

# Proposal for the test mode

2019.1. 9

Based on VIAQ-07-08,  
VIAQ-08-08,  
VIAQ-14-15

Korea Transportation Safety Authority

Korea Automobile Testing & Research Institute

# Background

## ➤ Background

- ✓ **Consumer complaints “Exhaust gas entering into vehicle cabin”**
- Exhaust smell can disturb driving and raises safety concerns
- ✓ **Ministry of Land, Infrastructure and Transport had launched an investigation into this issue**
- Possible leakage of exhaust fumes and exposure to carbon monoxide inside the vehicle
  - Defect Investigation in 2011 [49 vehicles] and in 2016 [1 vehicle]
  - Free repair service 3 vehicle models in 2012 and 1 model in 2016



< KBS news regarding “exhaust gas entering into vehicle cabin” >



		<b>보도참고자료</b> 2012.6.29(금) 제 1호(보문 1)	참여하는 공익사회 더 큰 희망 대한민국
담당 부서 자동차운영과	담당자 * 과장 조우형, 사무관 송영삼, 김용원 * 총 (02)2110-8694, 8697	보 도 일 시 즉시 보도 가능합니다.	

**현대차 그랜저 배기가스 유입 법과 원칙에 따라 처리**  
- '현대차 신형 그랜저 결함은혜 의혹' 검찰조사 관련 -

□ **참고내용**

- 국토해양부는 현대자동차 신형 그랜저 배기가스 실내유입을 인정한 즉시 전문가(교통안전공단 자동차안전연구원)에 조사토록 하여 기준과 절차에 따라 적극적인 무상수리를 하도록 하였음
- 당시 교통안전공단의 조사결과에 대해 외부전문가, 시민단체 및 소비자단체로 구성된 '자동차제결함심사평가위원회'에서
  - 배기가스 유입 허용량에 대한 기준이 국내는 물론 국제적으로 없고, 급가속을 반복(80km~140km/h)하는 극단적인 운행조건에서만 8~30ppm의 일산화탄소가 일시적으로 유입되는 것이 확인되었으나,
  - 계속주행상태가 되면 다시 배기가스가 없어지고, 의학전문가에 의뢰한 결과도 안전운행에 지장이 있다고 결론내리지 못해 리콜이 아닌 적극적 무상수리로 결정을 한 것임

< 보도 내용 (경향신문 6.29일, 12면 사회) >

현대차 신형 그랜저 배기가스 유입 일고도 리콜 않고 숨긴 혐의(결함은혜 의혹)로 검찰조사

이 보도자료와 관련하여 보도 자재한 내용이나 취재를 원하시면 국토해양부 자동차운영과 김용원사무관(☎: 2110-8697)에게 연락주시기 바랍니다.

< Official Press Release by MOLIT >

# Case Study

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## ➤ How could the exhaust gas enter into vehicle cabins?

- ✓ When cars highly accelerate with the condition on internal circulation mode, exhaust gases could enter the passenger compartment due to pressure difference in cabin and vortex flow in back part of the car.





< Recirculation mode >



< Fresh air mode >

- ✓ **Warning in vehicle owner`s manual** : The boot lid must always be completely closed when the vehicle is moving, otherwise exhaust fumes can be drawn into the interior

Display messages	Possible causes/consequences and ► Solutions
	Sedan: the trunk lid is open. ► Close the trunk lid.
	Wagon: the tailgate is open. <b>⚠ WARNING</b> When the engine is running, exhaust gases can enter the vehicle interior if the tailgate is open. There is a risk of poisoning. ► Close the tailgate.

### Closing boot lid

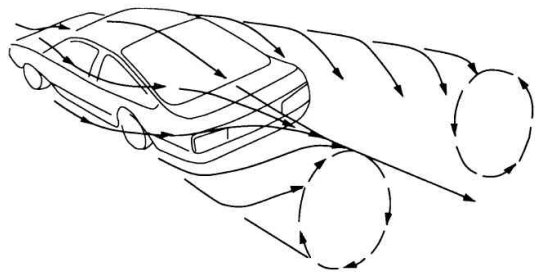
- Pull down the boot lid by the handle on the inside and let it drop into the latch = ⚠.

<b>⚠ WARNING</b>
• After closing the boot lid, always check that the catch has engaged properly. The boot lid could otherwise open suddenly when the vehicle is moving - this could result in an accident.
• The boot lid must always be completely closed when the vehicle is moving, otherwise toxic exhaust fumes can be drawn into the interior.

