

# **Introduction of the research concerning exhaust gas from the vehicle entering cabin**

2017. 1. 11

Korea Transportation Safety Authority

Korea Automobile Testing & Research Institute

## ➤ 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]
  - 3 vehicle models : Free repair service in 2012



< 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 * 직 (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 '자동차제작결함심사평가위원회'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,
  - 경속주행상태가 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 취재해 원하시면 국토해양부 자동차운영과 김용원사무관(☎:2110-8697)에게 연락주시기 바랍니다.

< Official Press Release by MOLIT >

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

- ✓ When cars pick up speed with the air conditioning system 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 = ⚠.

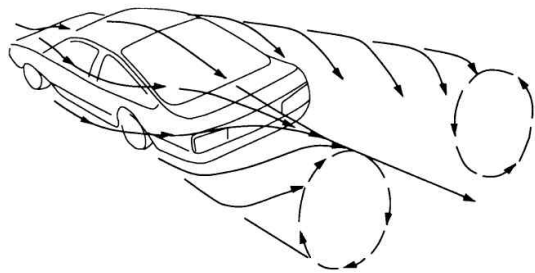
**⚠ WARNING**

- 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.

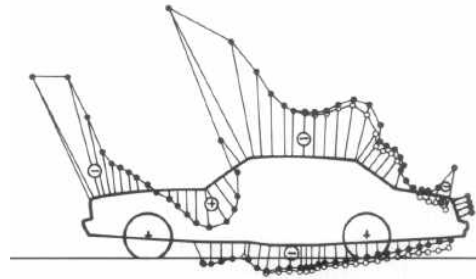
# Study on CFD(Computational Fluid Dynamics)

## ➤ Computational Fluid Dynamics(CFD)

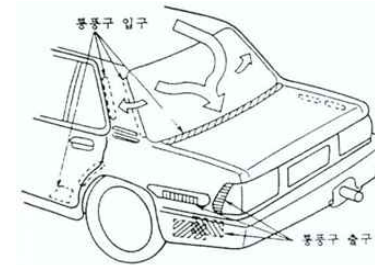
- ✓ Simulation for exhaust gases entering into cabin using the CFD method



<Vortex flow in back part of vehicle>



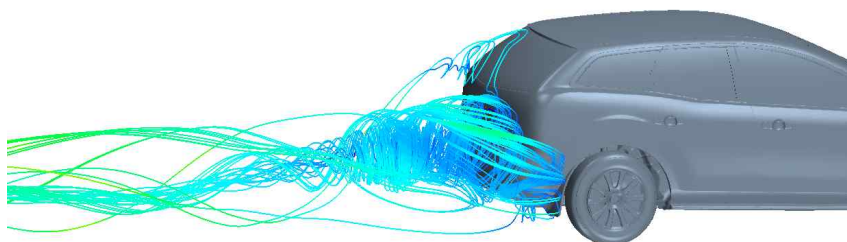
< Pressure of vehicle surface in high speed >



< 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)

