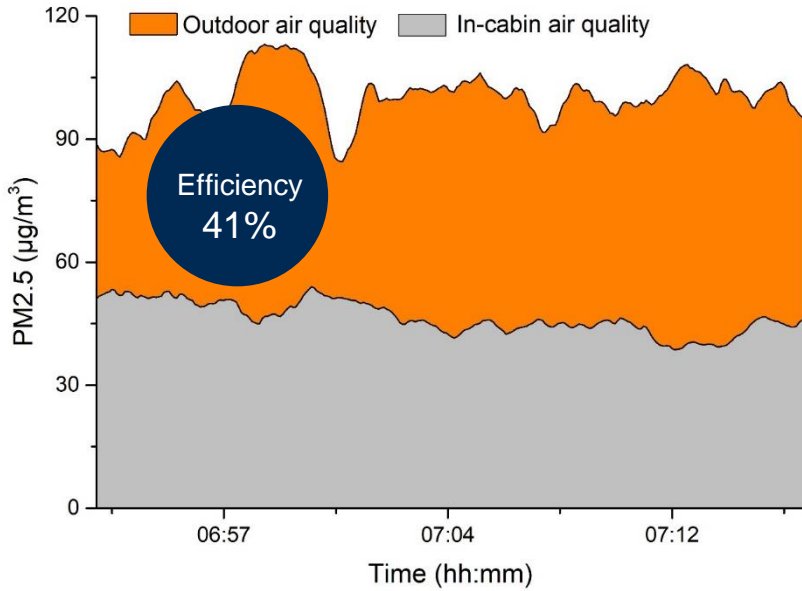
GM Envision

Test result – PM2.5 efficiency



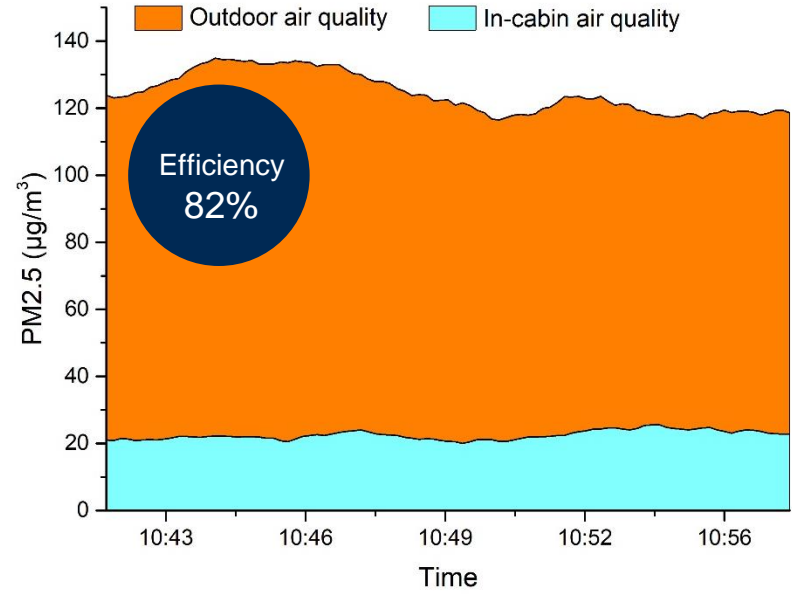
Cabin air cleaning solutions	Number of validated tests	PM2.5 removal efficiency
Existing filters	6	40%
New original OEM filter	5	80%
CabinAir Nordzone filter	7	84%
CabinAir Nordzone system	4	96%

