U.S. Department of Transportation
National Highway Traffic Safety Administration

OFFICE OF DEFECTS INVESTIGATION
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ODI RESUME

Investigation: EA 17-002
Prompted by: PE16-008, Consumer Reports
Date Opened: 07/27/2017 **Date Closed:** 01/17/2023
Investigator: Brian Smith **Reviewer:** Bruce York-B
Approver: Stephen Ridella
Subject: Exhaust Odor in Passenger Cab

MANUFACTURER & PRODUCT INFORMATION

Manufacturer: Ford Motor Company
Products: MY 2011 - 2017 Ford Explorer Including Police Interceptor
Population: 1,474,922

Problem Description: Complaints involving MY 2011 to 2017 Ford Explorers (including Police Interceptor models) report occupants smelling exhaust odors in the occupant compartment. Complainants expressed concerns about exposure to carbon monoxide.

FAILURE REPORT SUMMARY

	ODI	Manufacturer	Total
Complaints:	1,558	4,959	6,517
Crashes/Fires:	15	21	36
Injury Incidents:	86	461	547
Number of Injuries:	127	530	657
Fatality Incidents:	0	0	0
Other*:	0	3	3

***Description of Other:** Two fatality claims,a police claim (2 fatalities),and a civilian claim (1 fatality) were submitted to Ford. ODI reviewed the claims and excluded them from the fatality count. ODI has nothing to add to Ford's assessment of these claims in their IR response.

ACTION / SUMMARY INFORMATION

Action: Close Investigation EA17-002

Summary:

During the EA17-002 investigation, the agency reviewed and analyzed reports of exhaust odors in the passenger cabins of Model Year 2011 to 2017 Ford Explorers. This investigation required an approach that incorporated knowledge and expertise from the automotive, medical, environmental health, and occupational safety fields. The agency conducted an in-depth investigation that encompassed the review of over 6,500 consumer complaints, conducting field inspections, and testing the relevant vehicles, both independently and in coordination with Ford and other entities. During the investigation, the evolution of Ford service bulletins intended to reduce the level of exhaust odors and carbon monoxide (CO) entering the occupant compartment was examined and independent tests to evaluate the effectiveness of the final Field Service Actions (FSA) for both consumer and police vehicles were conducted. As part of the investigation, the agency also examined the effects of cracked exhaust mani-cats on the measured CO levels in the vehicles and tested the FSA repairs to ensure they did not adversely impact occupant compartment CO levels due to cracked mani-cats.

The investigation identified upfitting issues for Police Interceptor vehicles. Upfitting (sirens, lights, cages, auxiliary power, etc.) is typically performed by governmental fleet operations, independent repair facilities, or local Ford dealers after the sale of the new vehicle. Sealing issues caused by upfitting were responsible for the highest measured carbon monoxide levels in tested vehicles. The police FSA instructs how to inspect the quality of the vehicle upfits and how to properly seal any leaks caused by these upfits, at no cost to the police agency. Similarly, the highest CO levels measured in consumer vehicles were usually traced to sealing issues caused by rear crash damage where the repairs did not ensure sealing integrity. The most recent Ford FSA procedure for both the police (17B25) and consumer vehicles (17N03) includes an HVAC reprogramming operation. Tests by Ford and NHTSA have demonstrated a substantial reduction of CO levels due solely to the HVAC reprogramming. Other FSA repairs also demonstrated measurable contributions to CO level reductions during controlled tests.

Throughout the investigation, vehicles accurately measured with higher levels of carbon monoxide were almost always affected by upfitter alterations, damage, or other causes compromising rear passenger cabin seals.

NHTSA received thousands of reports alleging odors which triggered a variety of physiological responses, predominately nausea, headaches, and lightheadedness. NHTSA focused the investigation on accurately measuring vehicle CO levels, and accurately measuring carboxyhemoglobin (COHB) levels from properly administered blood tests. Using rigorous test methods to produce exhaust gas intrusion in vehicles with a properly performed FSA, occupant compartment CO levels remained below current environmental limits for CO in any environment (EPA ambient air quality standards). Furthermore, even without FSA repairs, no vehicles unaffected by upfitter issues or prior crash damage were identified with CO levels that exceed accepted occupational CO exposure levels. This investigation finds that the 2011-2017 Ford Explorer vehicles when accurately measured produce occupant compartment CO levels which fall below current accepted health standards, and could not identify COHB levels for vehicle drivers or other occupants, which exceeded thresholds for acute physiological effects. Therefore, the agency has not identified a defect that represents an unreasonable risk to motor vehicle safety.

This investigation is closed. The closing does not constitute a finding by NHTSA that no safety related defect exists. The agency reserves the right to take further action if warranted.

A detailed discussion of the investigation and related complaint numbers can be viewed in the attached closing report.

EA17-002 Closing Report
Ford Explorer Exhaust Odor

Contents

I. Overview

NHTSA's Office of Defects Investigation (ODI) opened Engineering Analysis (EA)17-002 to document the investigation of reports describing exhaust odors in the passenger cabins of Model Year 2011 to 2017 Ford Explorers. This investigation required an approach that incorporated knowledge and expertise from the automotive, medical, environmental health, and occupational safety fields. The agency conducted an in-depth investigation that encompassed the review of over 6,500 consumer complaints, conducting field inspections, and testing the relevant vehicles, both independently and in coordination with Ford and other entities. During the investigation, the evolution of Ford service bulletins intended to reduce the level of exhaust odors and carbon monoxide (CO) entering the occupant compartment was examined and independent tests to evaluate the effectiveness of the final Field Service Actions (FSA) for both consumer and police vehicles were conducted. As part of the investigation, the agency also examined the effects of cracked exhaust mani-cats[1] on the measured CO levels in the vehicles and tested the FSA repairs to ensure they did not adversely impact occupant compartment CO levels resulting from cracked mani-cats.

During the investigation, upfitting issues for Police Interceptor and Emergency vehicles were identified. The upfitting (sirens, lights, cages, auxiliary power, etc.) is typically performed by state and local government fleet maintenance operations, independent repair facilities, or local Ford dealers after the sale of the new vehicle. Sealing issues caused by upfitting were responsible for the highest measured CO levels in tested vehicles. The FSA for police vehicles inspects the quality of the vehicle upfits and properly seals any leaks caused by these upfits, at no cost to the police agency. Similarly, the highest CO levels measured in consumer vehicles were usually traced to sealing issues caused by prior rear crash damage where the repairs did not ensure sealing integrity. The most recent Ford FSA procedure for both the police (17B25) and consumer vehicles (17N03) includes an HVAC reprogramming operation. Tests by Ford and NHTSA have demonstrated a substantial reduction of CO levels attributable solely to the HVAC reprogramming procedure. The other FSA repair procedures also demonstrated measurable contributions to CO level reductions during the controlled testing described in Section IV.

Throughout the NHTSA investigation, vehicles accurately measured with higher levels of CO, were almost always affected by upfitter alterations, in-use damage, or other post-manufacturing causes which compromised the sealing of the rear passenger cabin. A lack of full vehicle history limited the ability to trace root cause in some instances.

[1] Mani-cat is the term used to refer to the combined exhaust manifold and catalytic converter assembly used on the subject and other vehicles of similar vintage.

The agency received thousands of reports alleging odors which triggered a variety of physiological responses, predominately nausea, headaches, and lightheadedness. NHTSA did not attempt to assess the validity of these claims, but instead narrowly focused the investigation to accurately measured CO levels in the vehicle, and accurately measured Carboxyhemoglobin (COHB) levels from properly administered blood tests. NHTSA recognizes that hypersensitivities to CO and other exhaust gas constituents exist within the overall population, however, the agency does not have authority to establish CO exposure limits or determine the adequacy of established safe levels. Even when using rigorous test methods to produce exhaust gas intrusion in vehicles with a properly performed Field Service Action, occupant compartment CO levels never exceeded the most stringent current environmental limits for CO in any environment (EPA National Ambient Air Quality Standard for 8 hour exposure[2]). Furthermore, even without FSA repairs, no vehicles which were unaffected by upfitter issues or prior crash damage were identified with CO levels that exceed currently acceptable OSHA occupational CO exposure levels[3] measured using calibrated meters. This investigation found that the 2011 -2017 Ford Explorer vehicles when accurately tested and measured produce occupant compartment CO levels which fall below currently accepted health standards and could not identify COHB levels for vehicle drivers or other occupants, which exceeded, or even approached thresholds for acute physiological effects. Therefore, the agency cannot identify a defect which represents an unreasonable risk to safety.

II. PE-16-008

A. Pre-investigation and Opening

The investigation, as described above, focused on obtaining accurate field data which could be analyzed to identify real issues related to CO levels in the vehicle, and the measured effects on vehicle occupants. Prior to the opening of Preliminary Evaluation (PE) 16-008, the subject vehicles were already the subject of multiple class-action lawsuits, resulting in the elevated complaint response expected for a high-visibility automotive safety concern. Based on the risk-based processes in place, ODI opened the PE on July 01, 2016, for Model Year 2011 to 2015 Ford Explorers.

Prior to opening the investigation, ODI reviewed complaints, and made efforts to evaluate the severity of CO intrusion into vehicles. The procedures and equipment required to perform a scientifically sound investigative inquiry were not fully developed and in-place for these preliminary investigative efforts.

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[2] https://www.epa.gov/criteria-air-pollutants/naaqs-table
[3] https://www.osha.gov/chemicaldata/462

B. Focus

The investigation during the PE phase focused on six concerns.