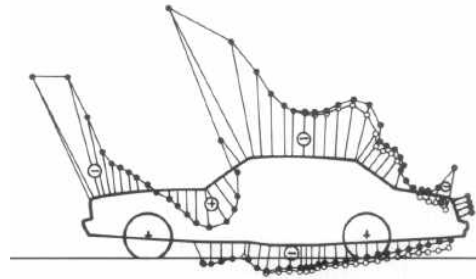
# Study on CFD(Computational Fluid Dynamics)

## ➤ Computational Fluid Dynamics(CFD)

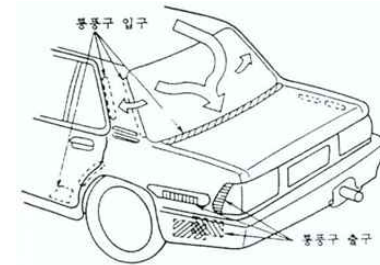
- ✓ Simulation for exhaust gases entering into cabin using the CFD method



<Vortex flow in back part of vehicle>



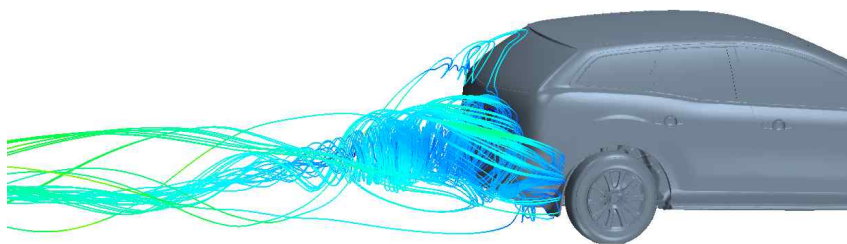
< Pressure of vehicle surface in high speed >



< position of extractor >

\* Source : Fundamentals of Vehicle Dynamics, Thomas D. Gillespie

- ✓ The vortex flow occurs in the back part of sedan vehicles depending on vehicle speed



0.00000 12.000 24.000 36.000 48.000 60.000  
Velocity: Magnitude (m/s)

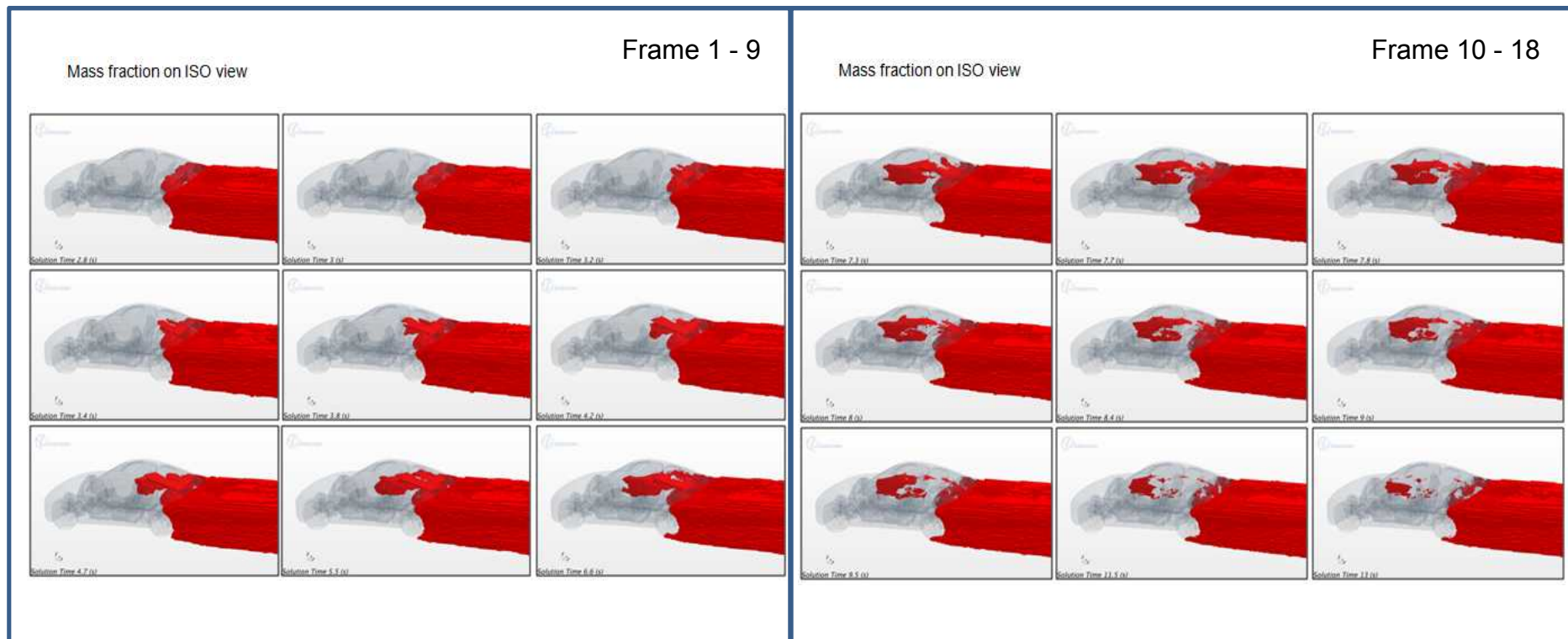


0.00000 12.000 24.000 36.000 48.000 60.000  
Velocity: Magnitude (m/s)

# Study on CFD(computational Fluid Dynamics)

## ➤ Computational Fluid Dynamics(CFD)

- ✓ Simulation for exhaust gases entering into cabin using the CFD method



## ➤ Test mode for exhaust gases entering into cabin

### ✓ Idling mode, (basic conditions)

- Engine idling in normal condition

### ✓ Constant speed driving mode, (normal conditions)

- $80 \pm 5$  km/h,  $100 \pm 5$  km/h,  $120 \pm 5$  km/h,  $140 \pm 5$  km/h

### ✓ Acceleration mode, (worst-case conditions)

- Accelerate vehicles from 65 km/h to 130km/h right after that coast-down (deceleration) to 65 km/h, repeat mode