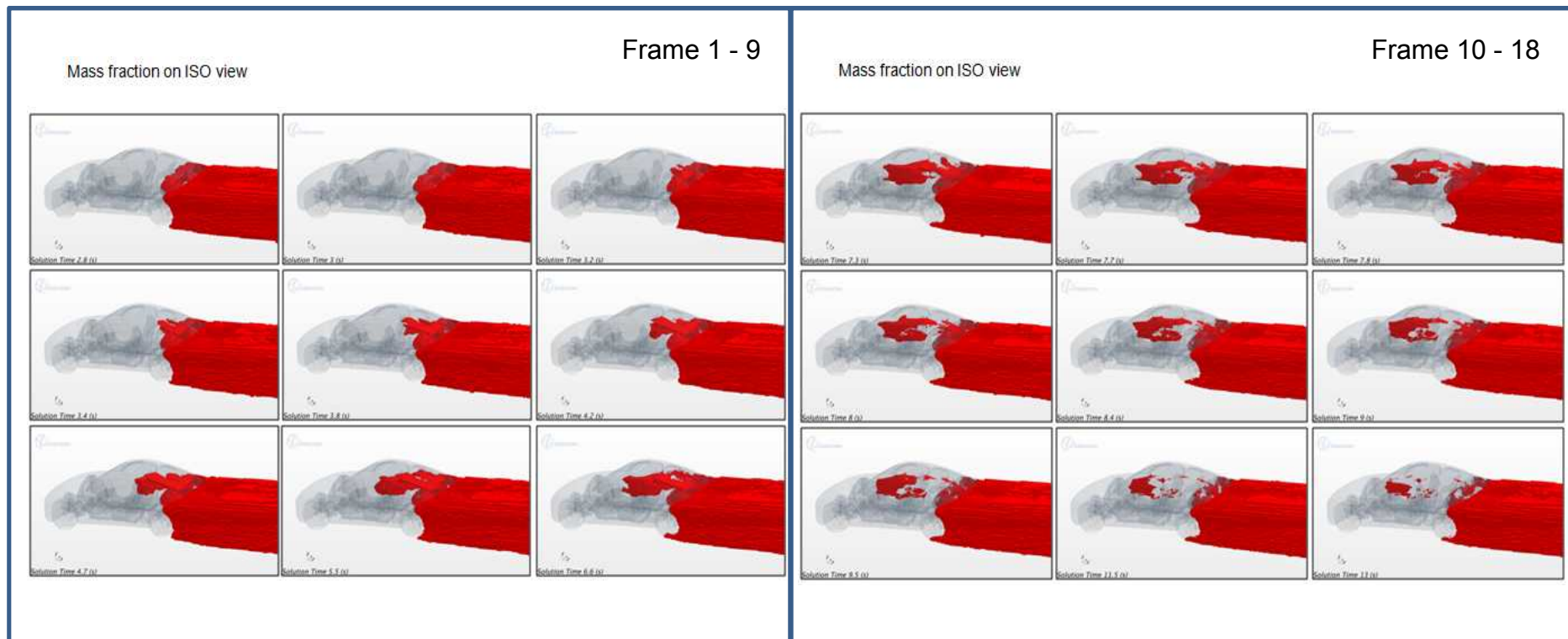


0.00000 12.000 24.000 36.000 48.000 60.000  
Velocity: Magnitude (m/s)

# Study on CFD(computational Fluid Dynamics)

## ➤ Computational Fluid Dynamics(CFD)

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



# Exhaust gas test

KATRI

Korea Automobile  
testing & research  
Institute

## ➤ Study on emission gas test on chassis dynamometer

- ✓ Identify air pollutant sources and measurements on Emission test mode

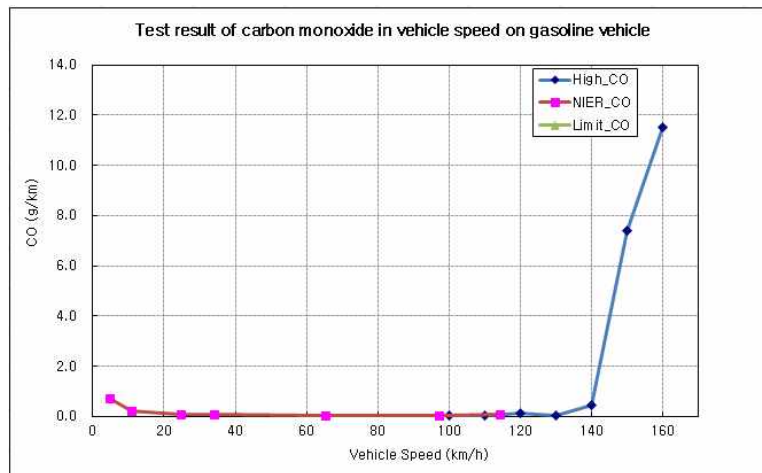


<Chassis dynamometer>

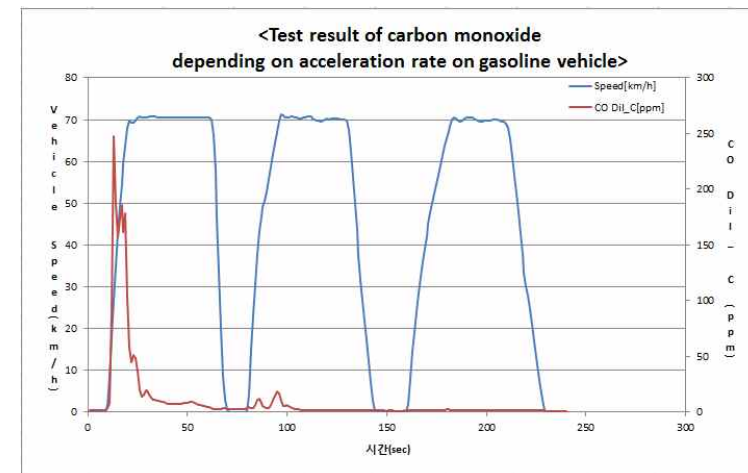


<Exhaust gas analyzer>

- ✓ Carbon monoxide occurring from very high speed (over 140km/h) and high acceleration(WOT)