1. Identify and investigate field complaints and incidents for vehicles which could provide accurate data on vehicle CO levels and vehicle occupant exposure levels, with focus on driver exposure.
2. Review appropriate global standards for CO exposure and apply those standards to data collection from the field. Discussions with occupational safety and medical professionals were included in this review.
3. Develop test protocols to induce a repeatable worst-case vehicle response which corresponds to driving scenarios described in field complaints. (primarily high speeds along with aggressive acceleration).
4. Obtain Ford's data related to complaints, lawsuits, inspections, and testing.
5. Obtain and review Ford's Technical Service Bulletins (TSB)s issued to address exhaust odor complaints in the subject vehicles.
6. Perform inspections and tests on exemplar vehicles at the NHTSA Vehicle Research and Test Center (VRTC) to understand the possible leak paths being addressed by Ford TSBs, to evaluate effects on CO ingress into the cabin for identified leak paths, (part of test protocol development in item 3 above) and evaluate the effectiveness of the Ford repair procedures including updates to the repair procedures.

C. Activities

An Information Request Letter (IR) was sent to Ford on July 13, 2016. The IR letter requested copies of claims and complaints describing exhaust odors (smells) inside the vehicle cabin, testing Ford may have conducted related to exhaust odors, design changes to the vehicle, and other information. Ford provided their response on August 24, 2016. ODI reviewed the response for information useful to planning the next steps in the investigation and for any significant incidents needing further examination.

On August 17, 2016, NHTSA received a complaint related to the crash of a Ford Police Explorer in Newport Beach, CA. ODI reached out to lawyers representing the officer driving the vehicle to obtain details regarding the CO allegations in the report. Since the vehicle was severely damaged in the incident, further vehicle testing and evaluation was not an option.

A 2013 Ford Explorer, used regularly by ODI staff, was sent to VRTC for test protocol development and leak path evaluation in September of 2016. VRTC engineers did a detailed review and teardown of the vehicle rear cabin to inspect and evaluate areas of concern covered by current Ford TSB repairs and searched for other leak paths not covered by the TSB repair procedures in place at that time. Test drives of the vehicle both on the track and the public roadways were performed to develop repeatable driving tests which could potentially produce elevated levels of CO in the cabin in the presence of rear cabin leaks.

III. Police Unit Incidents and Opening EA17-002

A. January 2017 – Kit Carson County Colorado K9 Vehicle

NHTSA received a complaint on December 30, 2016 (ODI 10938805) concerning high levels of CO being measured in the passenger compartment of a newly acquired police interceptor vehicle upfitted for police K9 use.[4] The CO measurements by the department reached peak readings exceeding 100 ppm of CO during sustained vehicle operation above 100 mph, and readings as high as 180 ppm were claimed during phone discussions with the Sheriff's department. The vehicle was repurchased by Ford in February 2017 and was used for evaluation and testing. The results were discussed with NHTSA during the investigation and were included as part of Ford's EA17-002 IR letter response.

B. February 2017 - Washington County Maryland Sheriff's Office

NHTSA received a complaint (ODI 10954841) on February 15, 2017 from the Washington County Maryland Sheriff's Office concerning a strong sulfur burning odor in the vehicle. The vehicle was at a dealer when NHTSA contacted the office, and the follow-up discussion indicated that the odor was traced to an internal failure of the Power Transfer Unit (PTU) which transfers the power to the front and rear axles for the 4-wheel-drive system. The PTU repair resolved the issue for this vehicle.

C. March 2017 - First City of Austin Police Department Incident

In March of 2017, an officer with the City of Austin Police Department suffered a medical incident while on patrol, and received medical treatment based on a suspected exposure to carbon monoxide. NHTSA sent an engineer, joined by a Ford engineer, to conduct a coordinated field inspection with City of Austin personnel at the City of Austin fleet garage. The inspection team conducted test drives and made measurements of the CO levels inside the vehicle for multiple driving and stationary idling conditions, reviewed vehicle maintenance records, and interviewed the officer involved in the incident. The CO levels measured during these tests were below normal occupational limits and could not be correlated to the symptoms experienced by the officer. Detailed inspection for upfitter leaks, which requires disassembly of the vehicle, was not permitted, to preserve the vehicle as evidence for future legal claims.

D. April 2017 - Henderson Police Department Incident

In April of 2017, an officer with the Henderson Police Department lost control of the Explorer being driven causing it to depart the roadway, strike the embankment of a

[4] The complaint was reviewed in January after the federal government re-opened on January 21, 2017 following the shutdown.

driveway, and roll over into a drainage canal. The driver sustained police-reported moderate injuries and was transported by ambulance to a local hospital, where she was diagnosed with elevated levels of CO and crash-related injuries. Since the vehicle was damaged in the incident, further vehicle testing and evaluation for CO levels in the cabin was not possible. It was also reported the driver was a cigarette smoker who had been smoking in the vehicle prior to the crash. As a result of these facts, no data could be collected from this event, but it was considered, at the time the investigation was upgraded to an EA.

E. June 2017 - Police Interceptor Exhaust Manifold Cracks

The City of Austin, as part of their ongoing efforts to investigate exhaust odors in Police Interceptor units, informed NHTSA of cracks they were identifying in the manifold-catalytic converter assembly commonly referred to as a mani-cat assembly. The cracks were found to be the source of exhaust odors in some vehicles. The City of Austin had also received reports of mani-cat cracks from California Highway Patrol (CHP) vehicle maintenance personnel. NHTSA investigators discussed the issue with CHP and then scheduled an inspection visit with a local police fleet maintenance facility which had several vehicles demonstrating alleged exhaust odor complaints. Using a borescope, NHTSA inspected and identified several vehicles in the local fleet which had cracks evident in the mani-cat assembly. NHTSA discussed the influence and effect of the cracked mani-cats with Ford and began gathering cracked units from the field for inspection at VRTC in anticipation of the testing discussed in Section IV.

F. July 2017 – Opening of EA17-002

Based on the growing number of consumer complaints, and the issues identified specific to Police Interceptor vehicles, NHTSA upgraded the investigation by opening EA17-002 on July 27, 2017. At the time of the opening, the City of Austin had announced they were taking more than 400 Ford Explorer PIU vehicles out of service until they could assure the vehicles did not exceed acceptable levels of carbon monoxide in the passenger compartment. The EA increased the model year range for the investigation to include MY 2017 vehicles, highlighted the unique issues related to Police Interceptor vehicles, and recognized the need to investigate the reported mani-cat cracks.

IV. Investigative Activities and Testing

A. July 2017 - City of Austin Police Vehicle Inspection and Testing

As a precaution, the City of Austin installed active CO alarms in their Police Interceptors. In the early July 2017 there were multiple incidents of alarms being triggered, resulting in the entire fleet of more than 400 Ford Explorer Police Interceptor vehicles being removed form service. A coordinated testing and inspection trip, with engineers from NHTSA and Ford in attendance, was held at the City of Austin maintenance facility. An aggressive drive cycle was developed and used to evaluate the vehicles before and after changes made to the vehicles. Multiple meters were also evaluated in the testing to gain understanding of the accuracy of various meters available in the marketplace. All data presented is based on calibrated NHTSA meters.

1. Upfitter Issues

During the 5 days of inspection and testing, many upfitter issues were identified on the vehicles. The identified issues resulted in passenger cabin leaks. Upfitting occurs after the new vehicle is sold by the dealer. A good description of typical upfitting issues is detailed in Ford TSB 17-044 found in Appendix A. The investigators used the Austin drive cycle tests to gather initial data on the impact and effectiveness of sealing the various leaks discovered during the inspections. The Austin test results and the controlled testing at VRTC in September of 2017 will be detailed later in this section of the report.

2. Exhaust Manifold Cracks

The city of Austin had previously identified vehicles with cracked exhaust manifolds, and had repairs performed to remedy the cracks. One vehicle with a cracked exhaust manifold was tested and then repaired with a new manifold. The pre and post replacement CO measurements were effectively unchanged with both measurements in the 15 to 20 ppm range. Other repairs related to exhaust gas ingress in the rear of the vehicle lowered these levels in subsequent testing.

3. Downturns for the Exhaust Tips

One TSB option available for consumer vehicles with the 3.5l engine was a replacement rear exhaust assembly with downturned exits instead of the factory straight-to-the rear exhaust exits. A pair of clamp-on tips were fabricated at a local muffler shop and installed for testing on a Police interceptor vehicle. The downturned tips lowered the previous 15 to 20 ppm CO readings to reading of 5 to 10 ppm. The City of Austin outfitted several more vehicles with exhaust tips and achieved similar results in further testing. Ford-developed replacement downturn tips were incorporated as a standard part of FSA 17B25 for the Police Interceptor vehicles.

B. VRTC Tests

1. Cabin Leak Source Evaluation

During the course of the investigation, both NHTSA and Ford identified a number of leak paths which could affect consumer and police Ford Explorers. The leak paths addressed by the earliest TSBs included the air extractors behind the rear bumper, poorly sealed body joints, and the rear liftgate drain holes. The other notable leak paths identified in the ongoing investigation include the rear liftgate trim sealing, lock sealing, rear air spoiler mount sealing, lift gate misalignment or damage to the liftgate opening seal, lost body plugs or tape seals in the rear of the vehicle, and damaged or improperly serviced seals for wiring to the taillights and liftgate. For the Police Interceptor units, the upfitting was often a cause for the leaks found in the above areas since many of the sealed areas needed to be disturbed or disassembled during the upfitting process. The following discussion will describe the process used to quantify the effects of the identified leak paths and evaluate the effectiveness of countermeasures Ford provided for mitigating these leaks.

a) Vehicle Evaluation Drive Cycle

VRTC experimented with several methods to efficiently reproduce the drive environment which maximized the intrusion of exhaust gases into the occupant compartment. Hard acceleration typical of passing on the highway or merging into traffic from an exit ramp was the most commonly reported driving maneuver which produced a noticeable smell of exhaust in the occupant compartment. The second driving maneuver noted was sustained operation above 100 mph. This operation, exclusive to police interceptor units, typically occurred during a police pursuit, or a long-distance emergency response in a rural jurisdiction. The drive cycle procedure VRTC developed was intended as a testing tool and was not meant to replicate real-world or other normal vehicle operation by any vehicle user, police or civilian. The final procedure used by VRTC was performed on the 7.5-mile High Speed Test Track (HSTT) at the Transportation Research Center of Ohio (TRC) where VRTC is located. The test procedure steps are outlined below.