### ✓ Real-road driving mode

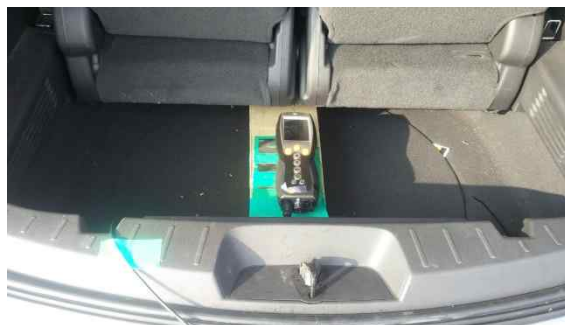
- Real-road driving mode with/without acceleration

## ➤ Proving Ground Test

- ✓ Proving ground driving test
  - Idling condition, cruising speed condition, acceleration condition
- ✓ Test vehicle : Gasoline vehicle, 3,000 cc, sedan
- ✓ Measurement devices setting position
  - Nose position of front seat, back seat
  - Center position of truck
  - Rear of vehicle



<front and rear seat>



<center of trunk>



<rear of vehicle>

## ➤ Gas and Speed Measuring Devices

- ✓ Test Device : Vbox mini
  - Speed Range : 0.1 ~ 1,609 km/h
  - Resolution : 0.1 km/h
  - Accuracy : 0.2 km/h
  
- ✓ Test Device : Testo 330 LL
  - CO Range : 0~500 ppm
  - Resolution : 0.1 ppm
  - Accuracy :  $\pm 2$  pm(0.0~39.9 ppm), Other range  $\pm 5\%$
  
- ✓ Test Device : Testo 350K
  - NO Range : 0~300 ppm
  - Resolution : 0.1 ppm
  - Accuracy :  $\pm 2$  pm(0.0~39.9 ppm), Other range  $\pm 5\%$
  - NO2 Range : 0~500 ppm
  - Resolution : 0.1 ppm
  - Accuracy :  $\pm 5$  pm(0.0~39.9 ppm), Other range  $\pm 5\%$



<Speed device>



<CO device>



<NO, NO2 device>



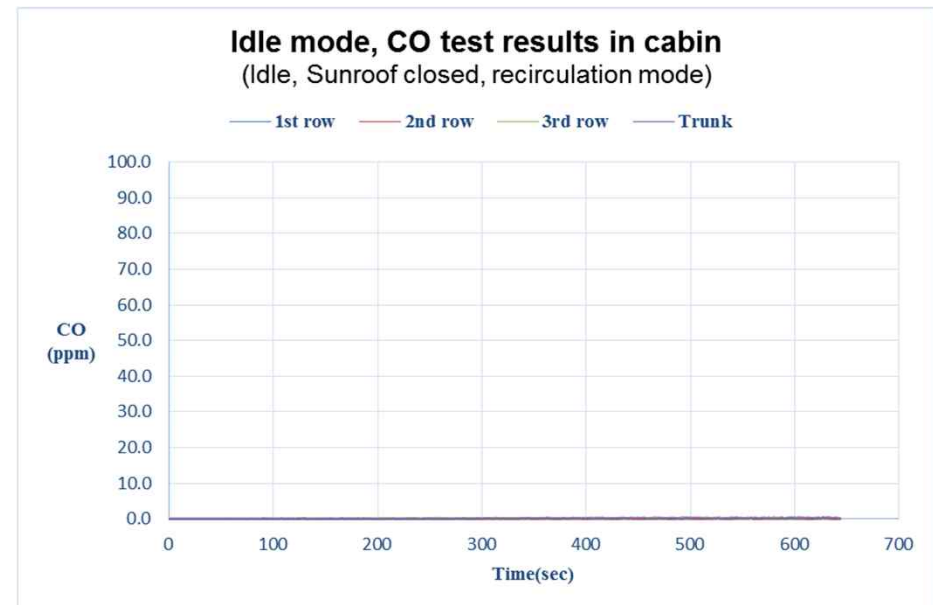
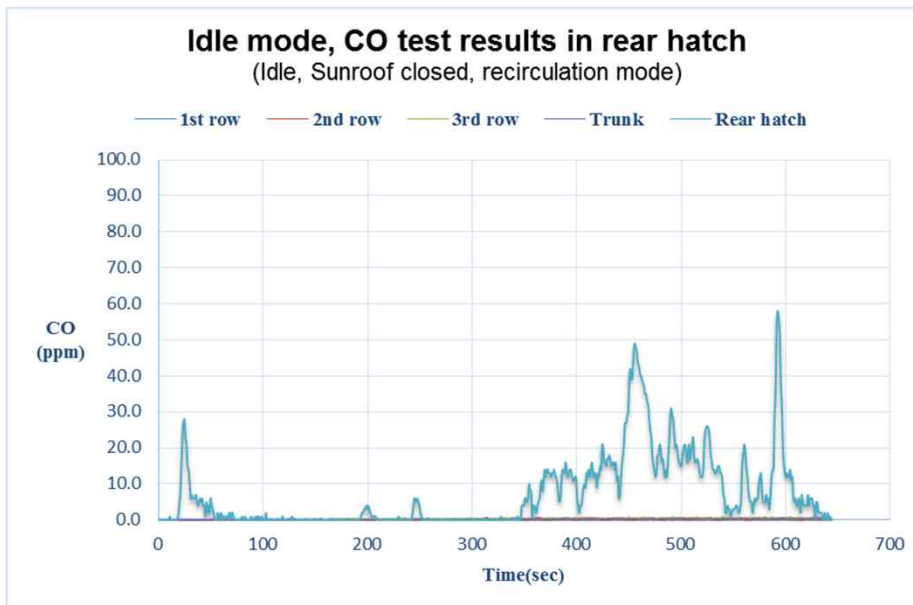
# Proving Ground Test