<Test result of carbon monoxide in vehicle speed on gasoline vehicle>



<Test result of carbon monoxide depending on acceleration rate on gasoline vehicle>

# Interior Air Extractor

KATRI

Korea Automobile  
testing & research  
Institute

## ➤ Expectation pass of exhaust gas entering into cabin

✓ Most vehicles have ventilation holes near trunk area

- i.e. Air Extractor



<Trunk picture>



<Air Extractor>

# Proving Ground Test

**KATRI**

Korea Automobile  
testing & research  
Institute

## ➤ Test for exhaust gas entering into cabin in proving ground

### ✓ Measurement devices setting position

- nose position of front seat, back seat
- center position of truck



<measurement device>



<front seat position>



<back seat position>



<center of trunk>



<sensor of CO>



# Proving Ground Test

**KATRI**

Korea Automobile  
testing & research  
Institute

## ➤ Test for exhaust gas entering into cabin in proving ground

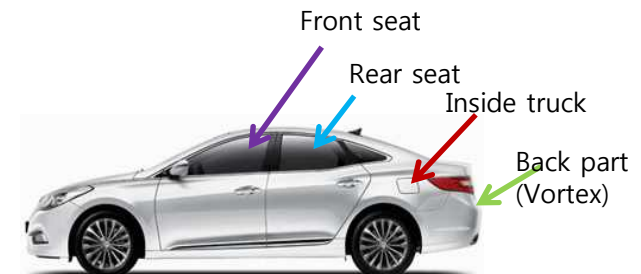
- ✓ Real driving test taking into account CFD and emission test on chassis dynamometer
  - Idling condition, constant high speed condition, high acceleration condition
- ✓ Test vehicle : Gasoline vehicle, 3,000 cc, sedan



<Proving ground>



<test vehicle>



<Position of measurement devices>

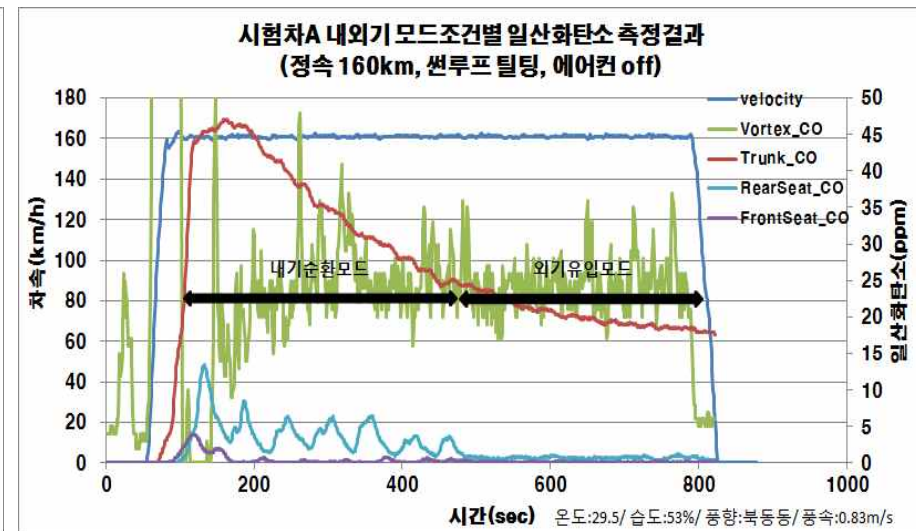
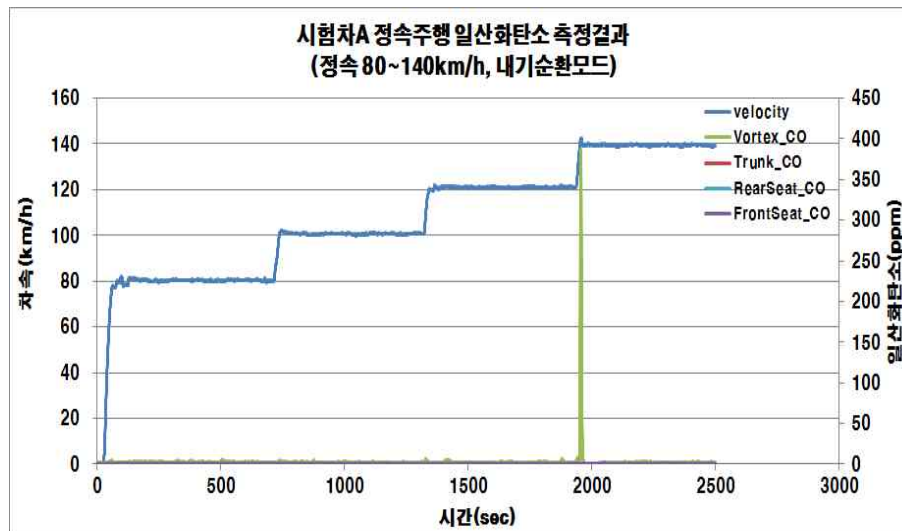
# Proving Ground Test