1. Drive forward at a speed of 10 mph;
2. Mark Time Zero;
3. Apply Wide Open Throttle (WOT) until a speed of 70 mph is reached;
4. Removed foot from throttle and allow vehicle to coast down to 10 mph;
5. Maintain 10 mph until 1 minute has elapsed since the last WOT to 70 mph;
6. Repeat steps 3 through 5 for two complete laps of the HSTT (14 miles or approximately 16 cycles).

b) Korean Test Methods

During the course of the investigation, a new United Nations Informal Working Group (IWG) was developing an international vehicle safety standard for the Vehicle Interior Air Quality (VIAQ). The first stage, initiated in 2015, addressed the outgassing of compounds from interior materials. The second stage, launched in 2017, focused on the entry of exhaust gasses into the vehicle. The stage 2 proposal was still in development and was expected to be completed in the latter part of CY 2020. The IWG considered several test modes for inclusion in the standard. A Korean proposal included acceleration tests which were similar to the NHTSA test cycles developed at VRTC. The Korean acceleration test uses a cycle starting at 65 kph (40mph) with a WOT acceleration to 130 kph (80 mph) followed by an immediate coast down to 65 kph (40 mph) and a 28 second cruise at that speed until the start of the next WOT acceleration ramp. The Korean members of the IWG proposed 8 cycles of this test (4 for stabilization and 4 for measurement). The Korean proposal characterized the acceleration test as the "worst-case condition" for exhaust gases entering the vehicle. This proposal is not included in the most recent version of the IWG Phase 2 proposal, which only includes idle and steady-speed driving test procedures. The full Korean acceleration test proposal presentation is included in Appendix D to this report. The proposal features test data for a Model Year 2016 SUV which appears to be relevant, and the data aligns with the NHTSA data collected during this investigation.

c) VRTC and Field Inspection Results

In September of 2017, repair evaluation testing was performed at VRTC with ODI and Ford engineers present. Two civilian trim Ford Explorers identified as being particularly susceptible to exhaust gas intrusion under the NHTSA test condition were used for the first test series (vehicles A and B). The tests performed and the results based on the VRTC test cycle are shown in Table 1. Two additional test series were conducted in October of 2017 (Vehicles B and G). The first series replaced the front exhaust manifold with a modified exhaust manifold which was pre-drilled with a 0.20-inch diameter hole in the area where cracks frequently occur on Police Interceptor vehicles. The second series utilized a Ford buy-back vehicle which had been damaged in a rear crash and inadequately repaired. The only modification tested for the second test series was the updated HVAC software. Four additional vehicles (Vehicles C through F) are included in Table 1documenting field inspections and repairs at fleet facilities and dealerships. The Local Road test cycles were not as aggressive as the VRTC test cycle, but the data was collected using the same systematic repair and evaluation process utilized for VRTC tests.

Table 1 - Testing of Final TSB Vehicle Repairs Using the VRTC Developed NHTSA Test Cycle and other on-road tests.

Vehicle	Modification	Pre - Mod Peak CO (ppm)	Post - Mod Peak CO (ppm)	% CO Reduction	Test Method	Engine
A	Rear Gate Sealing	30	21	30%	VRTC 1 Lap	2.0L
	Exhaust Downturn	65	11	83%	VRTC 2 Lap	2.0L
	Rear Gate and Exhaust	65	6	91%	VRTC 2 Lap	2.0L
	Combined Repairs	65	5	92%	VRTC 2 Lap	2.0L
B	Lower Gate Drain Plugs	33	23	30%	VRTC 1 Lap	3.5L NA
	Spoiler Sealing	23	14	39%	VRTC 1 Lap	3.5L NA
	Rear Gate Sealing	33	14	58%	VRTC 1 Lap	3.5L NA
	Rear Gate and Exhaust	55	7	87%	VRTC 2 Lap	3.5L NA
B	Exh. Man. with .20 dia hole	7	10	N/A	VRTC 2 Lap	3.5L
C	Legacy TSB	45	28	38%	Local Road	3.5L NA
	Upfitter Issues 1st Round	28	20	29%	Local Road	3.5L NA
	Final TSB	19	12	37%	Local Road	3.5L NA
	Upfitter Issues 2nd Round	12	5	58%	Local Road	3.5L NA
	Combined Repairs	45	5	89%	Local Road	3.5L NA
D	Rear Gate center drain hole	25	13	48%	Local Road	3.7L NA
	Baseline with Field Fab Exhaust Downturns	25	13	48%	Local Road	3.7L NA
	Exhaust and center drain	25	10	60%	Local Road	3.7L NA
	Seal rear gate leak	10	7	30%	Local Road	3.7L NA

	Combined repairs	25	7	72%	Local Road	3.7L NA
E	Spoiler Sealing	36	16	56%	Local Road	3.7L NA
	Field Fab Exhaust Downturns	16	7	56%	Local Road	3.7L NA
	Combined Repairs	36	7	81%	Local Road	3.7L NA
F	Rear Gate sealing	34	15	56%	Local Road	3.7L NA
G	Final HVAC Re-Calibration	124	5	96%	VRTC 2 Lap	2.0L

2. Discussion of Test Data

Utilizing earlier work to catalog leak paths, systematic repairs and modifications were applied to 7 different vehicles. This section will discuss the results of each repair type.

a) Upfitter repairs

The process of upfitting a police or other type of emergency response vehicle involves the addition of items including emergency lights, sirens, 2-way radios and antennas, interior barriers and seats, computer equipment, and auxiliary power supplies and batteries. Significant disassembly of the vehicle and additional holes for routing of wiring are often required during the upfitting process. The vehicle must be reassembled carefully to maintain the integrity of the original body seals, and any new holes added must also be sealed. Many of the police vehicles which had the highest CO readings were affected by improper sealing following the upfitting process. The correction of upfitting issues consistently resulted in reductions in measured CO levels and reductions greater than 50% were not uncommon (list which vehicles in table 1). The Ford 17B25 FSA included free inspection and repair of upfitting issues even though Ford was not responsible for causing these issues.

b) Rear Gate Drain Plugs and Other Sealing

The rear gate bottom drains were included in the vehicle design to permit drainage of liquids during the coating and painting processes in the factory. Ford identified these drains as a potential exhaust gas entry point and developed an insert to seal these drain holes. The original insert design clipped in the hole but had the drawback of being easily dislodged during normal use. An adhesive was added to later procedures to prevent dislodgement. The final FSA procedures specified a new design with improved securement. The seals were also added to production vehicles for later model years. Test results show CO level improvements of 30% to 48% after sealing these drains. One test series sealed then unsealed the drains to confirm that the pre-seal CO levels returned after removal of the drain seals.

c) Exhaust Downturns

The aerodynamics of Sport Utility Vehicles (SUV)s often result in a negative pressure zone in the rear of the vehicle which traps exhaust gases outside of the rear of the vehicle. Vehicles with operable rear windows have historically warned against opening these windows while the vehicle is in motion to prevent exhaust gas entry into the vehicle. Under normal driving conditions, the levels of noxious and harmful exhaust gases being released by the vehicle exhaust is low. During hard acceleration events, the engine management system enriches the fuel mixture to prevent overheating of the catalytic converters. This enriched mixture increases CO output along with increased nitrogen and sulfur compounds associated with the often-reported rotten egg smell[5]l. The location and direction of the exhaust system exit can affect the amount of exhaust gases trapped in the vehicle's negative pressure zone. Ford developed a replacement downturn rear exhaust section for the civilian Explorers equipped with the 3.5L engine and produced add-on downturn tips which were a baseline Police Interceptor modification for the 17B25 FSA. ODI conducted testing using both downturn tips and the replacement rear exhaust section. The exhaust downturns produced CO level reductions of 48 to 87% (Table 1: vehicles A, D, E). The downturns are especially beneficial to Police Interceptor vehicles which occasionally operate at sustained high speeds (greater than 100 mph) during response and pursuit situations. Ford included these downturns as part of the baseline Police Interceptor 17B25 FSA. The civilian replacement downturn part was only used to address residual odor concerns which remained unresolved by the baseline 17N03 FSA.

d) HVAC Recalibration

The operation of the heating and air conditioning system of vehicles has a direct result on the pressure differential from inside to outside of the vehicle. When outside air is used to feed the blower fan, the pressure in the occupant compartment is higher than the outside pressure. When the

[5] CO is odorless and tasteless however consumer reports do note a smell which is likely these nitrogen and sulfur compounds that are produced in higher proportions during hard acceleration.

already conditioned air inside the vehicle is used to feed the blower fan (recirculation mode), the occupant compartment air pressure is often lower than the outside air pressure, producing a negative pressure condition which can drive outside air into the occupant compartment through any available openings. The sealing procedures, described previously, address the paths that allow exhaust gases to enter the occupant compartment due to the negative pressure condition. The HVAC recalibration prevents the vehicle from being in a negative pressure condition during times when the exhaust is emitting elevated levels of CO. During heavy acceleration events like merging from an on-ramp, or passing a slower vehicle, the HVAC system will automatically switch from recirculation to fresh-air mode until the acceleration event is completed. After a small delay, the system returns to the mode it was in prior to the acceleration event. This change produces a positive pressure in the cabin which inhibits the entry of exhaust gases into the occupant compartment regardless of the opening present in the rear of the vehicle. ODI tested a vehicle which had been improperly repaired following a rear crash. The baseline on the vehicle using the VRTC test cycle after 2 laps was 124 ppm of CO. The only change to the vehicle prior to retest was the latest HVAC recalibration used for both FSA actions. The level during the retest was 5 ppm CO, or a 96% reduction in CO levels (Table 1: Vehicle G). Both Ford and ODI testing indicate that this change is highly effective in reducing CO levels in vehicles no matter what occupant compartment leaks may exist due to upfitter mods, or other vehicle damage.