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## ➤ Idling mode test

- ✓ Engine idling in normal condition, not moving
- ✓ Total test time : 10 min
- Stabilizing time : 5 min, Measuring time : 5 min
- ✓ CO was detected in the rear hatch, but not detected in cabins



# Proving Ground Test

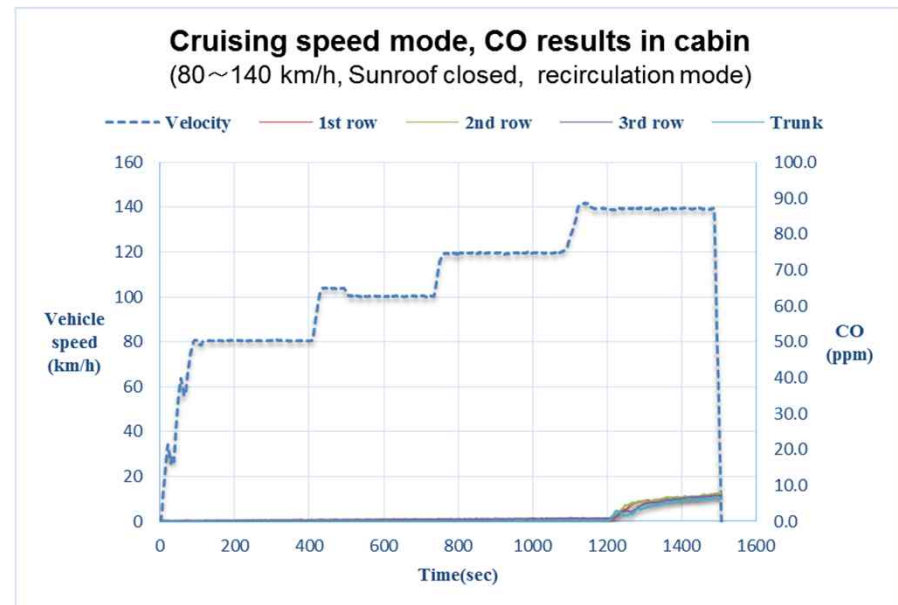
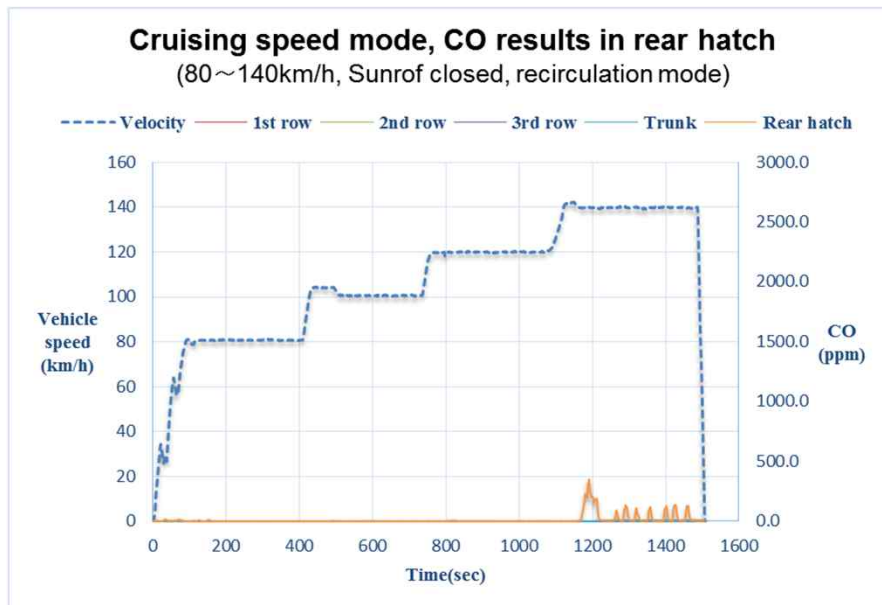
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## ➤ Cruising speed driving mode

### ✓ Cruising speed driving mode, (normal conditions)

- $80 \pm 5$  km/h,  $100 \pm 5$  km/h,  $120 \pm 5$  km/h,  $140 \pm 5$  km/h
- Each test time in stated speed : 5 min
- If CO is detected in test speed, test again that speed in 20 min
- CO was detected in 140 km/h,



