Title

AS 1668.2-1991 The use of mechanical ventilation and air-conditioning in buildings - Mechanical ventilation for acceptable indoor-air quality

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AS 1668.2—1991

Australian Standard®

The use of mechanical ventilation and air-conditioning in buildings

Part 2: Mechanical ventilation for acceptable indoor-air quality

This Australian standard was prepared by Committee ME/62, Mechanical Ventilation and Air Conditioning. It was approved on behalf of the Council of Standards Australia on 3 October 1990 and published on 4 March 1991.

The following interests are represented on Committee ME/62:

Association of Consulting Engineers, Australia
Australian Assembly of Fire Authorities
Australian Institute of Health Surveyors
Australian Institute of Refrigeration Air Conditioning and Heating
Australian Uniform Building Regulations Coordinating Council
Building Owners and Managers Association of Australia
Confederation of Australian Industry
Council of Air Conditioning and Mechanical Contractors Associations of Australia
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This Standard was issued in draft form for comment as DR 84089.

Australian Standard®

The use of mechanical ventilation and air-conditioning in buildings

Part 2: Mechanical ventilation for acceptable indoor-air quality

First published as AS 1668.2—1976.
Second edition 1980.
Third edition 1991.

PUBLISHED BY STANDARDS AUSTRALIA
(STANDARDS ASSOCIATION OF AUSTRALIA)
1 THE CRESCENT, HOMEBUSH, NSW 2140
ISBN 0 7262 6625 6

PREFACE

This Standard was prepared by the Standards Australia Committee on Mechanical Ventilation and Air-conditioning to supersede AS 1668 – 1980, *SAA Mechanical Ventilation and Air-conditioning Code*, Part 2: *Ventilation requirements*.

The main technical changes are as follows:

(a) Outdoor airflow rates are increased for most enclosures.

(b) Reduction in outdoor airflow rates is permitted where the return air is treated for particulate and gaseous contaminants.

(c) Ventilation system ‘Lead-time’ and ‘Lag-time’ concepts are introduced.

(d) New equations are used for calculation of total airflow rates in carparks.

(e) Supply ventilation is permitted for carparks.

(f) Alternative carpark ventilation system controlled by atmospheric contaminant concentration monitoring is described.

Editorially, consideration has been given to the incorporation of the Standard in building regulations.

In the preparation of this Standard, consideration was given to the relevant Standards published by the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) for contribution to Appendices G and J, and the American Conference of Governmental Industrial Hygienists, and acknowledgement is made of the assistance received therefrom.

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STANDARDS AUSTRALIA

Australian Standard

The use of mechanical ventilation and air-conditioning in buildings

Part 2: Mechanical ventilation for acceptable indoor-air quality

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard sets out requirements for air-handling systems which ventilate enclosures by mechanical means, where such systems are required by a Regulatory Authority. It sets minimum requirements for preventing an excess accumulation of airborne contaminants, or objectionable odours. These minima are based on needs for body odour control, food odour control, air contaminant control, or carbon dioxide concentrations or a combination of any or all of these factors, depending on the particular situation. It does not prescribe other requirements associated with comfort, such as temperature, humidity, air movement or noise.

This Standard also includes requirements for natural ventilation of carparks. Road tunnels are outside the scope of this Standard.

NOTES:

1 Fire-safety aspects related to air-handling systems are covered in AS 1668.1.

2 It is recommended that air-handling systems be designed, constructed and installed so that their use does not give rise to a nuisance arising from noise or vibration. For guidance on noise and vibration control see AS 1055 and AS 2107.

1.2 APPLICATION

1.2.1 Mechanical systems Where mechanical air-handling systems are required by a Regulatory Authority, they shall be selected in accordance with Figure 1.1 and as follows:

(a) *For occupancies requiring supply ventilation* – the air-handling system shall supply outdoor air in accordance with Section 2.

(b) *For enclosures requiring general exhaust ventilation* – the air-handling system shall extract air in accordance with Section 3, as appropriate.

(c) *For processes or enclosures requiring local exhaust* – the air-handling system shall collect the effluents and extract air in accordance with Section 3, as appropriate.

(d) *For enclosures accommodating automotive vehicles with internal combustion engines* – the air-handling systems shall ventilate the enclosure and dispose of the extracted air in accordance with Section 4.

1.2.2 Natural systems of carparks Where a natural ventilation system is used, it shall ventilate the enclosure in accordance with Clause 4.4.1(c).

1.3 REFERENCED DOCUMENTS The documents below are referred to in this Standard.

AS	
1055	Acoustics—Description and measurement of environment noise
1132	Methods of test for air filters for use in air-conditioning and general ventilation
1132.5	Part 5: Determination of arrestance efficiency, average arrestance efficiency, dust-holding capacity, and dust-holding capacity per unit of effective face area for test dusts Nos 1, 2 and 3
1200	SAA Boiler Code
1324	Air filters for use in air-conditioning and general ventilation
1482	Electrical equipment for explosive atmospheres – Protection by ventilation – Type of protection v
1530	Methods for fire tests on building materials and structures
1530.1	Part 1: Combustibility test for materials
1668	SAA Mechanical Ventilation and Air-conditioning Code
1668.1	Part 1: Fire precautions in buildings with air-handling systems
1677	Refrigerating systems
1735	Lifts, escalators, and moving walks
2107	Acoustics—Recommended design sound levels and reverberation times for building interiors
2676	Installation and maintenance of batteries in buildings

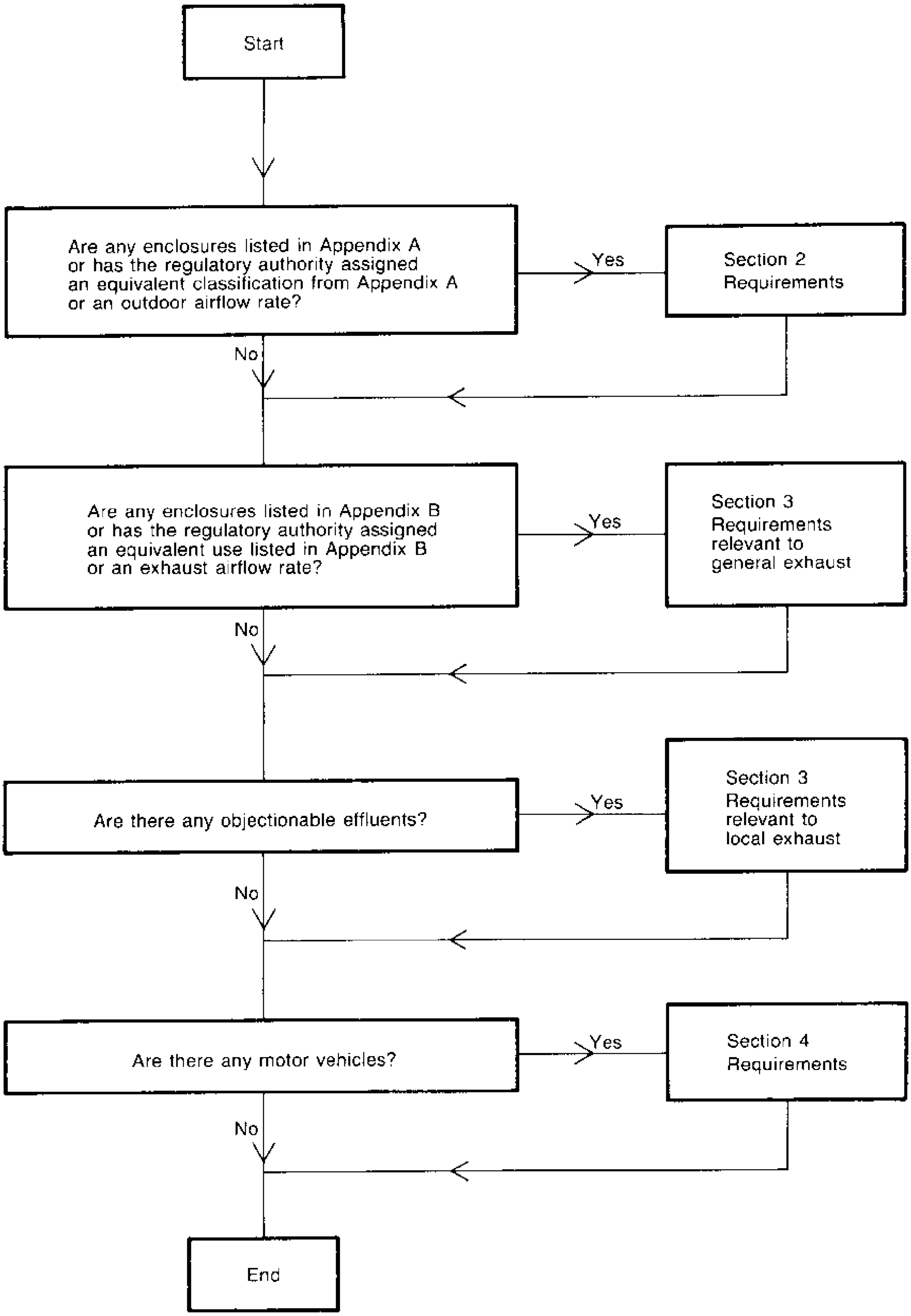


FIGURE 1.1 APPLICATION OF STANDARD

3000 SAA Wiring Rules

3666 Air-handling and water systems of buildings – Microbial control

BS
3928 Method for Sodium Flame test for air filters (other than air supply to I.C. engines and compressors)

ISO/DIS
6242 Building Construction—Expression of user's requirements
6242.2 Part 2: Air purity requirements

National occupational health and safety commission (Worksafe Australia) – Exposure Standards on air contaminants in the occupational environment

ASHRAE
62—1989 Ventilation for acceptable indoor-air quality

Industrial Ventilation, a Manual of Recommended Practice by the American Conference of Governmental Industrial Hygienists

UL
1046 Grease filters for exhaust ducts

1.4 DEFINITIONS For the purpose of this Standard, the definitions given in Figure 1.2 and those below apply.

1.4.1 Airflow rate (herein referred to as 'flow rate')—the volumetric flow rate derived from the mass flow rate by dividing it by the density, assumed to be 1.2 kg/m^3 (1.2 g/L).

1.4.2 Air-handling plant—a component part of an air-handling system that includes equipment providing air movement, as well as equipment for the purpose of controlling the direction, rate of airflow, division of airflow and condition of air, i.e. concentration level of contaminants, temperature and humidity.

1.4.3 Air-handling system—a system for the purpose of directing air in a controlled manner to or from specific enclosures by means of air-handling plant, ducts, plenums, air-distribution devices and automatic controls.

1.4.4 Air lock—a room or compartment required to disconnect a sanitary compartment or other enclosure from another room or space in the building.

1.4.5 Air outlet—any opening through which air is delivered to an enclosure by an air-handling system of a building.

1.4.6 Approved and approval—approved by, or the approval of, the Regulatory Authority concerned.

1.4.7 Duct—a component part of an air-handling system, intended for the passage of air from one part of an air-handling system to another. (See also definition of 'Plenum'.)

1.4.8 Enclosure—an individual room, space, or part thereof.

1.4.9 Exhaust air—air, other than return air, removed from an enclosure by mechanical means and discharged to atmosphere.

1.4.10 Exhaust-air intake—any opening through which air is extracted from an enclosure by an air-handling system of a building.

1.4.11 Exhaust outlet—an outlet from air-handling system, discharging to atmosphere.

1.4.12 Exposure standard (ES)—values designated by Worksafe Australia, which represent, airborne concentrations of chemical substances which should neither impair the health of, nor cause undue discomfort to, nearly all workers. Exposure standard applies to long term exposure over an eight-hour day for a normal working week, over an entire working life.

1.4.13 General exhaust ventilation—ventilation of an enclosure by extracting air from that enclosure, thereby allowing contaminants to be diluted by supply air or make-up air, the mixture being collected at exhaust-air grilles and discharged outside the building (see Figure 1.2).

1.4.14 Grease filter—device which removes grease and lint from air stream.

1.4.15 Hood—a component part of a local exhaust system intended for collecting effluents.

1.4.16 Incinerette—an automatic incinerator for the destruction of sanitary pads or similar items.

1.4.17 Indoor air—air inside the enclosure under consideration (see Figure 1.2).

1.4.18 Infiltration air—air, other than supply air and make-up air, that enters an enclosure or an air-handling system in an uncontrolled manner (see Figure 1.2).

1.4.19 Leakage air—air, other than exhaust air, return air and relief air, that escapes from an air-handling system in an uncontrolled manner (see Figure 1.2).

1.4.20 Local exhaust—extraction of objectionable or hazardous effluents close to the source and discharging to atmosphere (see Figure 1.2).

1.4.21 Make-up air—air that enters an enclosure or an air-handling system in a controlled manner but not by mechanical means (see Figure 1.2).

1.4.22 May—indicates the existence of an option.

1.4.23 Objectional effluents—any unwanted airborne constituents that may reduce the acceptability of air.

1.4.24 Occupied zone—the region within an occupied space between planes 75 mm and 1800 mm above the floor and more than 600 mm from the walls or fixed air-handling equipment.

1.4.25 Outdoor air—air outside the building (see Figure 1.2).

1.4.26 Outdoor air intake—any opening through which outdoor air is admitted to an air-handling system of a building.

1.4.27 Plant room—a room which contains any items of plant or machinery. (See Clause 2.2.2.)

1.4.28 Plenum—an air compartment or chamber, intended for the passage of air, to which one or more ducts may be connected and which forms part of an air-handling system.

1.4.29 Privacy lock—a room or compartment whose function is to provide a visual or acoustic barrier, and not required to disconnect a sanitary compartment from another room or space through which persons pass to enter the sanitary compartment.

1.4.30 Recycle air—that portion of indoor air removed from enclosures as return air and returned as part of the supply air, by mechanical means (see Figure 1.2).

1.4.31 Regulatory Authority—an authority having statutory powers to control design, construction, installation, operation or testing of air-handling systems in buildings.

1.4.32 Relief air—air that flows from an enclosure in a controlled manner by other than mechanical means (see Figure 1.2).

1.4.33 Required—required by any government Act, Regulation, By-law or statutory rule, or by any regulatory authority.

NOTE: Fire insurance underwriters and other bodies may have requirements in excess of those required by regulatory authorities.

1.4.34 Return air—air removed from an enclosure by mechanical means. All of the return air may be expelled as spill air, or all or part of it may be recycled (see Figure 1.2).

1.4.35 Shall—indicates that a statement is mandatory.

1.4.36 Should—indicates a recommendation.

1.4.37 Spill air—that portion of return air that is not recycled (see Figure 1.2).

1.4.38 Supply air—air introduced into an enclosure by mechanical means (see Figure 1.2).

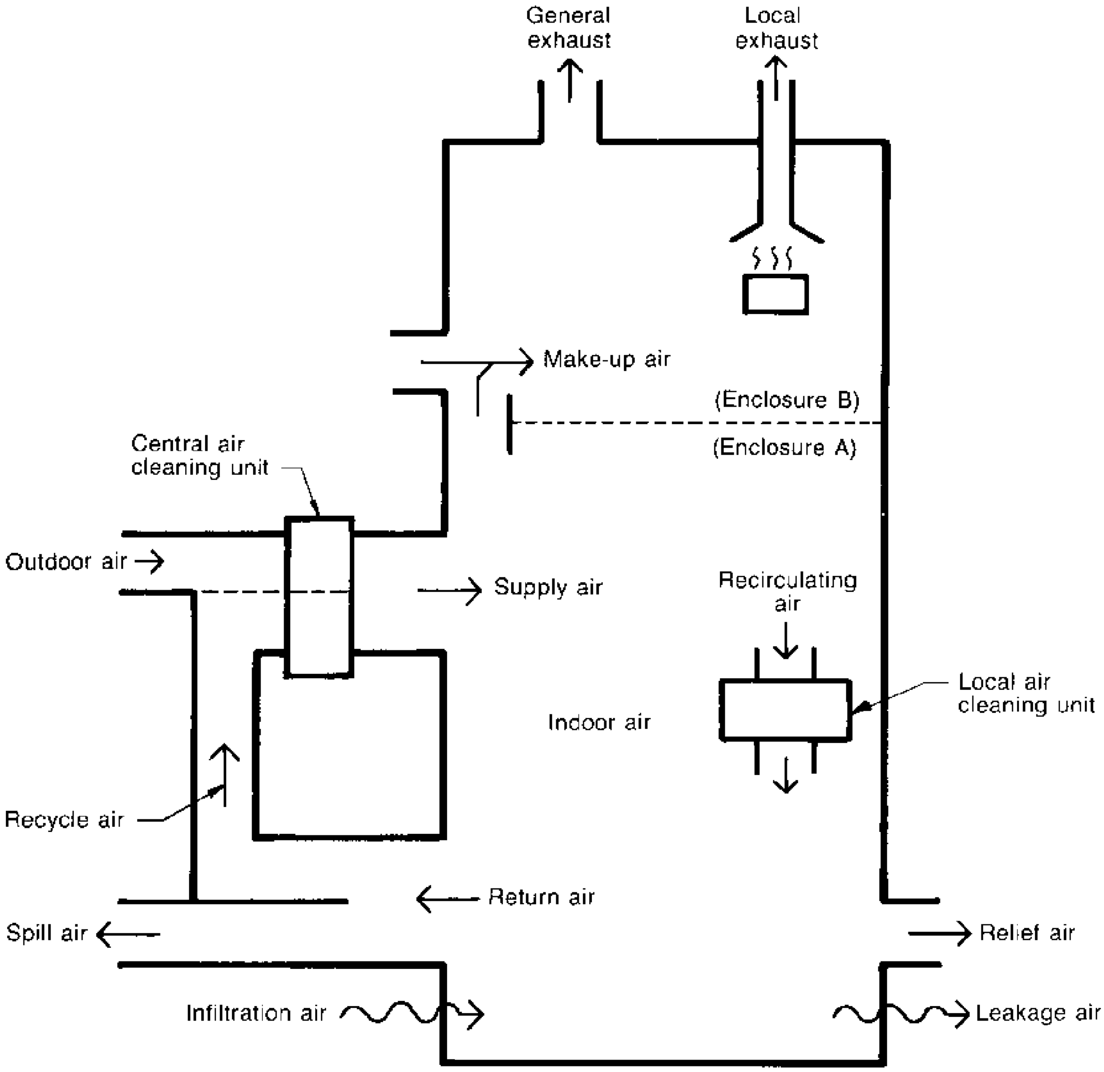


FIGURE 1.2 REPRESENTATION OF AIR HANDLING TERMS

SECTION 2 SUPPLY AIR DILUTION PROCEDURE

2.1 SCOPE OF SECTION This Section prescribes a method of mechanical ventilation whereby indoor air is maintained at an acceptable quality by introducing adequate amounts of outdoor air into the system.

NOTES:

1 This Standard assumes that the outdoor air is generally acceptable for the purpose of dilution ventilation. Where it has been established that the outdoor air is not acceptable, the Regulatory Authority may require pre-treatment of the outdoor air. Guidelines on the acceptability of outdoor air are given in Appendix C.

2 Application of this Section is shown in Figure 2.1.

3 Should the use of outdoor air be not approved for a particular location or a different means is to be proposed for maintaining an acceptable indoor-air quality to conserve energy or for some other reason, Appendix G provides guidelines on a performance-based approach to acceptable indoor-air quality.

2.2 OUTDOOR-AIR INTAKES

2.2.1 Location Intakes for outdoor air shall be located and arranged so that under all conditions of normal operation—

(a) contamination from air exhausts, cooling tower discharges, work processes and other sources of pollution do not reduce the quality of outdoor air entering the intake to a quality below that of outdoor air in the locality, except where outdoor air entering the intake is treated to achieve the same effect; and

(b) the effects of wind, adjacent structures and other factors do not cause the flow rate of outdoor air to be reduced below the minimum requirements of this Section.

NOTE: Attention is drawn to Clause 3.7.2(b) which specifies a minimum separation between air intakes and exhaust discharges, and Clause 3.7.3 which specifies requirements for obnoxious discharges.

2.2.2 Passage of air Outdoor air shall pass to the air-handling plant directly through an approved duct or plenum connected to the intake.

Enclosures used for storage of equipment, plant or materials likely to contaminate the air quality, shall not be used as plenums. A plant room housing equipment or materials that do not contaminate the air may act as a plenum (see also AS 1668.1 for fire-related requirements). Floor wastes serving such plant rooms shall be treated by an approved method(s). Condensate and equipment drainage shall comply with AS 3666.

2.3 OUTDOOR AIRFLOW RATES

2.3.1 General The flow rate of mechanically provided outdoor air shall comply with Clauses 2.3.2 to 2.3.8 and Appendix A as appropriate.

NOTES:

1 For reduction of flow rates under special circumstances see Clause 2.6.

2 Unless otherwise stated all airflow rates are in L/s.

2.3.2 Occupancy The occupancy (N) shall be the greater of—

(a) the maximum number of persons present in the enclosure for any period exceeding 30 min; or

(b) one-third of the maximum number of persons present in the enclosure at any time, except where the outdoor airflow has been reduced in accordance with Clause 2.3.4(c), in which case (N) shall be the maximum number of persons present in the enclosure at any time.

The occupancy should be stated by the owner of the building and shall be subject to approval. In the absence of such definite information, the number of occupants shall be not less than that estimated on the basis of floor area per person in accordance with Appendix A.

2.3.3 Minimum outdoor airflow rates, (q_f), to be supplied to an enclosure, based on area of the enclosure For an enclosure for which the minimum outdoor airflow rate in accordance with Appendix A is based on the area of the enclosure (L/s per m^2 of floor area), the outdoor airflow rate shall be—

$$q_f \geq a_f A \quad \text{2.3.3(1)}$$

where

a_f = the minimum outdoor airflow rate given in Appendix A, in litres per second metres squared of the floor area

A = the area of the enclosure in square metres.

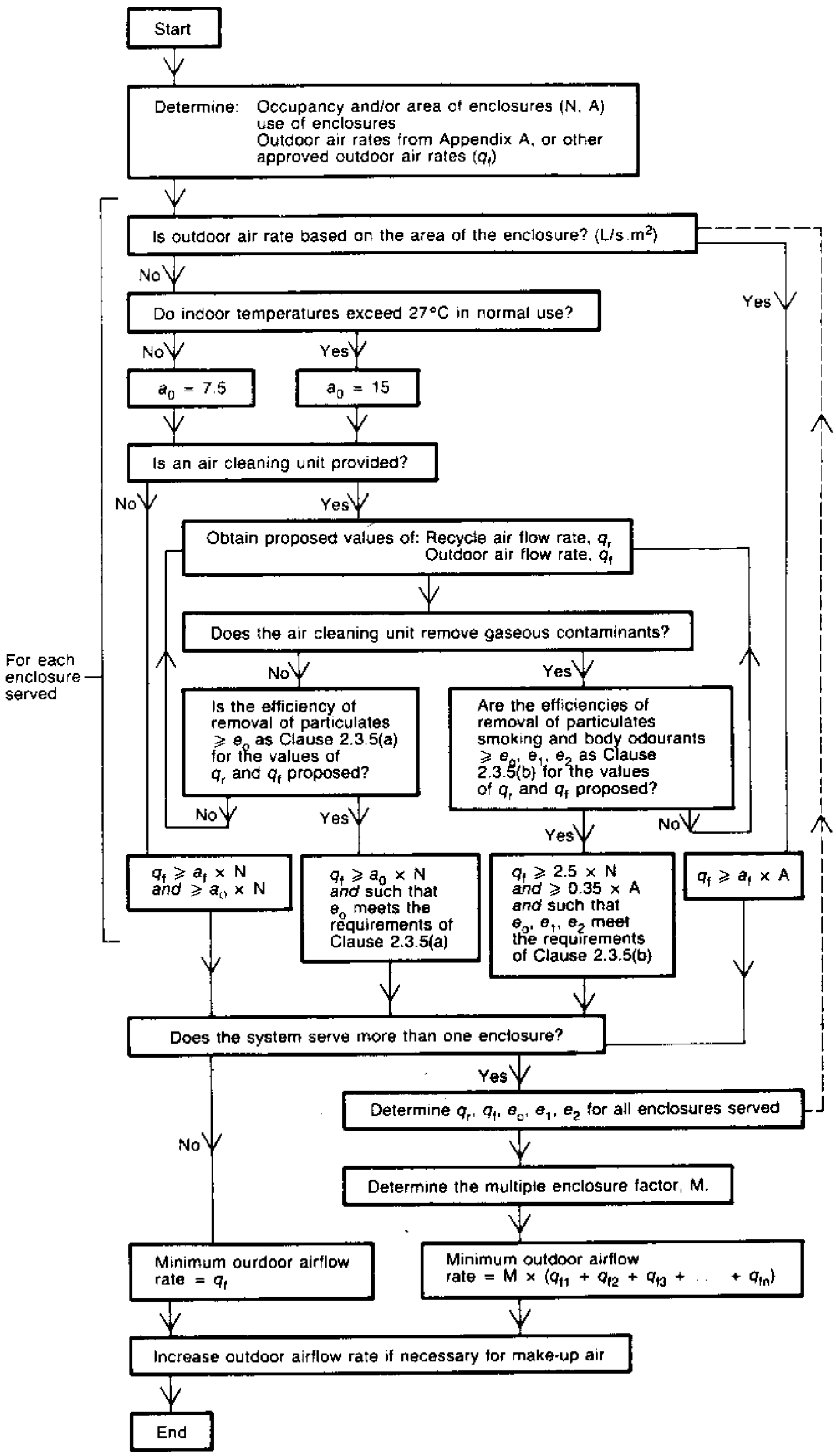


FIGURE 2.1 APPLICATION OF SECTION 2

2.3.4 Minimum outdoor airflow rates, (q_f), to be supplied to an enclosure, based on number of occupants in the enclosure For an enclosure for which the minimum outdoor airflow rate in accordance with Appendix A is based on the number of occupants (litres per second per person), the outdoor airflow rate shall be determined in accordance with Paragraphs (a), (b), and (c) below, as appropriate.

(a) Where an air cleaning unit, in accordance with Appendix D, is not provided, the greater of—

$q_f \geq a_f N$ . . . . 2.3.4(1); or

$q_f \geq a_o N$ . . . . 2.3.4(2).

(b) Where an air cleaning unit to remove particulate contaminants only, in accordance with Appendix D, is provided, q_f may be taken as—

$q_f \geq a_o N$ . . . . 2.3.4(3); or

(c) Where an air cleaning unit to remove particulates and odours, in accordance with Appendix D, is provided, q_f may be taken as the greater of—

$q_f \geq 2.5N$ . . . . 2.3.4(4); or

$q_f \geq 0.35A$ . . . . 2.3.4(5)

where

A = the area of the enclosure, in square metres

N = the occupancy, in accordance with Clause 2.3.2

a_f = the minimum outdoor airflow rate given in Appendix A, in litres per second per person (L/s person)

a_o = the minimum outdoor airflow rate for dilution of gaseous contaminants (e.g. body odours), in litres per second per person, as follows—

(i) a_o = 15 $L/_s$ per person if the temperature in the enclosure exceeds 27°C in normal use, or

(ii) a_o = 7.5 $L/_s$ per person if the temperature of the enclosure is below 27°C in normal use, except for:

autopsy rooms a_o = 50 L/s person
operating theatres a_o = 20 L/s person
delivery rooms a_o = 20 L/s person
embalming rooms a_o = 15 L/s person
air traffic control rooms a_o = 20 L/s person

NOTES:

1 The occupancy (N) should not exceed the number stated or estimated unless the outdoor-airflow rate is already sufficient, or is appropriately increased to satisfy such occupancy.

2 The installation of air cleaning units to remove particulates or odours does not permit any reduction in the outside air supply quantity for non-recirculatory systems.

2.3.5 Minimum flow rate of outdoor air into a single-enclosure system (q_F) Minimum flow rate of outdoor air into a single-enclosure system shall be the greater of—

(a) $q_F \geq$ the requirements in Clauses 2.3.3 and 2.3.4; or

(b) $q_F \geq$ the make-up air requirements, where the enclosure is also used for make-up air to another enclosure ventilated by an exhaust system (see Clause 3.5.2).

2.3.6 Minimum flow rate of outdoor air into a system serving a group of enclosures (Q_F) For the purpose of this Clause groups of enclosures used for a similar purpose and subject to the same density of occupancy such as general office space may, subject to approval, be regarded as a single enclosure. Minimum total outdoor airflow rate for a system serving any other group of enclosures shall be the greater of—

(a) $Q_F \geq MQ_f$ . . . . 2.3.6(1); or

(b) $Q_F \geq$ the rate at which make-up air must be admitted to the system (see Clause 3.5.2).

where the multiple enclosure factor $(M) = 1/(1 + R - r_c)$;

and where

Q_f = $\Sigma q_{fn} = (q_{f1} + q_{f2} + ... + q_{fn})$, that is, the sum of outdoor airflow rates for all enclosures served determined in accordance with Clauses 2.3.3 and 2.3.4

Q_s = $\Sigma q_{sn} = (q_{s1} + q_{s2} + ... + q_{sn})$, i.e. the sum of the supply airflow rates for all the enclosures served by the system

q_{fn} = the flow rate of outdoor air to be supplied to the n^{th} enclosure, in litres per second, determined in accordance with Clauses 2.3.3 and 2.3.4

q_{sn} = the flow rate of supply air to be supplied to the n^{th} enclosure, in litres per second

R = the ratio of the sum of outdoor airflow rates for all enclosures served to the total supply air for all enclosures served = Q_f/Q_s

r_c = the highest ratio, for the enclosures served, of outdoor air required by Clauses 2.3.3 and 2.3.4 to the corresponding supply air (q_f/q_s)

NOTES:

1 For the results of the application of Clause 2.3.6 to a specific example, refer to Table D2 in Appendix D.

2 Application of the multiple enclosure equation ensures that every enclosure receives at least its required outdoor air, even where cooling or heating considerations cause supply air to be distributed between enclosures in proportions that differ from the distribution of occupants.

3 The multiple enclosure factor *(M)* may also be determined by means of the nomogram given in Figure 2.2.

4 The use of reduced values for q_{fn}, on the grounds of air-cleaning (Clause 2.3.4) requires that air cleaning efficiencies be in accordance with Appendix D, as appropriate.

