Practice Note for Managing Air Quality in Air-conditioned Public Transport Facilities

Buses

Environmental Protection Department
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ENVIRONMENTAL PROTECTION DEPARTMENT

PRACTICE NOTE FOR PROFESSIONAL PERSONS

Introduction

1. This Practice Note provides guidelines to professional persons on the management of air quality in air-conditioned bus facilities operated within the territory of Hong Kong by the Hong Kong franchised bus companies.

2. The guidelines include the following:

   (i) **Air Quality Guidelines -** controlling parameters and limits to indicate better air quality in bus facilities;
   (ii) **Company Framework and Responsibilities -** incorporation of company policies or service pledge to achieve better air quality in bus facilities;
   (iii) **Design Considerations -** factors that should be considered in the design of bus facilities in order to achieve better air quality;
   (iv) **Operational Practices -** good practices to be followed for the achievement of better air quality in bus facilities; and
   (v) **Monitoring, Inspection and Maintenance Requirements -** sampling and maintenance to be taken to achieve and maintain better air quality in bus facilities.

3. Scope and Definitions

   (i) This Practice Note provides guidelines for all air-conditioned bus facilities, covering :
      (a) bus compartments for passengers; and
      (b) bus stations, i.e. passenger-waiting halls or lounges.
   (ii) "Bus facilities" in this Practice Note means "air-conditioned bus facilities".
   (iii) Semi-confined stations are covered by Professional Persons Environmental Consultative Committee Practice Note - ProPECC PN 1/98 'Control of Air Pollution in Semi-Confined Public Transport Interchanges' prepared by Environmental Protection Department.
   (iv) Environmental control system refers to the air-conditioning and ventilation system which sustains the intended environmental quality inside the bus facilities. All equipment and materials used in operation, maintenance and cleaning of the system are included.

Air Quality Guidelines

4. The number and higher density of people inside the bus facilities, and the quality of outdoor air taken into the bus facilities for the purpose of diluting pollutants influence the air quality in bus facilities. There are two major areas of concern in bus facilities:

   (i) adequacy of ventilation, i.e. supply and quality of outdoor air; and
   (ii) infiltration of exhaust gases into bus compartments due to short-circuiting.

5. Since it is difficult and resource intensive to effectively monitor the numerous air pollutants found inside bus facilities, an effective way to monitor the air quality is to measure appropriate surrogate air quality indicator(s). The choice of surrogate indicator(s) depends on many factors:

(i) how representative they are of actual air quality;
(ii) ease of measurement;
(iii) ease of interpretation of results;
(iv) possibility of real-time monitoring; and
(v) feasibility of incorporating measurements into a schedule of routine maintenance procedures.

6. Carbon dioxide (CO_2) is selected as a surrogate indicator because its concentration in an indoor environment is a good indicator of the effectiveness of ventilation system and the adequacy of ventilation. As regards the infiltration of exhaust gases into bus compartments, the condition of bus bodies and components will be monitored during routine inspections by bus operators as well as during statutory vehicle examination.

7. To allow flexibility for bus operators and to encourage them to strive for better air quality, a set of two-level air quality guidelines is established to act as the benchmark for evaluating and assessing air quality in bus facilities. The two-level air quality guidelines are as follows:

Level 1 - represents good air quality of a comfortable bus facility at which there is no health concern identified.

Level 2 - represents the air quality of a bus facility at which there is no health concern identified.

The numerical values of carbon dioxide for the two-level air quality guidelines are tabulated below:

Parameter	**Air Quality Guidelines (Hourly average)**	
	Level 1	**Level 2**
Carbon dioxide	2,500 ppm (4,500mg/m^3)	3,500 ppm (6,300 mg/m^3)

8. Since thermal comfort will influence the perception of indoor air quality in the bus facilities, the recommended ranges of temperature and relative humidity are set out in Annex A.

Company Framework and Responsibilities

9. Bus service providers should establish a framework and action plan to demonstrate their intention to achieve and maintain better air quality in their facilities, including but not limited to:

   (i) put up a pledge to maintain better air quality in bus facilities;
   (ii) make known the pledge in (i) above to all employees of the company and the public;
   (iii) set up procedures to take into account the pledge in (i) above in procurement, design, operation and maintenance of the bus facilities;
   (iv) take appropriate actions when the relevant air quality guidelines set out in paragraph 7 above have been exceeded;
   (v) operate a proper complaint procedure on air quality in bus facilities and make it known to the public;
   (vi) nominate air quality manager(s), either part time or full time, with authority and responsibility to maintain better air quality within bus facilities, including the investigation, mitigation and logging of air quality complaints.

