Two-way Enclosure - Normal Condition

Tunnel Parameter

Tunnel length (m), L	=	82
Tunnel height (m), H	=	8
Tunnel width (m), W	=	28 (Averaged width)
Tunnel size (m2), At	=	H * W
		224
Equivalent diameter (m), dt	=	$(4*At/\pi)^{0.5}$
		16.88804
Effective length of the tunnel (m), Le	=	L + 2*3*dt
		183.3282

Emission Data

Traffic Breakdown (%)

Tunnel traffic (Link no.)	Traffic flow (veh/hr)	Motor Cycles	Petrol PC &LGV	Taxi	Non-franchised Buses <6.4t	Non-franchised Buses 6.4-15t	Non-franchised Buses >15t	Private Light Buses <3.5t	Private Light Buses >3.5t	Diesel PC&LGV <2.5t	Diesel LGV 2.5-3.5t	Diesel LGV >3.5t	HGV<15t	HGV>15t	Single Deck Franchised Buses	Double Deck Franchised Buses	Public Light Buses
108	390	0.01	0.30	0.17	0.00	0.06	0.00	0.00	0.02	0.02	0.09	0.08	0.13	0.01	0.01	0.04	0.06
109	2828	0.01	0.38	0.07	0.00	0.02	0.00	0.00	0.01	0.01	0.05	0.04	0.36	0.02	0.00	0.01	0.02
88-90	4510	0.04	0.44	0.05	0.00	0.03	0.00	0.00	0.01	0.02	0.11	0.09	0.17	0.01	0.00	0.01	0.01
Total	7728	0.03	0.41	0.06	0.00	0.03	0.00	0.00	0.01	0.02	0.09	0.07	0.23	0.01	0.00	0.01	0.01
NOx Emission Factor (g/mile)		1.14	0.28	0.28	0.00	7.07	0.00	0.00	0.82	1.07	0.59	3.76	7.89	10.01	5.44	5.81	0.77

Weighted NOX E.F. (g/km/veh)	=	1.7360
NO2 emission factor per unit length (g/m/s), w1	=	12.5% * Weight NOX E.F. * Traffic flow
	=	4.66E-04
NO2 emission transferring from neighboring enclosures (g/s)	=	20% * (IN A2 + IN F2) (Note: For the amounts of IN A2 and IN F2 in normal condition, please refer to Appendix 4.4)
	=	5.31E-02
Length of Enclosure E1 (m)	=	82
NO2 emission transferring from neighboring enclosures (g/m/s), w2	=	6.48E-04
Total NO2 emission factor per unit length (g/m/s), w	=	w1+w2
	=	1.11E-03

Vehicle Data

Nominal dimensions of vehicles are given in Transport Planning and Design Manual, Vol. 2 as:

	W	H	L
Motor Cycles	1.7	1.5	4.6
Petrol PC &LGV	1.7	1.5	4.6
Taxi	1.7	1.5	4.6
Non-franchised Buses <6.4t	2.5	3.5	12
Non-franchised Buses 6.4-15t	2.5	3.5	12
Non-franchised Buses >15t	2.5	3.5	12
Private Light Buses <3.5t	2	3	6.5
Private Light Buses >3.5t	2	3	6.5
Diesel PC&LGV <2.5t	2.1	1.6	5.2
Diesel LGV 2.5-3.5t	2.1	1.6	5.2
Diesel LGV >3.5t	2.1	1.6	5.2
HGV<15t	2.5	4.6	16
HGV>15t	2.5	4.6	16
Single Deck Franchised Buses	2.5	3.5	12
Double Deck Franchised Buses	2.5	4.6	12

Appendix 4.4b   **Detailed Calculations of In-Tunnel Air Quality**
                       along Tuen Mun Road Town Centre Section in front of Pui To Road Flyover

Two-way Enclosure - Normal Condition

Public Light Buses   2   3   6.5

* No dimensions for motor cycles and non-franchised buses are provided.
* For the purpose of this study, the dimensions of motor cycles and taxi are assumed to be the same as private car
and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-sectional area (m2)   =   (1.7*1.5*0.03)+(1.7*1.5*0.41)+(1.7*1.5*0.06)+(2.5*3.5*0.03)+(2*3*0.01)+(2.1*1.6*0.02)+(2.1*1.6*0.09)+(2.1*1.6*0.07)+(2.5*4.6*0.23)+(2.5*4.6*0.01)+(2.5*3.5*0.001)+(2.5*4.6*0.01)+(2*3*0.01)
                                           =   5.288272
Number of lanes per direction, nl   =   4
Equivalent cross-sectional area for each direction (m2), Av   =   21.153087
Equivalent diameter of vehicle (m), dv   = $(4*Av/\pi)^{0.5}$
                                           =   5.189698