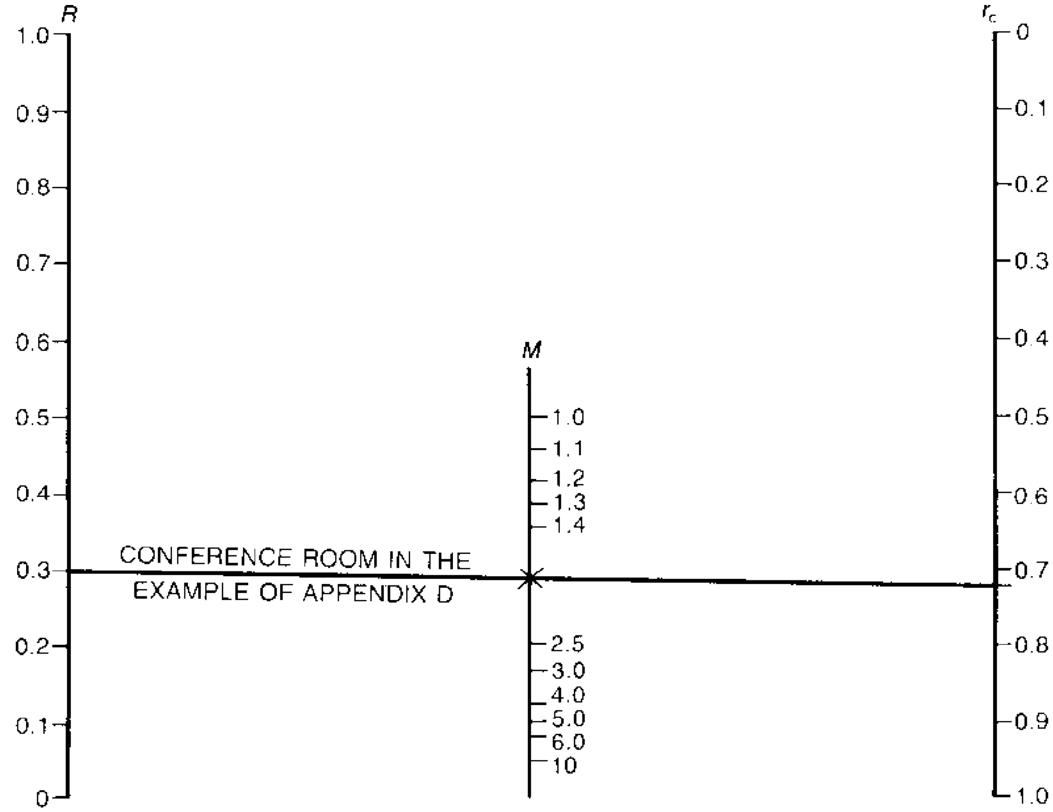


FIGURE 2.2 NOMOGRAM FOR DETERMINATION OF MULTIPLE ENCLOSURE FACTOR (*M*)

2.3.7 Variable air volume systems For a system with variable supply airflow rate, provision shall be made to ensure that the minimum outdoor airflow rate required by Clauses 2.3.3, 2.3.4 and 2.3.6 is maintained under all operating conditions.

NOTE: The requirements of Clause 2.3.6 at reduced flow rates vary as the distribution of air to the enclosures changes.

2.3.8 Make-up air requirement For a system serving enclosures from which make-up air for general or local exhaust is drawn, the outdoor airflow rate shall be in accordance with Clause 3.5.

2.4 PROHIBITION OF RECYCLE AIR Except where the recycle air is filtered in an approved manner, air-handling systems serving more than one enclosure shall not recycle air from any of the following enclosures:

(a) Any enclosure listed in Appendix B.

(b) Health care, autopsy, delivery, intensive care and operating rooms.

(c) Embalming rooms.

(d) Enclosures required to be ventilated by a general exhaust ventilation system.

2.5 OUTDOOR AIR MIXING AND DISTRIBUTION A substantially uniform distribution of outdoor air shall be achieved throughout the occupied zones for each enclosure, irrespective of whether or not the outdoor air is—

(a) introduced separately into the enclosure; or

(b) mixed with the recycle air in a central plant or local plant, e.g. fan-coil or induction unit.

2.6 OUTDOOR AIR FLOW

2.6.1 Systems serving enclosures in which the temperature may exceed 27°C under normal operation During periods when the temperature in the enclosures does not exceed 27°C, the outdoor airflow rate may be adjusted by dampers or other approved means to the flow rate that would be appropriate if the enclosures were not subject to temperatures exceeding 27°C in normal operation. For systems serving a group of enclosures, this will require calculation of a new multiple enclosure factor in order to determine the new value of Q_F.

The adjustment may be controlled manually, by mechanical or electrical means, or automatically by a thermostat.

2.6.2 Systems serving enclosures with transient or variable occupancy During periods of low occupancy the outdoor airflow rate may be adjusted by dampers or other means to the flow rate appropriate to the low occupancy.

When contaminants are generated independent of occupants or their activities and the contaminants do not present a short term health hazard, air-handling systems may be shut off during unoccupied periods.

When contaminants, other than those associated with occupants, are dissipated by natural means during unoccupied periods, the increase in outdoor airflow rate may lag behind the increase in occupancy subject to conditions (a) to (e) below.

(a) The lag time between variations in occupancy and the adjustment shall not exceed that determined in Figure 2.3.

(b) If the adjustment is subject to manual control, the control shall be operable from the enclosure with the largest occupancy load or from another approved enclosure.

(c) If the adjustment is subject to automatic control, means shall be provided to manually override the automatic control.

(d) The designer shall demonstrate that the means of adjustment and of control of adjustment ensure that contaminants do not exceed acceptable levels during occupied periods.

(e) The means of adjustment and of control of adjustment shall be subject to approval.

Where any contaminants that require provision of general or local exhaust systems continue to be generated in the enclosures during unoccupied periods, the increase in outdoor airflow rate shall lead the increase in occupancy by a time not less than that as shown in Figure 2.4.

NOTE: Rationale for lag or lead time for transient occupancies is provided in Appendix J.

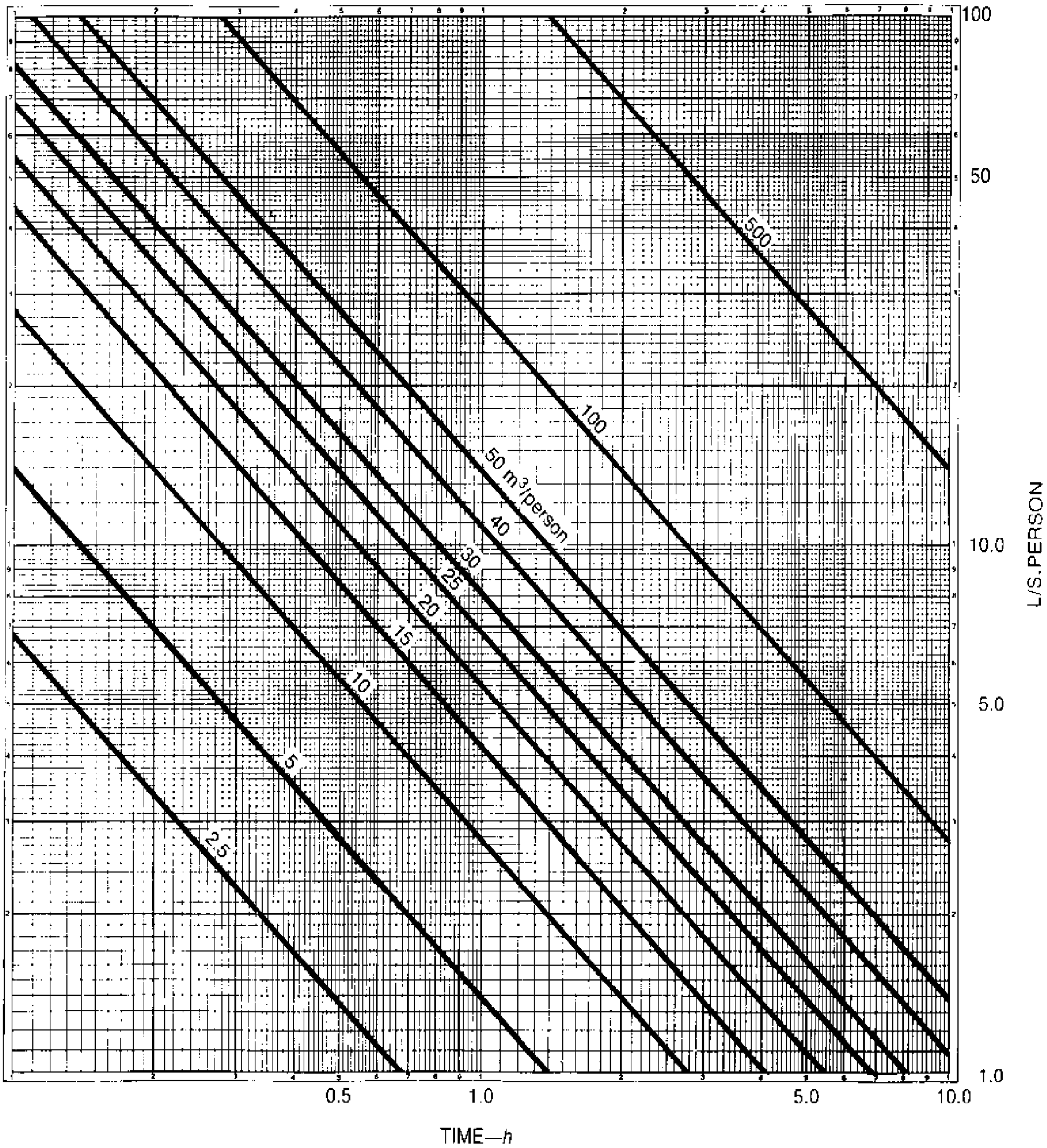


FIGURE 2.3 PERMISSIBLE LAG TIME-HOURS

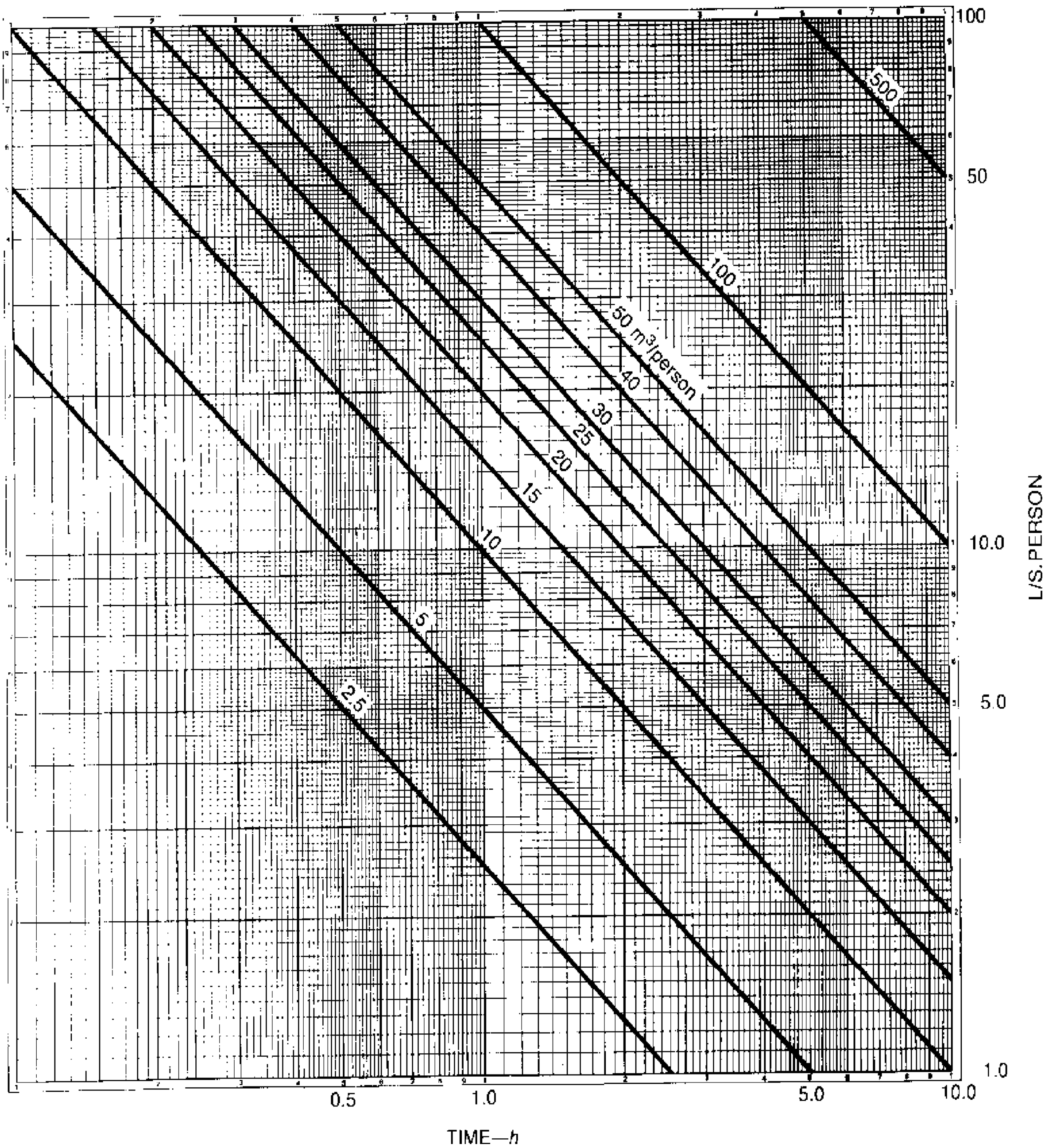


FIGURE 2.4 REQUIRED LEAD TIME-HOURS

SECTION 3 EXHAUST AIR DILUTION PROCEDURE

3.1 SCOPE OF SECTION This Section prescribes exhaust ventilation requirements for enclosures in which contaminants generated or contained therein need to be extracted for the purpose of maintaining the indoor air at an acceptable quality.

NOTE: For enclosures used by vehicles with internal combustion engines, see Section 4.

3.2 GENERAL EXHAUST VENTILATION

3.2.1 General Where an enclosure requires general exhaust ventilation, exhaust airflow rates shall be as specified in Appendix B.

NOTE: Local exhaust air systems which can be demonstrated as being effective in the removal of effluents may be used, subject to approval, in lieu of part or whole of the general exhaust ventilation.

3.2.2 Exhaust locations As far as practicable, exhaust-air intakes used for general exhaust-air collection shall be located on the opposite sides of the enclosure from the sources of make-up air to ensure that the effluents are effectively removed from all parts of the enclosure.

3.2.3 Enclosures served by both supply and general exhaust systems Where the enclosure is served by both a supply and a general exhaust system, the exhaust airflow rate shall exceed the supply airflow rate by at least 10 percent.

3.3 LOCAL EXHAUST

3.3.1 Types of effluents requiring local exhaust Effluents having any one or more of the properties specified in (a) or (b) below, shall be removed by local exhaust in accordance with Clause 3.3.2.

(a) *Type A:* Toxic, irritant, asphyxiant, offensive, flammable or explosive gases, dusts, fumes or vapours, excluding those effluents arising from cooking processes.

(b) *Type B:* Heated air, with or without water or grease vapour, produced by any one item of apparatus having a total maximum power input exceeding 8 kW, for electrical, or total gas input 29 MJ/h for a gas appliance, or more than one item of apparatus within a room and having a total maximum power input exceeding 0.5 kW /m^2 (1.8 MJ/m^2 for gas appliances) of floor area of the enclosure, or such equipment as the Regulatory Authority deems appropriate. Regulatory Authority may exempt apparatus used specifically for space heating, apparatus located higher than 2 m above floor level, apparatus in plant rooms, apparatus used solely for domestic purposes and apparatus which does not cause any objectionable conditions in the enclosure.

3.3.2 Effluent removal

3.3.2.1 *General requirements* The removal of effluents by means of local exhaust shall be as follows:

(a) The effluents shall be collected as they are being produced, as close as practicable to the source of generation, using special surroundings, hoods, surface mounting exhaust-air intakes or other approved means. The airflow rates shall be such as will ensure positive capture and removal of the effluents.

(b) Local exhaust airflow rates shall be in accordance with the relevant Australian Standards, where appropriate. In the absence of relevant Australian Standards the relevant requirements of any regulatory authority shall be complied with and, in the absence of the latter, the current recommendations which appear in the American Conference of Governmental Industrial Hygienists Industrial Ventilation manual.

NOTE: At present relevant Australian Standards are AS 1482, AS 2676 and AS 2243.8.

(c) Local exhaust may complement general exhaust and when satisfactorily distributed may substitute for the general exhaust where the total local exhaust-air quantity exceeds the total general exhaust-air quantity specified in Appendix B.

(d) Make-up air openings or mechanical ventilation system air outlets to an enclosure in which an exhaust hood is situated, shall be distributed and designed so as not to be detrimental to the performance of the hood, or cause excessive cross-draughts over any apparatus required to be ventilated.

3.3.2.2 *Type A effluents removal* In addition to the requirements of Clause 3.3.2.1, the velocity of air as it enters the hood, special surrounding or exhaust air intake used in the removal of Type A effluents, shall be not less than 0.5 m/sec. For incinerettes, Appendix H shall also apply.

3.3.2.3 *Type B effluents removal* Approved hoods for the collection of type B effluents shall be provided. Where the apparatus specified in Clause 3.3.1(b) is a cooking appliance, a kitchen exhaust hood complying with Appendix E shall be installed above the appliance.

Sufficient airflow shall be suitably distributed over exhaust hoods to effectively capture and convey all convected heat fumes and other aerosols to hood exhaust openings.

NOTE: Appendix F gives guidance on the subject of capture of emissions.

3.4 AIR FROM ENCLOSURES HAVING EXHAUST-AIR REQUIREMENTS

3.4.1 General requirements Air from an enclosure ventilated by a required general exhaust system shall not be recycled to other enclosures. Return air from enclosures with local exhaust systems shall not be recycled to other enclosures, unless approved.

3.4.2 Return-air intake location Where recycling of air is approved, return-air intakes shall be located as far as practicable from points of exhaust collection.

3.4.3 Air pressures All enclosures served by a required general exhaust system shall have air pressure less than that of adjacent enclosures not served by general exhaust systems, during operation of the system.

3.5 REPLENISHMENT OF EXHAUST AIR

3.5.1 Source The air extracted from enclosures shall be continuously replenished by outdoor air or by make-up air of an approved quality from an adjacent enclosure. Unless approved, make-up air shall not be drawn from an enclosure ventilated by a required exhaust system or from adjacent carpark served by mechanical supply ventilation system. Where desired, or where make-up air of an approved quality is not available, a supply-air ventilation system complying with Section 2 shall be provided. Where the make-up air is drawn from outside the building, the intake shall comply with Clause 2.2.

NOTE: Make-up air from an enclosure served by a non-required exhaust system in conjunction with a supply or natural ventilation system should not be prohibited. Also, make-up air from an enclosure ventilated by a required exhaust system in some cases may be acceptable, e.g. make-up air from a carpark for a garbage room exhaust system.

3.5.2 Amount Where the enclosure adjacent to the exhausted enclosure and from which make-up air is being drawn, is itself served by a supply ventilation system, the outdoor airflow rate to this supply ventilation system shall be increased if necessary to the amount of make-up air required for the exhaust ventilation system.

3.5.3 Pressure drop Openings required in enclosure walls, ceilings or floors to allow passage of make-up air from adjacent enclosures or outside the building shall be of adequate size to ensure that the pressure drop does not exceed 12 Pa.

3.5.4 Electrical interlocking of exhaust and make-up When a local exhaust system requires a mechanical supply air system for its make-up air, both systems may be required to be electrically interlocked, to prevent operation of the exhaust independently of the supply. An indicator light adjacent to the local exhaust shall be provided, to indicate that the supply-air system is on.

3.6 COMBINATION OF EXHAUST SYSTEMS Exhaust-air systems which serve different types of enclosures shall be kept separate unless otherwise approved. Enclosures that are similar in nature may be served by common exhaust systems and are grouped in Table 3.2 as follows:

TABLE 3.2

ENCLOSURES THAT MAY BE SERVED BY COMMON EXHAUST SYSTEM

Group	Typical use
1	Air lock, bathroom, change room, laundry, locker room, privacy lock, service sink closet, shower room, urinal compartment, wash room, water closet compartment.
2	Areas where food and beverages are prepared or consumed, e.g. dining room, dishwashing area, food preparation area, hotel bar, kitchen, reception area.
3	Plant rooms, e.g. boiler, machinery, refrigerator rooms.
4	Process rooms, e.g. document copying, plan printing, photographic processing rooms.
5	Automotive vehicle delivery, parking, pick-up, repair and servicing areas.
6	Boundary trap, garbage, grease trap, sewage ejector enclosures.

NOTE: Where an air lock or privacy lock is provided between an exhausted enclosure and another adjacent occupied enclosure, make-up air for the exhaust system may be drawn from the adjacent enclosure through the air lock or privacy lock. Make-up air and relief openings should comply with Clause 3.5. An air lock or privacy lock need not be exhausted separately.

3.7 AIR DISCHARGES

3.7.1 General All exhaust air and spill air shall be discharged to atmosphere in such a manner as not to cause danger or nuisance to occupants in the building, occupants of neighbouring buildings or members of the public.

Discharges that are not deemed objectionable shall comply with Clause 3.7.2 and discharges that are deemed objectionable shall comply with Clause 3.7.3. For the purpose of this Standard, any of the discharges at the flow rates specified in the table below shall be deemed to be objectionable.

TABLE 3.3
OBJECTIONABLE DISCHARGES

Exhaust-air discharge	Flow rate
Type A effluents as defined in Clause 3.3.1	Any flow rate
Toilet exhaust	> 1000 L/s
Kitchen exhaust from filtered hoods	> 1000 L/s

3.7.2 Discharges not deemed objectionable Air discharges that are not deemed objectionable (see Clause 3.7.1) shall be—

(a) located and arranged so that the effects of wind, adjacent structures or other factors do not cause the exhaust airflow rates to be reduced below the minimum requirement of this Standard;

(b) not less than 6 m from any outdoor-air intake opening, natural ventilation device or opening;

(c) emitted to the outside at velocities and in a direction that will ensure a danger to health or a nuisance will not occur;

(d) treated in an approved manner to reduce the concentration of contaminants when required; and

(e) not less than 6 m from the boundary to an adjacent allotment, except that where the dimensions of the allotment make this impossible, then the greatest possible distance shall apply.

NOTES:

1 The choice of a suitable method of discharging air depends on a number of local and environmental factors as well as the nature and quality of the effluent and the direction and velocity of the discharge. Generally, it is preferable to discharge exhaust air upwards in a vertical or near vertical direction above the roof. Discharges that extend less than 2 m above a thoroughfare or trafficable roof are not recommended. Where discharge extends less than 3 m above a pedestrian thoroughfare, the discharge where approved, should be diverted at a minimum angle of 30° to the horizontal, and should not create a nuisance.

2 Where large, relatively clean or high velocity discharges are soundly engineered, the regulatory authority may approve of separations less than specified in Sub-clause (b) above. The Regulatory Authority may require it to be demonstrated that any such 'engineered' discharge does not significantly pollute the outdoor air.

3 Where the outdoor air is liable to be significantly polluted, Sub-clause (d) above may be invoked. Reference to pollution control authorities is recommended for control requirements relating to concentration of contaminants.

3.7.3 Obnoxious discharges Air discharges that are deemed to be obnoxious (see Clause 3.7.1) shall be in accordance with Clause 3.7.2 and—

(a) be arranged vertically with discharge velocities not less than 5 m/s;

(b) be situated at least 1 m above the ridge of a pitched roof or 3 m above a flat roof. Discharge at a lower level may be approved, provided that it is more than 15 m from any adjacent higher structure located on the site and subject to consideration of structures on adjacent site; and

(c) located not less than 6 m from a property boundary without approval.

3.7.4 Disposal of rainwater and condensate Disposal shall be in accordance with AS 3666.

All exhaust air discharges likely to collect rainwater when exhaust fan is not operating, shall be provided with means for collection of rainwater and disposal thereof.

All ducts and plenums conveying water vapour likely to condense and accumulate under normal operating conditions, shall be installed with provision to collect and dispose of condensate.

SECTION 4 VENTILATION OF ENCLOSURES USED BY VEHICLES WITH INTERNAL COMBUSTION ENGINES

4.1 SCOPE OF SECTION This Section applies to all enclosures in which vehicles powered by internal combustion engines are parked, serviced or operated, e.g. carparks, automotive service and repair shops, enclosed driveways, loading docks and the like. It also gives monitoring requirements applicable where reduced ventilation rates are adopted as an energy-saving measure.

4.2 APPLICATION OF SECTION Requirements in this section apply as follows:

(a) For carparks, Clauses 4.4, and 4.6 to 4.12 shall apply.

(b) For enclosures other than carparks, Clauses 4.5 to 4.12 shall apply.

NOTE: The Regulatory Authority may approve alternative means of air distribution which do not comply with the prescriptive requirements of this Section, but achieve uniform dilution of contaminants in the enclosure and maintain contaminant concentrations below the recommended exposure standard (see Clause 4.3).

4.3 GENERAL CASE In general the ventilation shall ensure that concentrations of atmospheric contaminants within the enclosure do not exceed exposure standards listed by Worksafe Australia.

This Section recognizes the need to protect the health of both the general public and workers. In its preparation the recommendations of authorities such as Worksafe Australia and Nation Health and Medical Research Council (NHMRC) were considered.

4.4 CARPARKS

4.4.1 General Except as varied in accordance with Paragraphs (a), (b), or (c) below, carparks shall be mechanically ventilated by a combination of general exhaust with flow rates in accordance with Clause 4.4.2, and supply with flow rates specified in Clause 4.8.

(a) The mechanical supply-air system may be omitted provided that—

(i) the carpark has make-up air openings directly to outside (see Note 1);

(ii) the system complies with Clause 4.11;

(iii) pressure drop between any point within the carpark and the outside does not exceed 12 Pa (see Note 2); and

(iv) Location of openings complies with Clause 4.4.3.2.

NOTES:

1 Where make-up air source is subject to high ambient carbon dioxide level and the make-up air openings are located within 3 m of ground level, the Regulatory Authority may require the use of supply air ventilation from an approved source of outdoor air. (See Appendix C.)

2 The specified pressure drop would normally be achieved when the air velocity through the make-up openings does not exceed 1 m/s.

(b) The mechanical exhaust-air system may be omitted subject to approval, provided that—

(i) the floor is at or above natural ground level;

(ii) the carpark has relief openings directly to outside;

(iii) the supply-airflow rate complies with Clause 4.4.2;

(iv) the pressure drop between any point within the carpark and the outside does not exceed 12 Pa (see Note 1);

(v) the location of relief-air openings including car entries and exits are not less than 6 m away from any outdoor-air intake or natural ventilation opening;

(vi) location of openings complies with Clause 4.4.3.2(b); and

(vii) any adjacent occupied enclosure is at a pressure higher than the carpark (see Note 2).

NOTES:

1 The specified pressure drop may be achieved when the air velocity through the relief openings does not exceed 1 m/s.

2 Maintaining positive pressure at adjacent enclosures can be accomplished by the provision of a pressurized disconnecting compartment. Any disconnecting compartment may be served by the carpark supply system.

3 The regulatory authority may object to relief openings within 6 m of a thoroughfare where people congregate, e.g. a bus stop.

(c) Mechanical ventilation (supply *and* exhaust) may be omitted from certain areas of carparks as described in (i) to (vii) below, subject to conditions (A), (B), and (C) below.

The areas are as follows:

(i) Areas, other than queueing areas, where the parking capacity does not exceed six motor vehicles, with openings, not less than 5% of the floor area, uniformly distributed in at least two walls.

(ii) Areas, other than queueing areas, where the parking capacity exceeds six motor vehicles, with openings, not less than 12.5% of the wall area, uniformly distributed along the length of the wall, provided that no part of the floor area is more than 6 m from any such opening. (See Figure 4.1(a).)

(iii) Areas, other than queueing areas, situated within 18 m from either a boundary that is open to the outside or a perimeter wall having uniformly distributed unobstructed openings of minimum 2 m^2 per carparking space. (See Figure 4.1(b).)

(iv) Areas, other than queueing areas, situated between opposite boundaries that are not more than 75 m apart, and are either open to the outside or have walls with uniformly distributed unobstructed openings of a total area of at least 1 m^2 per carparking space. (See Figure 4.1(c).)

Where the permanent ventilation openings are located in adjacent walls the maximum allowable depth of the carpark may be increased as depicted in Figure 4.1(d). Where the permanent ventilation openings are in opposite walls which are of unequal length, each part shall be treated separately as shown in Figure 4.2.

Where it is not possible to provide cross-ventilation of carparks in excess of 18 m depth in the manner described in Figure 4.1(c), relocation of the required permanent ventilation openings on one side of the carpark to the carpark roof as depicted in Figure 4.3, may be approved.

Where the outdoor clear space as shown in Figure 4.1(c) is utilized as part of the carpark for access and parking the carpark depth '*D*' shall be as shown in Figure 4.4.

(v) Areas, other than queueing areas, where the carpark can be deemed to be a combination of Types in Figure 4.1 and those shown in Figure 4.3 and 4.4, parts of the combination shall be treated individually in accordance with relevant type.

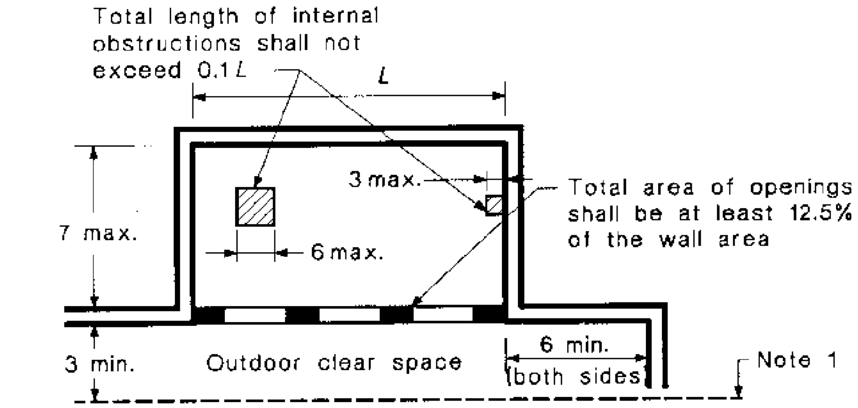
(vi) Queueing areas situated within 10 m from either a boundary that is open to the outside or a perimeter wall having an opening at least 2 m high for the full length of the approved queuing area, except for essential structural columns.

