Appendix 4T

In Tunnel Air Quality

APPENDIX 4T : IN-TUNNEL AIR QUALITY

Introduction

1.1.1.1 Emission factors from EMFAC-HK have been adopted to estimate the vehicle emission levels for the purposes of the air quality assessment for the EIA. However, the Tunnel Ventilation System (TVS), as part of the deliverables in the preliminary design stage to be submitted later, will estimate the pollution level based on PIARC 2012 and provide details to address the strategy in designing TVS for compliance with the result of the EIA and the in-tunnel air quality guidelines.

1.1.1.2 Air quality within the tunnel is to be monitored and a tunnel ventilation system installed to ensure that the air quality within the tunnel would comply with the air quality standard of EPD's "Practice Note on Control of Air Pollution in Vehicle Tunnels" which is mentioned in Section 4.2.4 of the EIA Section. This appendix describes how the air pollutant within the proposed tunnel section of the Trunk Road T2 is derived for the EIA study.

1.1.1.3 The tunnel ventilation system is designed to remove and dilute the vehicular emissions within the tunnel to comply the air quality standards which have been specified in the above noted EPD's Practice Note. The air quality standards are stated in the table below.

Table 1.1 Tunnel Air Quality Guidelines

Air Pollutant	Averaging Time (min)	Maximum Concentration	
		µg/m^3 [1]	ppm
Carbon Monoxide (CO)	5	115,000	100
Nitrogen Dioxide (NO_2)	5	1,800	1
Sulphur Dioxide (SO_2)	5	1,000	0.4
Visibility	**Averaging Time (min)**	**Distance (m^{-1})**	
Extinction Coefficient Limit	5	0.005	

Note: [1] Measured at reference condition of 298K and 101.325 kPa.

Tunnel Ventilation Design and Rate

1.1.1.4 A modified semi-transverse system with point exhaust by OHVD (dual mode: exhaust in normal, smoke extraction in emergency) is proposed for normal operating conditions during congested operation (non-fire incident). Subject to the final analysis of pollutant emission, initially it is estimated no mechanical ventilation supply to the tunnel will be required during normal operations. In order to limit the portal emissions, significant ventilation rates are proposed from the tunnel to the ventilation building, which are far greater than the ventilation rates needed for maintaining the in-tunnel air quality.

1.1.1.5 Air quality within the tunnels will be maintained by varying the number and configuration of operating fans to ensure the rate of airflow matches the tunnel air quality and portal emission criteria. During all traffic conditions, the fans will ensure that in-tunnel air is extracted through the ventilation buildings. In the preliminary design stage, an estimation of pollution level by PIARC 2012 will be performed with the correspondence to the traffic data given by the Traffic Consultant on Dec 2012, in order to illustrate the worst scenario for the tunnel ventilation system.

1.1.1.6 In conjunction with off-site air quality studies, the preliminary design of the tunnel ventilation system requires extraction of air at a maximum of approximately 400 m^3/s from a location approximately 50m from the exit tunnel portals of each tunnel bore to maintain acceptable air quality inside the tunnel and to prevent significant discharge of vitiated air from the portals.

1.1.1.7 The ventilation capacity for normal operation is defined by the air demand required to dilute vehicle emissions to maintain allowable in-tunnel air quality values. Ambient air supplied to the tunnel as fresh air contains background levels of CO, NO_2 and RSP. These background levels are normally relatively low, but could be higher in the case of urban tunnels. The control of tunnel ventilation system is dependant on the accuracy and reliability of monitoring equipment. Monitors require high levels of maintenance, protection and regular calibration. Monitors are generally not designed for the use in tunnels and are usually deployed and operated by non-specialists. The issue can be resolved by using multiple monitors for the monitoring through the tunnel. Control system shall not rely on a single monitor.

Calculation for Pollution Levels

1.1.1.8 An hourly estimation of emission result by EMFAC emission factor is generated to review the situation for EIA submission. The in-tunnel airflows and pollution levels will be calculated based on PIARC 2012 by the design engineer of the tunnel ventilation system with details of estimation to be submitted during in preliminary design report. The traffic data of different operation years (2021, 2026 and 2036) will be adopted in accordance with the traffic data provided in the approved TIA report. Linear interpolation of the parameters would be adopted for estimating the closest value to match with the criteria in PIARC 2012. The type of vehicle fleet has been grouped into passenger car, light duty vehicle and heavy goods vehicle accordingly and, also, the emission factors given in PIARC 2012 shall be adopted.

The parameters needed for the calculations of the fresh air required are as follows:

- The unit emissions of the vehicles (reference to PIARC 2012 or national recommendations);
- The traffic density and speed (reference to the traffic information provided in the TIA report); and
- The threshold limits for each pollutant (reference to EPD's Practice Note).

1.1.1.9 Generally, the sizing of the ventilation system is directly related to the calculated airflow requirement. This approach does not take into account the traffic piston effect. In some cases (uni-directional traffic), such as with fast moving traffic, the piston effect can self-ventilate the tunnel. The PIARC method of calculating the ventilation requirements is as follows:

$$V = n_{veh} x Q x \frac{1}{C_{adm} - C_{amb}}$$

Where:
V = Required ventilation, m^3/s
n_{veh} = Number of vehicle
Q = Emission per vehicle, m^3/s
C_{adm} = Admissible concentration, ppm
C_{amb} = Ambient concentration, ppm

1.1.1.10 The PIARC method of calculating vehicle induced airflow is as follows:

$$\Delta P_{veh} = \left[\frac{MxL}{V}\right]\frac{(c_w A)}{A_T}\frac{\rho}{2}(v \pm u)^2$$

Where:
ΔP_{veh} = Pressure difference created by vehicle, Pa
M = Traffic flow, vehicle/hr
L = Length of the tunnel, km
c_w = Coefficient of resistance for a vehicle type
A = The cross-sectional area for a vehicle type (typically $2m^2$ for a car, $7m^2$ for a truck), m_2
A_T = The cross sectional area of the tunnel, m^2
V = Velocity of moving traffic, m/s
u = Air velocity in the tunnel, m/s

1.1.1.11 A study shall be carried out during preliminary design stage to determine the point in which the vehicle induced airflow or piston effect, requires that the tunnel no longer requires ventilating. This would be established by comparing the ventilation required to meet the set level of various pollutants (i.e. NO_2, RSP) in the tunnel with the piston effect created by the traffic at a number of different speeds. Even when the traffic-induced ventilation is adequate for the dilution of pollutants in the normal traffic conditions, fans are often provided to cater for idling and slowly moving traffic.