3. Carbon Monoxide Meter Discussion

a) Overview

Meters used to detect CO are readily available in the marketplace, ranging from inexpensive home-use devices costing less than $50 to laboratory grade devices costing over $1000. As expected, meters at each price tier provide different levels of performance and are sometimes limited to use in the environment for which they were designed. ODI consulted with engineers at the Consumer Products Safety Commission (CPSC) and National Institute of Occupational Safety and Health (NIOSH) before selecting meters for field and laboratory use, and discussed the limitations of inexpensive meters in the automotive environment. The data collected and evaluated in this investigation was collected using calibrated meters with established reliability coupled with frequent checks using reference gas (60 ppm) verification.

b) Low-cost Meters

The average consumer trying to evaluate the levels of CO inside their vehicle often purchased low-cost meters to perform a measurement. The home CO monitors readily available at hardware retailers are specifically designed to perform inside the home in a temperature and humidity-controlled environment to measure levels from faulty home appliances and are not suitable for use in the more demanding automotive environment. Investigators also examined the performance of portable meters costing less than $200 and found that the accuracy and performance was not at a sufficient level of reliability to draw useful conclusions. Any data reported using lower cost meters had to be verified using accurate reliable meters in order to ensure the accuracy of the investigative effort.

c) Investigative CO Meters

The portable meters used in the field by investigators usually cost more than $200 and were capable of logging data to allow determination of both exposure level and exposure duration, which is crucial for comparison to established permissible exposure levels. The higher priced meters often included an internal pump which improved the response time of the meter since it actively draws ambient air into the sensor. The reading variations among the various meter models in this price range used during the investigation was minimal and the data collected using these meters form the basis for the report conclusions.

d) CO Meter Limitations

Based on literature review, field experience and laboratory testing, CO meters at all quality levels are susceptible to erroneous readings due to certain environmental factors. Transmitted RF signals from devices such as two-way radios used by the police and first responders, as well as cellphones if they are close to the meter, have demonstrated the ability to induce false readings and alarms in CO meters. This characteristic must be addressed when considering in-vehicle CO monitoring for the Police Interceptor vehicles. The meters can also be triggered by certain other compound in the environment such as citrus oils and human flatus. Finally, the temperature exposure of the meter should be considered, since most meters have temperature limits on their operating range.

V. Field Service Actions

Ford issued two Field Services Actions. The original FSAs had a 12-month limited duration for the free repairs and included reimbursements for prior repairs. The FSAs were later extended for an additional 3 years to provide future owners the opportunity to obtain the free service offered by the FSA. Ford conducted multiple mailings to registered owners to make them aware of the FSA being offered.

A. FSA 17B25 for Police Interceptor Vehicles

FSA 17B25 for Police Interceptor vehicles was issued in September of 2107. A copy of 17B25 is included in Appendix B. At the outset, Ford deployed field teams to work with fleets in getting the repairs successfully performed and to respond to any reported difficulties with the repair. The major components of this FSA are:

- Identify and seal Upfitter induced leaks
- Locate and seal leaks in the rear vehicle body and gate
- Installation of exhaust downturn tips
- Reprogram the HVAC system
- Check for emissions fault codes related to leaking mani-cats and repair if leaking

ODI closely monitored all reported difficulties from Police Departments and discussed the problems with Ford and involved parties to ensure the TSB was fully addressing customer concerns. ODI closely tracked efforts by the City of Austin Police Department. The City of Austin successfully repaired and returned to service the 400 Police Interceptor vehicles taken out of service in July of 2017. Each vehicle was tested using a rigorous driving cycle and a CO meter to monitor the levels of CO in the vehicle during the test.

B. FSA 17N03

FSA 17N03 for consumer Ford Explorers was issued in November of 2107. A copy of 17N03 is included in Appendix C. Ford field teams were available to dealers and responded to any reported difficulties with the repair. The major components of this FSA are:

- Locate and seal leaks in the rear vehicle body and gate
- Reprogram the HVAC system
- Downturn rear exhaust a second-tier option for 3.5L equipped vehicles with residual odor concerns.

ODI closely monitored all complaint reports and discussed substantive complaints with Ford and involved parties to ensure that the FSA repairs adequately addressed levels of CO in the vehicle. The screening metrics employed throughout this investigation were used to identify complaints requiring additional ODI attention. All substantive issues were resolved by proper application of the FSA. ODI occasionally noted certain odor complaints that were indicative of a PTU failure. After discussions with ODI, the vehicle owners obtained the appropriate repair that resolved the issue.

VI. Closing Risk Assessment

During the EA17-002 investigation, reports of exhaust odors in the passenger cabins of Model Year 2011 and newer Ford Explorers were reviewed and analyzed. This investigation was a multi-faceted endeavor, requiring an approach that encompassed knowledge and expertise from the automotive, medical, environmental health, and occupational safety fields. The agency conducted an in-depth investigation which encompassed thousands of complaint reports, reviewed all complaints for actionable data, and conducted field inspections and testing of the most relevant vehicles, both independently and in coordinated efforts with Ford and other entities. The investigation examined the evolution of Ford service bulletins intended to reduce the level of exhaust odors and CO entering the occupant compartment and conducted independent tests to evaluate the effectiveness of the final FSA for both consumer and police vehicles. The investigation also examined the effects of cracked exhaust mani-cats on the measured CO levels in the vehicles and tested to ensure that the FSA repairs did not adversely impact occupant compartment CO levels resulting from cracked mani-cats.

The investigation did identify upfitting issues for Police Interceptor and Emergency vehicles. The upfitting (sirens, lights, cages, auxiliary power, etc.) is typically performed by state and local government fleet maintenance operations, independent repair facilities, or local Ford dealers after the sale of the new vehicle. Sealing issues caused by upfitting were responsible for the highest measured Carbon Monoxide levels in tested vehicles. The FSA for police vehicles inspects the quality of the vehicle upfits and properly seals any leaks caused by these upfits, at no cost to the police agency. Similarly, the highest CO levels measured in consumer vehicles were usually traced to sealing issues caused by prior rear crash damage where the repairs did not ensure sealing integrity. The most recent Ford FSA procedure for both the police (17B25) and consumer vehicles (17N03) includes an HVAC reprogramming operation. Tests by Ford and NHTSA have demonstrated a substantial reduction of CO levels attributable solely to the HVAC reprogramming procedure. The other FSA repair procedures also demonstrated measurable contributions to CO level reductions during the controlled testing described in Section IV.

Throughout the NHTSA investigation, vehicles accurately measured with higher levels of (CO), were almost always affected by upfitter alterations, in-use damage, or other post-manufacturing causes which compromised the sealing of the rear passenger cabin. A lack of full vehicle history limited the ability to trace root cause in some instances.

The investigation received thousands of reports alleging odors which triggered a variety of physiological responses, predominately nausea, headaches, and lightheadedness. NHTSA did not interpret or assess these responses, and narrowly focused the investigation to accurately measured CO levels in the vehicle, and accurately measured carboxyhemoglobin (COHB) levels from properly administered blood tests. NHTSA recognizes that hypersensitivities to CO and other exhaust gas constituents exist within the overall population, however, the agency does not set limits or determine the adequacy of established safe levels. Even when using rigorous test methods to produce exhaust gas intrusion in vehicles with a properly performed Field Service Action, occupant compartment CO levels never exceeded the most stringent current environmental limits for CO in any environment (EPA indoor air quality standards). Furthermore, even without Field Service Action repairs, no vehicles which were unaffected by upfitter issues or prior crash damage were identified with CO levels that exceed currently acceptable occupational CO exposure levels measured using calibrated meters. This investigation found that the 2011 -2017 Ford Explorer vehicles when accurately tested and measured produce occupant compartment CO levels which fall below current accepted health standards and could not identify COHB levels for vehicle drivers or other occupants, which exceeded, or even approached thresholds for acute physiological effects. Therefore, the agency has not identified a safety related defect that represents an unreasonable risk to motor vehicle safety. This investigation is closed. The closing of this investigation does not constitute a finding by NHTSA that no safety-related defect exists. The agency reserves the right to take further action if warranted by circumstances.

