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IAQ and Ventilation Efficiency with Respect to Pollutants Inside Automobiles

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1 Introduction

Recently, there has been a growing public concern over indoor air quality not only in buildings but also in vehicles. Since the vehicle is the main form of daily transportation for most people, of particular concern is the symptoms suffered by both drivers and passengers such as fatigue, headache, and eye stimulation caused by formaldehyde and volatile organic compounds (VOCs) emitted from the interior materials of newly assembled vehicles.

In order to address this problem, leading automobile manufacturers have voluntarily conducted the measurement and management of indoor air quality for new vehicles. Audi and Mercedes Benz use sensory tests carried out by a Nose Team to control the odors in new cars. Furthermore, ISO/WD 16000-26, which specifies automobile interior materials, is currently being included in ISO/TC146 /SC6.

In June 2007, the Korean government also proposed “The standard of indoor air quality new vehicle” and reported the results, which demonstrate that the harmful impact of chemical pollutants might be minimised by

indoor air control strategies such as ventilation of the new vehicle within 90 days after it is manufactured. From the results [Ref 6-2], it can be seen that ventilation is as effective within a vehicle as it is in similarly enclosed spaces such as within buildings.

2 Status on indoor air quality in a car

In 2007, the ISO/CD 16000-2 was proposed as part of ISO/TC146/SC6, and in October 2007, ISO/WD 16000-26 was added to the section, “Car Interior", 6WG of the ISO/TC146/SC. (Indoor air-Part 26: Road vehicle test stand-Specification and method for the determination of volatile organic compounds in car interiors.) As a voluntary measure to reduce VOC levels in automobiles, the Japan Automobile Manufacturers Association (JAMA) made efforts to meet the indoor concentration criteria for 13 substances, as made efforts to meet the indoor concentration criteria for 13 substances, as established by the Ministry of Health, Labour, and Welfare in 2005. In Germany, the German Quality Management System for the automobile industry (VDA) put forward the VOC emission evaluation method for automobile interior materials, and the TÜV Rheinland group is operating the “Allergy Free" certification system for automobile interior materials.

Also, in China, the State Environmental Protection Administration has addressed the

measurement methods for air pollutants within the cabins of different types of vehicles (M1, M2, and M3) in 2007.

Thus, a number of countries have created their own standards for measurement methods and recommendation standards of total

volatile organic compounds (TVOC) in the indoor air of vehicles. It is expected that worldwide environmental restrictions will be placed on automobile manufacturers through establishing international testing standards and guidelines such as ISO/WD 16000-26.

Furthermore, considering the trends towards standardisation of the measurement technique of volatile organic compounds further research is also required on the effect of ventilation in cars.