Design Considerations

10. The following design guidelines should be taken into consideration when new bus facilities are built. Existing facilities should be upgraded or retrofitted to meet the design guidelines where reasonably practicable.

(A) Bus Compartment for Passengers

11. Design guidelines for bus compartment are:

   (i) Engine

      (a) give priority to low pollution emission models when specifying the engine type to reduce the amount of pollutants that may infiltrate into compartments.
      (b) locate the engine exhaust away from the outside air intake of the ventilation system to reduce the risk of short-circuiting of exhaust gases into the compartment.

   (ii) Compartment Body

      (a) isolate the interior of the compartment body from the exhaust of its own engine.
      (b) facilitate regular maintenance and cleaning works. Reduce niches that may accumulate dirt and micro-organisms.
      (c) ventilate all parts of the compartment adequately by airflow induced by the ventilation system.
      (d) select materials having minimum emission of pollutants for use inside the compartment, such as paints with low VOC content, and seat coverings that resist soiling to avoid the growth of bacteria and fungi, etc.

(iii) Ventilation System

(a) install induced outside air intake with an on-off damper operable by the captain and provide an on-off damper indicator at a prominent location which is easily recognisable by the captain.
(b) locate outside air inlet at high level of the compartment body to avoid intake of air pollutants from adjacent sources.
(c) install particulate filters making reference to the relevant ASHRAE standards.
(d) install fans of appropriate size, taken into account the expected operational resistance of the filters (prior to filter cleaning or disposal), to deliver the designed flow rate at all times.
(e) allow access for regular maintenance and cleaning.
(f) design and locate the air outlets and return air grilles so that air can be evenly distributed throughout the compartment for flushing all parts and yet avoiding excessive draughts on passengers.
(g) install adjustable vanes with air flow control dampers for air outlets with air stream directly impinging on the passengers.
(h) design the outside air ventilation rate based on the licensed maximum passenger carrying capacity to meet the relevant air quality guidelines in Paragraph 7 above.

(B) Station

12. Design guidelines for stations are:

(i) Ventilation System

(a) design the outdoor air supply flow rate and the ventilation rate based on the designed passenger transfer rate to meet the air quality guidelines set out in Paragraph 7 above.
(b) install particulate filters at the outside air inlet and, if needed, at the re-circulated path. Efficiency of the filters should follow the "General Specification for Air Conditioning, Refrigeration, Ventilation and Central Monitoring and Control System Installation" published by the Architectural Services Department or the relevant ASHRAE standards.
(c) install fans of appropriate size, taken into account the expected final resistance of the filters (prior to filter cleaning or disposal), to deliver the designed flow rate at all times.
(d) ensure that there will be no short-circuiting of foul air in the system and no reduction in outdoor and total supply air quantity due to by-pass away from intended air paths.
(e) install duty fans for minimum outside air and for total supply air for air-conditioning purposes. Outside air fans sized for 100% supply air (free cooling fans), individual supply air fans, return air fans and exhaust air fans should be considered, as usually they provide better system performance and flexibility with air circulation and re-circulation.
(f) take into account the expected latent heat load in calculating the cooling capacity of the primary air units and air-handling units. Construct equipment with adequate numbers of rows of cooling coils for the required duty. Avoid condensation and cold spots by careful

planning of the air distribution and the temperature set points. Reference shall be made to the relevant ASHRAE standards.

(g) allow access for regular maintenance and cleaning of the ductwork and cooling coils, and cleaning and replacement of the particulate filters.

(h) install a separate exhaust at kiosks if they are expected to emit excessive amount of air pollutant.

(i) provide a dedicated air cleaner or exhaust connections for temporary renovation sites within stations to avoid dispersal of pollutants if significant amounts of pollutants are expected.

(ii) Plumbing and Drainage System

(a) use durable materials for piping, valves and drains to avoid leakage and odour.

(b) provide drainage for underground water seepage and condensation to avoid accumulation of water.

(c) provide dedicated exhaust systems to areas that are considered to have higher risk of odour problems such as toilets, sump pits and culverts.

13. In general, bus service providers should use environmentally friendly materials in all bus facilities. If the use of any materials, which emit harmful pollutants or odour is unavoidable, the pollutants should either be baked out before the materials are put into service, or the concentration of the pollutant should be controlled at an acceptable level by operating the environmental control system in an appropriate mode (details are in Annex B).