The conditions are as follows:

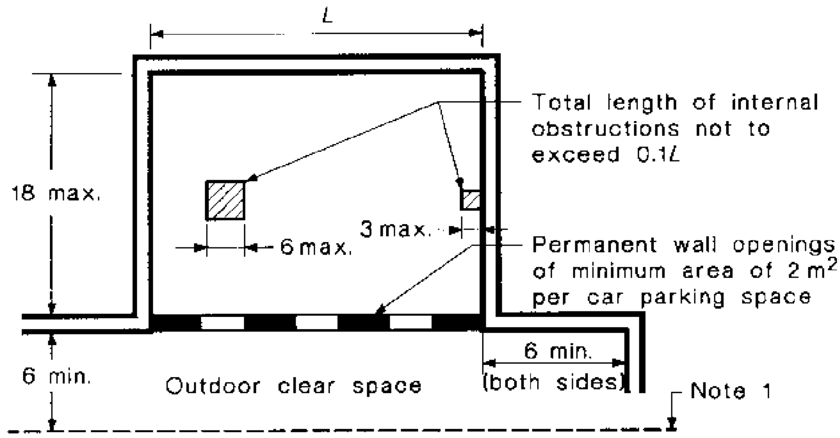
(A) The floor of the carpark shall be at or above the natural ground level of required outdoor clear space, having the permanent ventilation openings along at least one side. For Type 3 in Figure 4.1(c) this may be achieved on a sloping site by excavation down to level of lowest carpark floor over the required outdoor clear space area. (See Figure 4.5.)

(B) Outdoor areas immediately outside the required permanent ventilation openings of a carpark shall be free of vegetation or other obstructions to the free flow of air to and from the carpark for the minimum distances shown in Figures 4.1, 4.2, 4.3, 4.4 and 4.5 as appropriate, and extending upwards from a plane level with the lowest carpark floor.

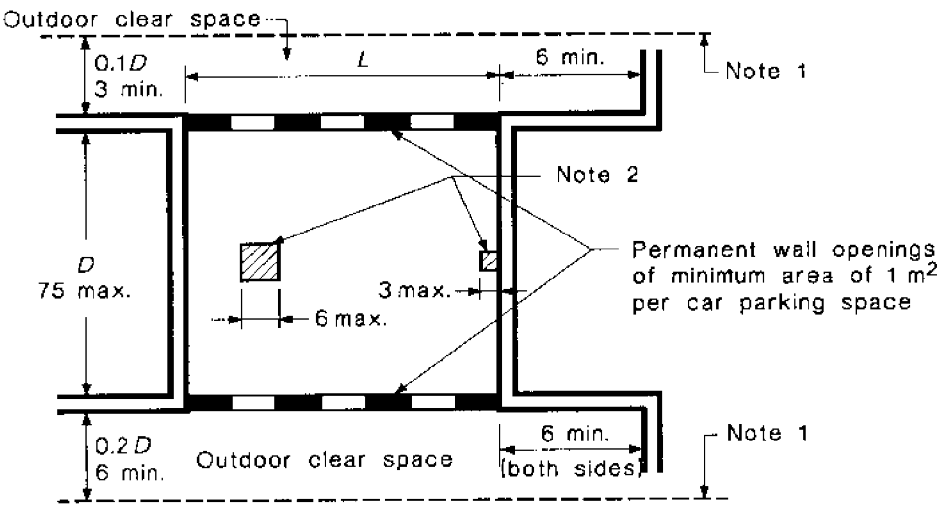
(C) The parking areas shall be free of internal permanent obstructions except as shown in Figure 4.1.



(a) Type 1



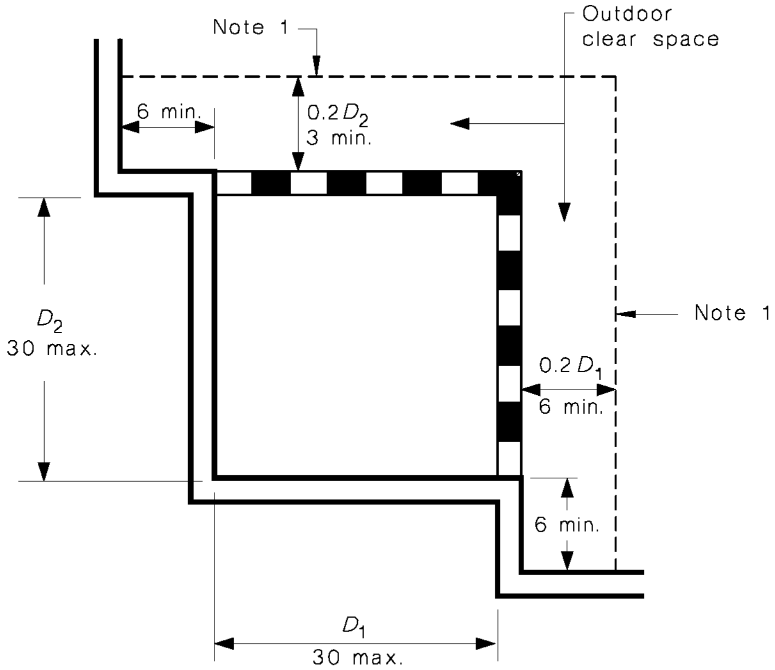
(b) Type 2



(c) Type 3

DIMENSIONS IN METRES

FIGURE 4.1 (in part) NATURAL VENTILATION OF CAR PARKS



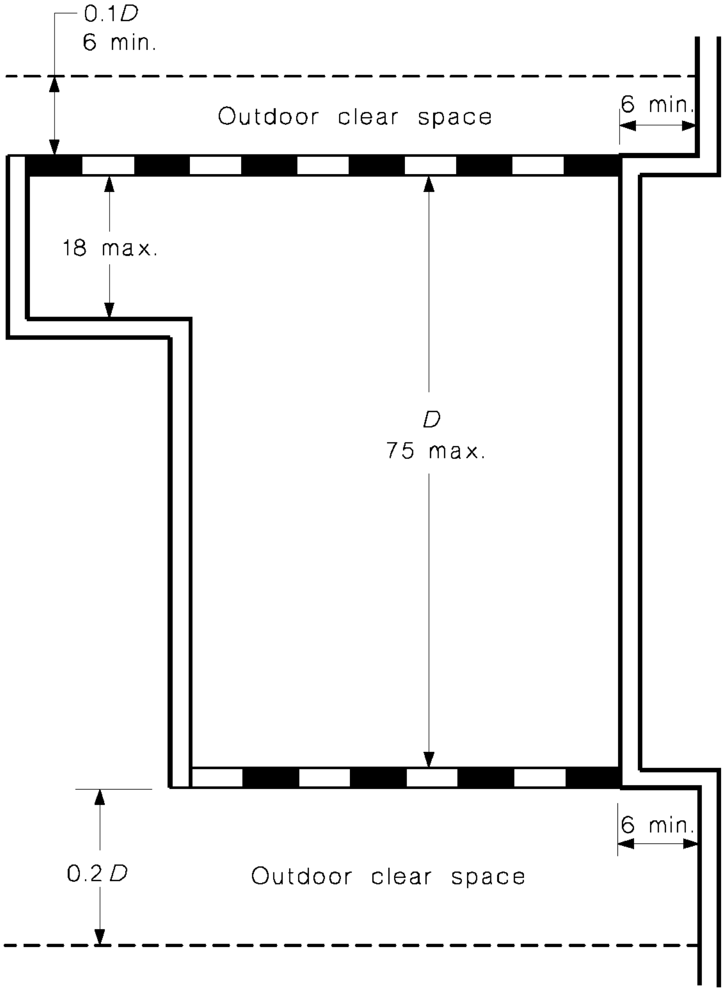
(d) Type 4

NOTES:

1. Adjacent building or permanent vertical obstruction to horizontal air flow. The outdoor clear space between car park and this obstruction to be free of obstructions vertically, such as awnings, extended upper floors etc, unless appropriately increased.
2. Total length of internal obstructions such as stairs, lifts, switchrooms, shall not exceed the lesser of -
   (a) 10 m; and
   (b) 0.2 *L*
   Separation between adjacent obstructions shall be at least the length of the larger obstruction.

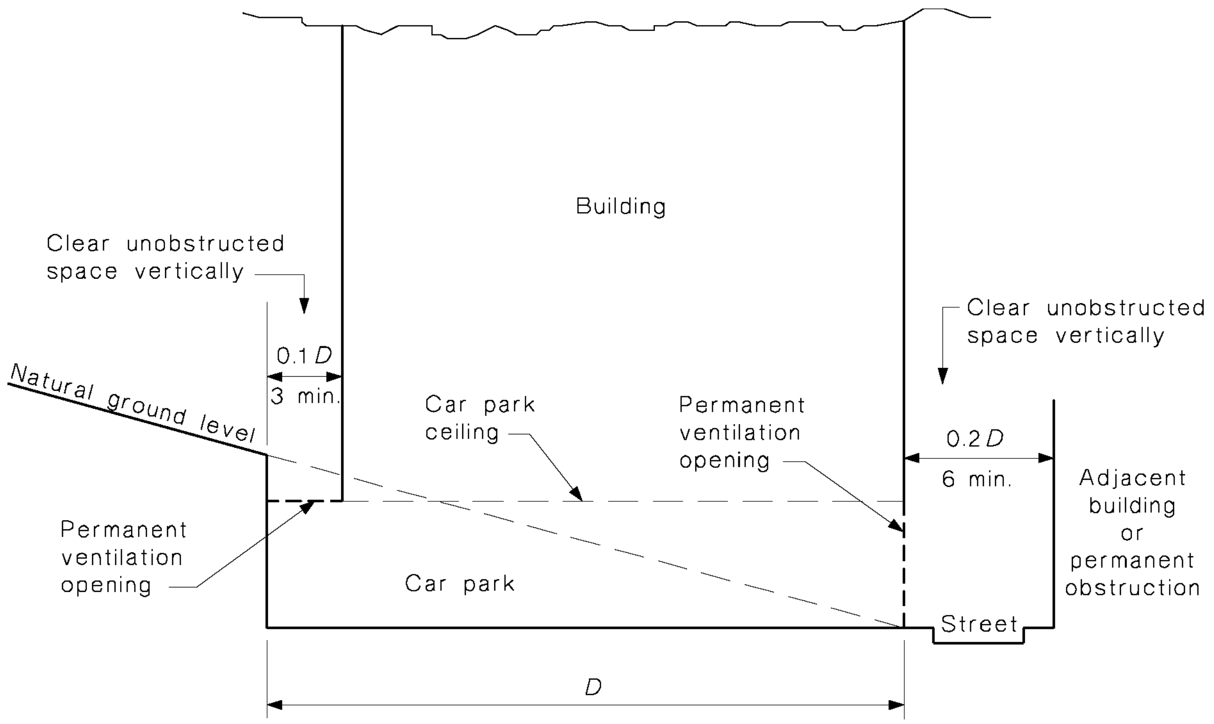
DIMENSIONS IN METRES

FIGURE 4.1 (In part) NATURAL VENTILATION OF CAR PARKS



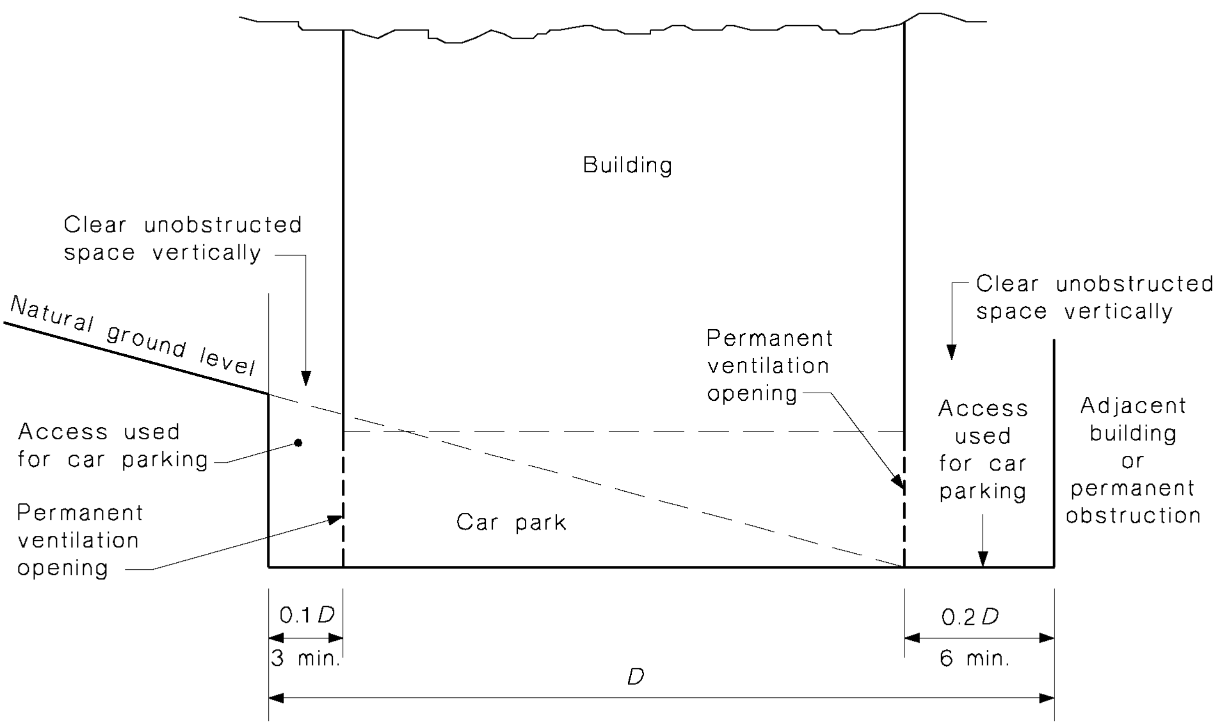
DIMENSIONS IN METRES

FIGURE 4.2 PERMANENT OPENINGS IN UNEQUAL WALLS



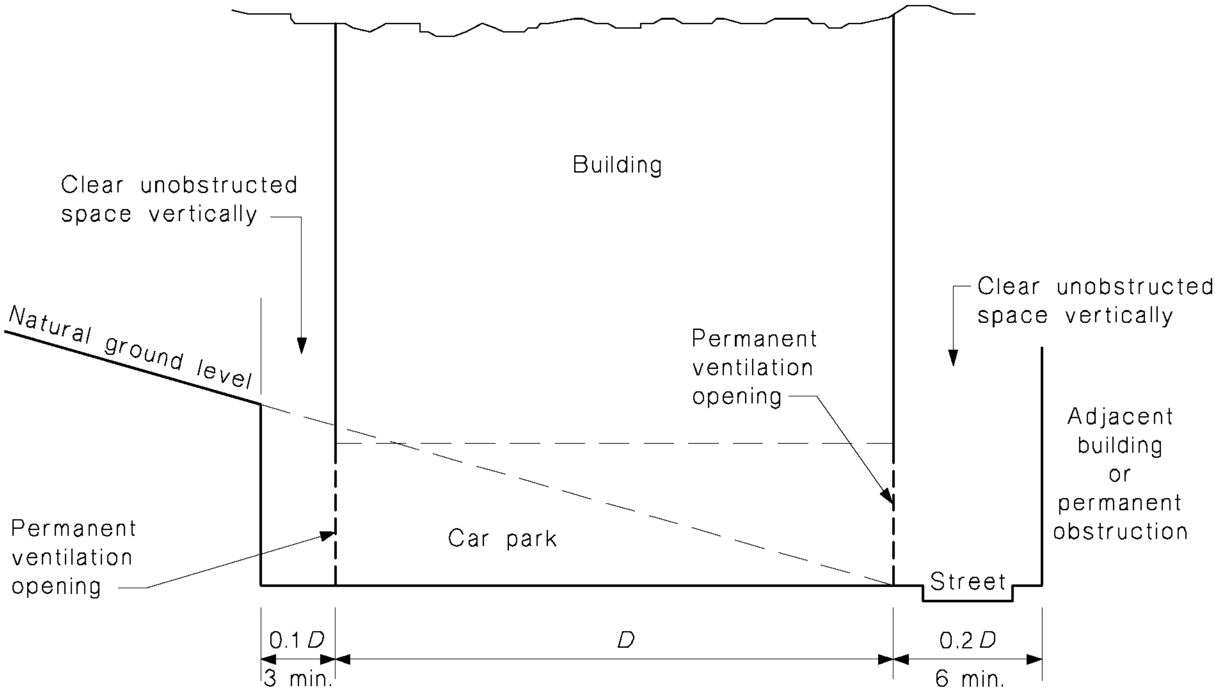
DIMENSIONS IN METRES

FIGURE 4.3 ELEVATION OF TYPE 3 CAR PARK ROOF OPENINGS



DIMENSIONS IN METRES

FIGURE 4.4 ELEVATION OF TYPE 3 CAR PARK CLEAR SPACE USED FOR ACCESS AND PARKING



DIMENSIONS IN METRES

FIGURE 4.5 ELEVATION OF TYPE 3 CAR PARK CONDITION A

4.4.2 Airflow rates

4.4.2.1 *General* For carparks, the airflow rate shall be calculated separately for each zone or level, and it shall be not less than the greatest of:

(a) 3000 L/s (the minimum air quantity for one operating engine);

(b) $p \times 1.2 \times (100 \times n_1 + n_1 \times d_1 + n_2 \times d_3)$ L/s (the minimum air quantity necessary to dilute CO during the peak hour for exit movements);

(c) $P \times 0.4 \times (100 \times n_1 + n_1 \times d_2 + n_2 \times d_4)$ L/s (the minimum air quantity necessary to dilute CO during the peak hour for entry movements); and

(d) $3.5 \times A$ L/s (the minimum air quantity based on the area of the carpark).

where

n_1 – the number of parking spaces in the zone or level under consideration.

d_1 – the average driving distance, in metres, within the zone or level under consideration for the exit of a car parked there.

d_2 – the average driving distance, in metres, within the zone or level under consideration for the entry of a car parked there.

n_2 – the lesser of: (i) the number of parking spaces situated in other parts of the carpark, the entry or exit routes which pass through the zone or level under consideration; and

(ii) When used in (b):

$\left(\frac{250}{P}\right)$ parking spaces per exit lane.

When used in (c):

$\left(\frac{250}{P}\right)$ parking spaces per entry lane.

d_3 – the average driving distance, in metres, within the zone or level under consideration for the exit of a car whose exit route passes through the zone or level, but excluding any part of the exit route designated as queueing area and ventilated in accordance with Clause 4.5.

d_4 – the average driving distance, in metres, within the zone or level under consideration for the entry of a car whose entry route passes through the zone or level, but excluding any part of the entry route designated as queueing area and ventilated in accordance with Clause 4.5.

P – The parking usage factor determined from Table 4.1.

A – the area, in square metres, of the zone or level.

TABLE 4.1

Use of carpark	Parking usage factor *(P)*
Residential	0.3
Commercial	0.5
Retail	0.7
Entertainment/Sports Centres	1.0
Diesel vehicle depots	2.0

Parking usage factors in Table 4.1 apply to self-parking. Where attendant, valet or mechanical stack parking is to be used the parking usage factor may, with approval, be reduced.

NOTES:

1 The Regulatory Authority may require a higher airflow rate if the carpark ventilation is used for other purposes such as smoke-clear ventilation.

2 The Regulatory Authority may approve the use of a distance equal to one-half of the perimeter of the carpark, in metres, as the value of d_1 or d_2.

4.4.2.2 *Small carparks* As an alternative to Clause 4.4.2.1, for carparks with 50 or less car spaces, the airflow rate may be taken as the greatest of—

(a) 3000 L/s per operating engine;

(b) 3.5*A* L/s; or

(c) 500 n_1P.

where n_1 and P are as defined in Clause 4.4.2.1.

4.4.2.3 *Number of car spaces* The number of car parking spaces (n_1) shall be, as shown on the drawings presented for approval except that, if this information is not shown on the drawings, the approved value of n_1 shall be taken as one-twenty-third (1/23) of floor area when measured in square metres including traffic lanes, ramps and the like, but excluding any area ventilated by other air-handling system(s) or covered by Clause 4.5.

4.4.3 Air openings

4.4.3.1 *General* Openings for mechanical or natural ventilation shall be located in order to ensure—

(a) dilution and removal of airborne contaminants from all parts of the enclosure; and

(b) visibility of any obstruction(s) to airflow due to debris and the like.

4.4.3.2 *Location of openings* Location of ventilation openings shall be as follows:

(a) For car parks with exhaust ventilation, the ventilation openings shall be located so that at least 90% of the area within the car park is not more than 3 m, and no part of carpark is more than 7 m from the shortest path(s) between any exhaust or relief-air opening with any make-up or supply air opening.

(b) For car parks with supply ventilation only—

  (i) any point in the car park shall be within 10 m of a supply-air opening; and

  (ii) each supply-air opening shall serve not more than 50 m^2 of area, and shall be designed to produce terminal velocity of at least 0.15 m/s within the area it serves.

NOTES:

1 Where exhaust-air intakes or any relief openings are further than 40 m away from supply-air outlet or any make-up air opening, consideration should be given to potentially deleterious effects of short circuiting, stack effect, wind forces and interaction with other systems. Where the distance is greater than 75 m, ability of such 'engineered' system to effectively dilute polluted air in all parts of the carpark should be demonstrated.

2 Carparks having floor level below that of the natural ground are also subject to the requirements of Clause 4.11.

3 Example layouts complying with Clause 4.4.3.2 are shown in Appendix L.

4.4.3.3 *Distribution of air* The airflow rates at each intake/outlet shall ensure that the quantity of air passing across areas of the carpark is in approximate proportion to the number of car-parking spaces through which the air passes.

4.5 ENCLOSURES OTHER THAN CARPARKS

4.5.1 Enclosed driveways associated with buildings Enclosed driveways giving access to areas in buildings including loading docks, carparks and servicing facilities, shall be ventilated by an exhaust air-handling system. The exhaust-airflow rate shall be not less than 200 L/s per metre length of each traffic lane in excess of 20 m from the outdoor air.

4.5.2 Loading docks Loading docks in which the rear of the docked vehicle may be located at a distance greater than 10 m from the external wall having approved ventilation openings, shall be ventilated by an exhaust system. The exhaust-airflow rate while the dock is in use shall be not less than 1500 L/s per vehicle docking space with a minimum of 3000 L/s.

4.5.3 Automotive service and repair shops

4.5.3.1 *General* Automotive service bays and repair shops, extending more than 10 m from the external wall having an approved ventilation opening shall, unless provision is made for directly ducting engine exhaust fumes as prescribed in Clause 4.5.3.2, be exhausted at a flow rate being the greater of 600 L/s per car space and 3000 L/s. Where separate provision is made to directly duct away engine exhaust fumes, the number of parking spaces requiring ventilation may be reduced accordingly.

4.5.3.2 *Direct ducting from tailpipes* Where provisions are made for direct ducting of engine exhaust fumes to outside, the flexible duct diameter shall be selected in accordance with Table 4.2. The flexible ducts shall be designed to slip over the engine tailpipe and shall be connected to an exhaust ventilation system having minimum exhaust-airflow rates in accordance with Table 4.2.

TABLE 4.2

MINIMUM EXHAUST-AIRFLOW RATES AND DUCT DIAMETER FOR VARIOUS TYPES OF VEHICLES

Type of vehicle	Minimum exhaust-airflow rate per tail pipe L/s	Minimum flexible duct diameter mm
Vehicles up to 150 kW N.E.P.*	50	75
Petrol-engined vehicles over 150 kW N.E.P.	100	100
Diesel-engined vehicles over 150 kW N.E.P.	200	110

* Net Engine Power, in accordance with Australian Design Rules.

4.5.3.3 *Dynamometer engine testing* Where dynamometer engine testing facilities are incorporated, each bay shall either—

(a) have engine exhausts directly ducted away as specified in Clause 4.5.3.2; or

(b) be provided with a general exhaust system extracting not less than 3000 L/s per bay.

Where the engine is tested under load on the dynamometer, the minimum ducted exhaust-airflow rate shall be—

(a) for cars and light-duty trucks—twice the relevant value given in Table 4.2; and

(b) for heavy-duty trucks—600 L/s.

NOTE: Flexible ducts may be used either to fit over the engine tailpipe, or to fit over any deflector attached to the tail pipe or to an approved hood.

4.5.4 Vehicular lifts and shafts

4.5.4.1 *Exhaust ventilation of vehicular lifts* Lifts used for transporting vehicles within a building shall be ventilated by an approved exhaust-air system. The exhaust-airflow rate shall be not less than 3000 L/s except that lifts having open sides and no ceiling, so as to allow for undisturbed airflow through the lift, may be exempted from the exhaust requirement, provided that the lift shaft complies with Clause 4.5.4.2.

4.5.4.2 *Exhaust ventilation of vehicular lift shafts* Vehicular lift shafts shall be ventilated by an approved mechanical exhaust-air system at a flow rate of not less than 3000 L/s.

4.5.4.3 *Make-up air distribution* Make-up air to the exhaust-air system serving vehicular lifts and shafts shall be uniformly distributed by—

(a) approved permanent openings in the lift and lift shaft; or

(b) a mechanical supply-air system complying with Clause 4.8.

4.5.5 Areas used by special-purpose vehicles Areas within buildings, where special-purpose vehicles (e.g. fork-lift trucks) operate, shall be ventilated by an approved exhaust-air system.

Unless otherwise approved, the exhaust-airflow rates given in Table 4.3 shall apply, subject to the following conditions:

(a) The free volume of the space within which the vehicles operate is not less than 4000 m^3 per vehicle.

(b) The operating time of the vehicles is not more than 50 percent of the total time (h/day) the enclosure is occupied.

(c) Make-up air is provided by means of—

  (i) uniformly distributed natural ventilation openings; or

  (ii) an approved supply-air system complying with Clause 4.8.

(d) The vehicle engines do not exceed 45 kW.

Where the above conditions are not met, the flow rates in Table 4.3 shall be adjusted proportionally upward.

NOTE: The Regulatory Authority may require a sign to be displayed in a conspicuous position, stating the maximum number of vehicles which may be operated in order to keep emissions within design levels.

TABLE 4.3

EXHAUST-AIRFLOW RATES FOR AREAS USED BY SPECIAL-PURPOSE VEHICLES

Fuel used by vehicle	Minimum exhaust-airflow rate
Liquefied petroleum gas	2 500 L/s per vehicle
Diesel oil	2 500 L/s per vehicle
Petrol	4 000 L/s per vehicle

4.6 QUEUING AREAS

4.6.1 General Enclosures where vehicles queue with engines operating for any purpose, including parcel pick-up, purchasing, payment at exits or awaiting entry or exit shall be mechanically ventilated by an exhaust-air system.

4.6.2 Queuing length The length of a queue shall be stated by the owner of the building and shall be subject to approval.

NOTES:

1 Several factors influence the length of queues, including use of the enclosure, number and location of entry and exit points and external traffic conditions. Carparks associated with entertainment and sporting venues tend to have longer queues than other carparks.

2 Tables 4.4 and 4.5 may be referred to for guidance in determining queue lengths.

3 Rationale for information contained in Tables 4.4 and 4.5 is provided in Appendix K.

TABLE 4.4

LENGTH OF QUEUES AT ENTRY POINTS

Type of entry	Queuing length
Barrier or ticket dispensing	Full length of entry lane up to barrier
Unhindered	Nil

TABLE 4.5

LENGTH OF QUEUES AT EXIT POINTS

Type of exit	Traffic conditions in street at exit	Queuing length (metres)
Barrier or checkpoint	Light	2.2 $n_L P$ -200
	Heavy	2.2 $n_L P$ -200
Unhindered (i.e. free or central payout)	Light	2.2 $n_L P$ -400
	Heavy	2.2 $n_L P$ -200

where

n_L = no. of carspaces per exit lane

P = parking usage factor determined from Table 4.1.

4.6.3 Airflow rate and distribution of air The exhaust-airflow rate shall be:

(a) 300 L/s per metre length of each exit lane queue; and

(b) 200 L/s per metre length of each entry lane queue.

The location and distribution of exhaust-air intakes and source of make-up air as well as airflow rates at each exhaust air intake shall be such that air passing across the queuing area is uniformly distributed for its full length.

4.7 AIR PRESSURE Air pressure in an enclosure ventilated by exhaust-air system shall comply with Clause 3.4.3.

4.8 REPLENISHMENT OF EXHAUST AIR Clause 3.5 shall apply generally for the replenishment of exhaust air. Where a supply ventilation system for replenishment of exhaust air is provided, it shall have a flow rate of not less than 75% and not more than 90% of the exhaust-airflow rate.

4.9 EXHAUST-AIR DISCHARGE Exhaust-air discharge shall be in accordance with Clause 3.7.

4.10 STAFF—VENTILATION RATE Where staff are employed in generally fixed areas within an enclosure, e.g. pay booth, outdoor air shall be provided to that area at a flow-rate that is at least the greater of—

(a) the flow rate specified in Section 2; and

(b) 5 L/s per square metre of the area.

4.11 LOCATION OF EXHAUSTS IN BELOW GROUND ENCLOSURES All enclosures having a floor level below that of the external natural ground level shall be served by a mechanical exhaust system and shall have between 30% and 50% of the required exhaust air drawn into exhaust-air intakes which have their bottom edges located within 100 mm of floor level. Low level intakes shall be arranged so that any blockage is clearly visible.

4.12 ENERGY SAVING Subject to the approval of the Regulatory Authority, the following energy-saving measures may be adopted:

(a) Where vehicles remain parked with all engines remaining unoperable for periods in excess of 2 h, the prescribed appropriate airflow rate may be halved during such periods.

(b) Automatic operation of systems at lower flow rates controlled by approved detection devices which continuously monitor the concentration of atmospheric contaminants in the enclosure in accordance with Clause 4.13.

4.13 MONITORING OF ATMOSPHERIC CONTAMINANTS

4.13.1 General Where the operation of mechanical ventilation is automatically controlled by approved atmospheric contaminant (AC) monitoring system(s), the air quantity required may be varied, subject to the requirements of this Clause. The atmospheric contaminant(s) to be monitored shall be approved.

NOTES:

1 This Clause specifies requirements where the critical AC is monitored.

2 The critical AC in an enclosure used solely by—

(a) petrol-fuelled vehicles is CO; and

(b) diesel-fuelled vehicles is NO_2.

3 An enclosure used by petrol-fuelled and diesel-fuelled vehicles should be monitored for CO and NO_2 unless the ratio of the different fuelled vehicles is less than 1:10. Where the ratio is greater than 1:10 response of the mechanical ventilation should be dictated by the higher signal of each monitoring system.