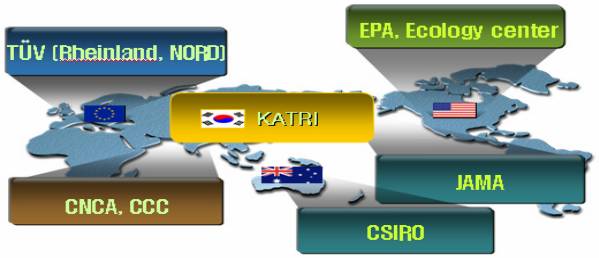

Figure 1: Development trends of indoor air quality in the main countries

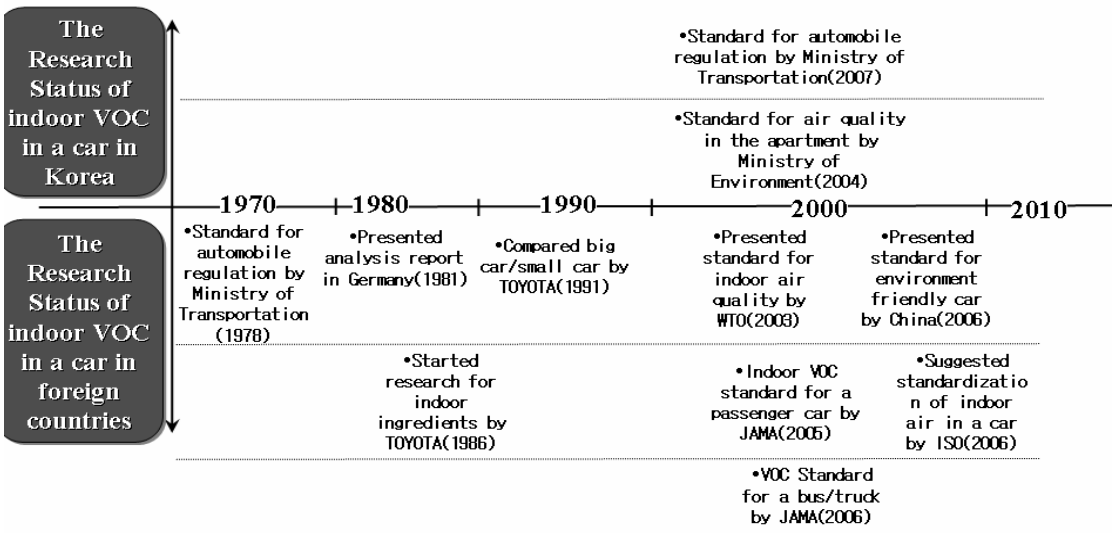

Figure 2: Standardisation Trends in the main countries

3 Measurement method of indoor air in new cars and the recommendation standards

Research results [Ref 6-1] from a Korean research show that measurements of indoor air quality in cars are generally conducted on newly assembled passenger cars within 4 weeks after the completion of assembly from the automobile manufacturer. They show that formaldehyde and volatile organic compounds, including benzene, toluene, xylene, ethyl-benzene, and styrene, which are regulated in the Indoor Air Quality Recommendation Standards, are substances that should be measured.

The probes point is the point between the test chamber and the driver's seat in the car. In the case of the test chamber, sampling should be made at a height of 1m from the floor and 0.3 m~ 1 m from the interior side of the car. Sampling is made at a point 50 cm from the front of the steering wheel.

Table 1. Measurement method of Indoor Air Quality in the new car

Number of passing day	Within 4 weeks
Temperature stabilization	25±2℃ (Min. 12 hours)
Ventilation hour before measurement	30 minutes
Status of testing car in the measurement	Parking in normal temp./ closed
Measurement temperature	25±2℃
Closing maintenance time	2 hours
Sampling volume	HCHO: 15ℓ VOCs: 1ℓ

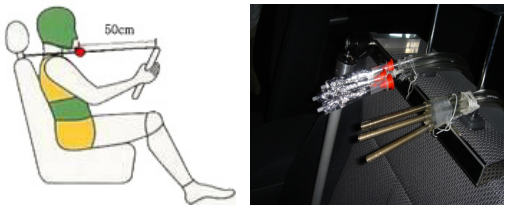

Figure 3: Measurement of probes point

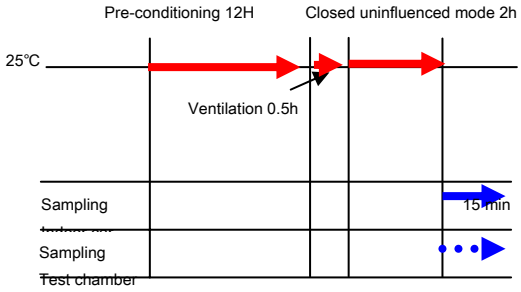

Figure 4: Measurement schedule of indoor air quality in a car (Korea)

In preparation for the measurement, all doors of the car must be open for no longer than 30 minutes. During this time, the sampling probes or temperature sensor must be installed.

Measurement should be performed in the test chamber and test car within two hours after closing all the opened doors of the car. Sampling is then taken for 15 minutes after this time, as shown in the measurement schedule in figure 4.

In December, 2004, several concerned administration departments in Korea established 'The basic plan of indoor air quality control', and selected detailed research projects to examine the indoor air quality control of new cars manufactured in March, 2005. In order to prepare the indoor air quality control standards for new cars, measurements were initially taken of the indoor air quality for 7 types of passenger cars and 2 types of large multi-3

purpose vehicles (9 types). This was carried out from May 2005 to December 2005. The vehicles were measured for 39 to 177 days, and 56 to 59 days after manufacturing for the passenger cars and for the multi-purpose vehicles, respectively. The measurement results are shown in Table 2.

In order to propose draft recommendation standards for new cars, several pollutants, including formaldehyde, benzene, toluene, xylene, ethyl-benzene, and styrene, were analyzed in 36 new cars.

Table 2:. Status of Indoor Air quality in a car (KOTSA Press Release 12th, January, 2006)

Classification	Measured concentration (μg/㎥)			
	Passenger car	Test chamber	Multi-purpose vehicle	Test chamber
HCHO	22~145	20~29	111~234	89~125
Benzene	1~22	0~6	20~29	4~7
Toluene	30~832	17~61	1,202~1,956	272~314
Ethyl Benzene	3~594	2~26	272~386	81~95
Xylene	10~919	8~148	698~1,000	218~248
Styrene	1~71	0~9	32~140	25~29

Table 3: Recommendation standard of indoor air quality for new cars (μg/m³)

Classification	Recommended standard concentration
HCHO	250
Benzene	30
Toluene	1,000
Xylene	870
Ethyl Benzene	1,600
Styrene	300