Examples of in-cabin air quality



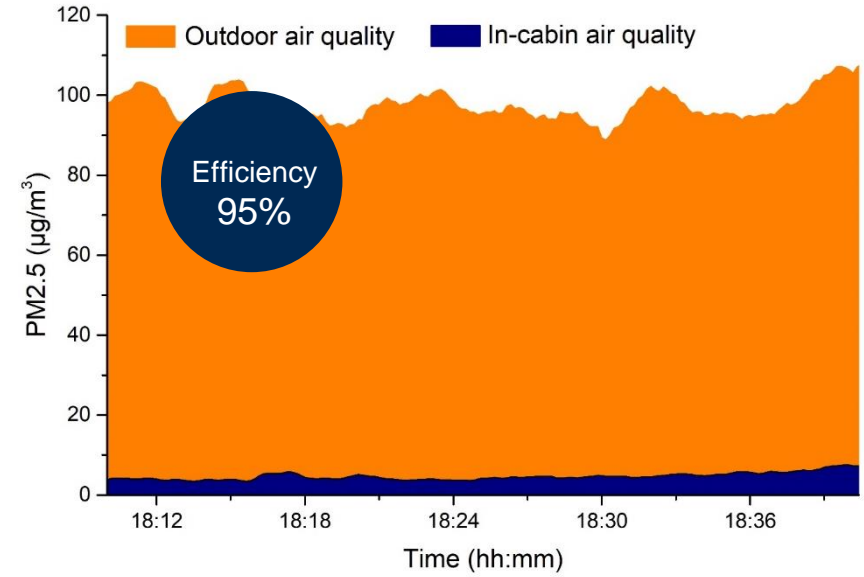
2020-05-28
Teramont

Existing filter



2020-07-01
Teramont

Newly installed original
OEM filter

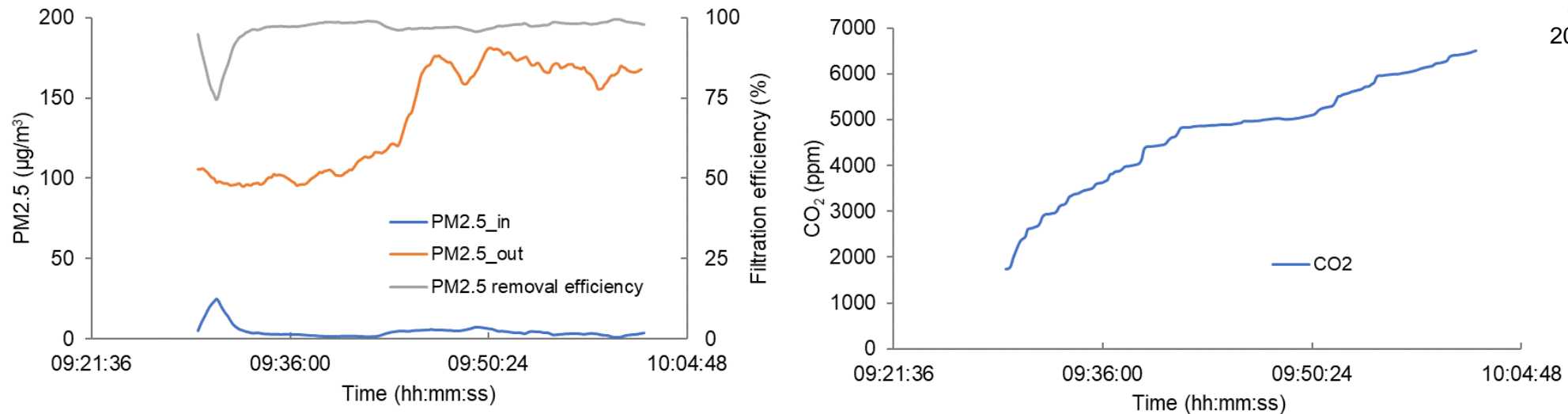


2020-06-23
Golf

CabinAir Nordzone™
system

Recirculation and CO₂ increase

Recirculation was activated automatically on some vehicles even though it was set to be off in the beginning