The ODI reports cited above can be reviewed at:
http://www-odi.nhtsa.dot.gov/owners/SearchNHTSAID
using the following complaint identification numbers:
10458341, 10466807, 10472937, 10485394, 10493493, 10497684, 10503135, 10511749, 10521718, 10522939, 10531802, 10534074, 10536610, 10537052, 10545106, 10545178, 10547404, 10548667, 10548860, 10550076, 10550377, 10558204, 10564269, 10565379, 10573079, 10595494, 10596480, 10604931, 10604940, 10604955, 10604967, 10604970, 10605097, 10605189, 10605241, 10605376, 10605403, 10605459, 10605966, 10606061, 10606271, 10606369, 10606461, 10606792, 10607217, 10607685, 10608498, 10608596, 10608674, 10608810, 10608917, 10609207, 10609211, 10609691, 10609894, 10609975, 10610102, 10610144, 10614840, 10616310, 10617546, 10617594, 10618335, 10618502, 10618520, 10618575, 10618745, 10618836, 10621834, 10626537, 10628773, 10629572, 10629634, 10631312, 10632027, 10632709, 10632986, 10633074, 10633076, 10633380, 10637147, 10639579, 10641360, 10641511, 10643108, 10643273, 10644216, 10644532, 10648221, 10648467, 10648822, 10653747, 10653896, 10654067, 10654392, 10655265, 10659295, 10659511, 10669298, 10671158, 10671421, 10676214, 10678149, 10679373, 10679757, 10680410, 10681254, 10689365, 10689417, 10692003, 10700778, 10702500, 10703134, 10712975, 10713736, 10717658, 10717754, 10725238, 10725436, 10727056, 10731089, 10731285, 10732586, 10732587, 10732799, 10733802, 10734961, 10735118, 10735146, 10735360, 10735627, 10735818, 10735901, 10735964, 10743443,

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VII. Appendix A Ford TSB 17-044

This TSB can be viewed using the following link:
https://static.nhtsa.gov/odi/tsbs/2022/SB-10212177-1234.pdf

VIII. Appendix B – FSA 17B25

This TSB can be viewed using the following link:
https://static.nhtsa.gov/odi/tsbs/2018/MC-10149785-9999.pdf

IX. Appendix C – FSA 17N03

This TSB can be viewed using the following link:
https://static.nhtsa.gov/odi/tsbs/2019/MC-10153981-9999.pdf

X. Appendix D Korean VIAQ Test Proposal Presentation

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

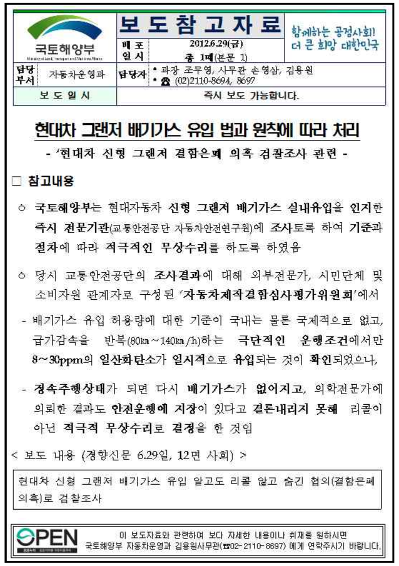
✓ Consumer complaints “Exhaust gas entering into vehicle cabin”

- 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” >



국토해양부

보 도 참 고 자 료

함께하는 공정사회! 더 큰 희망 대한민국

배포일시	2012.6.29(금) 총 1매(본문 1)		
담당부서	자동차운영과	담당자	• 과장 조무영, 사무관 손영삼, 김용원 • ☎ (02)2110-8694, 8697
보도일시	즉시 보도 가능합니다.		

현대차 그랜저 배기가스 유입 법과 원칙에 따라 처리

- '현대차 신형 그랜저 결함은폐 의혹 검찰조사 관련 -

□ 참고내용

○ 국토해양부는 현대자동차 신형 그랜저 배기가스 실내유입을 인지한 즉시 전문기관(교통안전공단 자동차안전연구원)에 조사토록 하여 기준과 절차에 따라 적극적인 무상수리를 하도록 하였음

○ 당시 교통안전공단의 조사결과에 대해 외부전문가, 시민단체 및 소비자원 관계자로 구성된 '자동차제작결함심사평가위원회'에서

- 배기가스 유입 허용량에 대한 기준이 국내는 물론 국제적으로 없고, 급가감속을 반복(80㎞~140㎞/h)하는 극단적인 운행조건에서만 8~30ppm의 일산화탄소가 일시적으로 유입되는 것이 확인되었으나,

- 정속주행상태가 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) >

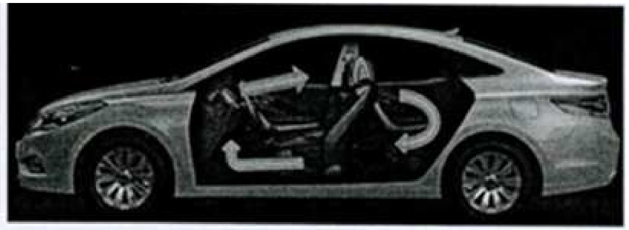
현대차 신형 그랜저 배기가스 유입 알고도 리콜 않고 숨긴 혐의(결함은폐 의혹)로 검찰조사

OPEN 이 보도자료와 관련하여 보다 자세한 내용이나 취재를 원하시면 국토해양부 자동차운영과 김용원사무관(☎02-2110-8697) 에게 연락주시기 바랍니다.

< Official Press Release by MOLIT>

➢ 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. ⚠ WARNING 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 ⇒ ⚠.

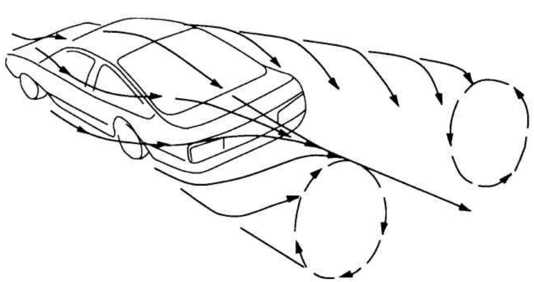
⚠ **WARNING**

- **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.**

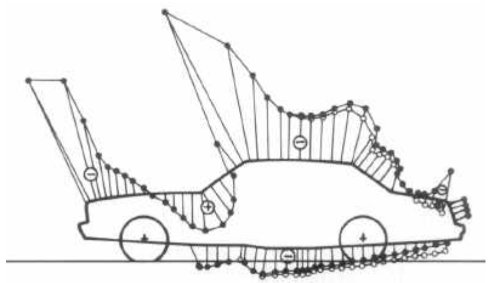
Study on CFD(computational Fluid Dynamics)

➢ Computational Fluid Dynamics(CFD)

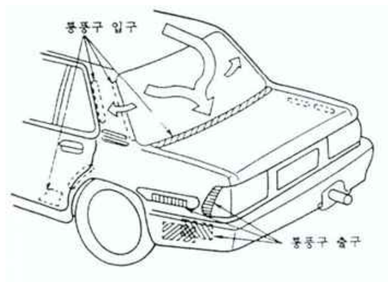
✓ **Simulation for exhaust gases entering into cabin using the CFD method**



<Vortex flow in back part of vehicle>



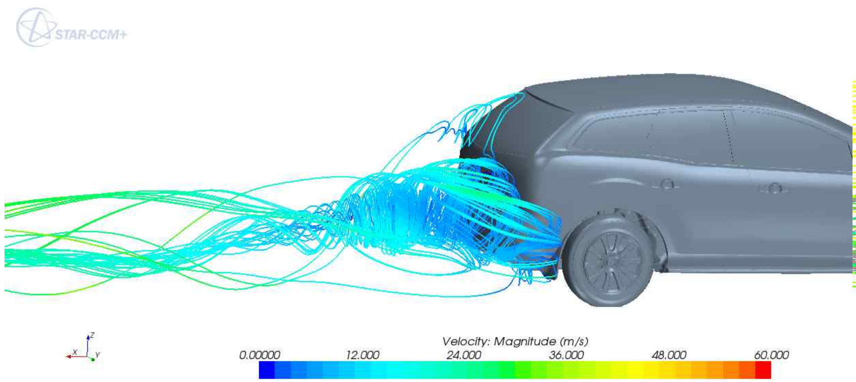
< Pressure of vehicle surface in high speed >

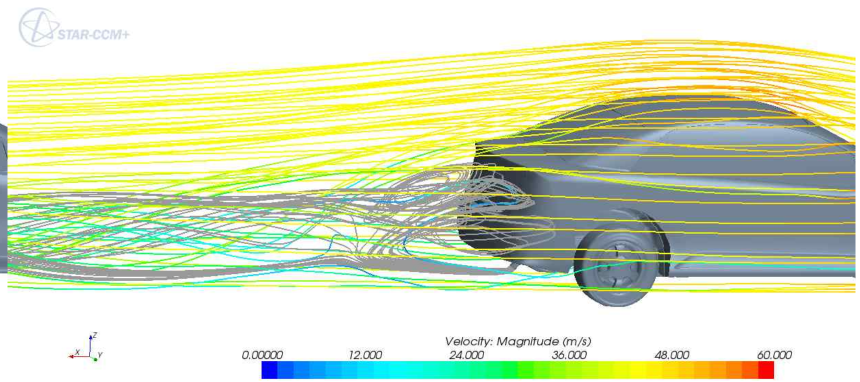


< position of extractor >

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

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





Study on CFD(computational Fluid Dynamics)