4 Requirements applicable to monitoring an AC as a comparator for another AC are not specified in this Clause.

5 Where an AC other than the critical AC is monitored, reliable air quality should demonstrably be achieved in any such controlled mechanical ventilation system.

4.13.2 System requirements An AC monitoring system installed to regulate mechanical ventilation serving a garage, parking station or other enclosure used for servicing or operation of motor vehicles shall—

(a) be provided with an approved analog or digital display;

(b) operate continuously and effectively whenever motor vehicles are present in the enclosure in accordance with Clause 4.13.3;

(c) under any fault condition automatically activate an alarm and operate the mechanical ventilation in the enclosure in accordance with Clause 4.13.6;

(d) be clearly marked to indicate servicing and calibration requirements in accordance with Clause 4.13.7; and

(e) analyse the air—

  (i) at all sampling points continuously and simultaneously and automatically operate the mechanical ventilation system in accordance with Clauses 4.13.4.2; or

  (ii) from all sampling points intermittently, at least twice every 4 min and automatically operate the mechanical ventilation in accordance with Clauses 4.13.4.1 and 4.13.4.2.

NOTE: This Standard permits AC monitoring systems which incorporate sampling and detection devices that analyse the air at sampling points and transmit signals to a central reporting station as well as AC monitoring systems which draw samples of air from sampling points to a central analyser which transmits signals to a central reporting station.

4.13.3 Operation and accuracy of AC monitors The monitoring system shall be selected to—

(a) operate 24 h per day or be automatically activated at such time as will ensure that it accurately analyzes and properly reacts to the first sample analysed after the premises are opened to receive vehicles, provided that the system operates continuously whenever motor vehicles are present in the enclosure; and

(b) measure the concentration of AC to within ±10% of—

 (i) the exposure standard (ES) in the range between 10% and 120% of the ES; and

 (ii) the full range deflection of the monitoring system (120% of the ES).

4.13.4 Analysis of AC and operation of mechanical ventilation

4.13.4.1 *Transportation of air to analyser* Where air samples are passed through tubing from the sampling point to the central analyser—

(a) one or more pumps shall draw air through sampling lines at a rate sufficient to ensure that transport lag time for air samples within any tube is less than 30 s;

(b) the flow rate through each sampling point in the system and through the analyser shall not vary by more than ±10% of the design rate.

(c) flow meters shall be provided in the system to monitor flow rates.

(d) the operation shall ensure that any previous sample is flushed from the analyzing cell before analysis of the next sample commences.

4.13.4.2 *Response time of monitoring systems* When a system detects—

(a) an increase in AC above a set point, reaction of the system to the increase above the value calculated in accordance with Clause 4.13.4.3 shall be immediate after the increase has been sustained for 4 min or detected on consecutive analyses of the same sampling point for a period not longer than 4 min; or

(b) a decrease in AC below a set point, reaction of the system to the decrease below the value calculated in accordance with Clause 4.13.4.3 shall be delayed until the decrease has been sustained for at least 4 min or detected on consecutive analyses of the same sampling point for a period not shorter than 4 min.

4.13.4.3 *Set points* A mechanical ventilation system which is controlled by one or more AC monitoring system(s) shall, when the concentration of the approved AC in the enclosure is—

(a) 80% or more of the ES, operate at the full ventilation rate in accordance with Clause 4.13.4.4;

(b) 50% or less of the ES, operate at not less than the minimum ventilation rate in accordance with Clause 4.13.4.5; and

(c) between 50% and 80% of the ES, operate at a rate not less than determined by the following equation—

$$VR = MR + \left[\frac{(C - 0.5)}{0.3} \right] \times (FR - MR)$$

where

VR = ventilation rate, in litres per second

MR = minimum VR (see Clause 4.13.4.5)

FR = full VR (see Clause 4.13.4.4)

C = concentration of AC, in parts per million.

4.13.4.4 *Full ventilation rate (FR)* The full ventilation rate of a mechanical ventilation system shall be not less than that required by Clause 4.2 according to the enclosure being ventilated.

4.13.4.5 *Minimum ventilation rate (MR)* The minimum ventilation rate of a mechanical ventilation system shall be not less than 25 % of the full ventilation rate *(FR)* but, in any case, not less than 3000 L/s for each zone or level.

Operation of mechanical ventilation in an enclosure may be intermittent, subject to—

(a) Concentration(s) of approved AC dropping below 15% of the ES;

(b) response time specified in Clause 4.13.4.2(b); and

(c) availability of approved natural ventilation, adequate to control low concentrations of pollutants.

4.13.4.6 *Make-up air* Where required, make-up air for each zone or level shall be maintained in accordance with Clause 4.8 to suit minimum, maximum and all intermediate ventilation rates of the mechanical ventilation systems.

4.13.5 Sampling points

4.13.5.1 *Number required* The number of sampling points required for an enclosure shall be the greater of that determined by Clause 4.13.5.2 and the following equation—

$$N = \frac{A}{1000} \times \sqrt{\frac{L}{W}}$$

where

N = number of sampling points, rounded up to the nearest whole number

A = area of the enclosure, in square metres

L = the length or major dimension, in metres

W = the width or minor dimension, in metres.

4.13.5.2 *Distribution* Sampling points shall be distributed as evenly as possible in the enclosure so that no part of the enclosure is more than 25 m away from a sampling point for CO monitoring systems and 12.5 m for NO_2 monitoring systems.

NOTE: Regulatory Authority may also require a sampling in an area where people congregate, such as a waiting area for drivers or passengers of motor vehicles, which is not within a separate pressurized ventilated area.

4.13.5.3 *Location* Sampling points shall be located—

(a) between 900 mm and 1800 mm above the floor surface in positions which will allow samples to be fully representative of the local atmosphere;

(b) at least 100 mm clear of walls, columns and other vertical or near vertical surfaces, and not in positions significantly influenced by either make-up air or motor-vehicle exhaust emissions; and

(c) closer to exhaust inlets than make-up air outlets, and as far as is practicable, situated so that the distance from exhaust openings is 3/10 of the distance between make-up air and exhaust air openings.

4.13.5.4 *Enclosure area* Where the enclosure does not consist of one regular area, each more or less regular area shall be treated as one enclosure.

4.13.6 Monitor failure

4.13.6.1 *Failure detection* Every monitoring system shall include devices to detect and signal fault conditions, including erroneous response or non-response to atmospheric contaminants concentration, and loss of power to the system.

4.13.6.2 *Mode of operation in the event of a failure* On detection of a failure and until the failure is rectified—

(a) an alarm located in an approved position shall be automatically activated; and

(b) mechanical ventilation to all enclosures monitored by that system or the faulty component(s) of the system shall automatically operate at the full ventilation rate (FR).

4.13.7 Marking, commissioning, reliability and records In order to ensure the extended reliability of monitoring systems and the evidence of that reliability, Appendix M is supplied for guidance.

APPENDIX A

MINIMUM OUTDOOR-AIR REQUIREMENTS BASED ON CLASS OF OCCUPANCY

(To be read in conjunction with Section 2)
(Normative)

For enclosure types listed in Table A1, corresponding minimum per person, or per unit area outdoor airflow rates shall apply.

TABLE A1
MINIMUM OUTDOOR AIRFLOW RATES (a_F)

Occupancy type*	Nett floor area per person † m^2	Minimum outdoor airflow rate		
		Quantity	Unit	Comments
Amusement centres				See sports centres.
Beverage services				See food services.
Churches				See theatres.
Colleges				See education.
Correction centres				See prisons.
Dormitories				See hotels.
Dry cleaners and laundries				More air may be required to laundries satisfy exhaust air requirements.
Commercial	10	10	L/s.person	
Coin-operated dry cleaning	5	10	L/s.person	
Coin-operated laundries	5	10	L/s.person	
Pick-up areas	3.5	10	L/s.person	
Storage areas	3.5	10	L/s.person	
Education				
Classrooms serving persons up to 16 years of age	2	12	L/s.person	
Classrooms serving persons over 16 years of age	2	10	L/s.person	
Laboratories	3.5	10	L/s. person	Special contaminant control systems may be required for processes or functions including laboratory animal occupancy.
Libraries	5	10	L/s.person	
Locker rooms	2	10	L/s.person	
Lounges	1.5	10	L/s.person	
Music rooms	2	10	L/s.person	
Training shops	3.5	10	L/s.person	
Food and drink services				
Bars	1	20	L/s.person	For occupancies where smoking is not permitted 10 L/s may be approved, subject to requirements such as the display of signs etc.
Cabarets	1.5	20	L/s.person	
Cafeterias	1	15	L/s.person	
Cocktail lounges	1	20	L/s.person	
Dining rooms	1.5	15	L/s.person	
Fast food outlets	1	15	L/s.person	
Food preparation, serving and storage	3.5	10	L/s.person	For cooking, see Section 3.
Funeral parlours		10	L/s.person	
Chapels	0.6	15	L/s.person	Air shall not be recirculated into spaces.
Embalming rooms	5	10	L/s.person	
Reception rooms	1			
General areas				General requirements (applies to all forms unless separately listed)
Corridors		1	L/s.m² floor	
Dressing rooms	2	10	L/s.person	
Foyers	—	1	L/s.m² floor	
Lobbies		1	L/s.m² floor	
Locker rooms	2	10	L/s.locker	
Pedestrian tunnels		1	L/s.m² floor	
Ramps		1	L/s.m² floor	
Rest rooms	1	10	L/s.person	
Smoking rooms	1.5	25	L/s.person	
Stairs	—	1	L/s.m² floor	For stairs, passageways, etc, used as a means of egress, see AS 1668.1.
Utility rooms	—	1	L/s.m² floor area	

(continued)

TABLE A1 *(continued)*

Occupancy type*	Nett floor area per person † m^2	Minimum outdoor airflow rate		
		Quantity	Unit	Comments
Health care				Applies to convalescent homes, dentists, doctors, hospitals, nursing homes, etc. Special requirements or codes and pressure relationships may determine minimum ventilation rates and filter efficiency.
Amphitheatres	0.6	10	L/s.person	
Autopsy rooms	5	50	L/s.person	NOTE: It should not be recirculated.
Consultation rooms	3.5	10	L/s.person	
Delivery rooms	5	20	L/s.person	} Procedures generating contaminants may require higher rates, laminar flow or dedicated systems.
Intensive care rooms	5	10	L/s.person	
Operating rooms	5	20	L/s.person	
Patient rooms	10	10	L/s.person	
Physical therapy area	5	10	L/s.person	
Procedure areas	10	10	L/s.person	
Ready rooms	5	10	L/s.person	
Recovery rooms	5	10	L/s.person	
Waiting areas	1.5	10	L/s.person	
Hotels, motels, resorts				
Assembly rooms (large)	1	15	L/s.person	
Bedrooms (single, double)	10	10	L/s.person	
Conference rooms (small)	2	15	L/s.person	
Dormitories	—	10	L/s.person	
Gambling casinos	1.5	15	L/s.person	
Living rooms (suites)	5	15	L/s.person	
Lobbies	3.5	10	L/s.person	
Laundries				See dry cleaners.
Merchandising				General requirements (apply to all forms unless separately listed).
Arcades	5	10	L/s.person	
Dispatch areas	10	10	L/s.person	
Fitting rooms	1	10	L/s.person	
Kiosks	1	10	L/s.person	
Malls	5	10	L/s.person	
Receiving areas	10	10	L/s.person	
Sales floors or: Showrooms				
Basement and street floors	3.5	10	L/s.person	
Upper floors	5	10	L/s.person	
Storage areas (serving sales and storerooms)	10	10	L/s.person	
Warehouses	20	10	L/s.person	
Motels				See hotels.
Museums				
Exhibits halls	1.5	10	L/s. person	
Warehouses	20	10	L/s. person	
Offices				
Art rooms	5	10	L/s.person	
Board rooms	1	15	L/s.person	
Committee rooms	1	15	L/s.person	
Computer rooms	25	10	L/s.person	
Conference rooms	1	15	L/s.person	
Drafting rooms	5	10	L/s.person	
Office areas	10	10	L/s.person	
Waiting areas	2	10	L/s.person	
Prisons				
Cell blocks	5	15	L/s.person	
Eating halls	1.5	15	L/s.person	
Guard stations	2.5	10	L/s.person	
Residential				
Private dwellings				Private dwelling places, multiple or single high or low rise.
Bedrooms	10	10	L/s.person	
Living areas— General	10	10	L/s.person	
Other dwellings				
Boarding houses				See hotels.
Guest houses				See hotels.
Hostels				See hotels.
Mobile homes	5	10	L/s.person	

(continued)

TABLE A1 *(continued)*

Occupancy type*	Nett floor area per person † m^2	Minimum outdoor airflow rate		
		Quantity	Unit	Comments
Resorts				See hotels.
Schools				See education.
Speciality services				
Animal rooms	—	5	L/s.m^2 floor	
Barber shops	4	15	L/s.person	
Beauty salons	4	5	L/s.person	
Broadcasting studios	1.5	10	L/s.person	
Electrical meter, switch rooms	—	4	L/s.m^2 floor	
Exercise rooms	5	10	L/s.person	
Fire control rooms	—	4	L/s.m^2 person	
Florist	10	10	L/s.person	
Greenhouses	100	10	L/s.person	
Hairdressers	4	15	L/s.person	
Health spas	5	10	L/s.person	
PABX rooms	—	4	L/s.m^2 floor	
Pet shops	—	5	L/s.m^2 floor	
Press booths lounges	1.5	10	L/s.person	
Radio booths	1.5	10	L/s.person	
Reducing salons	5	10	L/s.person	
Saunas	—	4	L/s.person	
Shoe repair shops (combined workrooms trade areas)	10	10	L/s.person	
Steam rooms	—	4	L/s.person	
Survival shelters	1	10	L/s.person	
Telephone main distribution frame (MDF) rooms	10	10	L/s.person	
Television booths	1.5	10	L/s.person	
Sports and Amusement centres				When internal combustion engines are operated for maintenance of playing surfaces, or any other purpose, exhaust ventilation may be required.
Ballrooms	1.5	15	L/s.person	
Bowling alleys (seating areas)	1.5	15	L/s.person	
Discotheques	1.0	15	L/s.person	
Games rooms	1.5	15	L/s.person	Amusement machines, billiards, cards, etc.
Locker rooms	2	10	L/s.locker	
Playing floors	3.5	10	L/s.person	Cricket, gymnasiums, ice skating, roller skating, squash, tennis, etc.
Spectator areas	0.6	10	L/s.person	
Swimming pools				Higher values may be required for humidity control.
Deck and pool area	3.5	10	L/s.m^2 area	
Spectator areas	1.5	10	L/s. person	
Temples				See theatres.
Theatres				
Auditoriums	0.6	15	L/s.person	For auditoriums where smoking is prohibited the figure of 15 may be reduced to 10, subject to the requirements of the Regulatory Authority.
Concert halls	0.6	15	L/s.person	
Foyers	0.6	15	L/s.person	
Green rooms	5	15	L/s.person	
Lecture halls	0.6	15	L/s.person	
Lobbies	0.96	15	L/s.person	
Opera halls	0.6	15	L/s.person	
Stages	1.5	10	L/s.person	Special ventilation will be needed to eliminate special effect, e.g. dry ice vapours, mists, etc, used in television, film, and radio productions.
Studios	1.5	10	L/s.person	
Ticket booths	—	10	L/s.person	
Transportation centres				
Baggage areas	1.5	10	L/s.person	
Concourses	0.6	10	L/s.person	

(continued)

TABLE A1 *(continued)*

Occupancy type*	Nett floor area per person † m^2	Minimum outdoor airflow rate		
		Quantity	Unit	Comments
Control towers	2	10	L/s.person	
Corridors	1.5	10	L/s.person	
Gate areas	1.5	10	L/s.person	
Hangars	50	10	L/s.person	
Platforms	0.6	10	L/s.person	
Ticket areas	1.5	15	L/s.person	
Waiting rooms	1.5	15	L/s.person	
Air traffic control	2	20	L/s.person	Refer to aviation standards
Veterinary centres				
Kennels	—	5	L/s.m^2 floor	
Operating rooms	—	5	L/s.m^2 floor	
Reception rooms	—	5	L/s.m^2 floor	
Stalls	—	5	L/s.m^2 floor	
Workrooms				This requirement covers continuous occupancy. When occupancy is intermittent, infiltration will normally be sufficient ventilation.
Bank vaults	10	10	L/s.person	
Industrial process				General requirements processes (apply to all forms unless separately listed).
High activity level (2.5 met) ‖	—	15	L/s.person	Mining, foundry, etc.
Medium activity level (2.0 met) ‖	—	15	L/s.person	Automotive repair, assembly line etc.
Low activity level (1.5 met) ‖	—	10	L/s.person	Laboratory work, light assembly, etc.
Meat processing	10	5	L/s.person	This requirement covers low temperature (-23°C to 10°C) rooms occupied continuously. Where occupancy is intermittent, infiltration will normally be sufficient ventilation.
Pharmacists	5	10	L/s.person	
Photography				Installed equipment may require exhaust, to control contaminants.
Camera rooms	10	10	L/s.person	
Dark rooms	10	10	L/s.person	contaminants
Duplicating rooms	3.5	10	L/s.person	
Printing rooms	3.5	10	L/s.person	
Stages	5	10	L/s.person	
Refrigerated rooms				Same as meat processing.
Strongrooms				Same as bank vaults.
Voucher storerooms				Same as bank vaults.

* Where an occupancy type is only listed under one building type, the values given apply to that type of occupancy in all building types.

† This column applies where the number of occupants is not known.

‖ 1.0 met = sedentary level = 58.2/W per m^2 body surface.

NOTES TO TABLE A1:

1 Occupancy types listed are typical, omission of an applicable occupancy from the Appendix does not obviate the need to comply in principle with this Standard (see Clause 2.1).

2 The values of 'nett floor area per person' are approximate.

3 The requirements for ventilation air given in these Tables represent the minimum conditions. Values higher than the above are sometimes recommended, taking into account the required environmental performance, and the effects of intensive smoking and various contaminants on the health and welfare of the occupants.

4 In enclosures where the temperature exceeds 27°C, the outdoor airflow rates need to be increased to compensate for the additional body odour generated at the elevated temperatures.

5 The tabulated values are a consensus judgement of appropriate minima to reduce odours and other contaminants to levels acceptable to the community. These are considerably in excess of the quantities required to ensure healthy breathing or maintain acceptable levels of oxygen, carbon dioxide, etc. Where normally bathed, cleanly clothed, relatively sedentary occupants are expected, the minima may be appropriate. Where unusual occupation or hygiene is expected, some appropriate increases should be made.

6 Some information given in the above Tables is drawn from ASHRAE publications. In some cases, the area per person is greater than existing regulation requirements for determination of exits, etc, since ventilation needs are based on a time-integrated requirement.

7 These values are based on current assessed levels of smoking for the listed occupancies.

APPENDIX B

MINIMUM EXHAUST AIR REQUIREMENTS BASED ON USE OF ENCLOSURE

(To be read in conjunction with Section 3)
(Normative)

For enclosure types listed in Table B1, corresponding minimum exhaust flow rates shall apply.

TABLE B1
MINIMUM EXHAUST VENTILATION FLOW RATES

Enclosure type	Quantity	Unit	Comments
Automotive vehicle			See Section 4.
Battery charging			See AS 2676.
Document copying process which emits obnoxious effluent	5	L/s.m^2 floor	
Drycleaning (solvent)	5	L/s.m^2 floor	
Garages			See Section 4.
Garbage room and service compartment	5	L/s.m^2 floor	
Gas meter	5	L/s.m^2 floor	
Grease arrestor	5	L/s.m^2 floor	
Hospital sterilizing	20	L/s.m^2 floor	May be 15 L/s.m^2 of floor when approved local exhaust provided over sterilizers (see Clause 3.3.1(b))
Kitchen			
Commercial	5	L/s.m^2 floor	
Residential	50	L/s.room	Rate is independent of room size. Operation of system may be intermittent.
Laundry			
Commercial	15	L/s.m^2 floor	
Hospital	15	L/s.m^2 floor	
Residential	20	L/s.room	Rate is independent of enclosure size. Operation of the system may be intermittent.
Sanitary compartment			
Bath	The		For calculation purposes, floor area per fixture
Incinerette	greater		shall be not less than 2.5 m^2; 0.6 m length of urinal
Shower	of — 10	L/s.m^2 floor	shall be equivalent to one fixture.
Urinal	and		
Water closet	25	L/s.listed fixture	
Bathroom, Toilet } Private dwellings and attached to bedroom of hotels, motels, resorts, etc.	25	L/s.room	May include bath, shower, water closet and handbasin in one compartment. Rate is independent of room size. Operation of system may be intermittent.
Disconnecting compartments			
Air locks	10	L/s.m^2 floor	
Privacy lock	5	L/s.m^2 floor	
Sewage ejection	5	L/s.m^2 floor	
Spa pools	5	L/s.m^2 floor	} Includes water surface area.
Swimming pools	2.5	L/s.m^2 floor	} Includes water surface area.
Theatre projection (carbon-arc equipment)	5	L/s.m* floor	Additionally, exhaust each lamp housing 50 L/s.
Plant room	5	L/s.m^2 floor	
Boilers and furnaces			See AS 1200.
Electrical equipment			See AS 3000.
Lifts			See AS 1735.
Refrigeration			See AS 1677.

NOTE: Enclosure uses in the Table B1 are typical. Omission of an applicable enclosure from this Appendix does not obviate the need to comply, in principle with this Standard (see Section 3).

APPENDIX C

OUTDOOR AIR CONTAMINANT LEVELS

(Informative)

TABLE C1
RECOMMENDED MAXIMUM ACCEPTABLE CONCENTRATIONS OF SOME CONTAMINANTS IN OUTDOOR AIR

Contaminant	Concentration μg/m^3	Condition	Source
Total suspended particulates	90	Annual geometric mean	NHMRC
	260	24 h maximum	USEPA
Suspended matter	40	Annual mean	WHO
Acid gases	60	Annual mean	WHO
Sulfur dioxide (SO_2)	365 (0.14 ppm)	24 h maximum	USEPA
	60 (0.02 ppm)	Annual arithmetic mean	NHMRC
Sulfates	15	Annual mean	NHMRC
Carbon monoxide (CO)	40,000 (35 ppm)	1 h maximum	WHO/USEPA
	9,900 (8.7 ppm)	8 h mean	WHO/USEPA
Nitrogen dioxide	100 (0.05 ppm)	Annual arithmetic mean	USEPA
	340 (0.16 ppm)	1 h maximum	NHMRC
Ozone	240 (0.12 ppm)	1 h maximum	NHMRC/USEPA
Non-methane hydrocarbons	24 pphm (0.24 ppm)	3 h maximum	USEPA
Lead compounds reported as lead	1.5	90 day average	NHMRC/USEPA

Abbreviations are:

NHMRC — National Health and Medical Research Council of Australia.
USEPA — United States Environmental Protection Agency.
WHO — World Health Organization.

Units are:

pphm — Parts per hundred million by volume.
ppm — Parts per million by volume.
μg/m^3 — micrograms per cubic metre.

NOTE RE PARTICULATES (TSP AND SUSPENDED MATTER): There is no upper particle diameter or size limit in the value of TSP in these values so the two are not directly comparable.

APPENDIX D

DERIVATION OF THE MULTIPLE ENCLOSURE FACTOR AND EQUATIONS FOR FILTRATION EFFICIENCIES IN A SINGLE AND SOME MULTIPLE ENCLOSURE SYSTEMS

(Normative)

D1 DERIVATION OF THE MULTIPLE ENCLOSURE FACTOR* Suppose that an air-handling system serves a number of enclosures, 1, 2, ... n, as shown in Figure D1.

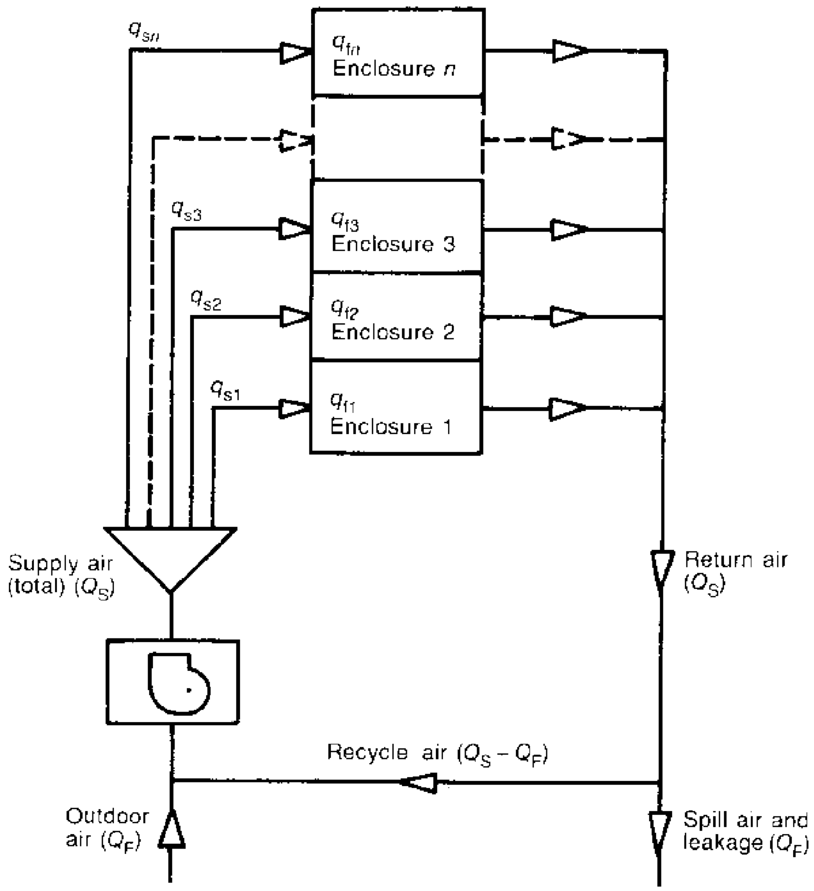


FIGURE D1 SCHEMATIC DIAGRAM OF A MULTIPLE ENCLOSURE AIR-HANDLING SYSTEM

q_{s1}, q_{s2}, q_{s3} ... q_{sn} are supply air rates to enclosures 1, 2, 3, ... n

$Q_s = \Sigma q_{sn} = q_{s1} + q_{s2}$ ..... $+ q_{sn}$

q_{f1}, q_{f2}, ... q_{fn} are the minimum outdoor air rates required by this Standard for these enclosures.

r_1, r_2, ... r_n = ratios q_{fn}/q_{sn}

* The above derivation is based on the concept of unused or surplus outdoor air in the return air. Reference may also be made to the derivation, based on mass balance of pollutants, given by J J Lowalczewski in *Australian Refrigeration, Air-conditioning and Heating*, Volume 27, No 2, February 1973, pp. 14-19.)

r_c	=	largest ratio q_{f1}/q_{s1}, q_{f2}/q_{s2} ... q_{fn}/q_{sn}
Q_f	=	$\sum_1^n q_{fn} = q_{f1} + q_{f2} + \ldots + q_{fn}$
R	=	ratio Q_f/Q_s
Q_F	=	rate of outdoor air supplied to the system direct from outside the enclosures
C	=	concentration of outdoor air in the supply air stream so that the outdoor air in the supply air stream is $C \times Q_s$ generally, and $C \times q_{sn}$ for a typical enclosure.

The Standard requires that the outdoor airflow rate supplied to any enclosure be equal to or greater than the minimum, i.e.

$$C \times q_{sn} \geq q_{fn}$$

hence

$$C \geq \frac{q_{fn}}{q_{sn}}$$

If the ratio of $\frac{q_{fn}}{q_{sn}}$ is the same for each enclosure, then the requirement is satisfied if $Q_F \geq Q_f$.

However if the ratio $\frac{q_{fn}}{q_{sn}}$ is not the same for each enclosure and Q_F is made equal to Q_f, then one or more enclosures will be oversupplied with outdoor air while one or more of the other enclosures will be undersupplied with outdoor air. It follows, therefore, that Q_F must be larger than Q_f so that the concentration of outdoor air is equal to or greater than that required to satisfy the critical enclosure, i.e. the enclosure with the largest value of q_{fn}/q_{sn}, viz r_c.

Thus C must be $\geq r_c$.

If it is considered that only q_{fn} is required to overcome contamination in enclosure n by dilution, then the return air from the enclosure will contain unused or surplus outdoor air having a magnitude of $(C \times q_{sn} - q_{fn})$. The total of unused outdoor air from all enclosures is therefore—

$$\sum_1^n (C \times q_{sn} - q_{fn}) = C \times \sum_1^n q_{sn} - \sum_1^n q_{fn}$$

$$= C \times Q_s - Q_f$$

A part of this unused outdoor air is lost as spill air and leakage air while the remainder, having a magnitude of—

$$\frac{(Q_s - Q_F)}{Q_s} \times (C \times Q_s - Q_f),$$

mixes with the outside air, Q_F, being taken in by the air-handling system. Thus the outdoor air (both from outside and recycled) in the supply stream is—

$$Q_F + \frac{(Q_s - Q_F)}{Q_s} \times (C \times Q_s - Q_f)$$

But by definition, the total outdoor air in the supply stream is $C \times Q_s$, hence—

$$C \times Q_s = Q_F + \frac{(Q_s - Q_F)}{Q_s} \times (C \times Q_s - Q_f)$$

Rearranging gives—

$$Q_F = \frac{Q_f}{\left(1 + \frac{Q_f}{Q_s} - C\right)}$$

To ensure that the outdoor air requirements of all enclosures are met; C must be at least equal to r_c, hence substituting for C and using R for Q_f/Q_s—

$$Q_F = \frac{Q_f}{[1 + R - r_c]} \quad \ldots\ldots \quad D(1)$$

The expression

$$\frac{1}{[1 + R - r_c]}$$

is called the multiple enclosure factor, M. Equation D(1) can be expressed as —

$$Q_F = M \times Q_f$$

EXAMPLE D.1: This example is intended to illustrate the use of the formula for the case of multiple occupancy with untreated recycled air, in which a central unit serves several enclosures with varied requirements for outdoor air to dilute contaminants and of supply air to take care of thermal loads. It is assumed that no enclosure is above 27°C. Table D1 may be read in conjunction with Figure D2.