KATRI

Korea Automobile  
testing & research  
Institute

## ➤ Test for high speed condition (circulation mode/fresh air mode)

- ✓ CO not detected in 80, 100, 120,140 km/h
- ✓ CO detected in 160 km/h, in circulation mode (Front seat 0.5ppm, back seat 4.0ppm)
- ✓ CO not detected in 160 km/h, in fresh air mode



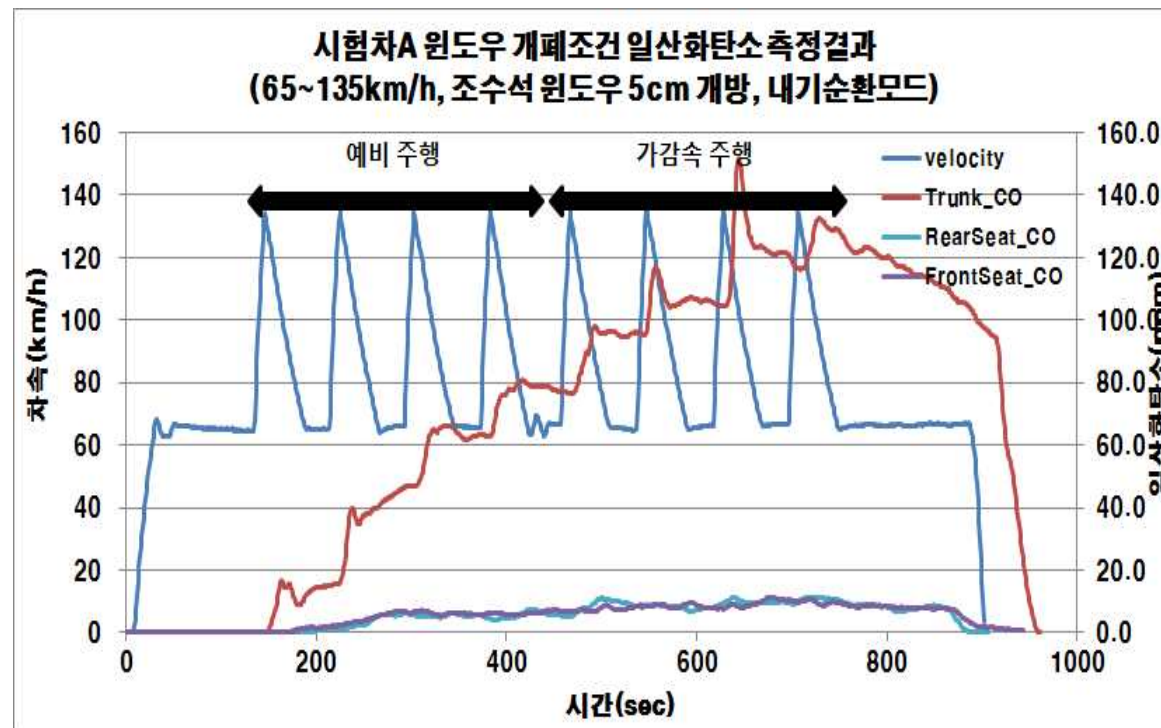
# Proving Ground Test

KATRI

Korea Automobile  
testing & research  
Institute

## ➤ Test for acceleration condition (windows open instead of sunroof)

- ✓ High level of CO detected in trunk in high acceleration condition
- ✓ CO detected in cabin (front seat 8.7ppm, back seat 9.1 ppm)



# Discussion regarding regulation

## ➤ Discussion on exhaust gas entering issues

### ✓ Meeting with car industry association

- KAMA (Korea Automotive Manufacturer`s Association)
- KAIDA (Korea Automotive Importers & Distributors Association)