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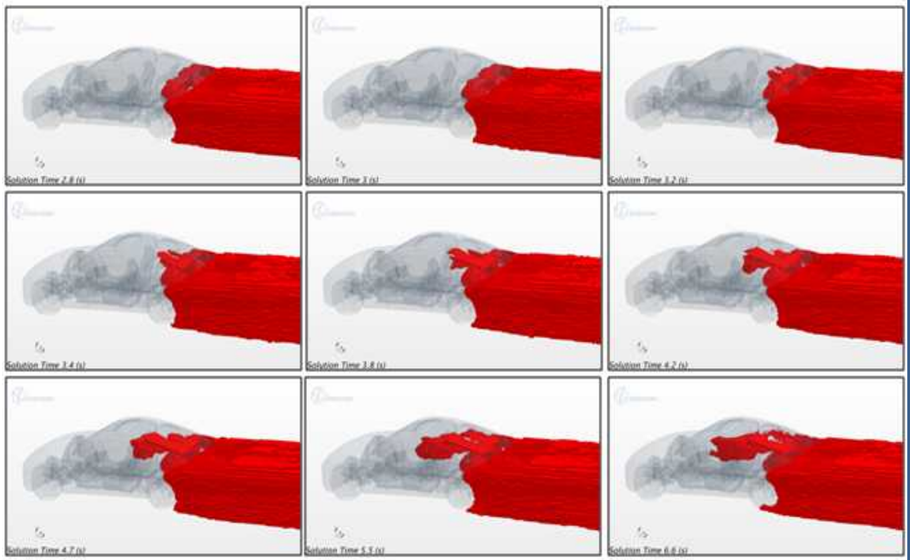
➢ Computational Fluid Dynamics(CFD)

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

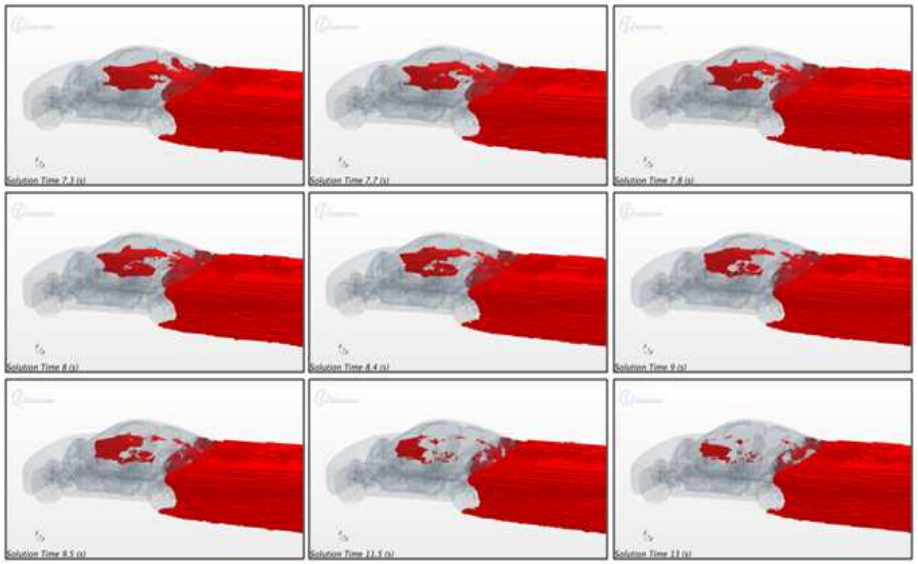
Frame 1 - 9

Mass fraction on ISO view



Frame 10 - 18

Mass fraction on ISO view



➢ Test mode for exhaust gases entering into cabin

✓ Idling mode, (basic conditions)

- Engine idling in normal condition

✓ Constant speed driving mode, (normal conditions)

- 80±5 km/h, 100±5 km/h, 120±5 km/h, 140±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 : ±2 pm(0.0~39.9 ppm), Other range ± 5%

✓ Test Device : Testo 350K

- NO Range : 0~300 ppm
- Resolution : 0.1 ppm
- Accuracy : ±2 pm(0.0~39.9 ppm), Other range ± 5%
- NO2 Range : 0~500 ppm
- Resolution : 0.1 ppm
- Accuracy : ±5 pm(0.0~39.9 ppm), Other range ± 5%

<Speed device>

<CO device>

<NO, NO2 device>

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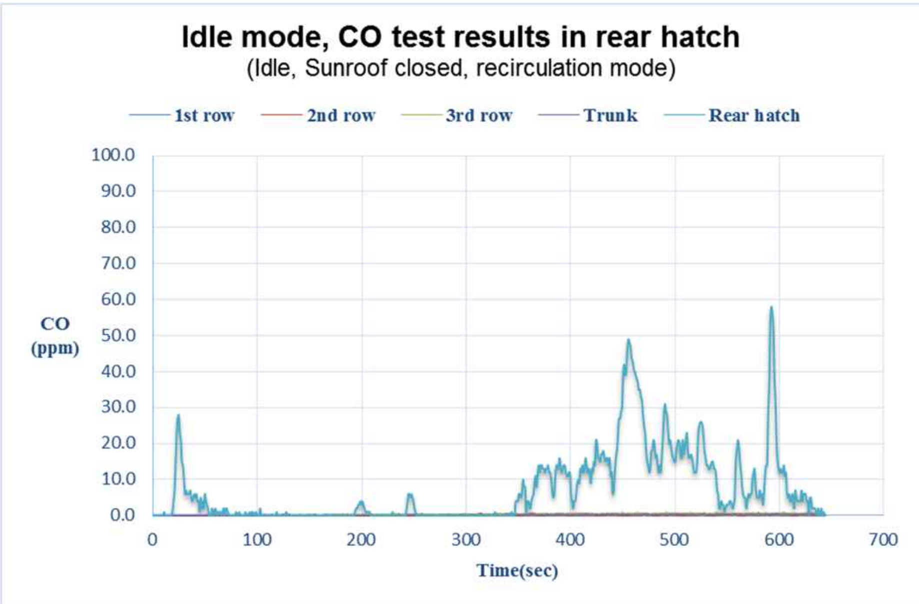
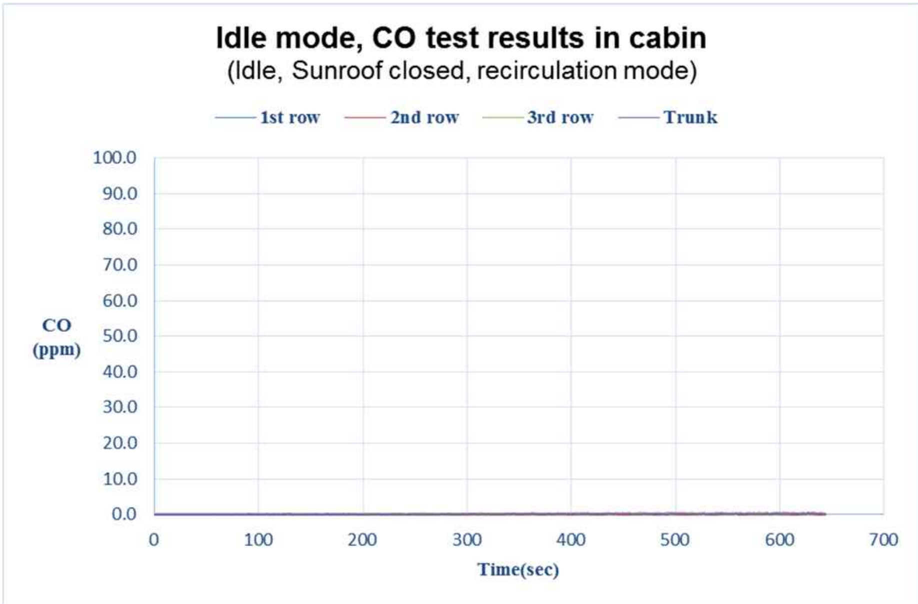
➢ Idling mode test

- ✓ 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

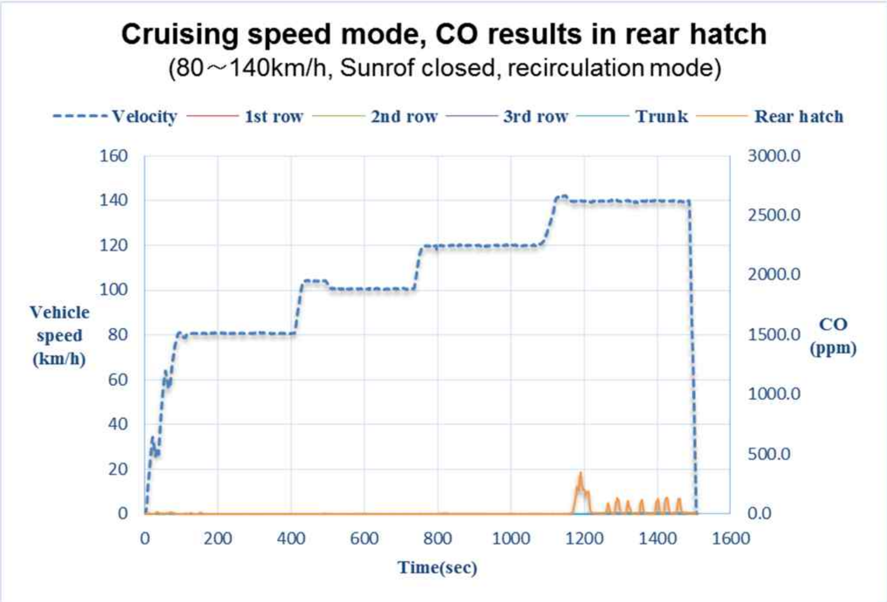


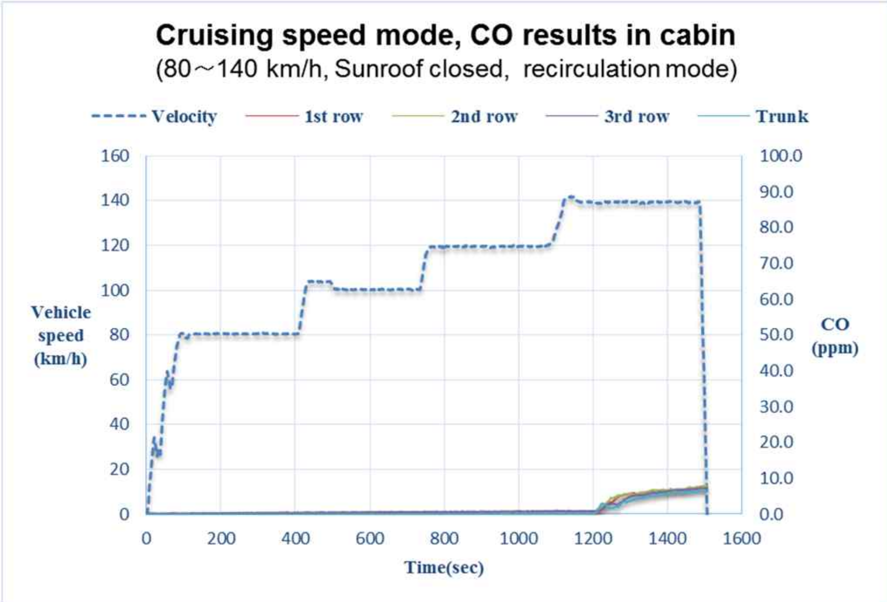


➢ Cruising speed driving mode

✓ Cruising speed driving mode, (normal conditions)