# Proving Ground Test

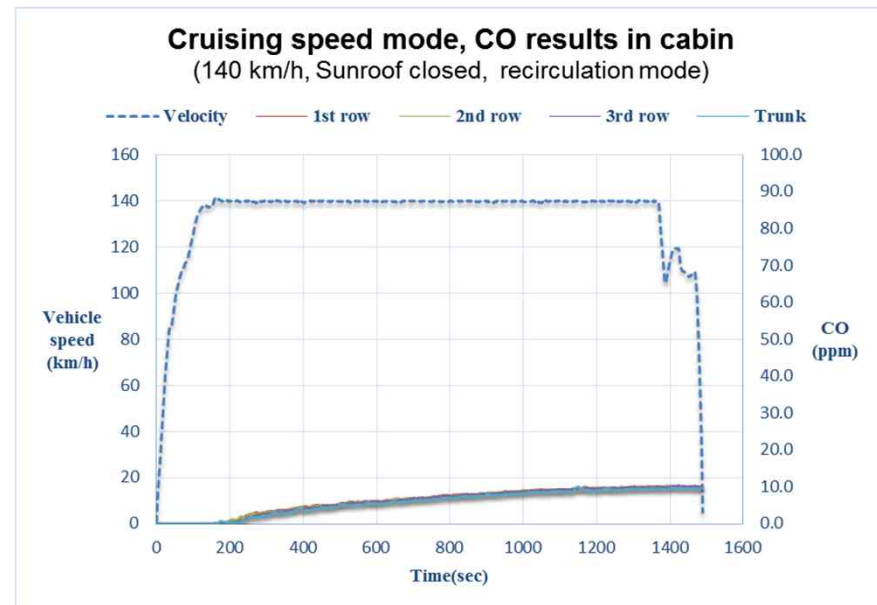
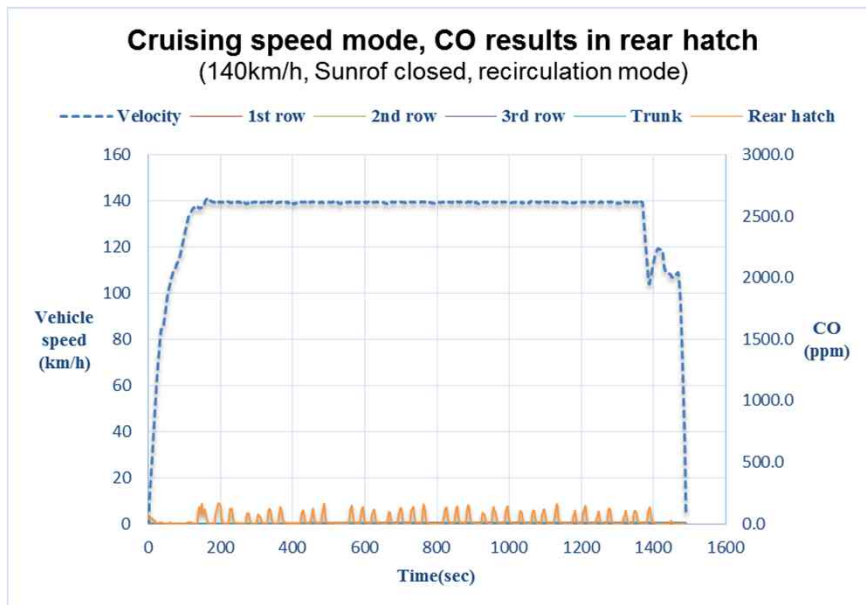
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## ➤ Cruising speed driving mode

### ✓ Cruising speed driving mode

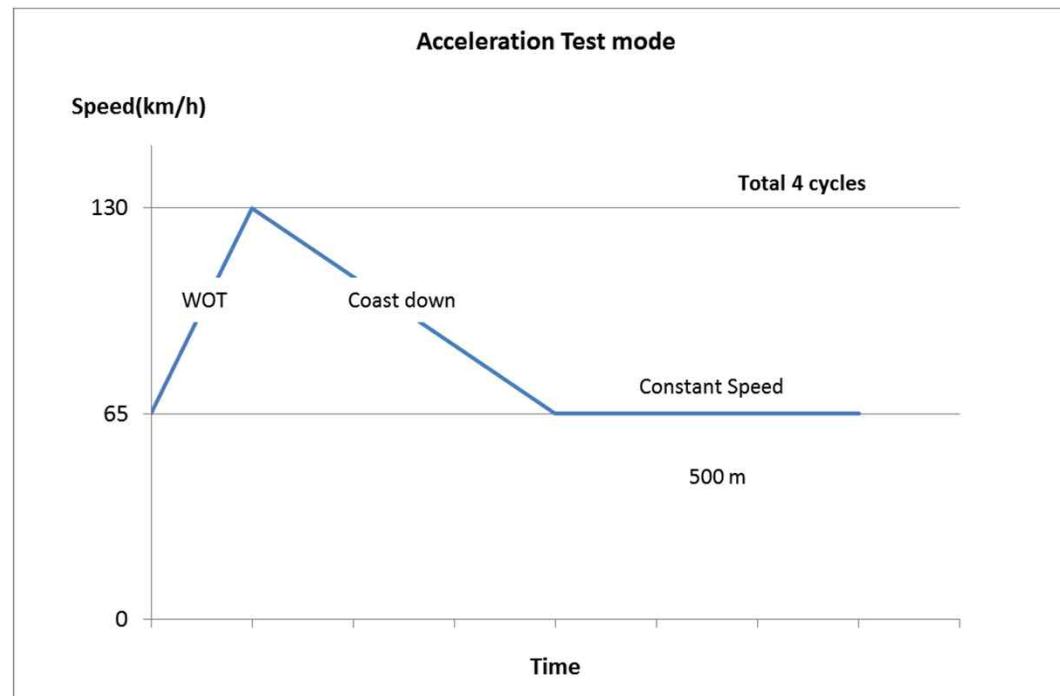
- $140 \pm 5$  km/h
- Total test time : 20 min (stabilizing time 10 min, measuring time 10 min)
- CO was detected in cabin with 140 km/h ( 8 ~ 9 ppm)