Number of passengers: 3

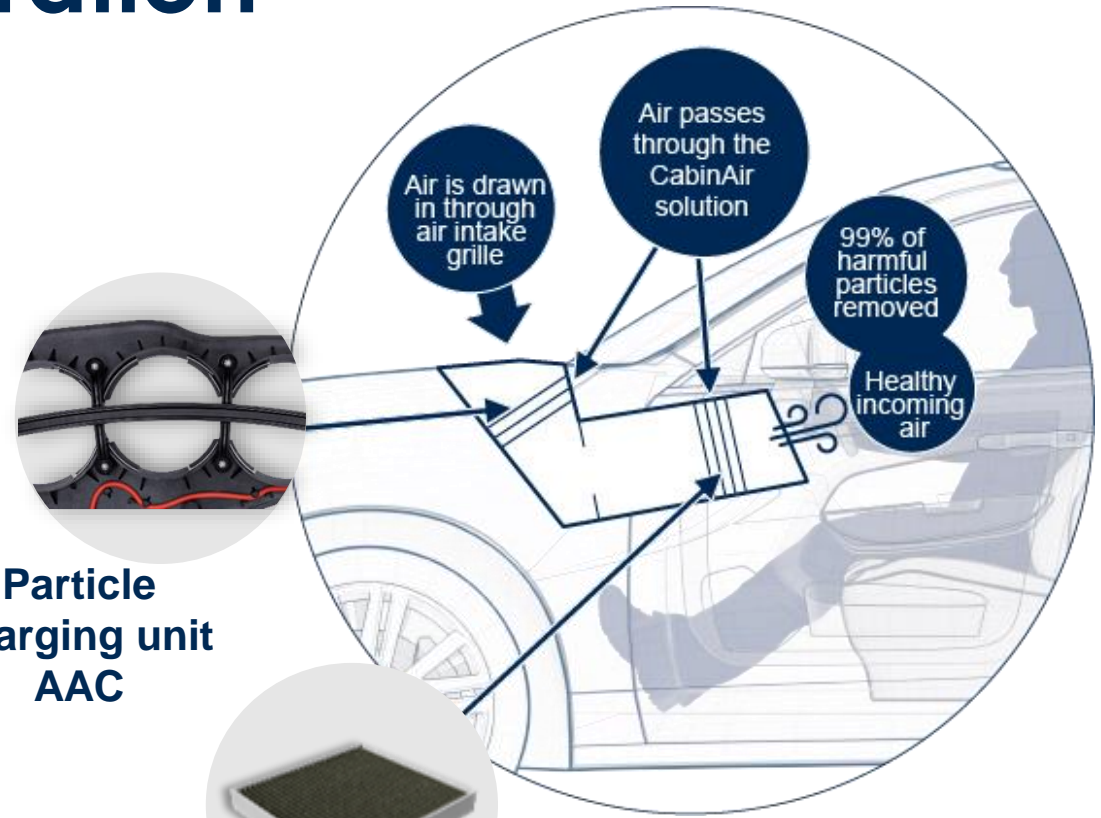
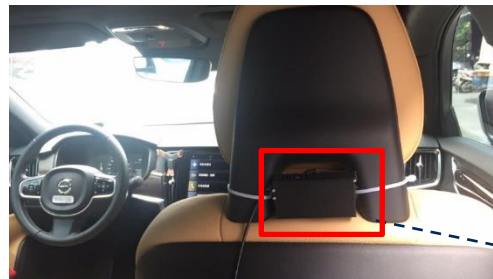
HVAC ventilation setting: recirculation off (confirmed by the driver)

Cabin air filter: Nordzone filter

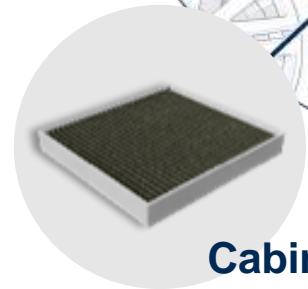
Long-term test of vehicle filtration

CabinAir Advanced Air Cleaner solution:
Based on Blueair HEPASlient™ two-step
technology (ionization + filtration)