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

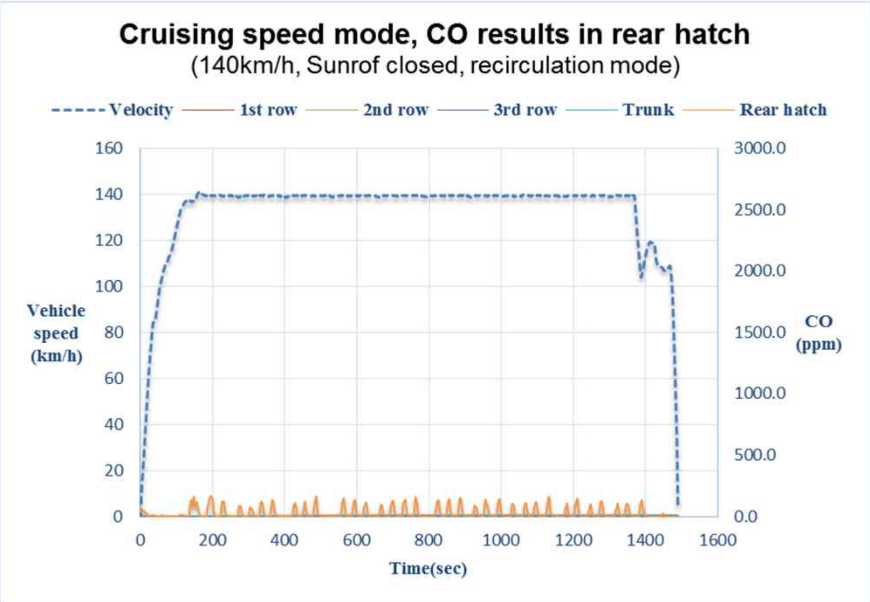


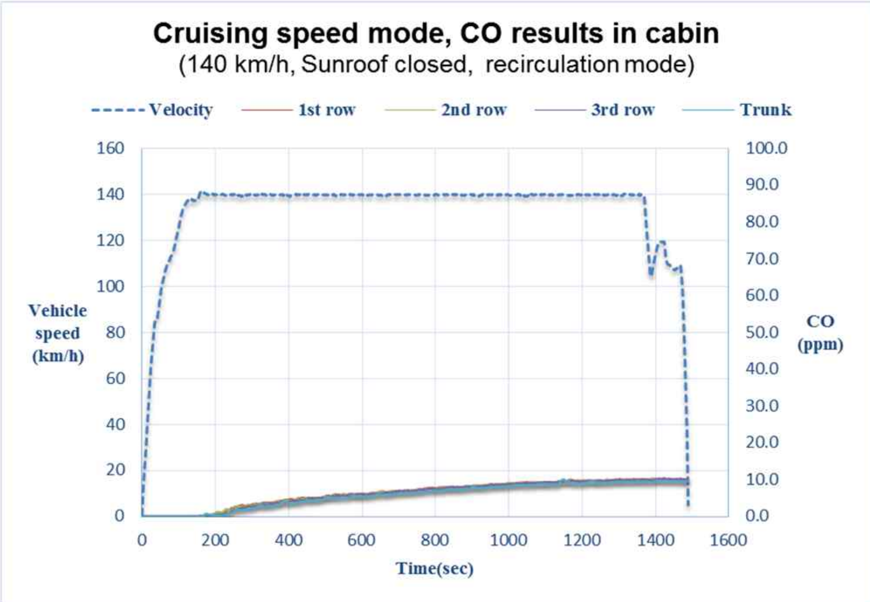


➢ Cruising speed driving mode

✓ Cruising speed driving mode

- 140±5 km/h
- Total test time : 20 min (stabilizing time 10 min, measuring time 10 min)
- CO was detected in cabin with140 km/h (8 ~ 9 ppm)

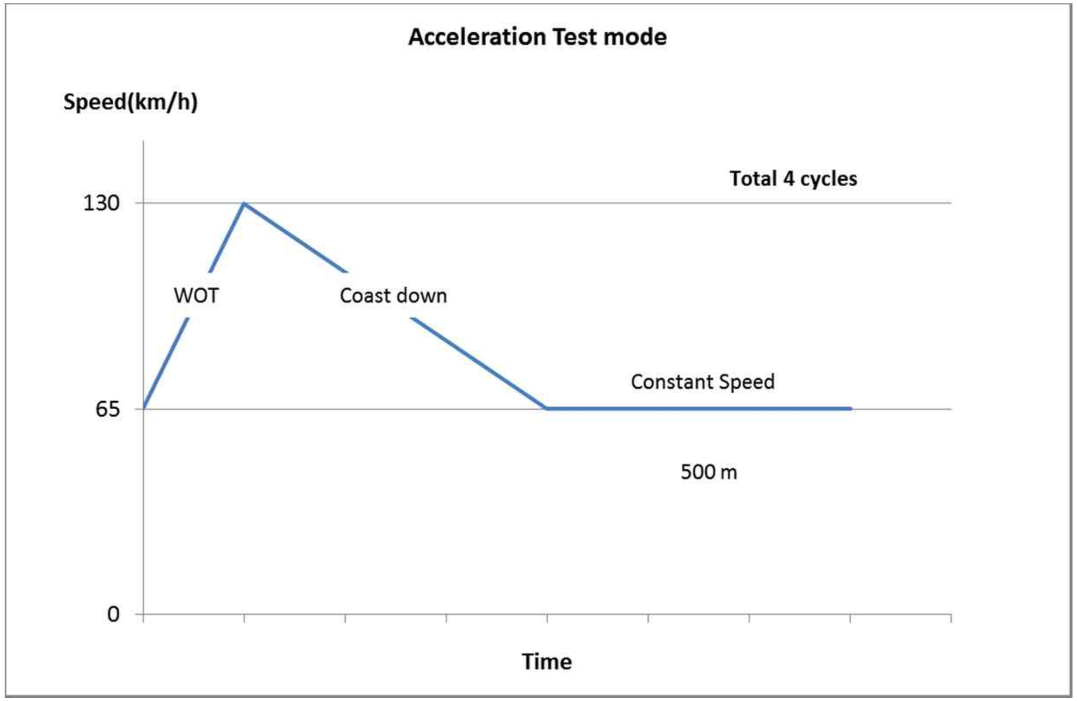




➢ Acceleration mode

✓ Acceleration mode, (worst-case conditions)

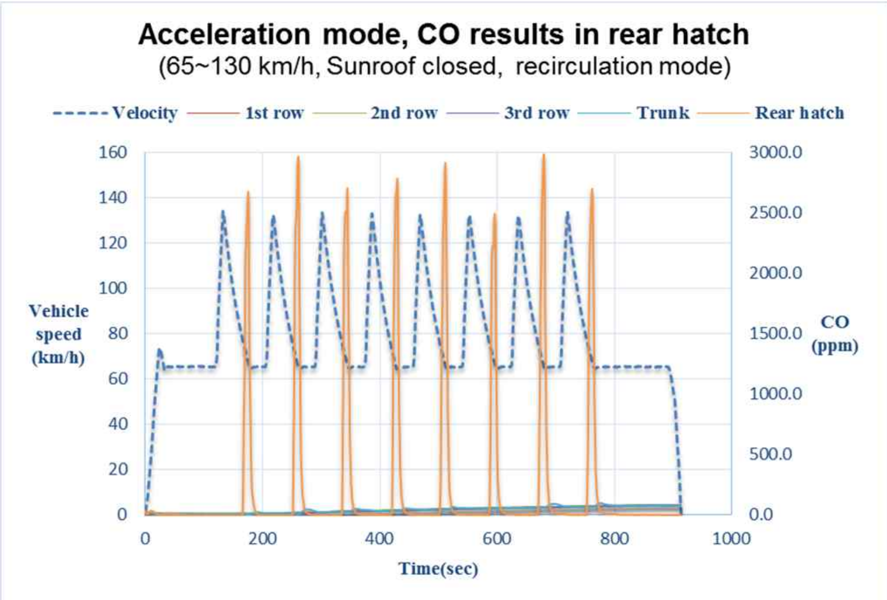
- Test cycle : accelerate vehicles from 65 km/h to 130km/h (WOT), right after that coast-down (deceleration) to 65 km/h, cruise drive 500 meter, and then repeat mode
- Total 8 cycle (4 stabilizing cycle, 4 measuring cycle)