## ➤ Acceleration mode

### ✓ Acceleration mode, (worst-case conditions)

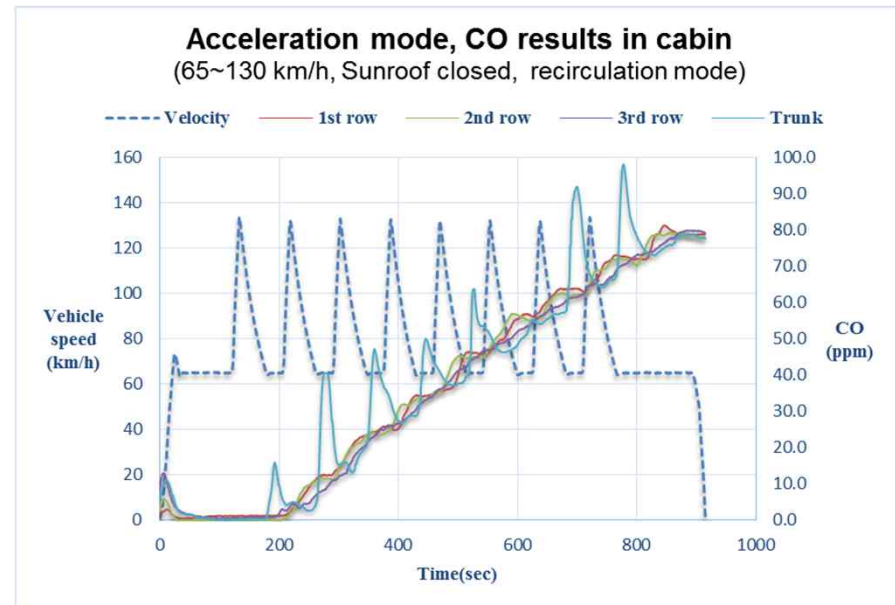
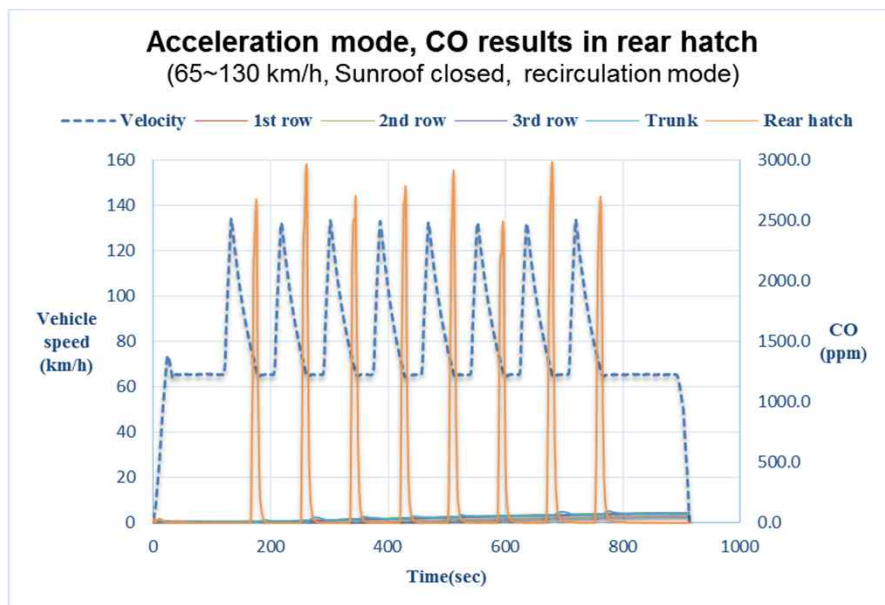
- Test cycle : accelerate vehicles from 65 km/h to 130km/h (WOT), right after that coast-down (deceleration) to 65 km/h, cruise drive 500 meter, and then repeat mode
- Total 8 cycle ( 4 stabilizing cycle, 4 measuring cycle)



