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Air Quality in Vehicle Tunnels

Introduction

This paper is to inform Members of the recent development of the air pollution issues in vehicle tunnels.

Air Pollution Problems in Tunnels

2. There are eight vehicle tunnels (3 privately owned and 5 government owned) in Hong Kong. The air pollution inside some of these tunnels, in particular, the Tate's Cairn Tunnel, has been a subject of complaint from the public and district boards in the past few years.
3. In response to the complaints, the Environmental Protection Department (EPD) has conducted some investigations and measurements of the air quality inside the vehicle tunnels. The findings showed that the carbon monoxide levels were well within the current limit but, on some occasions, the nitrogen dioxide and smoke concentrations could be high. This is due to the emissions from diesel vehicles which have been extensively used in Hong Kong.
4. Among all tunnels, the Tate's Cairn Tunnel has the highest potential for air pollution problem because of its longest length. In 1995, out of the 6 complaints received by the EPD against unacceptable tunnel air quality, 5 concerned the Tate's Cairn Tunnel. Recently, the residents of Sha Tin protested by putting on paper masks while travelling through the tunnel.

Control of Tunnel Air Quality

5. Control of the tunnel air quality is outside the purview of the Air Pollution Control Ordinance enforced by the EPD. At present, the only statutory instruments for controlling tunnel air pollution are through either the respective tunnel ordinances or management agreements, which are enforced and monitored by the Transport Department. However, these instruments stipulate only the standards for carbon monoxide. For many tunnels, these standards are also outdated.

6. To address the problem, the EPD has worked out a set of air quality guidelines for tunnels. These guidelines were endorsed by the then Environmental Pollution Advisory Committee (the predecessor of this Council) in November 1993. The EPD has then prepared and issued a technical guidance entitled "Practice Note on Control of Air Pollution in Vehicle Tunnels" (Appendix 1) to help the Transport Department and all tunnel operators in achieving these guidelines
7. Although the requirements of the technical guidance are yet to be fully implemented by most of the tunnel operators, some success have been achieved in the Lion Rock Tunnel. In last month, it has completed the installation of the nitrogen oxide monitors and upgraded its ventilation system for ensuring acceptable air quality.
8. For the Tate's Cairn Tunnel, the tunnel operator has recently started a trial test to explore the feasibility and effectiveness of increasing fan operation with its existing ventilation provision for two weeks starting from 1 July 1996. Upon the completion of the assessment, the EPD will work out a package of additional mitigation measures for the Transport Branch and the Transport Department to follow up with the Tate's Cairn Tunnel's management for implementation.
9. The longer term solution is to set the standards for air quality in tunnels through legislation. The Planning, Environment and Lands Branch is now considering the best legislative option for effective control of air quality in both existing and future tunnels in conjunction with the relevant branches and departments.

Environmental Protection Department
July 1996



Practice Note on
Control of Air Pollution
in Vehicle Tunnels

Air Services Group
Environmental Protection Department
November 1995



INTRODUCTION

1. This Practice Note provides guidelines on control of air pollution in vehicle tunnels by setting out:-

- (i) the air pollution concentration limits required for protection of public health; and
- (ii) other factors that should be considered in design and operation of vehicle tunnels.

CONCENTRATION LIMITS

2. Carbon monoxide, nitrogen dioxide and sulphur dioxide are the 3 indicative air pollutants inside vehicle tunnels in Hong Kong. To protect the health of the public, the air quality inside these tunnels should be kept within the following concentration limits:-

Air Pollutants	Averaging Time	Maximum Concentration	
		Microgrammes Per Cubic Metre (μm^3)*	Part Per Million (ppm)
(a) Carbon monoxide	5 minutes	115,000	100
(b) Nitrogen dioxide	5 minutes	1,800	1
(c) Sulphur dioxide	5 minutes	1,000	0.4

* Expressed at the reference condition of 298 K and 101.325 kPa.

3. In addition to the above, the visibility in tunnels is a gross indicator of the smoke concentration. It should be monitored and controlled to a level equivalent to an extinction coefficient of 0.005 per metre or less during any 5-minute interval.



VENTILATION REQUIREMENTS

4. The quantity of fresh air provided for a vehicle tunnel should be sufficient to ensure that the quality of the air is always maintained within the aforementioned concentration limits. To achieve this, the capacity of the ventilation system should be sufficient to cope with the maximum air pollution emission rate under the worst foreseeable traffic condition. Extra ventilation capacity would normally be required if tidal flow operation is expected.