TABLE D1

Term	Enclosures			Totals
	Library	Offices	Conference room	
N, persons	6	28	12	46
a_f L/s. person	10	10	15	
q_f L/s (minimum)	60	280	180	Q_f = 520 L/s
q_s L/s	300	1 200	250	Q_s = 1 750 L/s
$r = q_f/q_s$	0.20	0.23	<u>0.72</u>	$R = Q_f/Q_s$ = 0.30
Q_F, calculated from Equation (1) above = 895 L/s, based on r_c = 0.72. (M = 1.72).				
Outdoor air in the supply stream $= C \times q_s$ L/s	216	864	180	1260 L/s (NOTE: 1260/1750 = 0.72)
Unused outdoor air before spilling, L/s	156	584	<u>0</u>	740 L/s $= (CQ_s - Q_f)$
Unused outdoor recycled air	—	—	—	362 L/s $= \frac{(Q_s - Q_F)}{Q_s}(CQ_s - Q_f)$
Outdoor air in supply stream	—	—	—	895 + 362 ≈ 1260 as required (without rounding off, the equality would be exact)

(Some numbers have been rounded off for the sake of clarity.)

NOTE: To reduce the magnitude of the necessary Q_F, the designer may, if practicable, use other methods to satisfy the requirements of the enclosures supplied by the central unit. Alternatives include:

(a) Removing enclosures with high values of r_n from the central unit system.

(b) Increasing the supply airflow rates to enclosures with high values of r_n.

(c) Treating the air in the system, e.g. by installing a recirculating air treatment unit within the critical enclosure (see next section).

It may be seen from the above example that taking into account unused outdoor air, by this method, results in a reduction of Q_F from 1260 L/s (i.e. 1750 × 0.72, otherwise considered necessary to ensure that the critical enclosure is provided with sufficient outdoor air) to 895 L/s.

D2 REQUIREMENTS FOR AIR CLEANING EFFICIENCY WITH SOME AIR CLEANING ARRANGEMENTS

D2.1 Symbols In addition to the symbols defined in Clauses 2.3.3 and 2.3.4, and at the beginning of this Appendix, the following are defined:

a_{f1}, a_{f2}, ... a_{fn}, the minimum outdoor air flow rates per person, for the n enclosures, given in Appendix A, or other approved rates.

N_1, N_2, ... N_n, the occupancies (see Clause 2.3.2) of the enclosures.

a_o = the minimum outdoor air flow rate per person to be supplied to an enclosure for dilution of body odours (see Clause 2.3.4)

q_{fn} = the minimum outdoor air flow rate to be supplied to the nth enclosure for adequate air quality. When there is no air cleaning $q_{fn} = a_{fn}N_n$

q_F = the rate at which outdoor air is to be taken into a system comprising a single enclosure

q_s = supply rate in a system comprising a single enclosure

q_r = the flow rate of air, treated by a recirculating air cleaning unit, that is delivered to an enclosure

q_{sc} = the supply air flow rate to the critical enclosure, i.e. the enclosure with the largest value of q_{fn}/q_{sn} in a multiple enclosure system

N_c = the occupancy of the critical enclosure

r_c = the largest ratio q_{f1}/q_{s1}, q_{f2}/q_{s2}, ... q_{fn}/q_{sn}

r_c' = the second highest ratio q_{fn}/q_{sn}

$(r_c)_o$ = the highest ratio $a_o N/q_{sn}$

$(r_c)_o'$ = the second highest ratio $a_o N_n/q_{sn}$

$(r_c)_{cd}$ = the highest ratio (larger of 2.5 N_n and 0.35 A_n)/q_{sn}

Q_{FU} = $M\Sigma(a_{fn} N_n)$, the minimum rate at which outdoor air is to be taken into the multiple enclosure system when there is no air cleaning, where M is the multiple enclosure factor (see Clause 2.3.6) based on $q_{fn} = a_{fn}N_n$

Q_{FP} = $M\Sigma(a_oN_n)$, the minimum rate at which outdoor air is to be taken into a multiple enclosure system when there is adequate filtration of particulates, where M is the multiple enclosure factor (see Clause 2.3.6) based on $q_{fn} = a_qN_n$

Q_{FO} = $M\Sigma$(larger of 2.5 N_n or 0.35 A_n), the minimum rate at which outdoor air is to be taken into a multiple enclosure system when there is adequate filtration of particulates and adequate reduction of odours, where M is the multiple enclosure factor (see Clause 2.3.6) based on q_{fn} = (larger of 2.5 N_n or 0.35 A_n)

ε_o = the percentage efficiency of the air-cleaning unit for particulates as determined in accordance with either

(a) AS 1132.5 using test dust No. 1; or

(b) BS 3928, Sodium flame test; or

(c) AS 1324 Hot DOP test.

ε_1 = the percentage efficiency of the air-cleaning unit for odours and for gaseous irritants in tobacco smoke, under all operating temperatures, determined by means of an approved test

ε_2 = the percentage efficiency of the air-cleaning unit for body odours under all operating temperatures, determined by an approved test.

NOTE: At time of publication Standards Australia were not aware of suitable test specifications for the determination of ε_1 and ε_2.

D2.2 Single Enclosure

D2.2.1 Air treatment for particulates q_F may be any value $\geq a_oN$ and ≥ the rate at which make-up air in accordance with Clause 2.3.8 shall be admitted to the system, provided:

(a) for air treatment of the supply air stream—

(i) $\varepsilon_o \geq \dfrac{a_fN - q_F}{q_s - q_F} \times 100\%$; and

(ii) $\varepsilon_o \geq 20\%$.

Alternatively, the designer may choose a value of ε_o (≥ 20%), in which case q_F shall be as given by—

$$q_F \geq \frac{a_fN - 0.01\varepsilon_o q_s}{(1 - 0.01\varepsilon_o)}$$ and $\geq a_oN$ and ≥ make-up air requirement in Clause 2.3.8.

(b) for a recirculating air cleaner to the enclosure—

(i) $\varepsilon_o q_r \geq (a_f N - q_F) \times 100\%$; and

(ii) $\varepsilon_o \geq 20\%$.

Alternatively, the designer may choose a value of ε_o ($\geq 20\%$), in which case q_F shall be as given as—

(A) $q_F \geq a_f N - 0.01\, \varepsilon_o q_r$; and

(B) $\geq a_o N$ and $\geq$ make-up air requirement in Clause 2.3.8.

D2.2.2 Air treatment for particulates and odours q_F may be any value greater than or equal to the larger of 2.5N and 0.35A and greater than or equal to the rate at which make-up air in accordance with Clause 2.3.8 shall be admitted to the system, provided—

(a) for air treatment of the supply air stream—

(i) ε_o and $\varepsilon_1 \geq \dfrac{a_f N - q_F}{q_s - q_F} \times 100\%$;

(ii) ε_o and $\varepsilon_1 \geq 20\%$; and

(iii) $\varepsilon_2 \geq \dfrac{a_o N - q_F}{q_s - q_F} \times 100\%$

(b) for a recirculating air cleaner to the enclosure—

(i) $\varepsilon_o q_r \geq (a_f N - q_F) \times 100\%$;

(ii) $\varepsilon_o \geq 20\%$;

(iii) $\varepsilon_1 q_r \geq (a_f N - q_F) \times 100\%$;

(iv) $\varepsilon_1 \geq 20\%$; and

(v) $\varepsilon_2 q_r \geq (a_o N - q_F) \times 100\%$.

Alternatively, the designer may choose the efficiency value of one of the air cleaners, in which case the necessary value of q_F is obtained by simple algebra from the relevant expression above, and the necessary efficiency for the other air cleaner is obtained by substituting the value of q_F so found, in the expression for the efficiency of that air cleaner.

D2.3 Multiple enclosure systems

D2.3.1 Central air cleaning unit serving all enclosures

(a) *Particulate filtration only*

Choose a value of Q_F greater than or equal to Q_{FP} and greater than or equal to make-up air requirements rates in accordance with Clause 2.3.8, and calculate required filtration efficiency from—

(i) $$\varepsilon_o \geq \frac{Q_s\left(\dfrac{a_f N_c}{q_{sc}}\right) - Q_F - \left(\dfrac{Q_s - Q_F}{Q_s}\right)\left[Q_s\left(\dfrac{a_f N_c}{q_{sc}}\right) - \Sigma a_f N\right]}{Q_s - Q_F - \left(\dfrac{Q_s - Q_F}{Q_s}\right)\left[Q_s\left(\dfrac{a_f N_c}{q_{sc}}\right) - \Sigma a_f N\right]} \times 100\%;$$ and

(ii) $\varepsilon_o \geq 20\%$

When $Q_F = Q_{FP}$, the above reduces to—

(A) $\varepsilon \geq \dfrac{Q_{FU} - Q_{FP}}{Q_s - Q_{FP}} \times 100\%$; and

(B) $\varepsilon \geq 20\%$

An alternative approach to the above is to select a value for ε_o and calculate the value of Q_F required from the following expression:

$$Q_F \geq \frac{100 Q_{FU} - \varepsilon_o Q_s}{(100 - \varepsilon_o)}$$

provided—

(1) $Q_F \geq Q_{FP}$; and

(2) Q_F is greater than or equal to make-up air requirements in accordance with Clause 2.3.8.

(b) *Particulate filtration and odour reduction*

Choose a value of Q_F greater than or equal to Q_{FO} and greater than or equal to make-up air requirements in accordance with Clause 2.3.8 and calculate the required percentage efficiencies from:

(i) $$\varepsilon_o \text{ and } \varepsilon_1 \geq \frac{Q_s\left(\frac{a_f N_c}{q_{sc}}\right) - Q_F - \left(\frac{Q_s - Q_F}{Q_s}\right)\left[Q_s\left(\frac{a_f N_c}{q_{sc}}\right) - \Sigma a_f N\right]}{Q_s - Q_F - \left(\frac{Q_s\ Q_F}{Q_s}\right)\left[Q_s\left(\frac{a_f N_c}{q_{sc}}\right) - \Sigma a_f N\right]} \times 100\%$$

(ii) ε_o and $\varepsilon_1 \geq 20\%$; and

(iii) $$\epsilon_2 \geq \frac{Q_s\left(\frac{a_o N_c}{q_{sc}}\right) - Q_F - \left(\frac{Q_s - Q_F}{Q_s}\right)\left[Q_s\left(\frac{a_o N_c}{q_{sc}}\right) - \Sigma a_o N\right]}{Q_s - Q_F - \left(\frac{Q_s - Q_F}{Q_s}\right)\left[Q_s\left(\frac{a_o N_c}{q_{sc}}\right) - \Sigma a_o N\right]} \times 100\%$$

When $Q_F = Q_{FO}$, the above reduces to:

(A) $$\varepsilon_o \text{ and } \varepsilon_1 \geq \frac{Q_{FU} - Q_{FO}}{Q_s - Q_{FO}} \times 100\%$$

(B) ε_o and $\varepsilon_1 \geq 20\%$; and

(C) $$\epsilon_2 \geq \frac{Q_{FP} - Q_{FO}}{Q_s - Q_{FO}} \times 100\%$$

An alternative approach to the above is to select a value for the efficiency of one of the air cleaners (say the one for which high efficiencies are difficult to achieve) and calculate the necessary value of Q_F from the appropriate expression below:

(1) $$Q_F \geq \frac{100\ Q_{FU} - \epsilon_o Q_s}{(100 - \epsilon_o)}$$

(2) $$Q_F \geq \frac{100\ Q_{FU} - \epsilon_1 Q_s}{(100 - \epsilon_1)}$$

(3) $$Q_F \geq \frac{100\ Q_{FP} - \epsilon_2 Q_s}{(100 - \epsilon_2)}$$

Subject to:

(1) $Q_F \geq Q_{FO}$; and

(2) Q_F is greater than or equal to make-up air requirements in Clause 2.3.8.

Once Q_F is determined in this way, it is substituted in the expressions above to give the necessary efficiency values for the other air cleaners.

D2.3.2 Air cleaning units for each enclosure

The following is based upon arranging for the concentration of particulate-free air in the supply stream to be equal to the concentration of odour-free air, in the case of particulate filtration, and for the concentration of particulate-free and odour-free air in the supply stream to be equal to the concentration of carbon-dioxide-free air, in the case of both particulate filtration and odour reduction. This may not always give an optimum solution, but it does enable the calculation of a set of εq_r values that satisfy the enclosure requirements.

(a) *Particulate filtration only*

Set the value of Q_F greater than or equal to Q_{FP} and greater than or equal to the make-up air requirement in Clause 2.3.8, and calculate the value of $\varepsilon_{on}\ q_{rn}$ for all n enclosures from:

(i) $$\varepsilon_{on}\ q_{rn} \geq \frac{(a_f N_n - a_o N_n) q_{sn}}{\{q_{sn}\ [1 - (r_c)_o] + a_o N\}} \times 100\%\text{; and}$$

(ii) $\varepsilon_{on} \geq 20\%$, where $(r_c)_o$ is the largest $\left(\frac{a_o N_n}{q_{sn}}\right)$ value.

(b) *Particulate filtration and odour reduction*

Set the value of Q_F greater than or equal to Q_{FO} and greater than or equal to the make-up air requirement in Clause 2.3.8, and calculate as follows:

(i) $$\varepsilon_{on} q_{rn} \text{ and } \varepsilon_{1n} q_{rn} \geq \frac{\left\{ a_f N_n - \begin{pmatrix} \text{larger of } 2.5N_n \\ \text{and } 0.35A_n \end{pmatrix} \right\} q_{sn}}{\left\{ q_{sn}[1 - (r_c)_{cd}] + \begin{pmatrix} \text{larger of } 2.5N_n \\ \text{and } 0.35A_n \end{pmatrix} \right\}} \times 100\% ;$$

(ii) ε_o and $\varepsilon_1 \geq 20\%$; and

(iii) $$\varepsilon_{2n} q_{rn} \geq \frac{\left\{ a_o N_n - \begin{pmatrix} \text{larger of } 2.5N_n \\ \text{and } 0.35A_n \end{pmatrix} \right\} q_{sn}}{\left\{ q_{sn}[1 - (r_c)_{cd}] + \begin{pmatrix} \text{larger of } 2.5N_n \\ \text{and } 0.35A_n \end{pmatrix} \right\}} \times 100\% ;$$

where $(r_c)_{cd}$ is the largest value of $\dfrac{\begin{pmatrix} \text{larger of } 2.5N_n \\ \text{and } 0.35A_n \end{pmatrix}}{q_{sn}}$

NOTES:

1 If Q_F is greater than Q_{FP} (or Q_{FO}, as the case may be) the results of the calculations are conservative.

2 To take advantage of this, by calculating reduced values of εq_{rn}, requires iterative methods too detailed to be included here.

D2.3.3 Air cleaners on the supply to each enclosure

(a) *Particulate filtration only*

The method used here is based on ensuring that the concentration of particulate-free air in the supply stream is equal to the concentration of odour-free air. The results may not be optimal, but the method does enable calculation of a set of ε_o values that satisfy the enclosure requirements.

Set the value of Q_F greater than or equal to Q_{FP} and greater than or equal to make-up air requirements in Clause 2.3.8, and calculate the value of ε_{on} for all enclosures from—

(i) $$\varepsilon_{on} \geq \frac{a_f N - a_o N_n}{q_{sn}[1 - (r_c)_o]} \times 100\% ;\text{ and}$$

(ii) $\varepsilon_{on} \geq 20\%$.

where $(r_c)_o$ is the largest of the $\left(\dfrac{a_o N_n}{q_{sn}} \right)$ values

(b) *Particulate filtration and odour reduction*

The method used here is based on ensuring that the concentration of particulate-free air in the supply stream is equal to that of odour-free, and that of carbon-dioxide-free air. The results may not be optimal, but the method does enable calculation of a set of ε values that satisfy the enclosure requirements.

Set Q_F greater than or equal to Q_{FO} and greater than or equal to the make-up air requirements in Clause 2.3.8.

The values of ε_{on} and ε_{1n} are given by—

(i) $$\varepsilon_{on} \text{ and } \varepsilon_{1n} \geq \frac{\left\{ a_f N_n - \begin{pmatrix} \text{larger of } 2.5N_n \\ \text{and } 0.35A_n \end{pmatrix} \right\}}{q_{sn}[1 - (r_c)_{cd}]} \times 100\% ;\text{ and}$$

(ii) ε_{on} and $\varepsilon_{1n} \geq 20\%$.

and the values of ε_{2n} are given by—

$$\varepsilon_{2n} \geq \frac{\left\{ a_o N_n - \begin{pmatrix} \text{larger of } 2.5N_n \\ \text{and } 0.35A_n \end{pmatrix} \right\}}{q_{sn}[1 - (r_c)_{cd}]} \times 100\%$$

where $(r_c)_{cd}$ is the largest of the $\dfrac{\left(\begin{array}{c}\text{larger of } 2.5N_n\\ \text{and } 0.35A_n\end{array}\right)}{q_{sn}}$ values

NOTES:

1 If Q_F is greater than Q_{FP} (or Q_{FO} as the case may be), the ε values calculated are conservative.

2 If advantage is to be taken of the increased outdoor air intake, by calculating reduced values of ε, it is necessary to use iterative methods which are too detailed to be included here.

D2.3.4 Air cleaners for the critical enclosure only

The method used here assumes that air cleaning will be sufficient to provide for the requirements of the critical enclosure, so it is concerned with attending to the requirements of the other enclosures.

D2.3.4.1 *Particulate filtration only*

(a) Determine the value of r_c', the second highest value of $\dfrac{a_f N_n}{q_{sn}}$

(b) Set Q_F greater than or equal to Q_{FP} and greater than or equal to make-up air requirements in Clause 2.3.8.

(c) Calculate C_{PF}, the ratio of particulate-free air in the supply stream from—

$$C_{PF} = \frac{Q_{FP} - \left(\dfrac{Q_s - Q_{FP}}{Q_s}\right)(\Sigma a_f N_n - a_f N_c)}{Q_s - \left(\dfrac{Q_s - Q_{FP}}{Q_s}\right)(Q_s - q_{sc})}$$

NOTE: It is assumed here that the designer would initially choose $Q_F = Q_{FP}$.

(d) If C_{PF} is greater than or equal to r_c', calculate ε_o from—

(i) Filter on supply to critical enclosure;

(A) $\varepsilon_o \geq \dfrac{a_f N_c - q_{sc} C_{PF}}{q_{sc}\,(1 - C_{PF})} \times 100\%$; and

(B) $\varepsilon_o \geq 20\%$; or

(ii) Recirculating air cleaner to critical enclosure;

$\varepsilon_o q_r \geq (a_f N_c - q_{sc}\, C_{PF}) \times 100\%$; and $\varepsilon_o \geq 20\%$

(e) If $C_{PF} < r_c'$, calculate new value of Q_F and ε_o from—

(i) $Q_F = \dfrac{Q_s\,(\Sigma a_f N_n + q_{sc} r_c' - a_f N_c)}{Q_s(1 - r_c') + (\Sigma a_f N_n + q_{sc} r_c' - a_f N_c)}$; and

(ii) Filter on supply to critical enclosure;

$\varepsilon_o \geq \dfrac{a_f N_c - q_{sc} r_c'}{q_{sc}\,(1 - r_c')}$ and $\varepsilon_o \geq 20\%$; or

(iii) Recirculating air cleaner to critical enclosure;

$\varepsilon_o q_r \geq (a_f N_c - q_{sc} r_c') \times 100\%$ and $\varepsilon_o \geq 20\%$.

D2.3.4.2 *Particulate filtration and odour reduction*

(a) Determine r_c', the second highest value of $\left(\dfrac{a_f N_n}{q_{sn}}\right)$, and $(r_c)_o'$, the second highest value of $\left(\dfrac{a_o N_n}{q_{sn}}\right)$.

(b) Set Q_F greater than or equal to Q_{FO} and Q_F greater than or equal to make-up air requirements in Clause 2.3.8.

(c) Calculate C_{PF}, the ratio of particulate-free air in the supply stream, from—

$$C_{PF} = \frac{Q_{FO} - \left(\frac{Q_s - Q_{FO}}{Q_s}\right)(\Sigma a_f N_n - a_f N_c)}{Q_s - \left(\frac{Q_s - Q_{FO}}{Q_s}\right)(Q_s - q_{sc})}$$

NOTE: It is assumed here that the designer would initially choose $Q_F = Q_{FO}$.

(d) If $C_{pF} < r_c'$, go to Step (k).

(e) If C_{PF} is greater than or equal to r_c', calculate ε_o and ε_1 from—

(i) Filter on supply: ε_o and $\varepsilon_1 \geq \frac{a_f N_c - q_{sc} C_{PF}}{q_{sc}(1 - C_{PF})} \times 100\%$, and $\varepsilon_o \geq 20\%$; or

(ii) Recirculating air cleaner: $\varepsilon_o q_r$ and $\varepsilon_1 q_r \geq (a_f N_c - q_{sc} C_{PF}) \times 100\%$, and $\varepsilon_o \geq 20\%$

(f) Calculate C_{OF}, the ratio of odour-free air in the supply stream from—

$$C_{OF} = \frac{Q_F - \left(\frac{Q_s - Q_F}{Q_s}\right)(\Sigma a_o N_n - a_o N_c)}{Q_s - \left(\frac{Q_s - Q_F}{Q_s}\right)(Q_s - q_{sc})}$$

NOTE: Q_F might still be equal to Q_{FO}, or it might be a larger value, as calculated at step (j) or step (k).

(g) Compare C_{OF} with $(r_c)_o'$

(h) If $C_{OF} \geq (r_c)_o'$, calculate ε_2 from:

(i) Air cleaner in supply: $\varepsilon_2 \geq \frac{a_O N_c - q_{sc} C_{OF}}{q_{sc}(1 - C_{OF})} \times 100\%$; or

(ii) Recirculating air cleaner: $\varepsilon_2 q_r \geq (a_o N_c - q_{sc} C_{OF}) \times 100\%$.

(j) If $C_{OF} < (r_c)_o'$, the odour dilution requirements of the second most critical enclosure will not be satisfied, so Q_F should be increased.

Calculate new Q_F from—

$$Q_F \geq \frac{Q_s\,[\Sigma(a_o N) - a_o N_c + q_{sc}(r_c)_o']}{Q_s[1 - (r_c)_o'] + [\Sigma(a_o N - a_o N_c + q_{sc}(r_c)_o']}$$

and ε_2 from—

(i) Air cleaner on supply $\varepsilon_2 \geq \frac{a_o N_c - q_{sc} r_c}{q_{sc}(1 - r_c)} \times 100\%$ or

(ii) Recirculating air cleaner $\varepsilon_2 q_r \geq (q_o N_c - q_{sc} r_c) \times 100\%$.

Now go back to Step (c), substituting the new Q_F for Q_{FO} in the equation.

(k) If $C_{PF} < r_c'$, calculate new value of Q_F and then ε_o from—

$$Q_F = \frac{Q_s\,[\Sigma a_f N_n + q_{sc} r_c' - a_f N_c]}{Q_s[1 - r_c'] + [\Sigma a_f N_n + q_{sc} r_c' - a_f N_c]}$$

(i) Filter on supply: ε_o and $\varepsilon_1 \geq \frac{a_f N_c - q_{sc} Q_c}{q_{sc}(1 - r_c')} \times 100\%$; and $\varepsilon_o \geq 20\%$; or

(ii) Recirculating air cleaner: $\varepsilon_o q_r$ and $\varepsilon_1 q_r \geq (a_f N_c - q_{sc} r_c') \times 100\%$ and $\varepsilon_o \geq 20\%$.

(l) Go to step (f).

D2.3.5 Combination of a central air-cleaning unit and a recirculating air-cleaning unit for the critical enclosure

(a) *Particulate filtration only*

(i) Determine r_c', the second highest ratio $\left(\frac{a_f N_n}{q_{sn}}\right)$ and $(r_c)_o$, the highest ratio $\left(\frac{a_o N_n}{q_{sn}}\right)$, i.e. $\left(\frac{a_o N_c}{q_{sc}}\right)$.

(ii) If $r_c' < (r_c)_o$, a central filter is not required and the situation reverts to the case considered in Section D2.3.4.1.

(iii) If r_c' is greater than or equal to $(r_c)_o$, set Q_F greater than or equal to Q_{FP} and greater than or equal to the make-up air requirements in Clause 2.3.8, and calculate the ε_o values from—

(A) Critical enclosure: $\varepsilon_o q_r \geq (a_f N_c - q_{sc} r_c') \times 100$ and $\varepsilon_o \geq 20\%$, and

(B) Central: $$\varepsilon_o \geq \frac{r_c' Q_s - Q_{FP} - \left(\frac{Q_s - Q_{FP}}{Q_s}\right) \times \Sigma(r_c' q_{sn} - a_f N_n) \text{ excluding critical enclosure}}{Q_s - Q_{FP} - \left(\frac{Q_s - Q_{FP}}{Q_s}\right) \times \Sigma(r_c' q_{sn} - a_f N_n) \text{ excluding critical enclosure.}} \times 100\%$$

and $\varepsilon_o \geq 20\%$,

(b) *Particulate filtration and reduction of odours*

(i) (A) Determine r_c', the second highest value of $\left(\frac{a_f N_n}{q_{sn}}\right)$;

(B) $(r_c)_o'$, the second highest value of $\left(\frac{a_o N_n}{q_{sn}}\right)$; and

(C) $(r_c)_{cd}$, the highest value of $\frac{(\text{Larger of } 2.5\ N_n \text{ and } 0.35\ A_n)}{q_{sn}}$

(ii) If $(r_c)_o'$ is less than or equal to $(r_c)_{cd}$, no central air cleaner for reduction of body odour will be required since the carbon dioxide-free air will be sufficient for the purpose, and the situation reverts to that considered in Clause D2.3.4.2.

(iii) If $(r_c)_o'$ is less or equal to $(r_c)_{cd}$, set Q_F greater than or equal to Q_{FO} and greater than or equal to the make-up air requirements in Clause 2.3.8, and calculate the ε_2 values from—

(A) Critical enclosure: $\varepsilon_2\ q_r \geq [a_o N_c - q_{sc}(r_c)_o'] \times 100$

(B) Central air cleaner:

$$\varepsilon_o \geq \frac{r_c Q_s - Q_{FO} - \left(\frac{Q_s - Q_{FO}}{Q_s}\right) \times \Sigma(r_c' o_{sn} - a_o N_n) \text{ excluding critical enclosure}}{Q_s - Q_{FO} - \left(\frac{Q_s - Q_{FO}}{Q_s}\right) \times \Sigma(r_c' o_{sn} - a_o N_n) \text{ excluding critical enclosure.}}$$

(iv) If r_c' is less than or equal to $(r_c)_{cd}$, no central air cleaner for filtering particulates and reducing the odour and gaseous irritants of tobacco smoke will be required, and the situation reverts to that consideration in Clause D2.3.4.1, except that Q_F is Q_{FO} and not Q_{FP}.

(v) If $r_c' > (r_c)_{cd}$, calculate the values of ε_0 and ε_1 from:

(A) Critical enclosure:

$\varepsilon_0\ q_r$ and $\varepsilon_1\ q_r \geq (a_f N_c - q_{sc}\ r_c') \times 100$, and ε_0 and $\varepsilon_1 \leq 20\%$

(B) Central: $$\varepsilon_o \text{ and } \varepsilon_1 \geq \frac{(r_c)_o' Q_s - Q_{FO} - \left(\frac{Q_s - Q_{FO}}{Q_s}\right) \times \Sigma(r_c' q_{sn} - a_f N_n) \text{ excluding critical enclosure}}{Q_s - Q_{FO} - \left(\frac{Q_s - Q_{FO}}{Q_s}\right) \times \Sigma(r_c' q_{sn} - a_f N_n) \text{ excluding critical enclosure.}} \times 100\%$$

and ε_o and $\varepsilon_1 \geq 20\%$

Example D.2: The system of enclosures discussed in Example D.1 of this Appendix has been considered under all the filtration arrangements described above, and the results are set out in Table D.2.