## ➤ Acceleration mode

### ✓ Acceleration mode, (worst-case conditions)

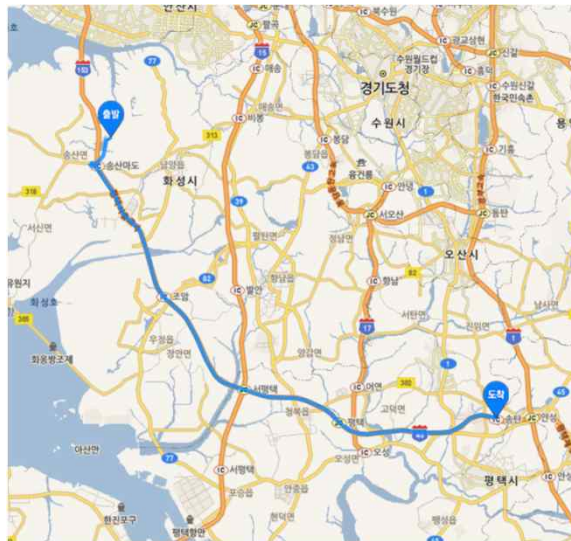
- When accelerating, high concentration of CO was detected in rear area (max 3,000 ppm)
- When accelerating, CO enter into the trunk zone through the rear of hatch (max 100 ppm)
- CO concentration was increased gradually from 40 ppm to 80 ppm



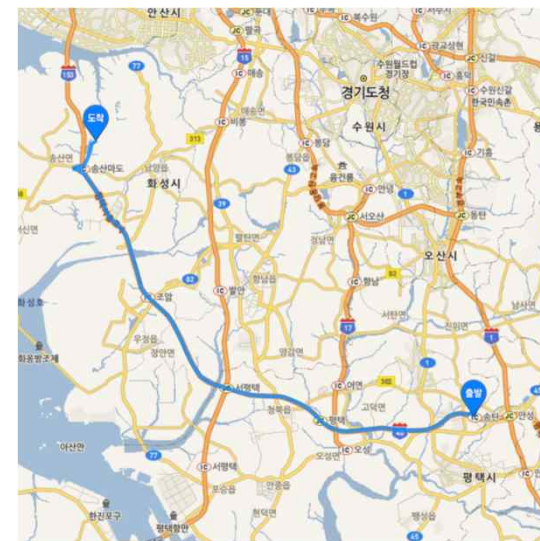
## ➤ Real-road Driving test

### ✓ Real-road driving mode

- Real-road driving test in same course with/without acceleration (2 mode)
- Driving course : 45 km (most of highway road)
- Average vehicle speed : approx 80 km/h
- Driving time : approx 40 min



<KATRI -> Songtan IC>



<Songtan IC -> KATRI>

# Real-road Driving Test

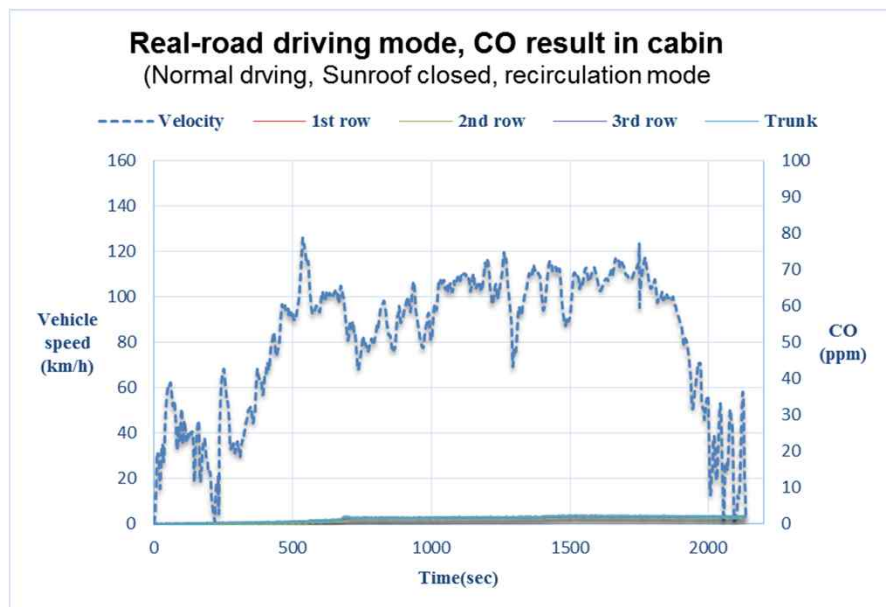
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## ➤ Real-road Driving test

### ✓ Real-road driving mode

- Real-road driving test in same course without acceleration
- Smoothing driving, Throttle open not more than 50%
- CO was not detected in cabin