Operational Practices

14. The following good operational practices should be adopted:

(i) shut the outside air damper when the bus is traversing polluted areas, during congestion or when in tunnels.

(ii) operate the environmental control system in an appropriate mode such that the relevant air quality guidelines in Paragraph 7 will be met.

Monitoring, Inspection and Maintenance Requirements

15. Sampling for compliance checking of carbon dioxide:

(i) all bus stations should be selected.

(ii) at least 10% of the bus fleet of the same model or such percentage as determined by the air quality manager(s) based on statistical method should be selected.

16. Inspection frequency:

(i) monitor 1-hour average concentration of carbon dioxide during normal operations at peak hours at least once a year.

(ii) check the ventilation rate or ventilation system in bus compartments for passengers in the workshop at least once every three years.

17. When the relevant air quality guidelines in Paragraph 7 above are exceeded, the air quality manager(s) should conduct investigation and suggest mitigation measures to ensure the compliance of the relevant guidelines.

18. The air quality manager(s) should develop a cleaning programme to remove dirt and rubbish, avoid water or damp materials, and remove stains, bacteria and mould growth, etc. The programme should cover, but not limited to, the following:

(i) regular cleaning and replacement of air filters in ventilation systems of the bus facilities;
(ii) regular (or at such interval as recommended by manufacturers) cleaning of cooling coils, drain pans and those accessible air ducts in bus compartments for passengers. Use a high suction power vacuum cleaner with HEPA filters or other equivalent equipment as determined by the air quality manager(s) in order to avoid dust being returned to the compartment;
(iii) adequate purging of areas including air ducts and cooling coils that have undergone cleaning procedure or fumigation with outdoor air before the stations/buses are returned to service; and
(iv) keeping cleaning records for individual buses and stations.

Enquiries

19. Please contact the Air Policy Group of the Environmental Protection Department (Telephone: 2594 6262, Facsimile: 2827 8040) for enquiries on managing air quality in bus facilities.

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Annex A

Thermal Comfort

1. Air temperature and relative humidity are indicators of thermal comfort conditions which influence the perception of air quality in bus facilities. For example, cold drafts are frequently a cause of passenger complaints and high relative humidity encourages the proliferation of bacteria and fungi.

2. The recommended air temperature range is 20 to 28^{o}C and the recommended relative humidity range is 40 to 70%, or such comfortable ranges as recommended by the air quality manager(s), taking into consideration the preference of the passengers as indicated in any opinion surveys carried out from time to time.

3. Although the thermal comfort conditions in buses and bus stations could be influenced by the outside weather conditions, the bus operators should endeavour to design, operate and maintain the environmental control systems on board to achieve the recommended ranges of air temperature and relative humidity under normal operating modes of their new facilities. For existing facilities, they should be upgraded or retrofitted to meet the recommended ranges of air temperature and relative humidity, where reasonably practicable.

Annex B

Harmful Pollutants

1. The air quality manager(s) should :

   (i) ensure that environmental friendly material is used in bus facilities as much as possible;

   (ii) be aware of any potential risk of harmful substances, including odour, emitted from any material if the use of such material is unavoidable;

   (iii) obtain information such as the emission rate of air pollutants from the supplier and manufacturer of the material in (ii) above; and

   (iv) dilute the harmful pollutants with adequate outdoor air by properly managing the environmental control system.

2. The air quality at any zone of a bus facility is a function of the pollutants, ventilation rate and quality of the outside air. The concentration of a pollutant at steady state condition is given by:

$$C_{ss} = C_o + G/Q$$

   where C_{ss} = concentration of a pollutant at steady state of an operating mode of the environmental control system

   C_o = in-facility background concentration of that pollutant of the effective ventilation

   G = generation rate of the pollutant at the zone of concern

   Q = effective ventilation rate at the zone of concern.

   C_o and G constitute the inventory of a pollutant. It can be determined by adopting appropriate measurement protocols to suit the characteristics of the zone and configuration of the environmental control system. The dynamic characteristics of the pollutants can be taken into account by determining the profiles of the pollutants.

3. The "Guidance Notes for the Management of Indoor Air Quality in Offices and Public Places" published by the Indoor Air Quality Management Group of the HKSAR Government in September 2003 and the "Guidelines for Air Quality" published by the World Health Organization (WHO), Geneva, 2000 provide guidelines for the most common pollutants in indoor air.