AIR POLLUTION EMISSION RATES

5. Before the ventilation requirement can be determined, it is necessary to assess the maximum emission rates of the air pollutants inside a vehicle tunnel. The air pollution emission rates are determined by a number of factors including the traffic mix, speed limits as well as the configuration of the tunnel. The assessment would need to be done by specialists with suitable experience and background. Appendix 1 gives the categories of the basic emission values making reference to the emission factors recommended by the Permanent International Association of Road Congresses in the publication "Road Tunnels - XIXth World Road Congress, 1991".

MONITORING

6. Monitoring of the traffic flow and air pollution concentrations inside vehicle tunnels is essential in ensuring acceptable air quality. There should be a real time system to feedback the information to the tunnel management so that the ventilation system can always be operated at the appropriate capacity level. If the air quality cannot be maintained to within the concentration limits, the traffic flow may need to be regulated to help reduce the air pollution. Appendix 2 sets out the normal requirements in monitoring air pollution inside vehicle tunnels.

TRAINING, SUPERVISION AND MAINTENANCE



7. Training, supervision and preventive maintenance are also vital factors to ensure an effective air pollution control system for vehicle tunnels. For these purposes, appropriate management plans should be derived.

ENQUIRIES

8. Officers in the Air Services Group of the Environmental Protection Department are glad to answer any enquiries concerning the control of air pollution in vehicle tunnels. Enquiries can be addressed to the Senior Environmental Protection Officer, Air Services Group, Environmental Protection Department (Telephone: 25946265, Facsimile: 28278040).



Appendix 1

EMISSION FACTORS

The emission factor is determined by:-

$$Q = q_0 \times f_v \times f_i \times f_H$$

where: q_0 = basic emission value per vehicle and hour at a velocity of 60 km/h

f_v = speed factor, relative to hourly emission value

f_i = gradient factor

f_H = altitude factor

Vehicle Type	Registration Date	Basic Emission Value To Be Derived from PIARC 1991 Under the Following Category
Passenger Cars	Registered before 1 January 1992	EEC R15/04 (No control)
	Registered on or after 1 January 1992	FTP 75
Taxis and Vans Having Gross Weights Less Than 2.5 Tonnes	Registered before 1 January 1992	EEC R24 (No control)
	Registered on or after 1 January 1992	FTP 75
Diesel Engine Goods Vehicles	Registered before 1 April 1995	EEC R24 (No control)
	Registered on or after 1 April 1995	EURO 1 (or approximately equivalent to US Transient 1990/91)
	Registered on or after 1 January 1998	EURO 2 (or approximately equivalent to US Transient 1994)

Appendix 2

MONITORING REQUIREMENTS

1. Continuous measurement of parameters including carbon monoxide, nitrogen dioxide and visibility should be conducted inside a tunnel. At least one analyzer for each parameter at each kilometre section of the tunnel should be installed and operated. For sulphur dioxide, although it is a parameter for tunnel design, considering the traffic mix in Hong Kong, continuous monitoring is normally not required.

2. The monitoring of nitrogen dioxide may be replaced by that for nitric oxide through the application of the following equation or any correlation relationship between these two parameters with a regression coefficient of not less than 0.85:-

$$\begin{array}{l} \text{Nitrogen dioxide} \\ \text{concentration } (\mu\text{g}/\text{m}^3) \end{array} = 320 + 0.1056 \times \begin{array}{l} \text{Nitric oxide} \\ \text{concentration } (\mu\text{g}/\text{m}^3) \end{array}$$

3. To ensure accurate measurement of the air quality, all monitoring instruments should be checked for zero and span once a week and calibrated and certified at least once per year by an independent environmental laboratory in accordance with the manufacturers' recommendations.

4. For existing tunnels, prior to the retrofitting of the nitrogen oxides/nitrogen dioxide analyzer, the tunnel professional persons should estimate the nitrogen dioxide concentration and ensure compliance with the air quality guidelines by applying the following equation:-

$$\begin{array}{l} \text{Nitrogen dioxide} \\ \text{concentration } (\mu\text{g}/\text{m}^3) \end{array} = 560 + 0.0141 \times \begin{array}{l} \text{Carbon monoxide} \\ \text{concentration } (\mu\text{g}/\text{m}^3) \end{array}$$

5. The analyzer mentioned in paragraph 3 above should activate an audible alarm in the main control room of the tunnel whenever the measured carbon monoxide and nitrogen dioxide concentrations exceed $60,000 \mu\text{g}/\text{m}^3$ and $1,000 \mu\text{g}/\text{m}^3$, respectively. Prompt action, including the fan operation, restriction of the traffic flow and other acceptable means should be taken whenever appropriate.

6. For individual cases, additional measures might be required. Advice from the Environmental Protection Department should be sought before finalising the monitoring requirements for a vehicle tunnel.