# Real-road Driving Test

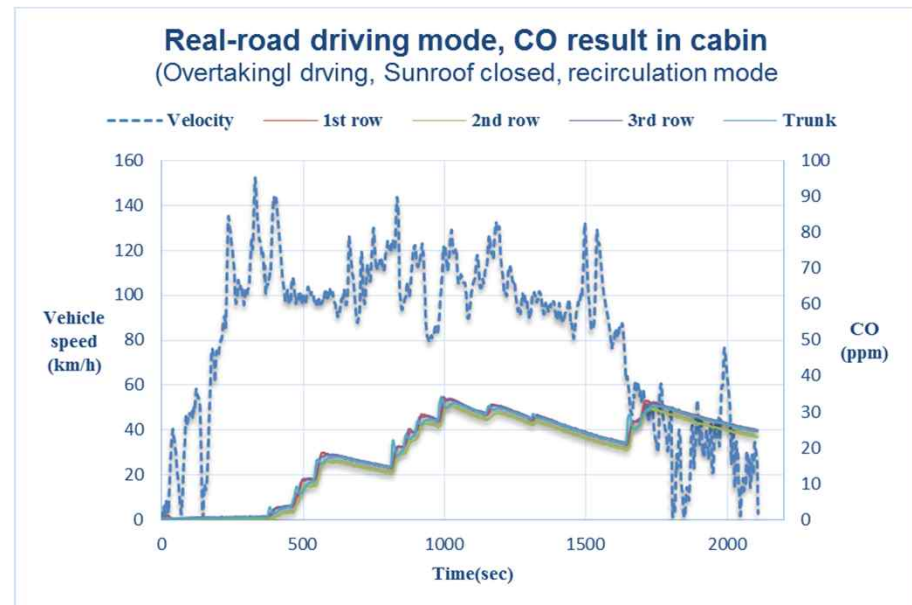
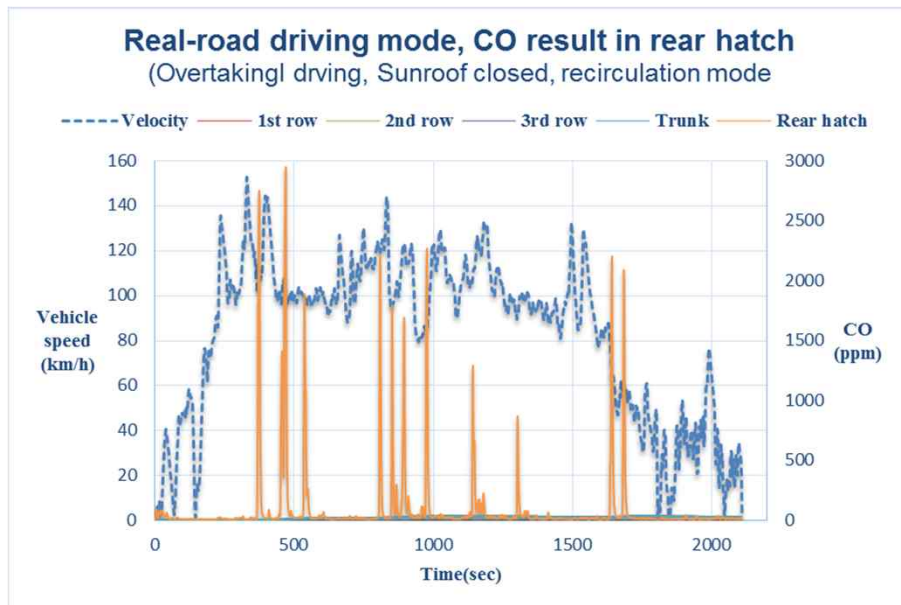
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## ➤ Real-road Driving test

### ✓ Real-road driving mode

- Real-road driving test in same course with acceleration (near WOT)
- Overtaking driving depending on road traffic
- CO was detected in cabin 20 ~ 35 ppm





# Test Results

## ➤ Test results

- ✓ CO gas could enter into cabin with acceleration or high speed driving, especially for overtaking driving in highway, with the condition of the recirculation mode
- ✓ After repair, CO gas was not detected in most test mode
- ✓ Rear hatch door sealing problems, air extractor design, sunroof tilt open, tail pipe position might affect exhaust leak into cabin

Test results for CO gas incursion		Before repair		After repair	
Sunroof		closed	tilt open	closed	tilt open
Idle mode		N.D.	-	N.D.	-
Cruising mode	80	N.D.	N.D.	N.D.	N.D.
	100	N.D.	N.D.	N.D.	N.D.
	120	N.D.	N.D.	N.D.	N.D.
	140	8~9 ppm	0~3 ppm	0~3 ppm	0~2 ppm
Acceleration mode		40~80 ppm	30~35 ppm	N.D.	10~15 ppm
Real-road driving mode	Normal driving	N.D.	-	N.D.	-
	Overtaking driving	20~35 ppm	-	0~2 ppm	-

# Discussion on test mode

## ➤ Proposal for Test mode

<b>Test mode, if exhaust gases, which are generated from their own engine, could enter into cabin</b>	
<b>Idling mode</b>	- Russian Proposal
<b>Constant speed mode</b>	- Driving vehicles at constant speed (e.g. 130±5 km/h)
<b>Acceleration mode</b>	- Test mode : Accelerate vehicles from 65 km/h to 130km/h after that coast-down (deceleration) to 65 km/h , repeat 8 cycle, - Target : SI Engine, CO should be measured

# Thank you

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Korea Transportation Safety Authority

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