Vehicle test in Shenzhen, China



Particle charging unit AAC



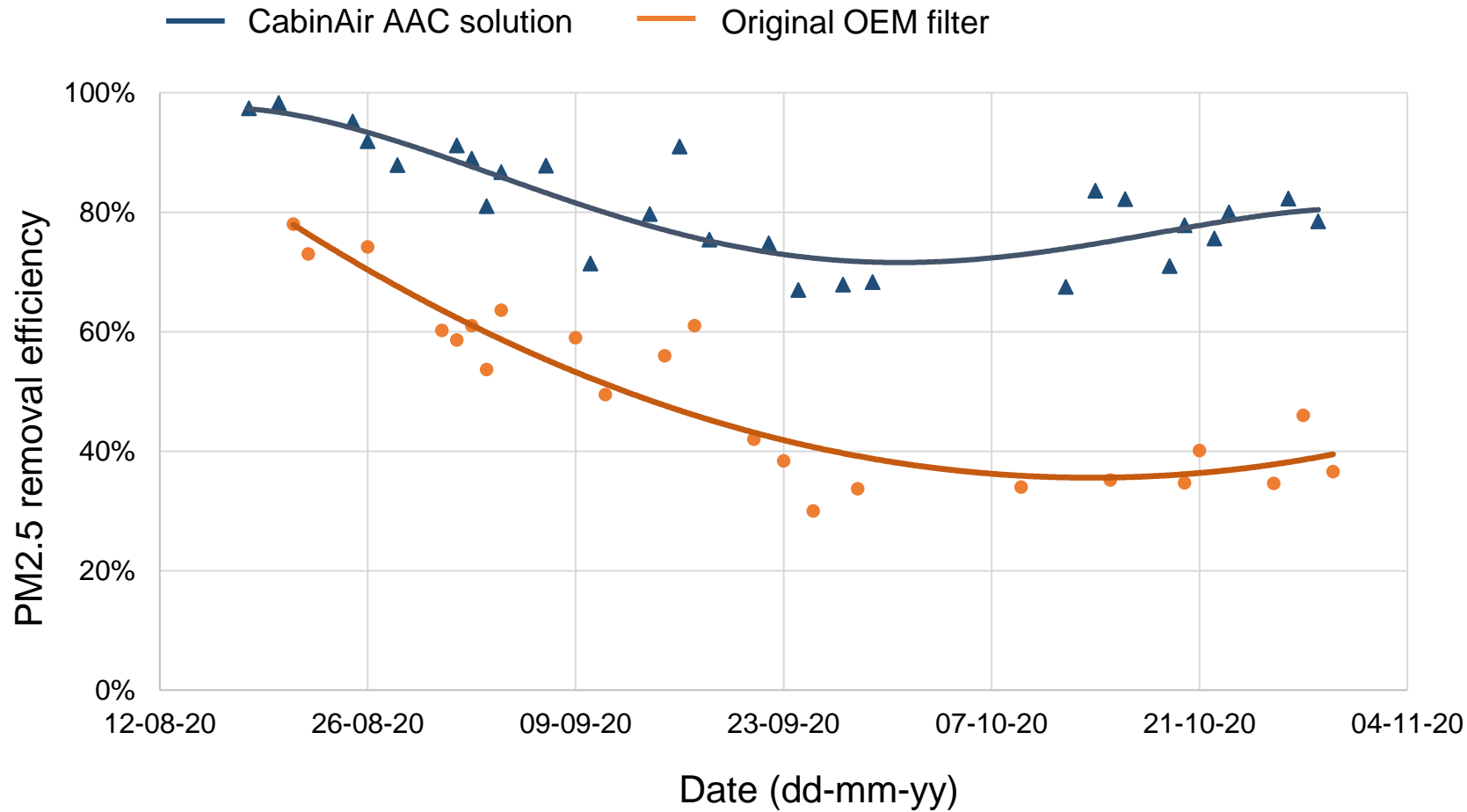
Cabin air filter

Outdoor sensors

Indoor sensors

CabinAir

Long-term performance



Location of test: Shenzhen
Driving time per day: > 60 min
No. of days with filter: 23
No. of days with AAC: 27

Original filter: OEM filter
Filter Installed: 2020-08-18
AAC installed: 2019-09-30

Vehicle settings
Ventilation: Fresh air
Fan speed: medium

Summary

1. The CabinAir mobile test method can be used for short-term, long-term, and fleet vehicle test for VIAQ and filter filtration performance evaluation
2. Boundary conditions are important to properly evaluate the performance of different cabin air cleaning solutions
3. CO₂ measurement should be done in parallel to avoid impact of recirculation
4. Aged filters (>3 months used) can filter out 20-50% small particles
5. Ionization technology can significantly improve the PM2.5 efficiencies of both new and aged filters



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