Appendix 4.4

Calculation of Ventilation Rate for the Lorry Parking Spaces Inside the Wholesale Fish Market
Appendix 4.4 Calculation of Mechanical Ventilation Rate for the Lorry Parking Area Inside the WFM

1. Introduction

The proposed Wholesale Fish Market (WFM) at Tuen Mun Area 44 will be enclosed and provided with mechanical ventilation. It will accommodate sorting, auction and marshalling area for the fish wholesale operation as well as a lorry parking area where the loading and unloading of fish will take place. The following section details the determination of the mechanical ventilation rate required for the lorry parking area inside the WFM to ensure compliance with the Environmental Protection Department (EPD) air quality guidelines.

1.1 Air Quality Guidelines

The following guidelines as stipulated in the EPD Professional Persons Practice Note ‘Control of Air Pollution in Car Parks’ (PN 2/96 issued in June 1996) should be met within the lorry parking area.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration</th>
<th>Averaging Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Nitrogen Dioxide (NO₂)</td>
<td>1,800 µg/m³</td>
<td>5 min</td>
</tr>
<tr>
<td></td>
<td>300 µg/m³</td>
<td>1 hour</td>
</tr>
<tr>
<td>b) Carbon Monoxide (CO₂)</td>
<td>115,000 µg/m³</td>
<td>5 min</td>
</tr>
<tr>
<td></td>
<td>30,000 µg/m³</td>
<td>1 hour</td>
</tr>
</tbody>
</table>

For the NO₂ and CO are the major constituents of vehicle exhaust, the build up of these pollutants is the controlling factor of the ventilation rate required for the WFM.

1.2 Emission Factors

The vehicular emission factors of heavy good vehicles are adopted in the calculation as given below:

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Basic Emission Factors (g/km-veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Heavy Good Vehicle</strong></td>
</tr>
<tr>
<td>NOₓ</td>
<td>5.83</td>
</tr>
<tr>
<td>CO</td>
<td>8.27</td>
</tr>
</tbody>
</table>

1.3 Background Air Quality

The ambient concentration for fresh air intake of CO and NO₂ is taken from record of EPD's air quality monitoring statistics given in ‘Air Quality in Hong Kong, 2000’. The 95 percentile of the pollution concentration measured at Tsuen Wan District was used as tabulated below.
<table>
<thead>
<tr>
<th>Pollutant</th>
<th>$\mu g/m^3$</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO$_2$</td>
<td>122</td>
<td>0.065</td>
</tr>
<tr>
<td>CO</td>
<td>1490</td>
<td>1.303</td>
</tr>
</tbody>
</table>

### 1.4 Vehicular Movement within the WFM

The worst-case traffic during the peak-hour operation of the WFM was adopted in the calculation. It assumes that a maximum of 40 vehicles per hour will be using the parking area.

<table>
<thead>
<tr>
<th>Vehicle Types</th>
<th>Headway</th>
<th>Total vehicle movements per hour</th>
<th>Idling time per movement</th>
<th>Total idling time per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lorries</td>
<td>N/A</td>
<td>40 lorries</td>
<td>3 minutes</td>
<td>120 minutes</td>
</tr>
</tbody>
</table>

The average speed of vehicle movements is assumed to be 5km/h. The length of the longest lane of the various types of vehicle is given below.

<table>
<thead>
<tr>
<th>Vehicle types</th>
<th>Length of longest lane inside the car park</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lorries</td>
<td>85m</td>
</tr>
</tbody>
</table>

### 1.5 Conversion Ratio for NO$_x$ / NO$_2$

The conversion factor used for NO$_x$ / NO$_2$ is 20%.

### 1.6 Volume of WFM

The effective volume of WFM is estimated to be 32,109.66m$^3$.

### 2. Calculation of Ventilation Rates

Using the following formulas (extracted from PIARC 1987), the air quantity required for the dilution of carbon monoxide and nitrogen dioxide emitted from the idling and travelling vehicles inside the car park can be estimated.

**Carbon monoxide**

$$QF = \frac{q \cdot CO}{3600} \cdot \frac{1 \times 10^6}{CO_{lim}} (\text{Idling})$$

$$QF = \frac{q \cdot CO}{3600} \cdot \frac{1 \times 10^6}{CO_{lim}} D (\text{Travelling})$$
Nitrogen dioxide

\[
Q_F = \frac{q^o NO_2}{3600} D_{pc} \frac{1 \times 10^6}{NO_2_{lim}} \quad \text{(Idling)}
\]

\[
Q_F = \frac{q^o NO_2}{3600} D_{tc} \frac{1 \times 10^6}{NO_2_{lim}} D \quad \text{(Travelling)}
\]

where:

\( Q_F \) = required air quantity per second (\( m^3/s \))

\( q^o CO \) = basic value of CO emission per vehicle (g/hr,veh)

\( q^o NO_2 \) = basic value of NO\(_2\) emission per vehicle (g/hr,veh)

\( D_{pc} \) = number of idling vehicles with engine running

\( CO_{lim} \) = maximum permissible CO concentration (\( \mu g/m^3 \) CO)

\( D_{tc} \) = number of travelling vehicles per km = \( \frac{M_{tc}}{\nu} \)

\( NO_2_{lim} \) = maximum permissible NO\(_2\) concentration (\( \mu g/m^3 \) NO\(_2\))

where \( M_{tc} \) = hourly traffic volume of travelling vehicles, and

\( \nu \) = mean driving speed of vehicles

\( D \) = travelling distance (km)

Unit conversion of the air quality limits as stipulated in the EPD's guidelines are given as follows.