TABLE D2

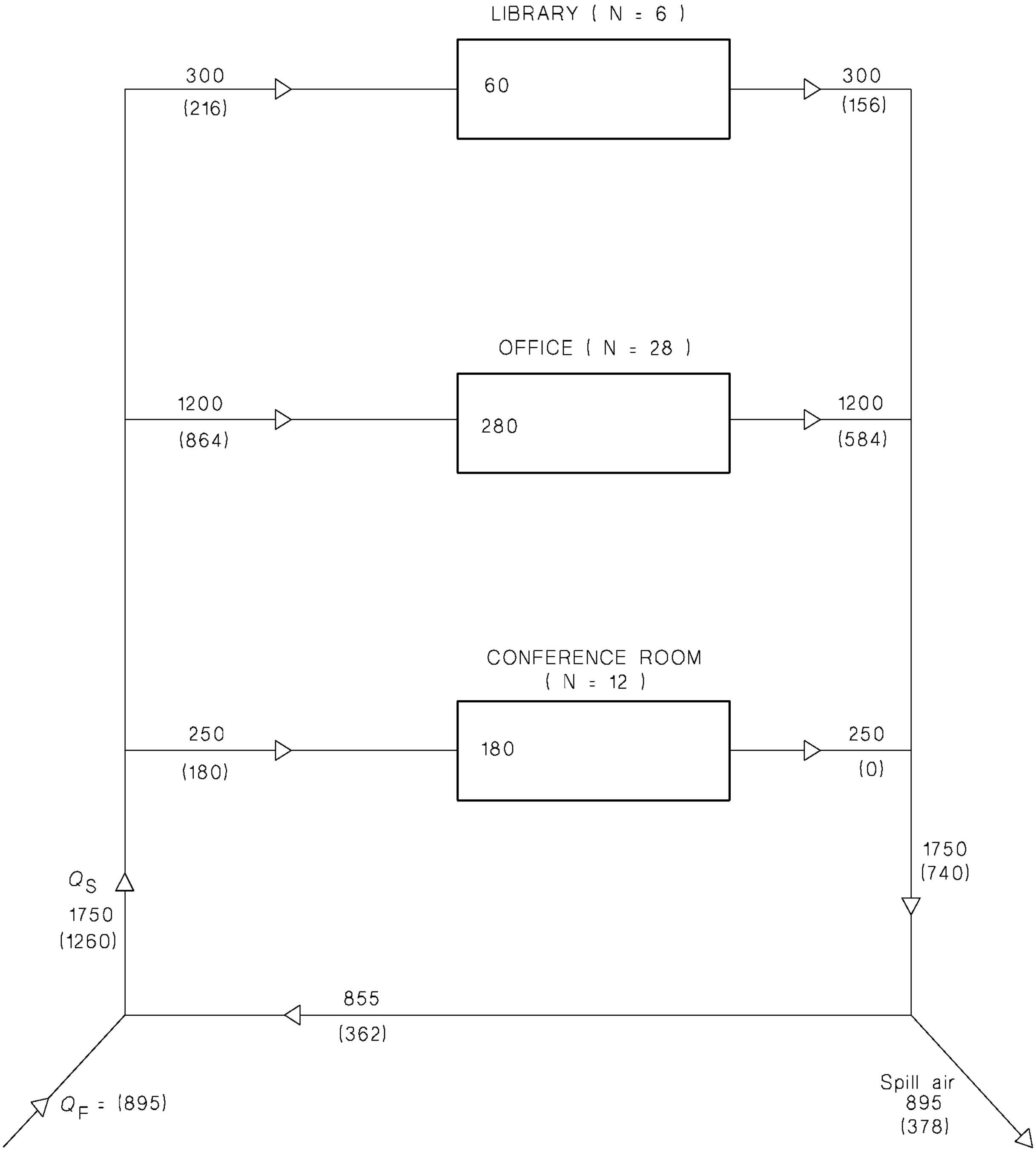
Minimum efficiencies for the given air cleaning arrangements (Rounded to nearest integer)

Air cleaning arrangements	**Enclosure**	**Particulate filtration (Q_{FP} = 412 L/s) ε_o (%)**	**Particulate filtration and odour reduction (Q_{FO} = 149 L/s except when stated otherwise)**		
			ε_o'	ε_1	ε_2 (%)
Central air cleaner (Clause D2.3.1)	'Central'	36		47	17
Recirculating air cleaner for each enclosure (q_r = 250 L/s) (Clause D2.3.2)	Library Office Conf. Rm.	20 34 36		20 75 60	13 47 24
Air cleaner on supply to each enclosure (Clause D2.3.3)	Library Office Conf. Rm.	20 20 56		20 20 68	11 11 27
Recirculating air cleaner for critical enclosure (q_r = 250 L/s) (Clause D2.3.4)	Conf. Rm.	47		49	2
Air cleaner on supply to critical enclosure (Clause D2.3.4)	Conf. Rm.	— — 63	Q_F = 399 L/s	— — 64	— — 3
Central air cleaner + recirculating air cleaner for critical enclosure (q_r = 250 L/s) (Clause D2.3.5)	'Central' Conf. Rm.	0 47		20 49	9 19

NOTES:

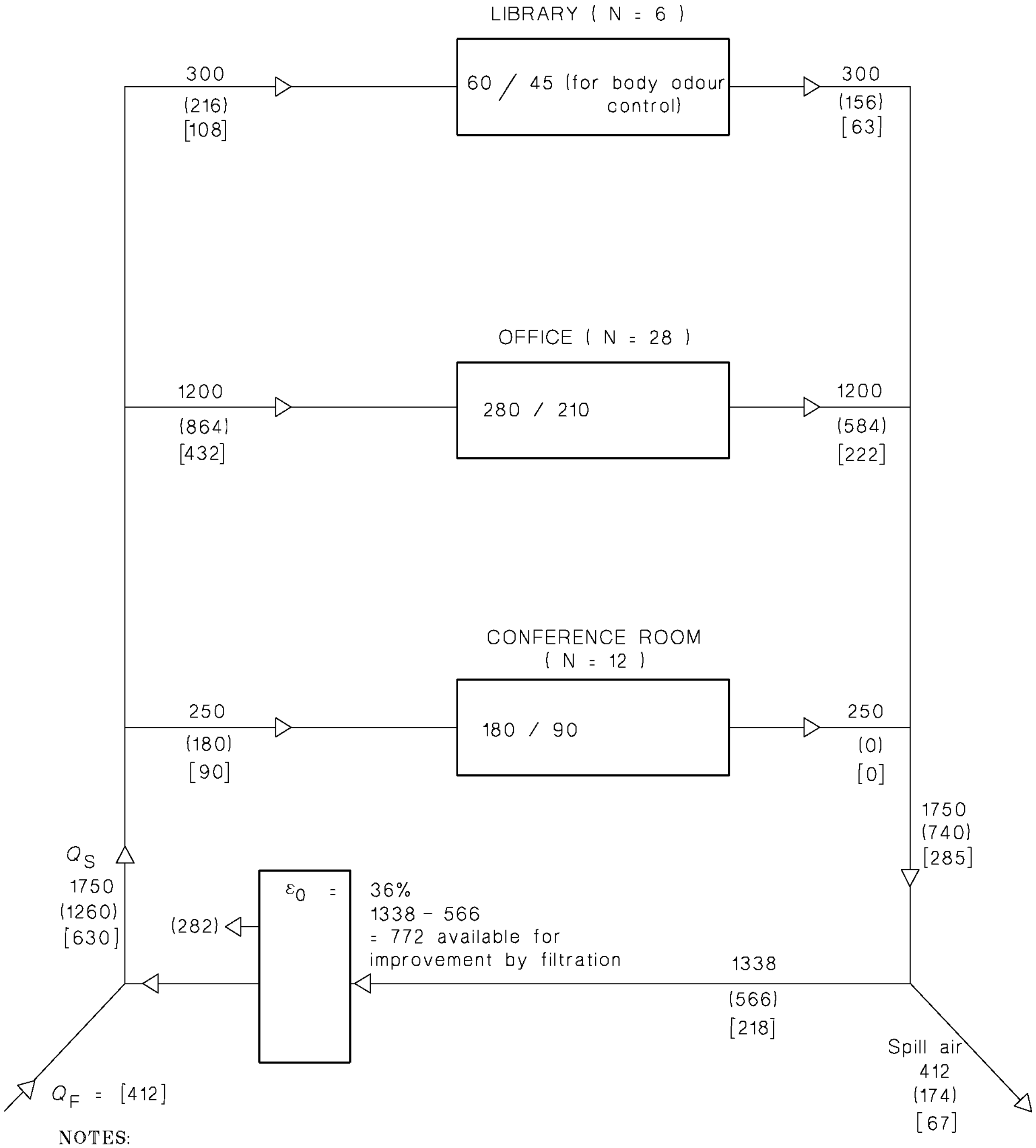
1 Where calculated efficiency values for particulate filters fell below 20%, a figure of 20% has been used as a default value.

2 For this example, when both particulate filtration and odour reduction are used, q_f for the office is dictated by the requirement that q_f is greater than or equal to 0.35A L/s (Clause 2.3.4(c)(ii)). Value of A has been taken to be $10 \times 28 = 280$ m^2, hence q_f is greater than or equal to 98 L/s.



NOTE: Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.

FIGURE D2 EXAMPLE D1 - CENTRAL AIR CLEANING UNIT

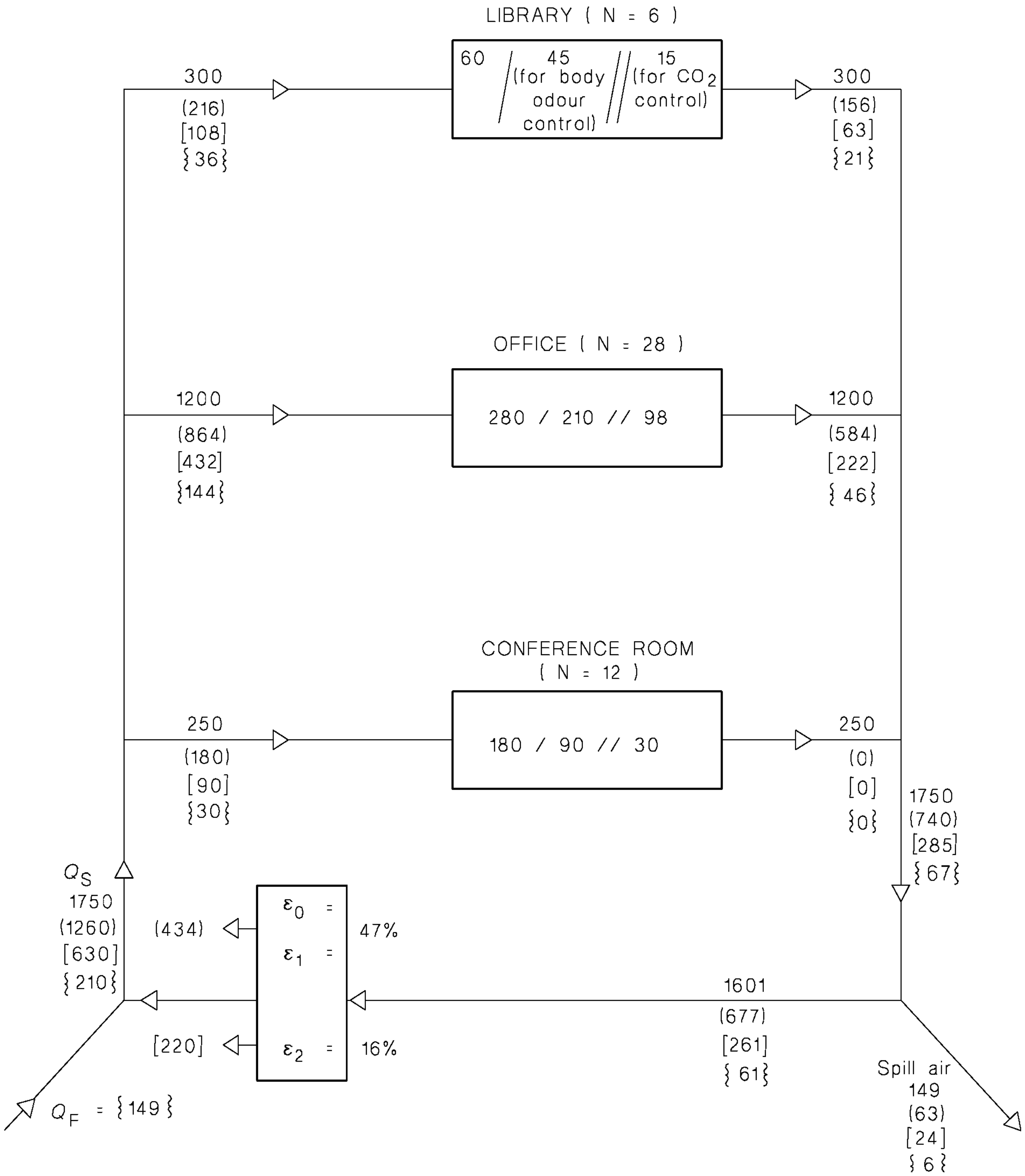


NOTES:

1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.

(a) Particulate filtration only

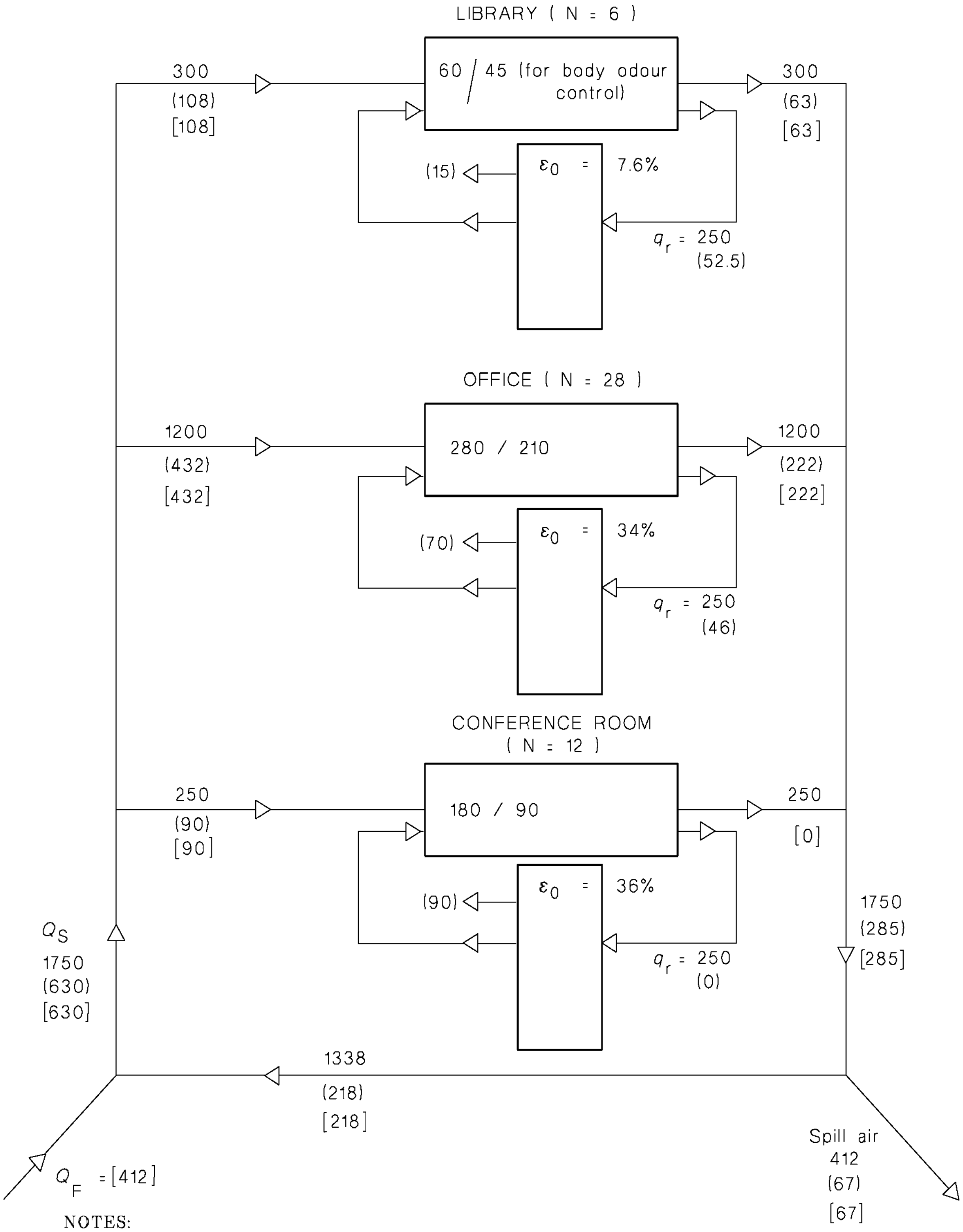
FIGURE D3 (in part) EXAMPLE D2 - CENTRAL AIR CLEANING UNIT



NOTES:
1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.
3. Unused air flow serving to dilute concentration of CO_2 shown in braces.

(b) Filtration for particulates and reduction of odours

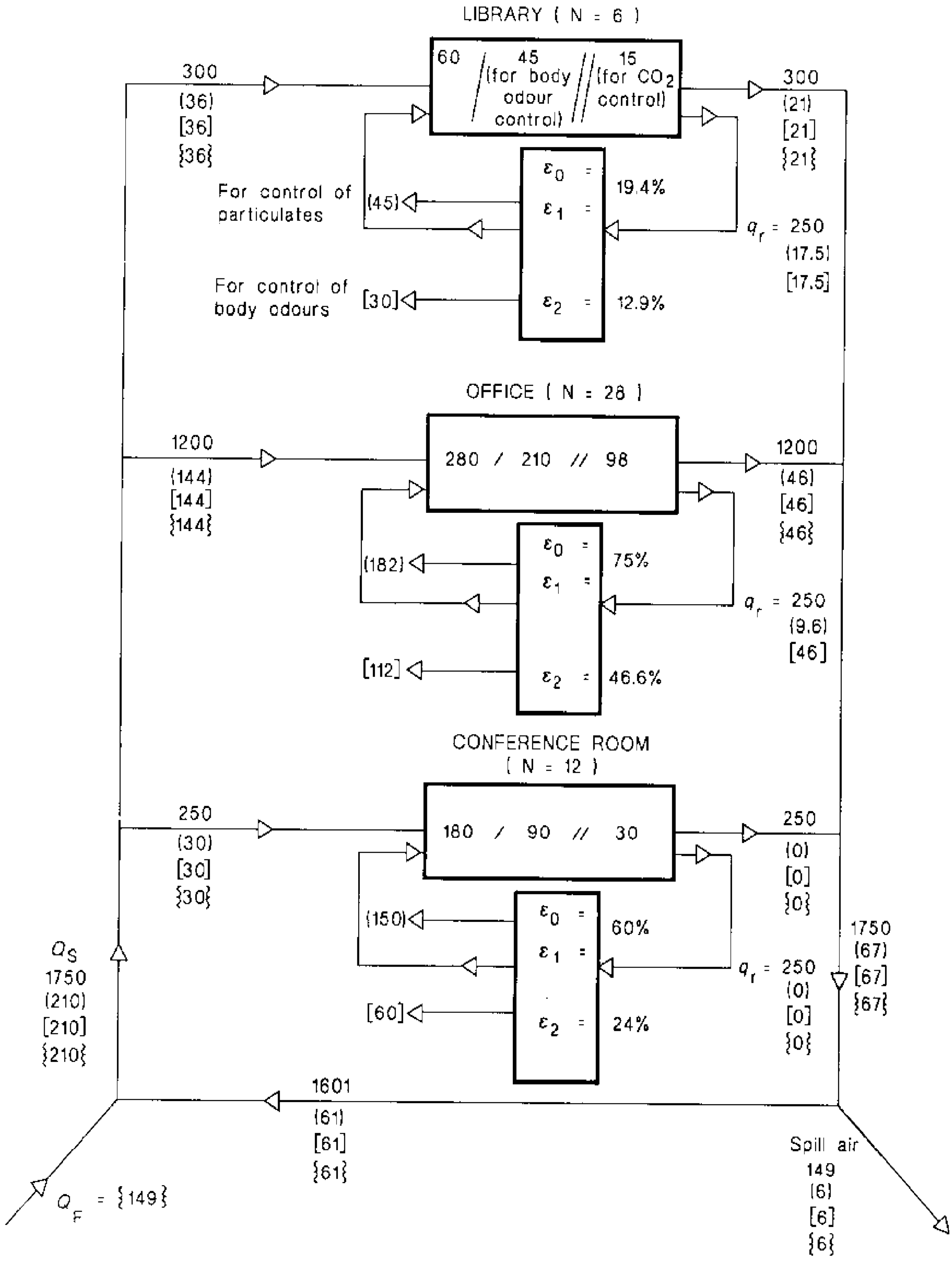
FIGURE D3 (in part) EXAMPLE D2 - CENTRAL AIR CLEANING UNIT



NOTES:
1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.

(a) Particulate filtration only

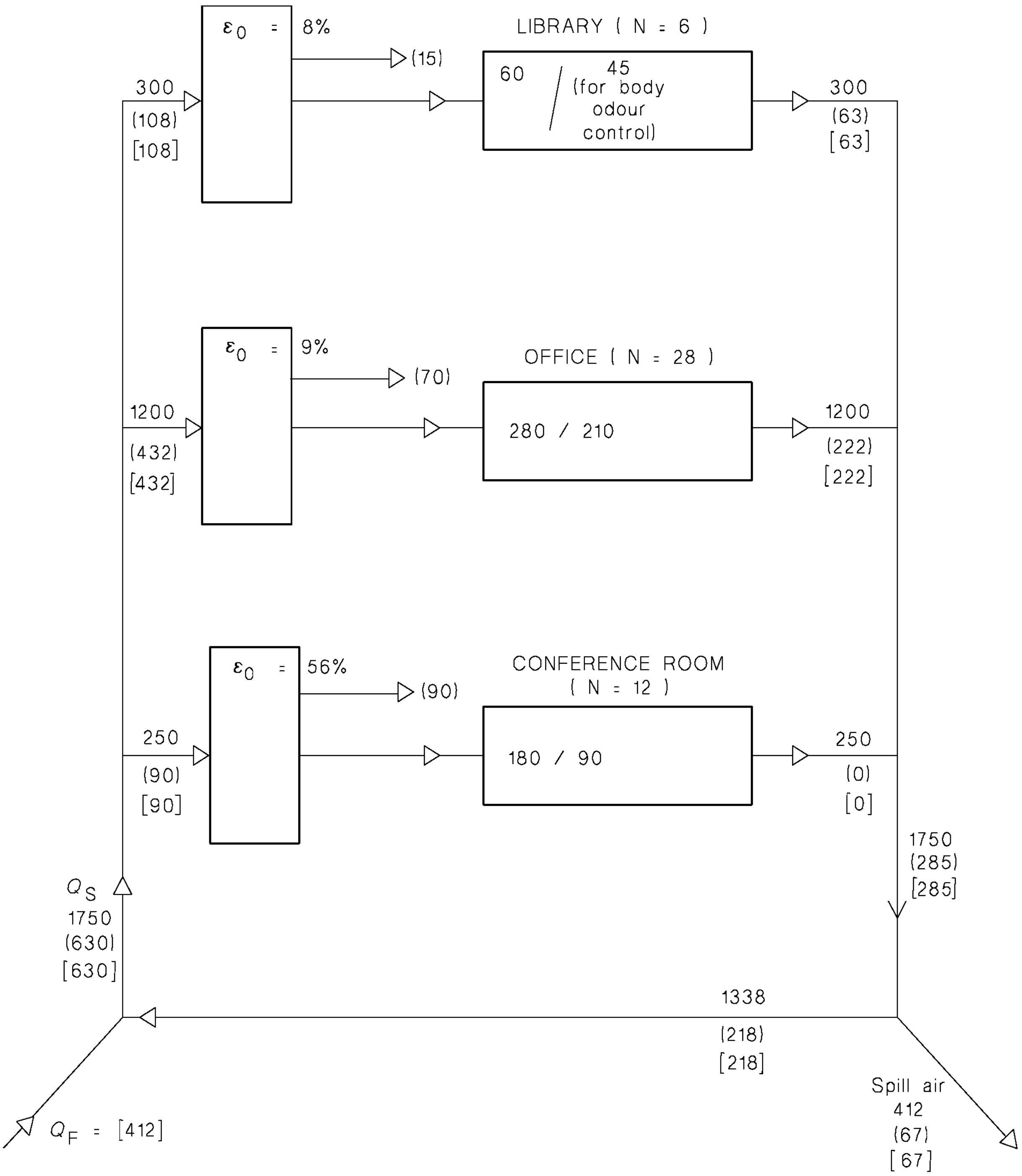
FIGURE D4 (In part) EXAMPLE D2 - RECIRCULATING AIR CLEANING UNITS FOR EACH ENCLOSURE



NOTES:
1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.
3. Unused air flow serving to dilute concentration of CO_2 shown in braces.

(b) Filtration for particulates and reduction of odours

FIGURE D4 (in part) EXAMPLE D2 - RECIRCULATING AIR CLEANING UNITSFOR EACH ENCLOSURE

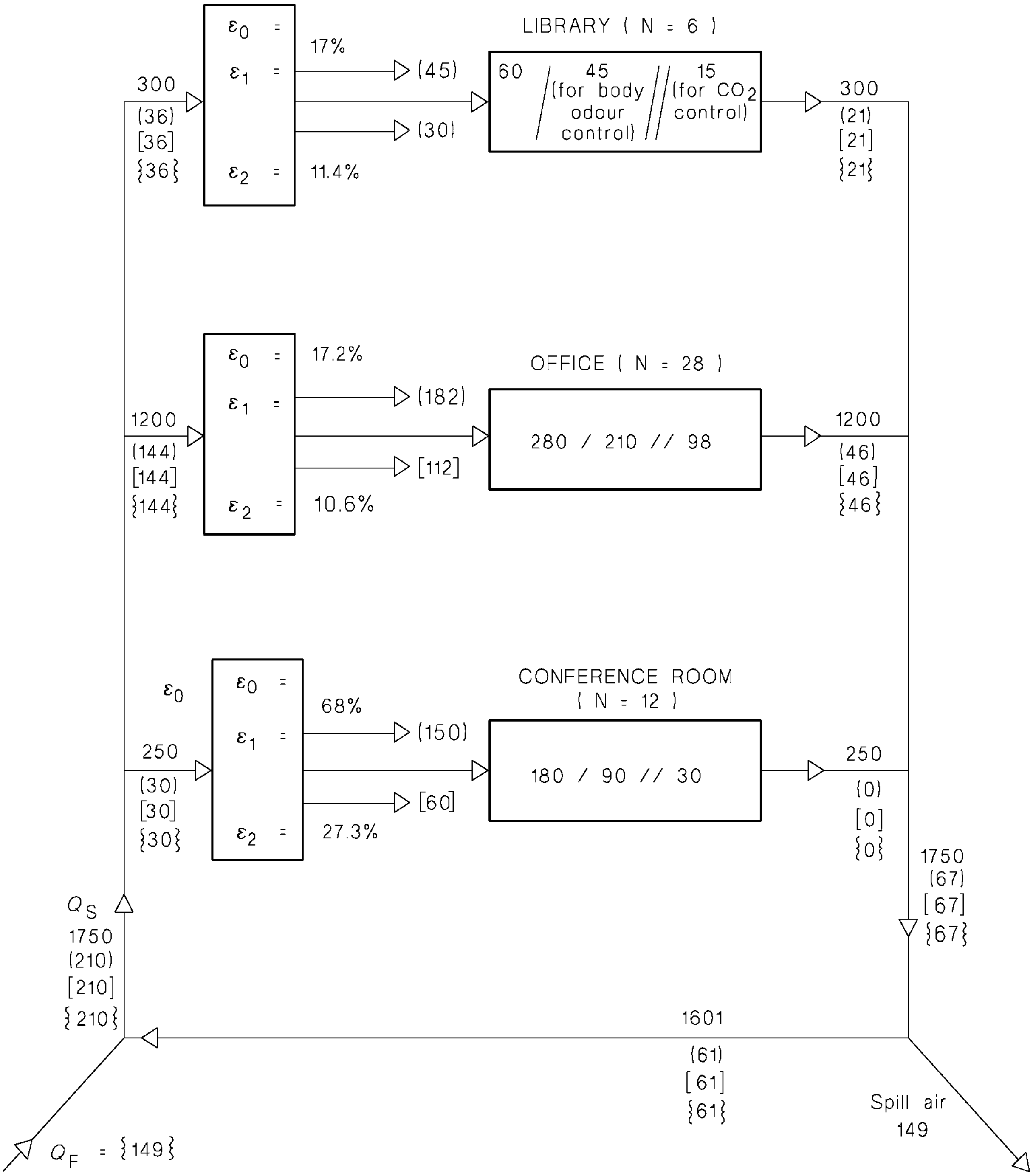


NOTES:

1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.

(a) Particulate filtration only

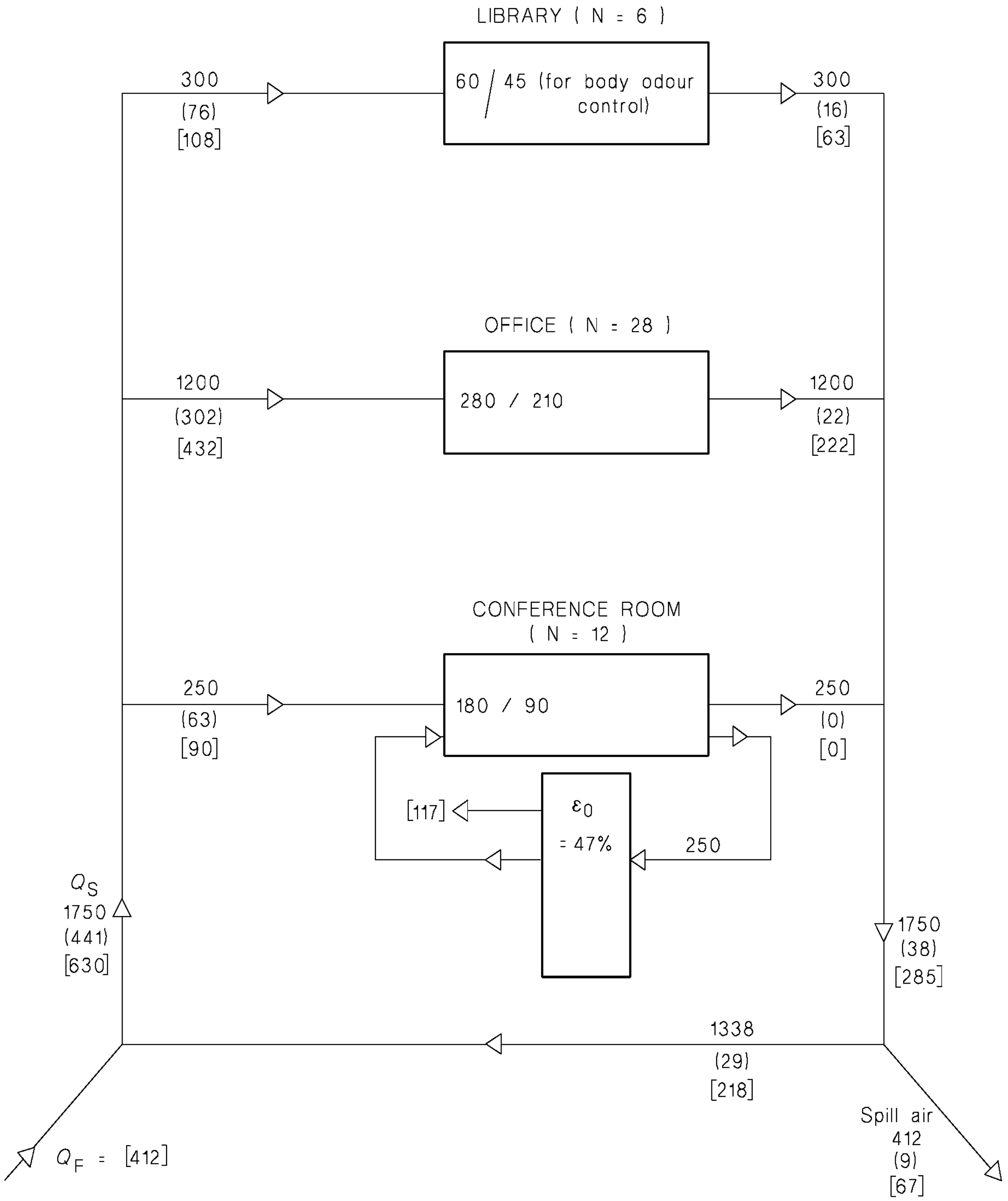
FIGURE D5 (In part) EXAMPLE D2 - AIR CLEANING UNITS ON THE SUPPLY TO EACH ENCLOSURE



NOTES:
1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.
3. Unused air flow serving to dilute concentration of CO_2 shown in braces.