Traffic density (traffic flow /s), N   =   2.146667
Average vehicle speed (m/s), v   =   50 km/hr
                                           =   13.88889
Head to head distance on a lane (m), l   = $2*nl*v/N$
                                           =   51.75983

Diffusion Parameters
Reynolds number, Re   = $(v*dv)/\sigma$ where $\sigma = 15.6*10^{-6}$
                                           =   4620458
According to Figure 16 (Ohashi and Koso)
Since   l / dt   =   3.064881
D / (N * dt^2 * Re^0.13)   =   0.32
Longitudinal
diffusion coefficient (m2/s) , D   = $0.32 * (N * dt^2 * Re^{0.13})$
                                           =   1440.397

Maximum Concentration of NO2
Cmax (µg/m3)   = $w * Le^2 / (8 * D * At)$
(without background)   =   15

Appendix 4.4b **Detailed Calculations of In-Tunnel Air Quality**
along Tuen Mun Road Town Centre Section in front of Pui To Road Flyover

Two-way Enclosure - Worse Condition

Tunnel Parameter

Tunnel length (m), L	= 82	
Tunnel height (m), H	= 8	
Tunnel width (m), W	= 28	(Averaged width)
Tunnel size (m2), At	= H * W	
	224	
Equivalent diameter (m), dt	= $(4 \cdot At/\pi)^{0.5}$	
	16.88804	
Effective length of the tunnel (m), Le	= L + 2*3*dt	
	183.3282	

Emission Data

Traffic Breakdown (%)

Tunnel traffic (Link no.)	Traffic flow (veh/hr)	Motor Cycles	Petrol PC &LGV	Taxi	Non-franchised Buses <6.4t	Non-franchised Buses 6.4-15t	Non-franchised Buses >15t	Private Light Buses <3.5t	Private Light Buses >3.5t	Diesel PC&LGV <2.5t	Diesel LGV 2.5-3.5t	Diesel LGV >3.5t	HGV<15t	HGV>15t	Single Deck Franchised Buses	Double Deck Franchised Buses	Public Light Buses
108	390	0.01	0.30	0.17	0.00	0.06	0.00	0.00	0.02	0.02	0.09	0.08	0.13	0.01	0.01	0.04	0.06
109	2828	0.01	0.38	0.07	0.00	0.02	0.00	0.00	0.01	0.01	0.05	0.04	0.36	0.02	0.00	0.01	0.02
88-90	4510	0.04	0.44	0.05	0.00	0.03	0.00	0.00	0.01	0.02	0.11	0.09	0.17	0.01	0.00	0.01	0.01
Total	7728	0.03	0.41	0.06	0.00	0.03	0.00	0.00	0.01	0.02	0.09	0.07	0.23	0.01	0.00	0.01	0.01
NOx Emission Factor (g/mile)		1.02	0.38	0.38	0.00	10.41	0.00	0.00	1.21	1.55	0.86	5.57	11.82	15.06	9.45	10.26	1.14

Weighted NOX E.F. (g/km/veh)	=	2.5801	
NO2 emission factor per unit length (g/m/s), w1	=	12.5% * Weight NOX E.F. * Traffic flow	
	=	6.92E-04	
NO2 emission transferring from neighboring enclosures (g/s)	=	20% * (IN A2 + IN F2)	(Note: For the amounts of IN A2 and IN F2 in worse condition, please refer to Appendix 4.4)
	=	8.52E-02	
Length of Enclosure E1 (m)	=	82	
NO2 emission transferring from neighboring enclosures (g/m/s), w2	=	1.04E-03	
Total NO2 emission factor per unit length (g/m/s), w	=	w1+w2	
	=	1.73E-03	

Vehicle Data

Nominal dimensions of vehicles are given in Transport Planning and Design Manual, Vol. 2 as:

	W	H	L
Motor Cycles	1.7	1.5	4.6
Petrol PC &LGV	1.7	1.5	4.6
Taxi	1.7	1.5	4.6
Non-franchised Buses <6.4t	2.5	3.5	12
Non-franchised Buses 6.4-15t	2.5	3.5	12
Non-franchised Buses >15t	2.5	3.5	12
Private Light Buses <3.5t	2	3	6.5
Private Light Buses >3.5t	2	3	6.5
Diesel PC&LGV <2.5t	2.1	1.6	5.2
Diesel LGV 2.5-3.5t	2.1	1.6	5.2
Diesel LGV >3.5t	2.1	1.6	5.2
HGV<15t	2.5	4.6	16
HGV>15t	2.5	4.6	16
Single Deck Franchised Buses	2.5	3.5	12
Double Deck Franchised Buses	2.5	4.6	12

Appendix 4.4b   **Detailed Calculations of In-Tunnel Air Quality**
along Tuen Mun Road Town Centre Section in front of Pui To Road Flyover

Two-way Enclosure - Worse Condition

Public Light Buses	2	3	6.5

* No dimensions for motor cycles and non-franchised buses are provided.
* For the purpose of this study, the dimensions of motor cycles and taxi are assumed to be the same as private car
and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-sectional area (m2) = (1.7*1.5*0.03)+(1.7*1.5*0.41)+(1.7*1.5*0.06)+(2.5*3.5*0.03)+(2*3*0.01)+(2.1*1.6*0.02)+(2.1*1.6*0.09)+(2.1*1.6*0.07)+(2.5*4.6*0.23)+(2.5*4.6*0.01)+(2.5*3.5*0.001)+(2.5*4.6*0.01)+(2*3*0.01)
= 5.288272

Number of lanes per direction, nl = 4

Equivalent cross-sectional area for each direction (m2), Av = 21.15309

Equivalent diameter of vehicle (m), dv = $(4*Av/\pi)^{0.5}$
= 5.189698

Equivalent length of each vehicle (m) = (4.6*0.03)+(4.6*0.41)+(4.6*0.06)+(12*0.03)+(6.5*0.011)+(5.2*0.018)+(5.2*0.09)+(5.2*0.07)+(16*0.23)+(16*0.01)+(12*0.001)+(12*0.01)+(6.5*0.01)
= 7.886188

Distance between vehicle (m) = 1   (worst case)

Head to head distance on a lane (m), l = 8.886188

Traffic density (traffic flow /s), N = 2.146667

Average vehicle speed (m/s), v = l*N/(2*nl)
= 2.384461

Diffusion Parameters

Reynolds number, Re = $(v*dv)/\sigma$ where $\sigma = 15.6*10^{-6}$
= 793245.6

According to Figure 16 (Ohashi and Koso)

Since   l / dt = 0.526182

D / (N * dt^2 * Re^0.13) = 0.13

Longitudinal
diffusion coefficient (m2/s) , D = 0.13 * (N * dt^2 * Re^0.13)
= 465.3604

Maximum Concentration of NO2

Cmax (μg/m3) = w * Le^2 / (8 * D * At)
(without background) = 70

Appendix 4.4b   **Detailed Calculations of In-Tunnel Air Quality**
                      along Tuen Mun Road Town Centre Section in front of Pui To Road Flyover

Overall Concentrations

Six assessment points (ASRs E11-E16) at the boundary of the enclosure are chosen.
Using CALINE4 and ISCST3 model, the air pollutants concentrations at the 6 assessment points at different levels are calculated.
The highest concentration among the six assessment points is assumed to be the background
concentration inside the proposed enclosure section.

Elevation	NO2 Concentrations (ug/m3) at Various Levels	
	(mAG)	NO_2
E11	0.0	296
	3.0	280
	6.0	256
E12	0.0	266
	3.0	263
	6.0	259
E13	0.0	320
	3.0	305
	6.0	280
E14	0.0	259
	4.0	279
	8.0	305
E15	0.0	241
	4.0	251
	8.0	284
E16	0.0	236
	4.0	262
	8.0	279

Therefore, the NO2 background concentration inside the enclosure is   320 ug/m^3

Total Maximum NO2 concentration inside enclosure of
Tuen Mun Road in front of Pui To Road Flyover (Normal Speed)   =   15 + 320
                                                                     =   335   ug/m3

Total Maximum NO2 concentration inside enclosure of
Tuen Mun Road in front of Pui To Road Flyover (Worse Case)   =   70 + 320
                                                                   =   390   ug/m3