For carbon monoxide:

Molecular weight of CO = 28.01

\[
\text{EPD guideling} = \frac{30000 \times 0.02445}{28.01} \text{ppm} = 26.19 \text{ppm CO}
\]

For nitrogen dioxide:

Molecular weight of NO\(_2\) = 46.01

\[
\text{EPD guideling} = \frac{300 \times 0.02445}{46.01} \text{ppm} = 0.16 \text{ppm NO}_2
\]
2.1 Idling Vehicles

2.1.1 Carbon monoxide

Ventilation rate required to dilute CO level has been calculated as shown below.

**Lorry idling with engine running**

\[ q^0_{CO} = 2 \text{ g/min} \times 60 = 120 \text{ g/hr} \]

\[ QF = \frac{120}{3600} \times 2 \times \frac{1 \times 10^6}{30000} \times \left[ \frac{1}{1} - \frac{1.303}{26.19} \right]^{*} \text{ m}^3/\text{sec} \]

\[ = 2.339 \text{ m}^3/\text{sec} \]

* = factor for ambient fresh air concentration of CO.

2.1.2 Nitrogen dioxide

Ventilation rate required to dilute NO\(_2\) level has been calculated as shown below.

**Lorry idling with engine running**

\[ q^0_{NO_2} = 2 \text{ g/min} \times 60 \times 0.20 = 24 \text{ g/hr} \]

\[ QF = \frac{24}{3600} \times 2 \times \frac{1 \times 10^6}{300} \times \left[ \frac{1}{1} - \frac{0.065}{0.16} \right]^{*} \text{ m}^3/\text{sec} \]

\[ = 74.854 \text{ m}^3/\text{sec} \]

* = factor for ambient fresh air concentration of NO\(_2\).
2.2 Travelling Vehicles

2.2.1 Carbon monoxide

Ventilation rate required to dilute CO level has been calculated as shown below.

Lorry travelling

\[ q^0_{CO} = 8.27 \text{ g/km-veh} \times 5 \text{ km/hr} \]
\[ = 41.35 \text{ g/hr} \]
\[ M_{sc} = 40 \text{ veh/hr} \]
\[ D_{sc} = \frac{M_{sc}}{v} = \frac{40 \text{ veh/hr}}{5 \text{ km/hr}} = 8 \text{ veh/km} \]
\[ D = 0.085 \text{ km} \]
\[ QF = \frac{41.35 \times 1 \times 10^6}{3600 \times 30000} \left[ 1 - \frac{1}{1.303} \right] \times 8 \times 0.085 \]
\[ = 0.274 \text{ m}^3/\text{sec} \]

* = factor for ambient fresh air concentration of CO.

2.2.2 Nitrogen dioxide

Ventilation rate required to dilute NO\(_2\) level has been calculated as shown below.

Lorry travelling

\[ q^0_{NO_2} = 5.83 \text{ g/km-veh} \times 5 \text{ km/hr} \times 0.20 \]
\[ = 5.83 \text{ g/hr} \]
\[ M_{sc} = 40 \text{ veh/hr} \]
\[ D_{sc} = \frac{M_{sc}}{v} = \frac{40 \text{ veh/hr}}{5 \text{ km/hr}} = 8 \text{ veh/km} \]
\[ D = 0.085 \text{ km} \]
\[ QF = \frac{5.83 \times 1 \times 10^6}{3600 \times 300} \left[ 1 - \frac{1}{0.965} \right] \times 8 \times 0.085 \]
\[ = 6.182 \text{ m}^3/\text{sec} \]

* = factor for ambient fresh air concentration of NO\(_2\).
3. Ventilation Rate Required for the WFM

3.1 Estimated Ventilation Rates

<table>
<thead>
<tr>
<th>Source of emissions</th>
<th>Ventilation rates required for different pollutants</th>
<th>CO</th>
<th>NO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDLING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lorries</td>
<td>2.339</td>
<td>74.854</td>
<td></td>
</tr>
<tr>
<td>TRAVELLING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lorries</td>
<td>0.274</td>
<td>6.182</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in m³/s</td>
<td>2.613</td>
<td>81.036</td>
<td></td>
</tr>
<tr>
<td>in m³/hour</td>
<td>9406.8</td>
<td>291729.6</td>
<td></td>
</tr>
<tr>
<td>Volume of WFM</td>
<td></td>
<td>32109.66</td>
<td></td>
</tr>
<tr>
<td>Air changes/hour</td>
<td>0.3</td>
<td>9.1</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Mechanical Ventilation Requirement

The above calculation results indicate that the total air volume required for the dilution of nitrogen dioxide will be a dominant factor affecting the ventilation requirement for the WFM. The minimum ventilation rate required for dilution of nitrogen dioxide within the WFM is estimated be 9.1Ac/hr. It is therefore concluded that the EPD Air Quality Guidelines for Car Parks can be met with a ventilation provision of say 10 Ac/hr.