(b) Filtration for particulates and reduction of odours

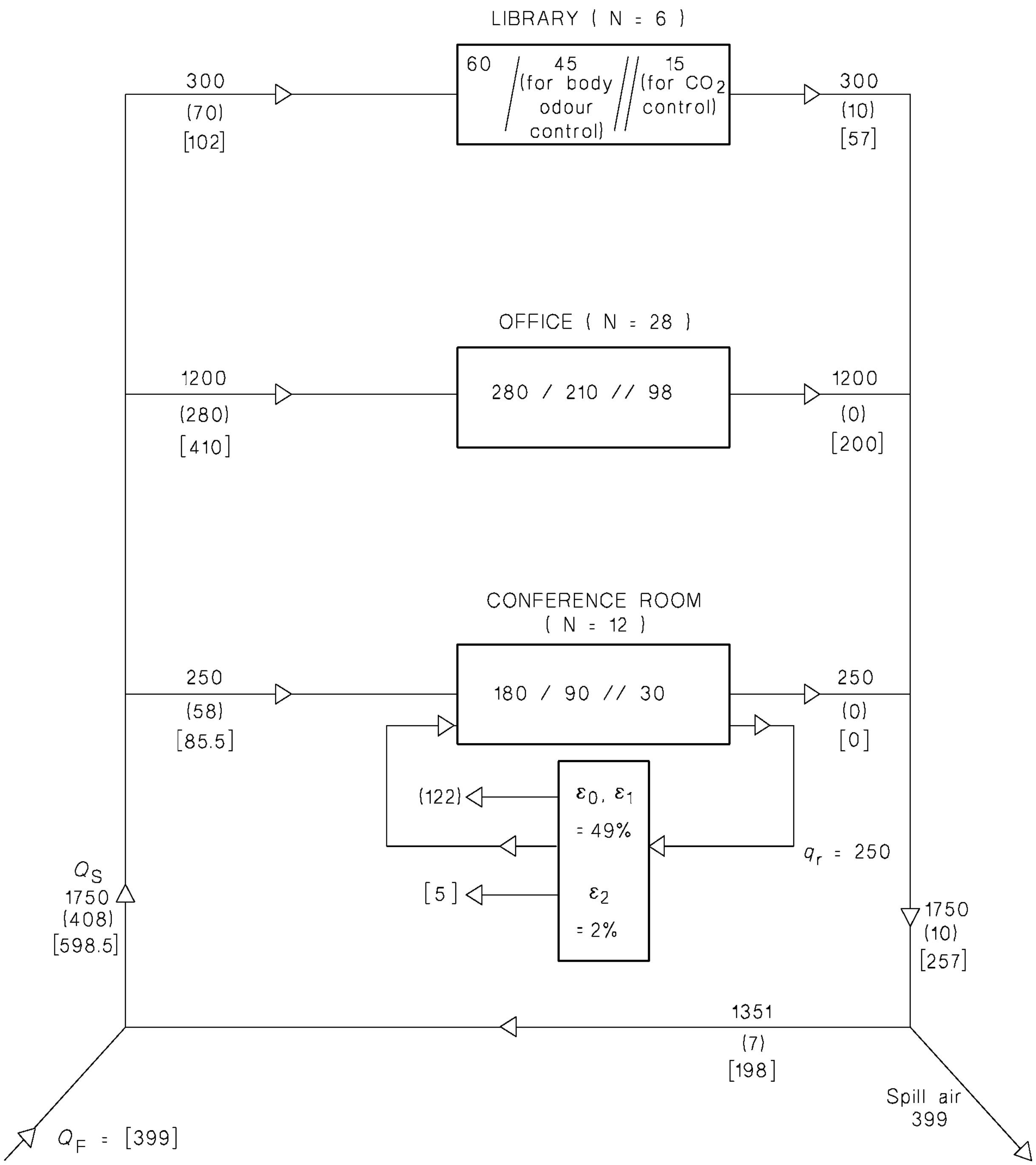
FIGURE D5 (in part) EXAMPLE D2 - AIR CLEANING UNITS ON THE SUPPLY TO EACH ENCLOSURE



NOTES:
1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.

(a) Particulate filtration only

FIGURE D6 (in part) RECIRCULATING AIR CLEANING UNIT FOR THE CRITICAL ENCLOSURE

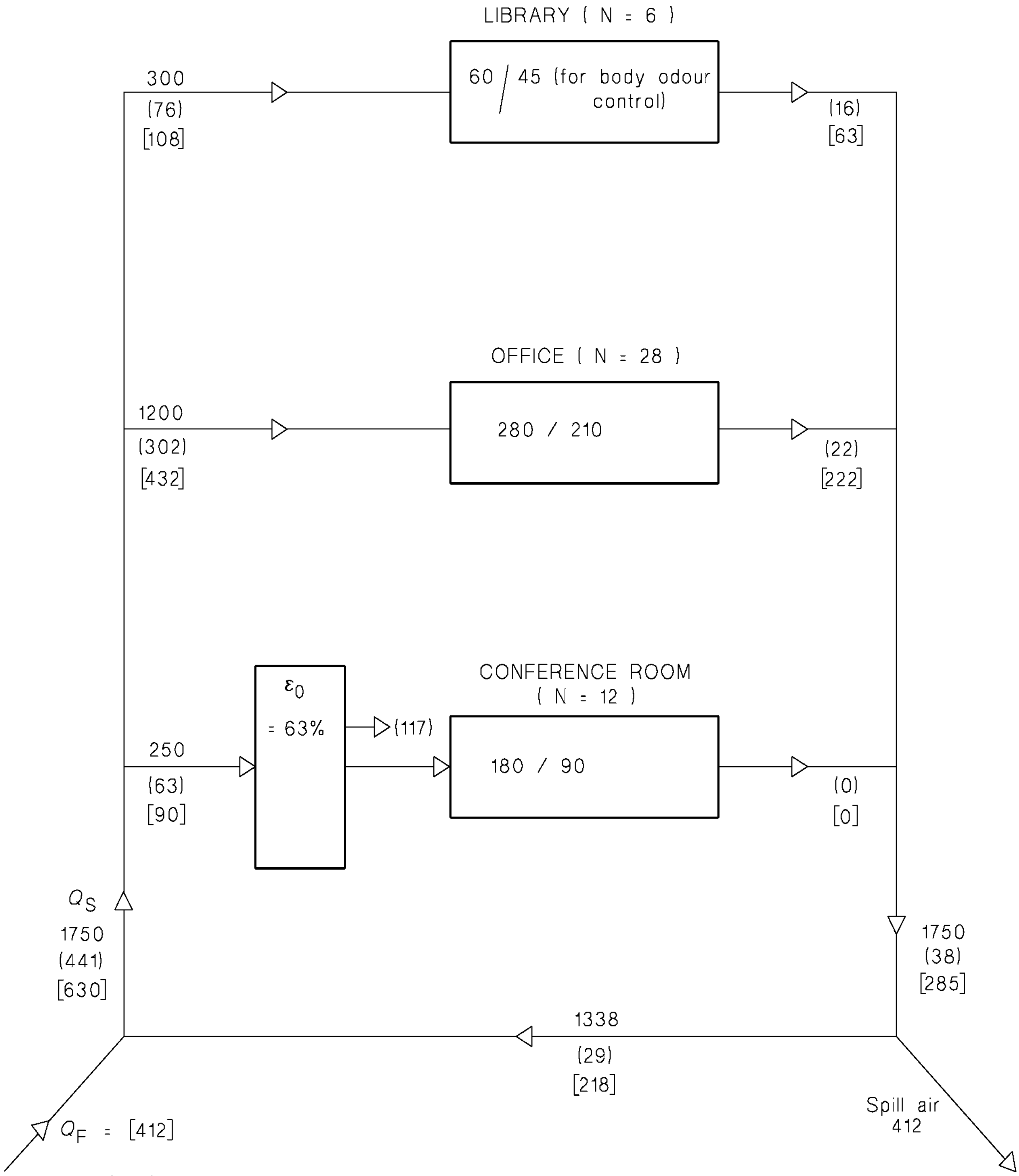


NOTES:

1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.
3. No need to consider CO_2 levels because outdoor air intake is far greater than the Q_{Fo} value, 149 L/s.

(b) Filtration for particulates and reduction of odours

FIGURE D6 (in part) RECIRCULATING AIR CLEANING UNIT FOR THE CRITICAL ENCLOSURE

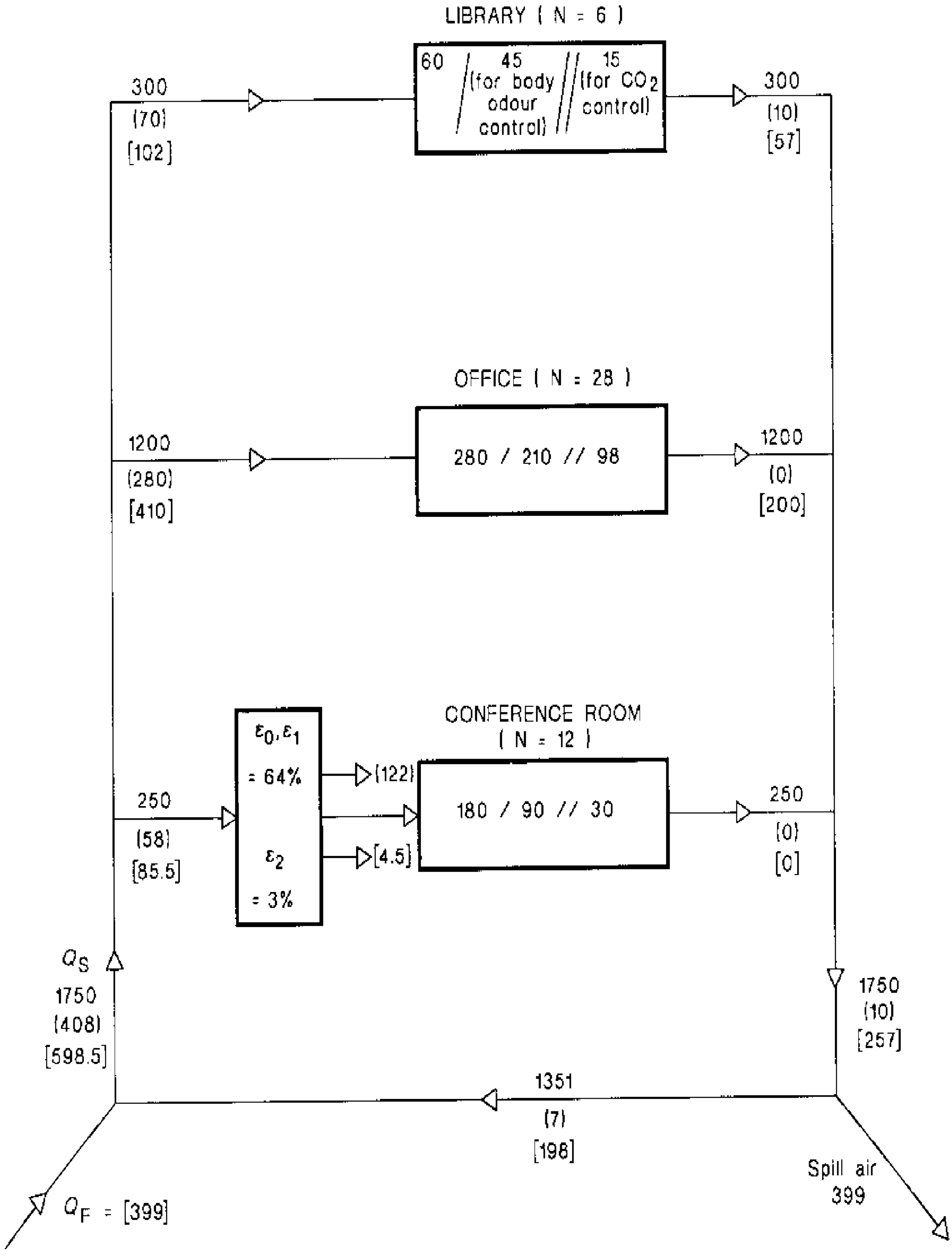


NOTES:

1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.

(a) Particulate filtration only

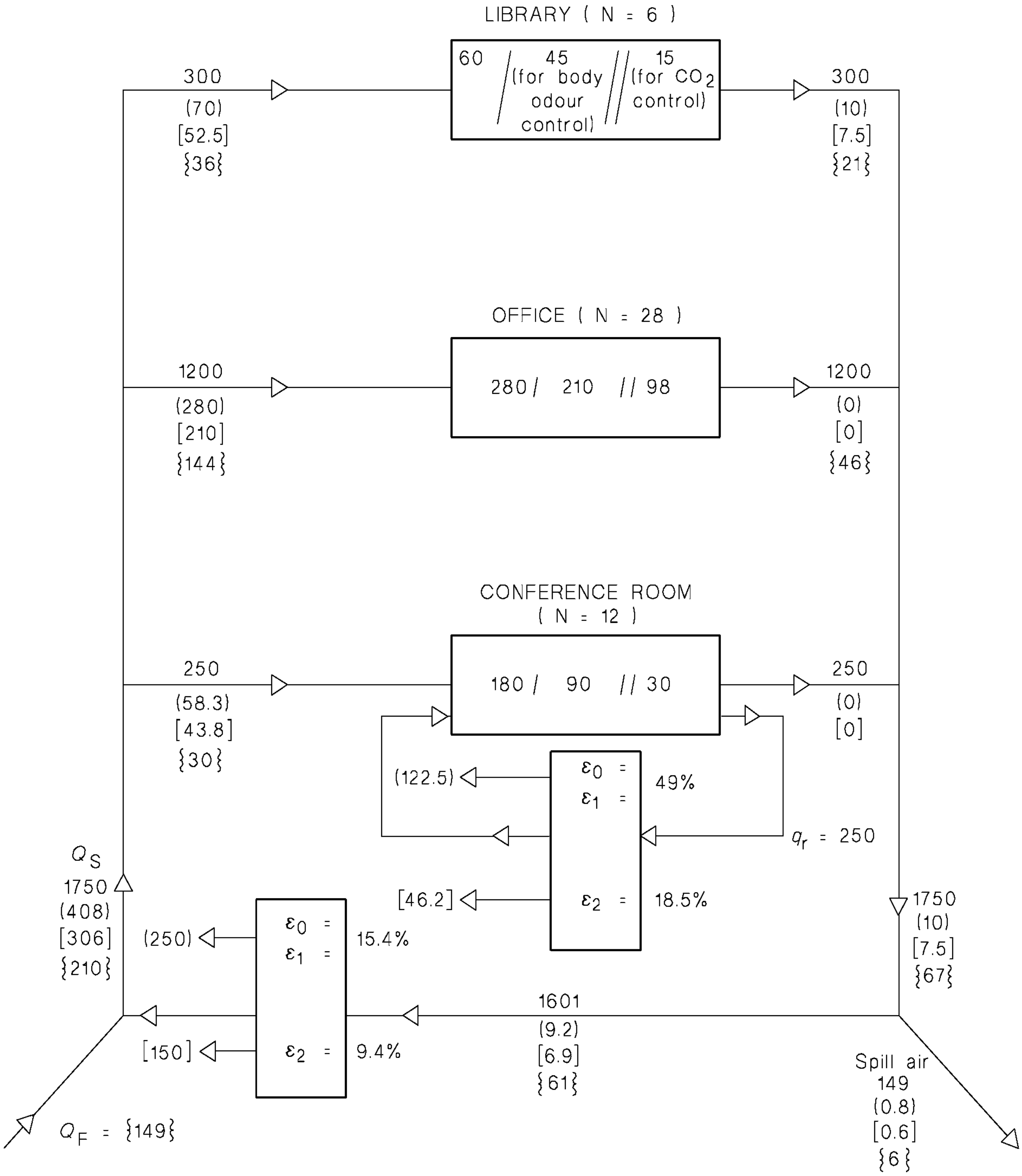
FIGURE D7 (in part) AIR CLEANING UNIT ON THE SUPPLY TO CRITICAL ENCLOSURE



NOTES:
1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.
3. No need to consider CO_2 levels because outdoor air intake is far greater than the Q_{Fo} value, 149 L/s.

(b) Filtration for particulates and reduction of odours

FIGURE D7 (in part) AIR CLEANING UNIT ON THE SUPPLY TO CRITICAL ENCLOSURE



NOTES:

1. Unused outdoor airflow rates serving to dilute particulates are shown in parentheses.
2. Unused outdoor airflow rates serving to dilute body odours are shown in square brackets.
3. Unused air flow serving to dilute concentration of CO_2 shown in braces.

FIGURE D8 CENTRAL AIR CLEANING UNIT AND AIR CLEANING UNIT FOR THE CRITICAL ENCLOSURE (PARTICULATE FILTRATION AND ODOUR REDUCTION)

APPENDIX E
KITCHEN EXHAUST HOODS
(Normative)

E1 SCOPE This Appendix sets out requirements for the design, construction and installation of kitchen exhaust hoods (hereinafter referred to as 'hoods'), where their provision is required under Clause 3.3.2.3.

The Regulatory Authority may approve other designs which effectively meet the requirements of Clause 3.3.

NOTE: Appendix F describes the purpose and function of hoods, and provides guidelines on the capture (by hoods) of emissions.

E2 APPLICATION Where a kitchen exhaust hood is required, it shall comply with Clauses E3, E5, and E6, and where grease vapour is present, also with Clauses E4 and E7, or Clause E8.

E3 HOOD DESIGN AND MANUFACTURE

E3.1 General Hoods shall be designed—

(a) to capture cooking vapours and associated products of combustion;

(b) to exhaust cooking vapours and associated products of combustion together with dilution air;

(c) to prevent condensate falling onto the food, cooking appliance(s) or the floor;

(d) to permit easy access to cleaning spaces where condensate may accumulate;

(e) with vertical flat sides where walls abut; and

(f) to be free of insulation material on the internal surface of the hood or exhaust plenum between the hood and connecting duct.

E3.2 Manufacture Hoods shall be manufactured from rigid impervious hard-faced material not deemed combustible when tested in accordance with AS 1530.1, such as steel or stainless steel, reinforced where necessary to provide stability and rigidity with smooth-faced liquid-tight seams and joints made by approved methods, such as the following:

(a) Continuous welding.

(b) Grooving or lapping, riveting and continuous soldering.

(c) Continuous jointing and sealing with an appropriate compound unaffected by grease, water or cleaning agents, e.g. silicone rubber which is in compression at the joint.

E3.3 Openings Exhaust openings in hoods shall be—

(a) suitably located in relation to the types of cooking and heating appliances being ventilated and positioned so that a uniform capture velocity is maintained;

(b) not more than 500 mm from the extremities of the exhaust plenum, not more than 1 m apart, and of dimensions which permit access into the exhaust plenum for cleaning purposes; and

(c) designed to prevent condensate from the top surface of the exhaust plenum or duct from falling through the exhaust opening.

NOTE: Removable panels between filters provide easy access to exhaust plenum for cleaning.

E3.4 Internal lights Where fitted light fittings shall be flush mounted to comply with E7.4.2.

NOTE: Access from the outside face of the hood avoids disturbing the vapour seal to the inside face of the hood during servicing.

E4 DISTANCE FROM GREASE ARRESTING DEVICE TO HEAT SOURCE

E4.1 General Unless otherwise approved (see E4.2), the distance between the lowest edge of a grease arresting device and the cooking surface shall be not less than—

(a) for charcoal and similar type of open fires . . . . 1350 mm;

(b) where the heat source is provided by means of a naked flame, e.g. gas stove . . . . 1050 mm; and

(c) where the heat source is provided by electrically operated equipment or a fixed plate or pan above gas flame (e.g. solid grill plate or deep fryer) . . . . 600 mm.

E4.2 Reduction of distances In variation to Clause E4.1 above and subject to approval, the distance of grease arresting filters from the heat source given in Clause E4.1 may be reduced where the kitchen exhaust system is provided with an approved fire protection system which in the event of fire—

(a) automatically floods the cooking appliance and the exhaust plenum between the filters and the exhaust duct with fire 'quenching' media; or

(b) is automatically activated to inhibit fire.

E5 DISTANCE TO FLOOR LEVEL The lower edge of a canopy-type kitchen exhaust hood shall be not less than 2 m above floor level at the operator side of the appliance being ventilated.

E6 OPERATION INDICATOR A signal light or other indicator shall be provided on the external surface of the hood, or in close proximity to it to indicate whether the system is operating (see also 3.5.4).

E7 KITCHEN EXHAUST HOODS INCORPORATING GREASE FILTERS

E7.1 Grease filters Grease filters shall comply with UL 1046.

E7.2 Grease arresting filters The hoods shall incorporate approved grease arresting filters as follows:

(a) Filter holding frame shall be constructed of rigid material not deemed combustible when tested in accordance with AS 1530.1.

(b) The number, size and distribution of the filters shall be such that the air temperature and flow rate through each filter is within the manufacturer's design limits.

(c) The filters shall be installed so as to prevent significant leakage of air around their perimeter.

(d) Unless otherwise approved, the faces of filters shall be either vertical or sloped at an angle not greater than 30 degrees from vertical.

(e) The filters shall be fitted at exhaust openings of the hood so that any grease draining from filters is collected and disposed of without spilling or otherwise contaminating the kitchen area (e.g. filter support channel designed to collect and convey grease into hood gutter).

(f) The filters and the filter retaining devices shall not project beyond the surface of the hood exposed to the appliance being ventilated.

(g) The filters shall be removable by hand without the need of tools for the purpose of their cleaning and the cleaning of the supports and the grease-drainage devices, unless an approved *in situ* washing system is provided.

NOTE: Cleaning system should be automatic and at least as effective as the manual cleaning.

E7.3 Hood gutters Hood gutters not less than 50 mm wide and not less than 25 mm deep shall be provided around the lower edges of canopy-type hoods and shall include 25 mm minimum diameter drainage holes fitted with removable caps.

For side-draught hoods, grease may be drained into removable collection containers.

E7.4 INTERNAL SURFACE

E7.4.1 Sloping All surfaces of hoods exposed to the appliance being ventilated shall be sloped at an angle not greater than 40 degrees from the vertical, unless the design and performance of hoods prevent the formation of any condensate on such surfaces.

E7.4.2 Profile The surfaces of the canopy hood exposed to the appliance being ventilated shall be free of stiffeners or any protrusions, other than fire-extinguisher heads, which shall be installed to approval.

E7.5 Distance from grease gutter to perimeter of appliance In a canopy-type kitchen exhaust hood, the inside edge of the grease gutter shall be not less than 150 mm beyond the plan perimeter of the appliance over which the hood is installed, except on sides adjoining a wall.

E8 KITCHEN EXHAUST HOODS INCORPORATING GREASE REMOVAL DEVICES Kitchen exhaust hoods incorporating grease removal devices other than those in Paragraph E7 shall—

(a) remove grease from the cooking vapours;

(b) prevent grease from falling back onto food, the cooking appliance or floor;

(c) provide for manual or automatic cleaning of grease trapping devices, and all internal surfaces of the device housing; and

(d) be demonstrated to capture and remove cooking vapours and grease with efficiency at least equal to that of kitchen exhaust hoods complying with Paragraph E7.

APPENDIX F

CAPTURE OF EMISSIONS BY KITCHEN EXHAUST HOODS

(See also Appendix E)
(Informative)

F1 GENERAL Because vapours mix intimately with air and follow air currents, the release of vapours, from hot processes and operations which release sudden surcharges of hot vapours, is usually controlled by canopy hoods. Most kitchen exhaust hoods are of the canopy type, but lateral or side-draught-type hoods are also sometimes employed. Water and grease vapours, hot air and pollutants such as oxides of nitrogen or carbon monoxide generated by the cooking and heating of food and combustion of fuel and food, can be controlled by properly designed exhaust hoods of adequate dimensions positioned above appliances used for cooking and heating of food. In addition to the size and location of a kitchen exhaust hood, the effectiveness of control is dependent upon the position of hood exhaust openings in relation to the normal line of vapour travel, uniform distribution of exhaust airflow and, most importantly, the creation of an airflow capable of capturing all potentially noxious or hazardous fumes and heat, and ejecting them via the local exhaust system.

The capture velocity of the airflow is the key factor in the design of an effective exhaust device. The quantity of air to be exhausted therefore will depend on the shape of the hood opening, the distance between the hood opening and the source and nature of the fumes. It is therefore difficult to prescribe a general formula for the derivation of the quantity of exhaust air. Data for guidance and choice of adequate design is summarized in this Appendix.

F2 FACTORS INFLUENCING EXHAUST FLOW RATE The exhaust flow rate *(Q)* may reasonably be expected to depend on the following factors:

(a) Dimensions of apparatus to be ventilated (length *(L)*, width*(W)*).

(b) Shape of the apparatus (L/W).

(c) Height of hood above the apparatus.

(d) Process.

(e) Configuration.

(f) Overhang.

NOTE: The absence of any cross-draughts between the hood and appliance being ventilated is necessary for effective performance.

The equation adopted by a regulatory authority rarely incorporates all these factors. Therefore, to ensure effective control and capture of emissions arising from cooking or heating of food, the designer is advised to make due allowance for any factor(s) not included in the formula.

Where an equation does not make allowance for the process or configuration the following multiplying factors are suggested as a guide:

(i) *For processes:*

(A) For conventional frying and similar processes emitting a steady flow of vapours . . . . 1.0.

(B) For barbecuing and similar flame-flare processes and processes emitting sudden surcharges of hot vapours . . . . . 1.5.

(C) For boiling . . . . 0.75.

(ii) *For configuration:*

(A) For a corner-mounted canopy hood (at the intersection of two walls) . . . . 1.0.

(B) For canopy hood against one wall . . . . 1.5.

(C) For an island canopy hood . . . . 2.3.

F3 CALCULATION OF EXHAUST AIRFLOW RATE The exhaust airflow rate *(Q)* for a kitchen exhaust hood may be calculated using one of the equations* outlined below, as appropriate. Attention is drawn to the fact that these are based on 150 mm minimum overhang. Regulatory Authority may approve lower flow rate, depending on size of the overhang and efficiency of the grease extracting device.

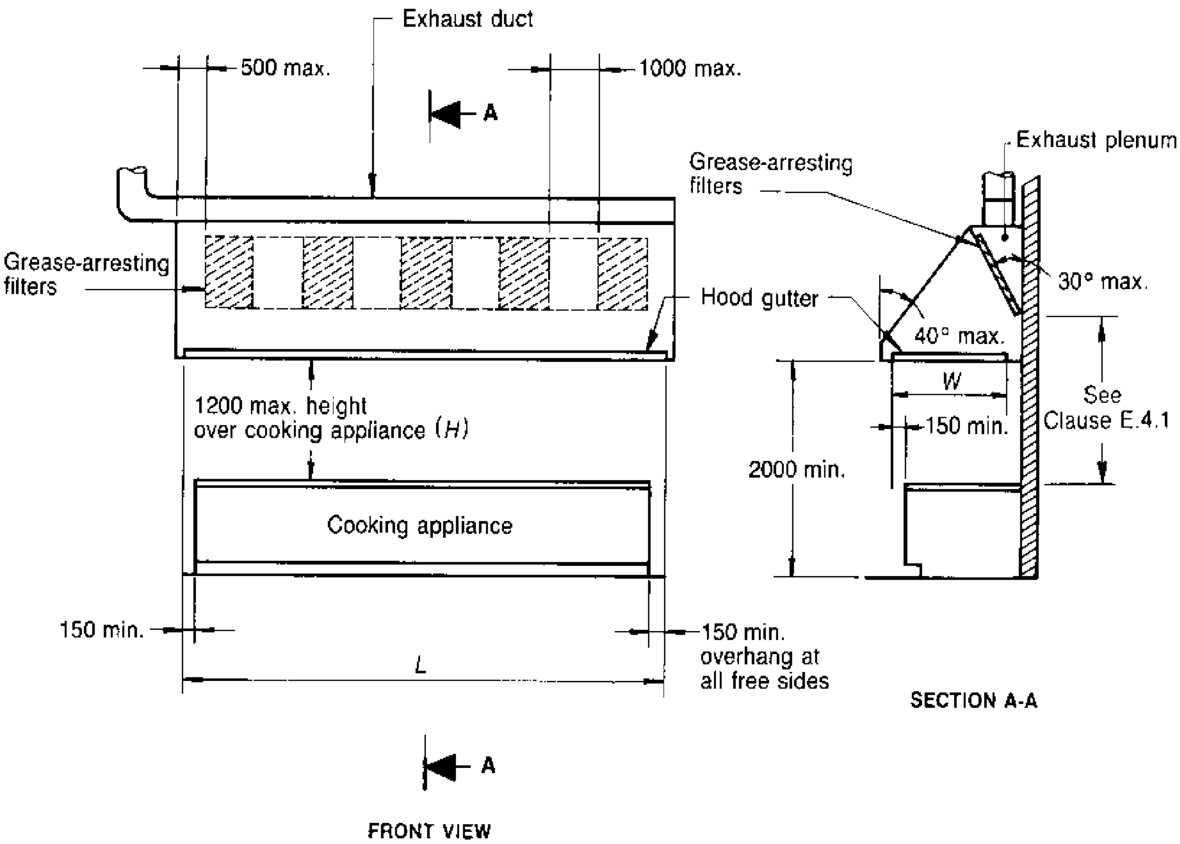
* Based on the Industrial Ventilation Manual, 19th ed, 1986 by the American Conference of Governmental Industrial Hygienists—P.O. Box 16153, Lansing, Mich, 48901, USA.

(a) *Canopy-type hood against a wall* A typical installation is shown in Figure F1. For optimum results Q is recommended to be not less than the greater of those indicated below, as appropriate:

For conventional frying	For barbeques	For boiling
$Q = 400 \times W \times L$ $Q = 250 \times P \times H$	$Q = 600 \times W \times L$ $Q = 375 \times P \times H$	$Q = 300 \times W \times L$ $Q = 190 \times P \times H$

where

Q — exhaust airflow rate, in litres per second
W — width of hood, in metres (see Figure F1)
L — length of hood, in metres (see Figure F1)
P — perimeter of free sides of hood, in metres
—$2W + L$ in this case
H — height of hood above the cooking appliance, in metres (see Figure F1).