Existing test mode(2011)	New Test mode for exhaust gases entering into cabin(2016)	
<p>차실내 배기가스 유입현상 조사 시험모드</p> <p>100 km/h(1분) 급가속 120 km/h(1분) 급가속 140 km/h(1분)</p> <p>감속 140 km/h(1분) 급가속 100 km/h(1분) 감속</p> <p>총 6 cycle 주행(약 82km주행, 32분 소요)</p> <p>K7 가감속주행 일산화탄소 측정결과(100~140km/h)</p>	<b>Idling mode (basic condition)</b>	- Engine idling in normal condition
	<b>Constant driving mode (normal condition)</b>	- Driving vehicles at constant speed <ul style="list-style-type: none"> <li>. 80±5 km/h</li> <li>. 100±5 km/h</li> <li>. 120±5 km/h</li> <li>. 140±5 km/h</li> </ul>
	<b>Acceleration mode (worst condition)</b>	- Accelerate vehicles from 65 km/h to 130km/h after that coast-down (deceleration) to 65 km/h , repeat mode

# Discussion regarding regulation

## ➤ Discussion on the draft of test procedures

- Most manufactures agree on using the three test mode instead of existing test mode
- Vehicle categories, substances to be measured, limit values of substances (draft document)
- What kind of regulation will be made from MOLIT? (Under discussion)

## ➤ Conclusion

- ✓ If any contracting parties and members are interested in this issue, we are willing to share our results, technical data, and expertise with you

배기가스 실내유입 측정방법(시험방법) 검토자료	
1. 목적	- 자동차 배기가스 가 실내 유입 여부 확인을 위한 측정방법 및 조건 제출 방법
2. 적용대상	- 승용자동차
3. 측정대상물질	- 일산화탄소
4. 측정장치의 세원	4.1 일산화탄소 측정장치 - 측정범위 : 0 ~ 500 ppm - 분해능 : 0.1 ppm - 정확도 : ± 3 ppm(50 ~ 40.0 ppm), ± 0.5 % (나머지 측정범위)
4.2 속도기록장치	- 측정범위 : 0 ~ 200 km/h - 분해능 : 0.1 km/h - 정확도 : 0.2 km/h
5. 측정조건	5.1 시험조건 - 온도 : 0 ~ 30℃ - 습도 : 90 %RH 이하 - 풍속 : 5m/s 이하
5.2 도로 조건	- 평탄한 비포 노면(교차주행로)
5.3 측정시각이 조건	- 평상, 저속, 대기중, 대기후 달음 등

- 세어선, 저의 중 환기장치를 끄고 내기순환모드로 설정
- 대기순환모드로 설정
5.4 측정 위치
- 교차로 교 포물위(바리 중심 높이)
- 교차로 교 포물위(바리 중심 높이)
- 드림크 중앙 위치
6. 시험방법
6.1 공회전모드(기본 조건)
- 운전할 노면에서 열린 공회전 조건으로 초기
6.2 정속주행모드(일반 조건)
- 자동차가 일정한 속도를 유지하면서 주행
- 80.0 km/h
- 100.0 km/h
- 120.0 km/h
- 140.0 km/h
6.3 가변속주행모드(고속조건)
- 자동차가 65 km/h에서 130km/h로 달기후 5분 뒤 정속으로 65 km/h 까지 감속하는 사이클을 반복 주행
7. 측정방법
7.1 시험절차
- 시험자 독입실 확인
- 차 실내 공간, 내장재, 유리창, 도어 및 계기판 검토 확인
- 연료 90%이상
- 측정 장치를 자실내 설치
7.2 공회전모드 측정방법
- 시험자동차를 도로 조건에서 6시간 이상 온도안정화
- 시험자동차 실내 온도 5m 안에 다른 자동차나 생활물품이 들어가지 않
- 시험이 시작되기전 5분 동안 차문을 모두 열고 환기

- 세어선, 저의 중 환기장치를 끄고 내기순환모드로 설정
- 측정장치를 부착하고 5분 전에 자동차의 시동을 켜
- 20초(±2초)정확 측정 기록
7.3 정속주행모드 측정방법
- 시험이 시작되기전 5분 동안 차문을 모두 열고 환기
- 세어선, 저의 중 환기장치를 끄고 내기순환모드로 설정
- 자동차를 도로로 이동하여 65 km/h(±0.5 km/h) 속도로 주행하여 차속이 안정화 되면 측정용 시작
- 자동차가 65 km/h에서 130km/h로 달기후 5분 뒤 정속으로 65 km/h 까지 감속하는 사이클을 반복 주행
- 20초(±2초)정확 측정 기록
9. 측정 결과 처리
- 측정용 10분간으로 수평 한시도로 기록하여 평균값으로 그 결과를 기록

# Thank you

[jongsoon@kotsa.or.kr](mailto:jongsoon@kotsa.or.kr)

Korea Transportation Safety Authority

Korea Automobile Testing & Research Institute