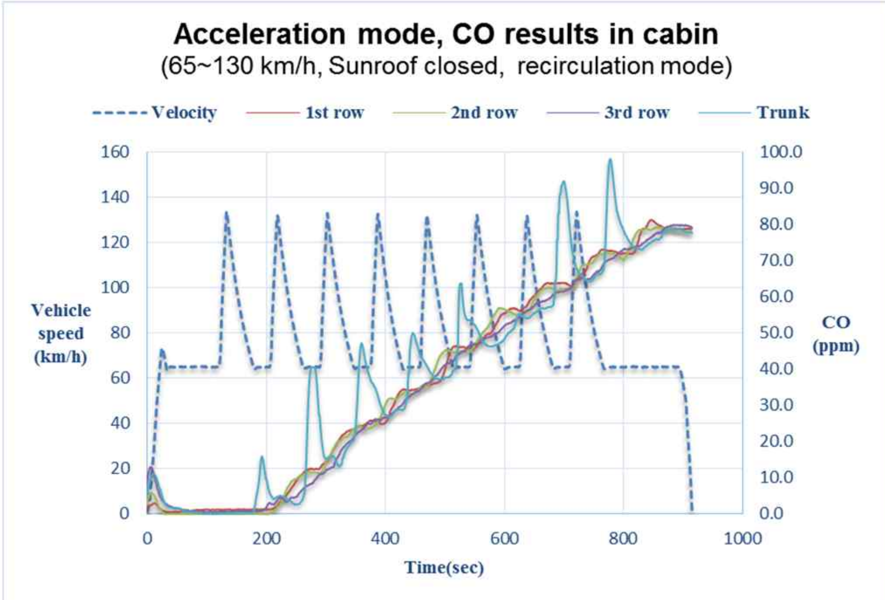


➢ Acceleration mode

✓ 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

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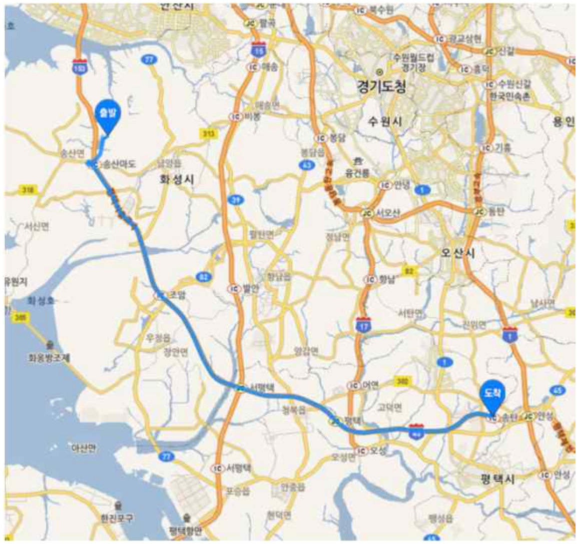
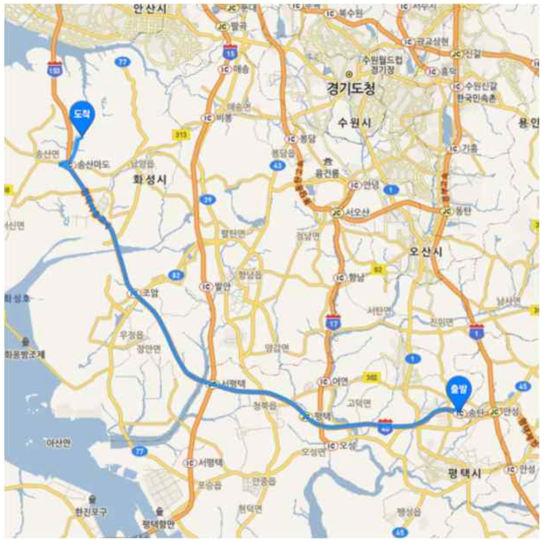
➢ Real-road Driving test

✓ 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>

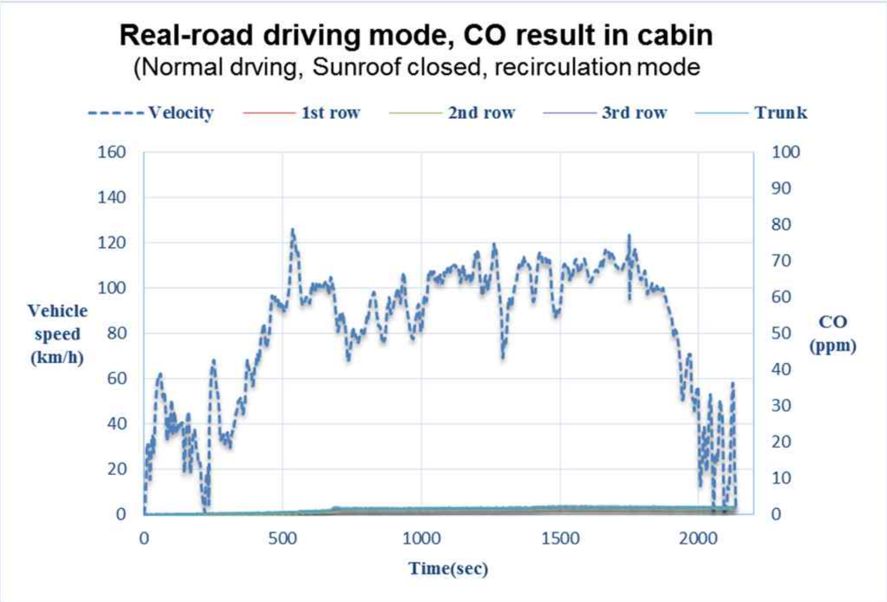


<Songtan IC -> KATRI>

➢ Real-road Driving test

✓ Real-road driving mode

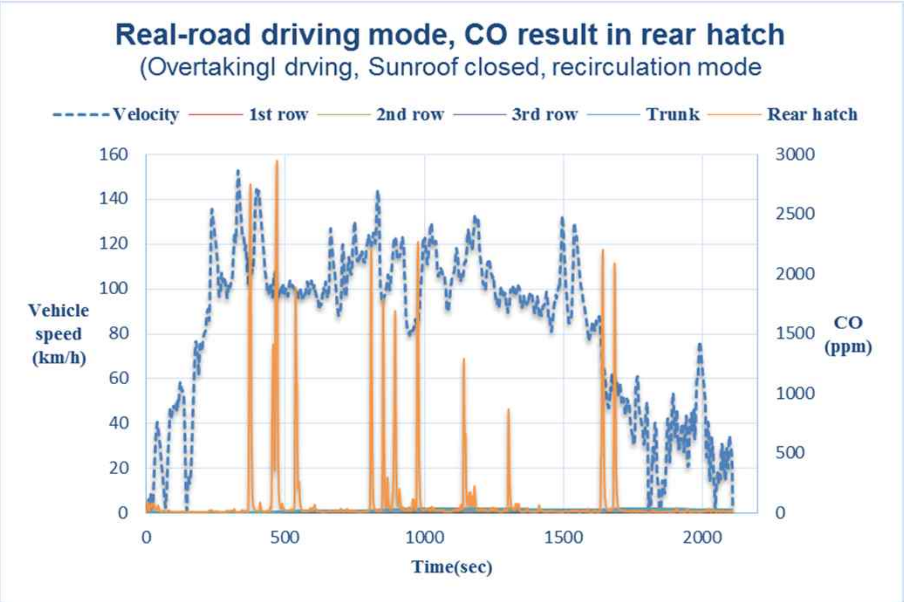
- Real-road driving test in same course without acceleration
- Smoothing driving, Throttle open not more than 50%
- CO was not detected in cabin

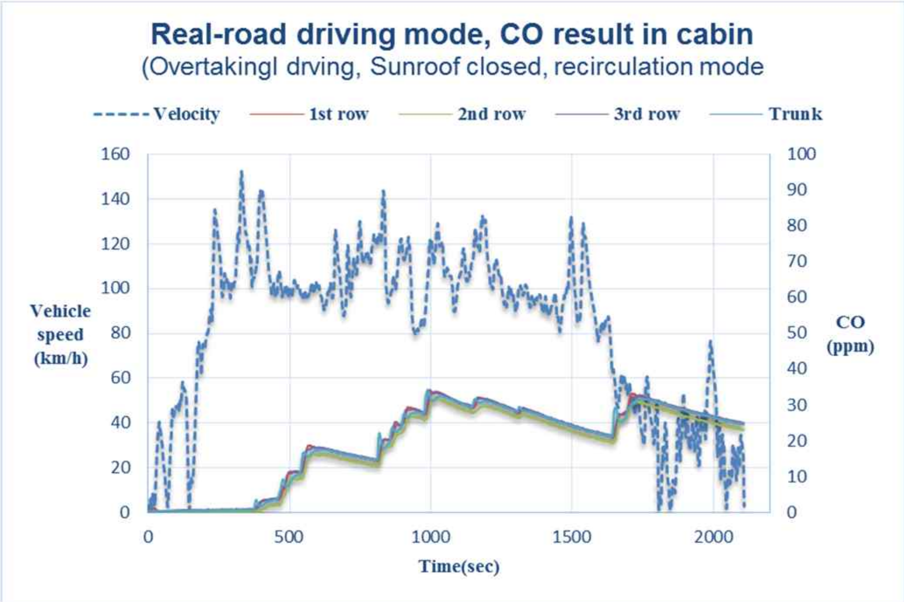


➢ Real-road Driving test

✓ 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

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➢ 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

Test mode, if exhaust gases, which are generated from their own engine, could enter into cabin	
Idling mode	- Russian Proposal
Constant speed mode	- Driving vehicles at constant speed (e.g. 130±5 km/h)
Acceleration mode	- 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

Jongsoon LIM

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Korea Transportation Safety Authority

Korea Automobile Testing & Research Institute