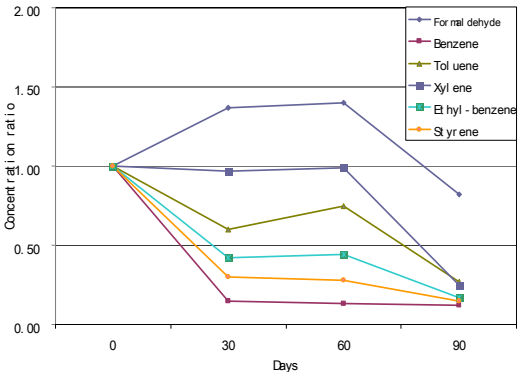

Figure 5: Reduction ratio of contaminants with the passage of time

Figure 6. Measurement method of indoor air in a car at stop mode

The analysis included the initial concentrations of the substances after assembly, as well as time variations in the concentrations. Ventilation feasibility and a risk assessment were also carried out. The average measurement concentration and recommendation standards are presented in Table 3.

According to the, research results of the time variation in pollutant concentrations as presented by the KOTSA press release, the concentration of pollutants was generally reduced with the passage of time, as shown in Figure 5. At approximately 3 months after manufacturing, the concentrations of 5 selected volatile organic compounds, with the exception of formaldehyde, were reduced by rates of 75% to 95%. As shown in figure 5, formaldehyde concentrations showed a tendency to increase slightly on the 60th day after car manufacturing and to thereafter be reduced. Overall, the pollutant concentrations in new cars decreased with the passage of time. However, it is necessary to rapidly eliminate the harmful pollutants and to reduce the concentrations directly after manufacturing by using mechanical ventilation systems or opening windows.

4 Evaluation of Ventilation Performance within a Car

Due to the serious consequences of exposure to contaminated indoor air for drivers and passengers of cars, careful consideration of indoor air quality for cars is required. In a number of countries that manufacture automobiles a great deal of research is being conducted in order to determine various ways to improve and enhance the indoor air quality. Methods used to reduce indoor contaminants can be generally classified into those where the external contaminants do not intrude into the interior, and those that rapidly reduce the contaminants within the interior.

In one of these methods, contaminants are diluted by ventilation or by discharging them to the outdoors. The ventilation rates of 8 cases were tested in order to investigate the effectiveness of this method.

In order to collect the indoor air at the car stop mode, the change in concentration of a detection gas (SF6) was measured after connecting to the gas monitor (INNO VA Multi-gas Monitor 1302), as shown in figure 6.

As shown in figure 7, the measurement instrument was installed in the trunk of the car and the measurements were taken under conditions for the average driving speed (20 km/h~ 30 km/h) within the city of Seoul.

Figure 7. Measurement method of indoor air in a car at drive mode

Measurements were taken at three different experimental conditions, including: the ventilation volume according to the speed control (low speed/high speed) of an indoor air circulation fan while the car was in stop mode, the speed of air circulation produced by a fan while the car was in drive mode, and the ventilation volume produced by opening a window. The air tightness of the car was about 1.1 (m^3/h). The measurement results are shown in Table 4.

The results show that, with the operation of an air circulation fan (low speed/high speed) while the car was at stop mode, the volatile organic compounds and formaldehyde increased in the indoor air, as the pollutants were continuously emitted from the interior materials. In the case where the ventilator was operated by external circulation and the car was in drive mode, the concentration of indoor contaminants was significantly reduced. 5 minutes after the car window was opened, the effect of contaminants reduced by a minimum of 70%.

5 Conclusion

Ventilation is one of the most effective methods available to dilute or reduce indoor air contaminants, and it is comparatively beneficial to be able to discharge the contaminants to the outdoors.

This is particularly the case when the type and movement characteristics of contaminants in the indoor air are unknown. From the experiment results for the ventilation performance of the car, it can be concluded that the reduction ratios of volatile organic compounds and formaldehyde, which may be noxious to the human body, can be significantly lowered by the operation of a fan within the passenger car. This can be achieved by streaming the external air into the car, in either the stop or drive mode, or by providing ventilation by opening a window. In particular, it is considered that ventilation is the most practical way to reduce contaminants that have complicated characteristics, such as formaldehyde, volatile organic compounds, cigarette smoke, to reduce unpleasant smells, and to improve the indoor air quality of newly assembled cars.

Therefore, it is considered that a positive response to the standardisation of automobile ventilation is necessary, as it is one of the most effective methods for reducing contaminants. Furthermore, the standardisation of evaluation techniques for automobile indoor contaminants is required in the future.

Table 4: Measurement of ventilation of a car

Testing conditions			Small car	Remarks
At stop mode	Internal circulation	Low speed fan	1.2	Low speed: 1st level High speed: 4th level
		High speed fan	1.6	
	External circulation	Low speed fan	3.4	
		High speed fan	6.5	
	Perfect window opening	Indoor	5.0	Fan off
		Outdoor	6.7	Fan off
At drive mode		External circulation	2.4	Fan off
		Window opening	3.7	Opening 10~15cm

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