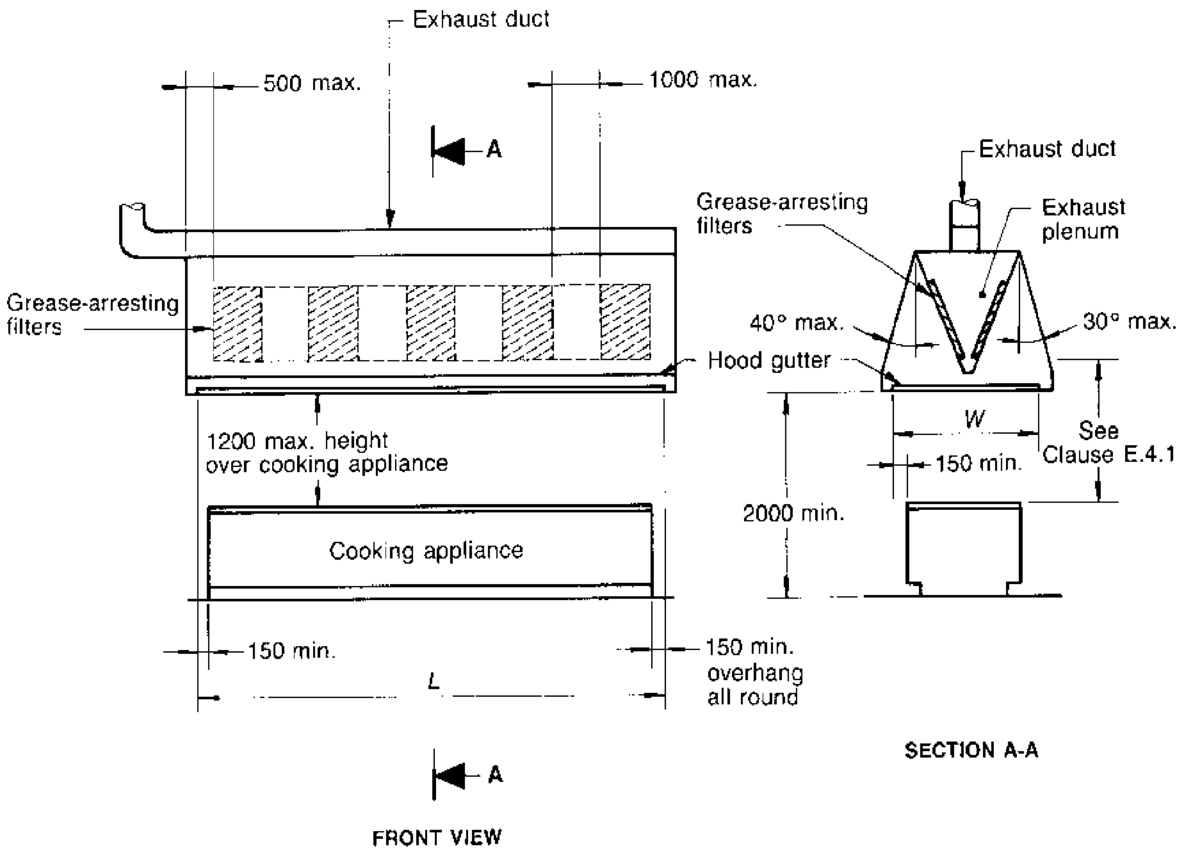
DIMENSIONS IN MILLIMETRES

FIGURE F1 CONVENTIONAL CANOPY-TYPE HOOD AGAINST WALL INCORPORATING GREASE FILTERS

(b) *Island type canopy hood* A typical installation is shown in Figure F2. For optimum results Q is recommended to be not less than the greater of those indicated below, as appropriate:

For conventional frying	**For barbeques**	**For boiling**
$Q = 635 \times W \times L$ $Q = 250 \times P \times H$	$Q = 950 \times W \times L$ $Q = 375 \times P \times H$	$Q = 475 \times W \times L$ $Q = 190 \times P \times H$

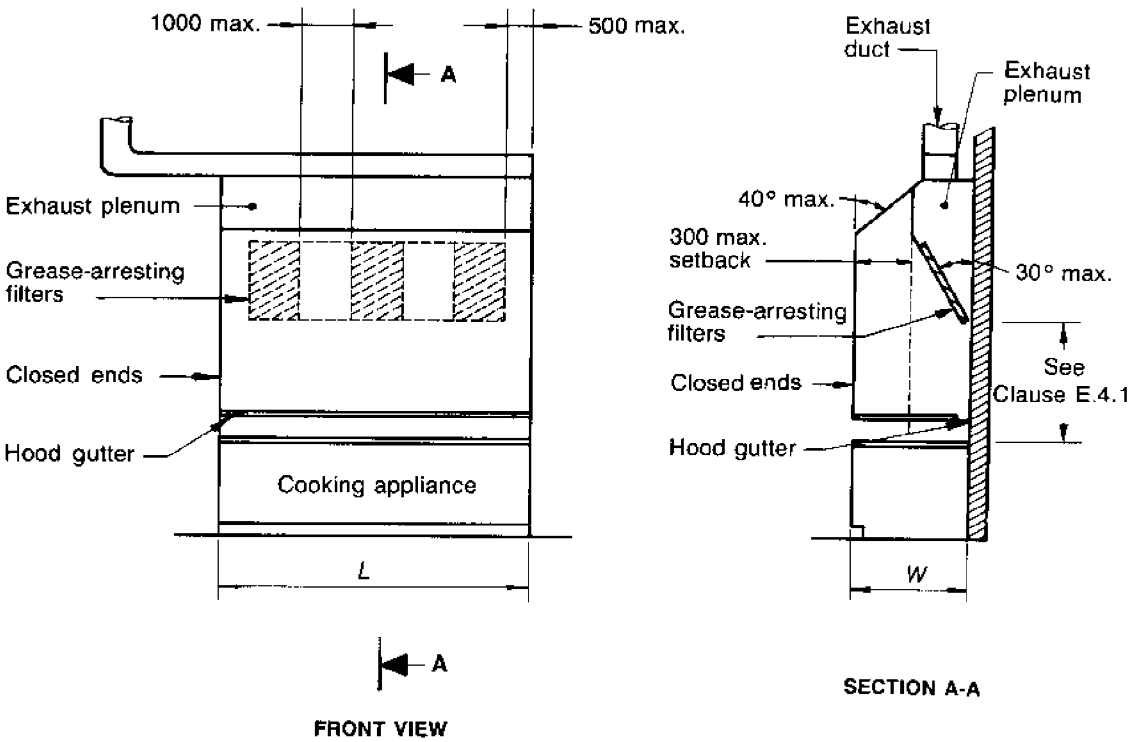
where the parameters are the same as in (a) above, except that in this case $P = 2 \times (W + L)$.



DIMENSIONS IN MILLIMETRES

FIGURE F2 CONVENTIONAL ISLAND-TYPE CANOPY HOOD INCORPORATING GREASE FILTERS

(c) *Lateral or side draught type hood* A typical installation is shown in Figure F3. For optimum results Q is recommended to be not less than 300 L, where L is the length in meters of the cooking appliance as depicted in Figure F3. For fumes arising from barbeques, and similar facilities increase this to 400 L.



DIMENSIONS IN MILLIMETRES

FIGURE F3 CONVENTIONAL LATERAL OR SIDE-DRAUGHT-TYPE HOOD INCORPORATING GREASE FILTERS

F4 CAPTURE VELOCITY It can be seen from the equations in Clause F3, for values of *Q* based on hood entry area, that—

$$V = \frac{Q \times 10^{-3}}{W \times L} \text{ m/s}$$

where

V—capture velocity

Recommendations for conventional canopy-type hoods are as follows:

	AGAINST A WALL	ISLAND—TYPE
(i) For water vapour	0.3 m/s	0.47 m/s
(ii) For general cooking vapours and aerosols	0.4 m/s	0.6 m/s
(iii) For fumes and aerosols arising from barbeques and similar facilities	0.6 m/s	0.95 m/s

APPENDIX G

A PERFORMANCE APPROACH TO ACCEPTABLE INDOOR AIR QUALITY

(Informative)

G1 SCOPE This Appendix sets out guidelines for the adoption of a performance approach to acceptable indoor air quality as an alternative to the dilution procedure set out in Section 2.

Such an approach may be considered appropriate or necessary where —

(a) the level of contaminants in the outdoor air make it more desirable to treat the recycle air and not use outdoor air for maintaining indoor-air quality;

(b) the level of temperature or humidity of the outdoor air make it more economic to treat recycled air than to cool, heat, humidify or dehumidify outdoor air for maintaining indoor-air quality; and

(c) it is established that greater reductions in outdoor air requirements than are prescribed by the use of air cleaning units in Section 2, are possible by means of a performance approach.

G2 PROPOSAL SUBMISSION A proposal based on the performance approach may receive consideration by the Regulatory Authority provided it is prepared by an appropriately qualified person(s).

The Regulatory Authority may require the design to be independently reviewed by another appropriately qualified person(s).

G3 DESIGN OBJECTIVES The draft International Standard ISO/DIS 6242, Part 2 sets down the following objectives to be fulfilled if air quality within a building is to be controlled:

(a) Prevent the accumulation in indoor air of contaminants (e.g. gases, particles, aerosols) injurious to health.

(b) Prevent the accumulation in indoor air of contaminants detrimental to comfort.

(c) Provide an adequate supply of oxygen for combustion appliances.

(d) Control nuisance due to odours.

An additional objective, not stated in the ISO draft Standard would be

(e) The oxygen content in indoor air to be not less than 18% and not more than 21%, at any time.

Criteria to meet these objectives are stated in the draft ISO Standard as needing to reflect —

(i) the activities to be accommodated;

(ii) the age and health of the occupants;

(iii) the proportion of likely occupants it is intended to satisfy;

(iv) the character and location of combustion appliances dependent on indoor air;

(v) the proportion of the time the requirement needs to be satisfied (taking account of climate extremes and intermittency); and

(vi) any facility for local control of air purity by the occupants.

G4 INDOOR AIR QUALITY PROCEDURE

G4.1 General The procedure in Section 2 through prescription of required ventilation rates, provides only an indirect solution to the control of indoor contaminants. A direct solution would bring the concentrations of contaminants to some specified, acceptable levels. The indoor air quality procedure described below is based on ASHRAE Standard 62 — 1989 and provides guidelines for certain notable contaminants. It incorporates both quantitative and subjective evaluation.

G4.2 Quantitative evaluation Appendix C of this Standard and Table 1, National Primary Ambient-Air Quality Standards for Outdoor Air as set by the U.S. Environmental Protection Agency, of ASHRAE 62 furnish information on acceptable contaminant levels in outdoor air. ASHRAE states that this Table also applies indoors for the same exposure times. Section 6.1.1, Acceptable Outdoor Air, of ASHRAE 62 contains additional information on contaminants in the outdoor air.

Table 3, Guidelines for Selected Air Contaminants of Indoor Origin, of ASHRAE 62 contains limits for four other indoor contaminants. Three of these are limits set by other bodies as indicated in the table. Other potential contaminants for which definite limits have not been set are discussed in Appendix C, Guidance for the Establishment of Air Quality Criteria for the Indoor Environment, of ASHRAE 62. Tables C1, Standards Applicable in the United States for Common Indoor Air Pollutants and Table C3, Summary of Canadian Exposure Guidelines for Residential Indoor Air Quality, of ASHRAE 62 do not include all known contaminants that may be of concern, and these concentration limits may not, *ipso facto*, ensure acceptable indoor air quality with respect to other contaminants.

Human occupants produce carbon dioxide, water vapour, particulates, biological aerosols, and other contaminants. Carbon dioxide concentration has been widely used as an indicator of indoor-air quality. In the absence of sources of carbon dioxide other than human respiration a limit of 1000 ppm CO_2 is recommended to satisfy comfort (odour) criteria. In the event CO_2 is controlled by any method other than dilution, the effects of the possible elevations of other contaminants must be considered.

In recent years a number of indoor contaminants have received increased attention and emphasis. Some of these contaminants, such as formaldehyde or other vapour phase organic compounds, are generated by the building, its contents, and its site. Another important group of contaminants is produced by unvented indoor combustion. The presence and use of consumer and hobby products, as well as cleaning and maintenance products, introduce a range of largely episodic releases of contaminants to the indoor environment (see Ref. 30, NAP 1981 Indoor Pollutants. 1981. National Academy Press, Washington DC, ASHRAE 62).

There are also complex mixtures, such as environmental tobacco smoke (see Ref. 31, The Health Consequences of Involuntary Smoking. 1986. U.S. Surgeon General, U.S. Department of Health and Human Service, ASHRAE 62), infectious and allergenic biologic aerosols, emanations from human bodies, and emanations from food preparation. Precise quantitative treatment of these contaminants can be difficult. To some degree, adequacy of control must rest upon subjective evaluation.

In the case of some odourless biological aerosols, subjective evaluation is irrelevant. Application of generally acceptable technology, and vigilance regarding adverse influences of reduced ventilation, must therefore suffice. Appendix C, Guidance for the Establishment of Air Quality Criteria for the Indoor Environment, of ASHRAE 62 contains information on standards and guidelines for selected air contaminants. Uniform governmental policies - regarding limits on exposure to environmental carcinogens-have not yet emerged.

G4.3 Subjective evaluation Various indoor activities may give rise to odour of unacceptable intensity or character, or to airborne materials that irritate the eyes, nose, or throat. In an absence of objective means to assess the acceptability of such contaminants, the judgement of acceptability must necessarily derive from subjective evaluations of impartial observers. One method referred to in Appendix C, Guidance for the Establishment of Air Quality Criteria for the Indoor Environment, of ASHRAE 62 is as follows. The air can be considered acceptably free of annoying contaminants if 80% of a panel of at least 20 untrained observers deems the air to be not objectionable under representative conditions of use and occupancy. An observer should enter the space in the manner of a normal visitor and should render a judgement of acceptability within 15 sec. Each observer should make the evaluation independently of other observers and without influence from a panel leader. Caution should be used in any subjective evaluation procedure to avoid unacceptable concentrations of other contaminants since this is only a test for odours.

G4.4 Monitoring The proposal would need to include a system for monitoring the indoor air quality in terms of its contaminants and basic constituents.

G4.5 Information to be provided A proposal would need to include the following:

(a) Flow rate of recycle air for the enclosures.

(b) Contaminant removal efficiency for each air cleaning unit as applicable to the various types of contaminants to be controlled.

(c) Method or methods of maintaining basic constituents of the indoor air within acceptable ranges.

(d) Method for monitoring indoor air quality.

APPENDIX H
VENTILATION REQUIREMENTS FOR INCINERETTES
(Normative)

Incinerettes installed in buildings shall comply with the following requirements:

(a) The exhaust-airflow rate shall be not less than 20 L/s.

(b) The incinerette's exhaust ventilation system shall be in operation concurrently with operation of an incinerette electrical heating element.

(c) Where incinerettes are located within an enclosure served by a general exhaust ventilation system, the incinerettes' exhaust system shall operate whenever the general exhaust ventilation system is in operation.

(d) A non-return device or other approved means shall be provided to prevent reverse flow of air from the incinerettes exhaust system into the room or compartment in which the incinerette is installed.

(e) An incinerette exhaust system may ventilate more than one incinerette but shall not ventilate any other apparatus or enclosure.

APPENDIX J

RATIONALE FOR LAG OR LEAD TIME FOR TRANSIENT OCCUPANCY

(Informative)

When spaces such as classrooms, auditoriums, or offices are unoccupied for several hours and then occupied, operation of the ventilation system may be delayed to use the capacity of the air in the space to dilute contaminants. This applies to cases where the inside contaminants are associated only with human occupancy and where contaminants are dissipated by natural means during long vacant periods. The operation of the ventilation system can then be delayed until the concentration of contaminants reaches the acceptable limit associated with the minimum ventilation requirements at steady state.

The concentration of any contaminant (C_θ) in the absence of ventilation in a given space of volume ($V1$) is expressed as follows:

$$C_\theta = \frac{N}{V1}\theta \qquad \text{(J.1)}$$

where (N) is the contaminant generation rate, ($V1$) is volume and (θ) is time. The contaminant concentration (C_s) under a steady state condition with ventilation rate (V2) is:

$$C_s = \frac{N}{V2} \qquad \text{(J.2)}$$

The maximum permissible ventilation delay time (θ_d) after the space is occupied is when C_θ equals C_s or:

$$\theta_d = \frac{V1}{V2} \qquad \text{(J.3)}$$

The equation is plotted in Figure 2.3 for various ventilation rates in litres per second per person and space volume in cubic metres per person.

When contaminants are generated independent of people or their activities, and the contaminants do not present a short-term health hazard, ventilation may be shut off during unoccupied periods. In these cases, however, ventilation must be provided in advance of the time of occupancy, so that acceptable conditions will exist for people at the start of occupancy. It is impractical to operate the ventilation at the minimum requirement until steady-state is reached, because this is approached asymptotically with time, and may take several hours to reach practical equilibrium. An engineering estimate of a permissible contaminant level of 1.25 times the steady-state value has therefore been selected as the maximum level at the time of occupancy. The occupants would, for a time, be subjected to somewhat higher values of contaminant than the steady-state value. It is postulated that the factor of safety implicit in the values in Clause 2.3 are adequate so that, for practical purposes, the required air quality is provided over the entire occupancy period.

When an initially contaminated room with a level of concentration (C_i) is diluted by a given rate of ventilation ($V2$), the time required to lower the concentration to a fraction (X) above the final steady-state concentration level can be expressed as follows:

$$\theta_a = \frac{V_1}{V_2} \ln\left[\frac{(C_i V/N) - 1}{X}\right] \qquad \text{(J.4)}$$

where

$V1$ = Room volume

θ_a = Lead time

N = Contaminant concentration generation rate

$V2$ = Ventilation rate

C_i = Initial concentration.

Figure 2.4 is a plot of this relationship where C_i is assumed to be approximately 10 times the steady-state value and X = 0.25 or 25%.

APPENDIX K
BASIS FOR LENGTH OF VEHICLE QUEUE
(Informative)

K1 CARPARKS WITH PAY BOOTHS For carparks, the ventilation equation assumes $n_L P$ cars attempt to exit through each lane in one hour at peak. Consider two criteria:

(a) The build-up for the whole peak hour

$n_L P$—B = number of cars in queue

where B = the number of cars a pay booth can process in 1 h; and

(b) The build-up for a 10 min period with the rate at double the 1 h peak rate
($2n_L P$—B) ÷ 6 = number of cars in queue.

If a pay booth can process 1 car every 20 sec, B = 180, then for a commercial carpark (P = 0.5), we obtain results as follows:

n_L	500	400	300	200	150	
$n_L P$	250	200	150	100	50	
$n_L P$-180	70	20	–	–	–	cars length at the end of 1 h
1/6 ($2n_L P$-B)	53	37	20	3	–	cars length at the end of 10 min
[$2.2n_L P$-200]	350	240	130	20	–	m length

Below n_L = 450, $n_L P$ = 225, the criteria 1/6($2n_L P$-180) is the highest.

Above n_L = 450, the rate given by the ventilation equation is close to the rate required for exit lanes.

∴ use the expression 1/6 ($2n_L P - 180$)

In arriving at the rate for exit lanes, we have assumed 6.5 m length per car.

∴ the length of queue = $6.5 \times 1/6(2n_L P - 180)$
= ($2.17\ n_{LP}$ - 195) m
round to ($2.2\ n_L P$ - 200)m.

K2 CARPARKS WITHOUT PAY BOOTHS

Using same approach, but assume rate of exit to street is the criterion.

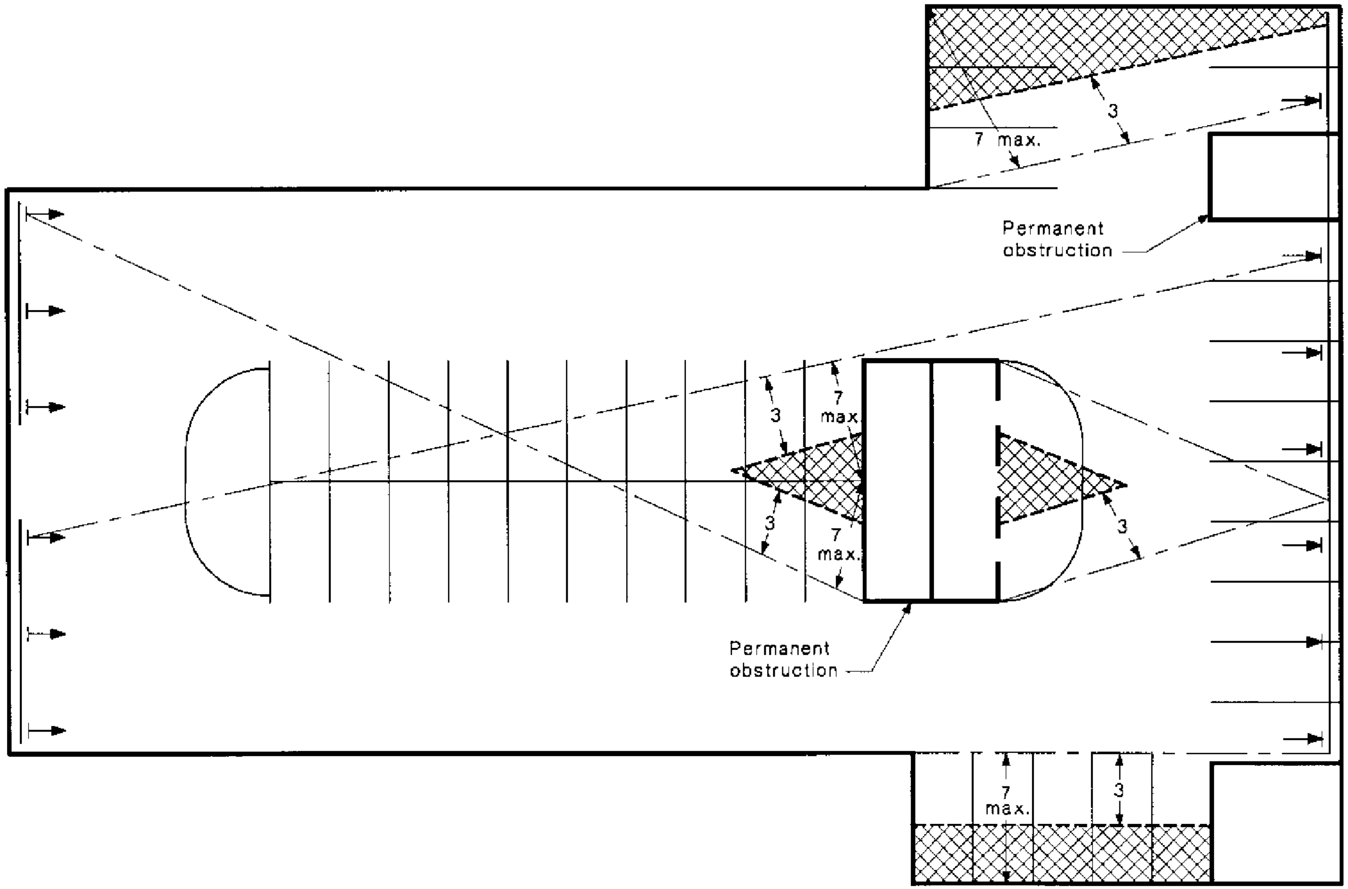
For light traffic, 1 exit per 10 sec → B = 360 → $2.2\ n_L P - 400$

For heavy traffic, 1 exit per 20 sec → B = 180 → $2.2\ n_L P - 200$

APPENDIX L

EXAMPLES OF LAYOUTS OF CARPARK VENTILATION

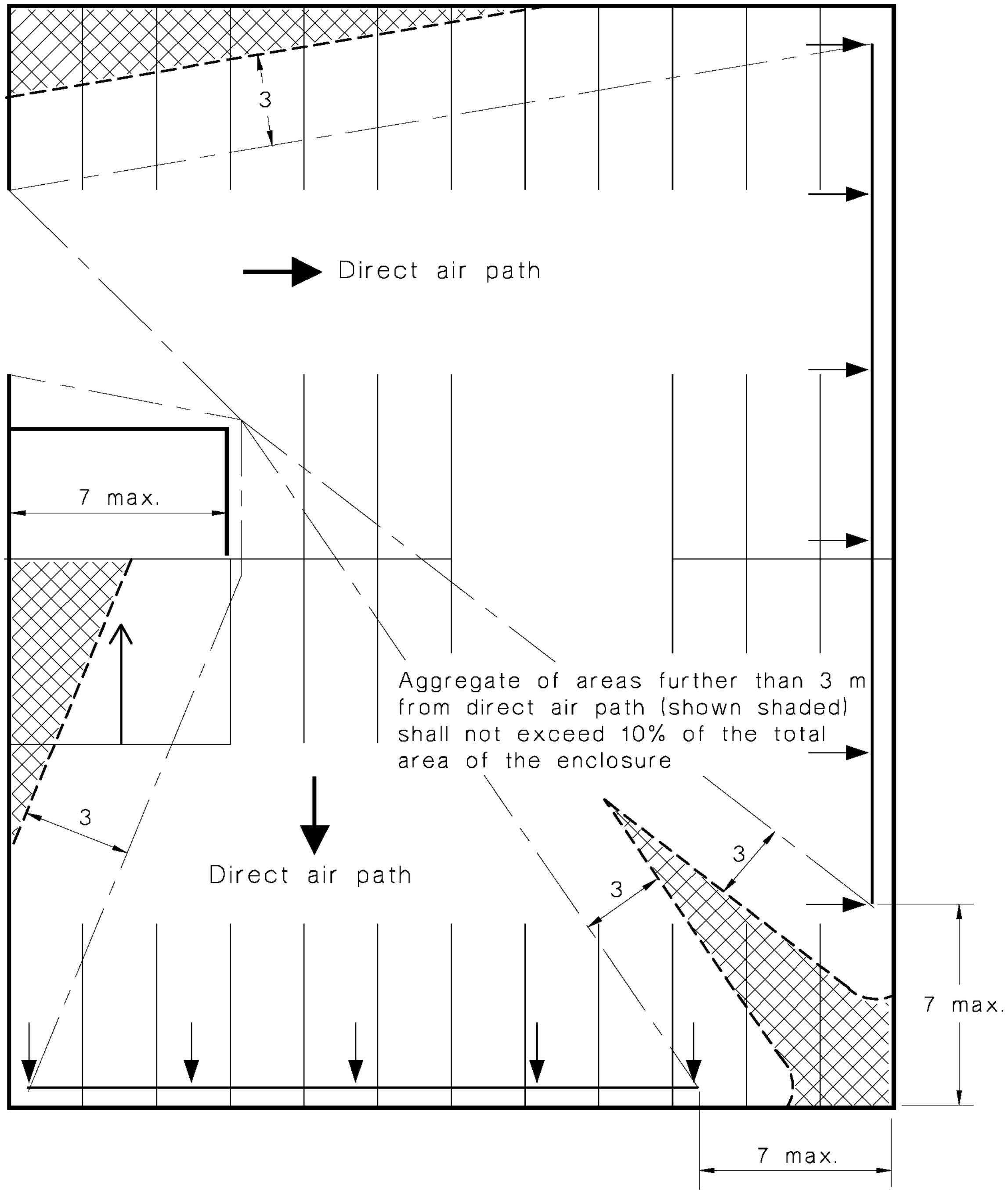
(Informative)



NOTE: If register spacing exceeds 6m, part of the carpark between registers will be farther than 3m from direct air path.

DIMENSIONS IN METRES

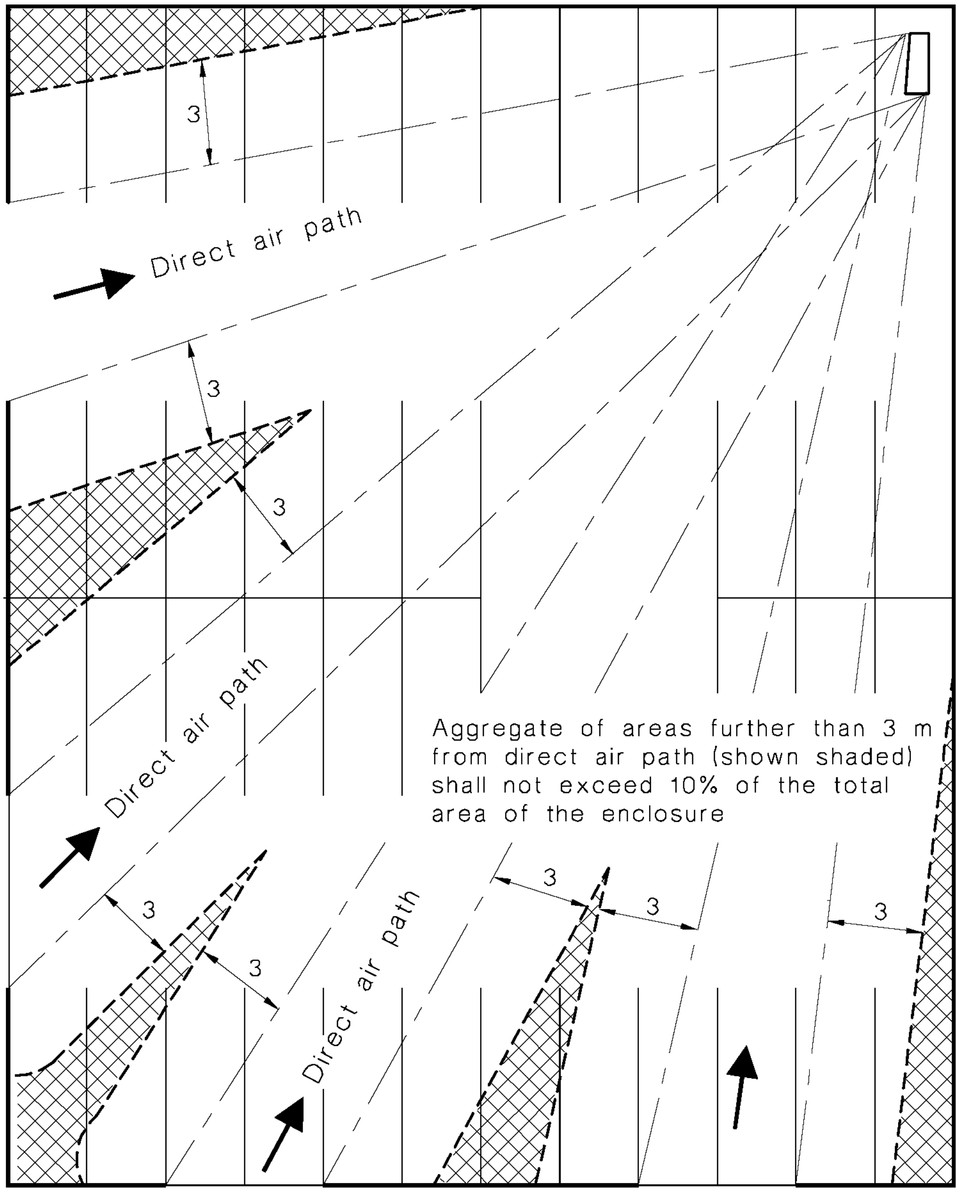
FIGURE L1 EXHAUST VENTILATION OF AN ‘L-SHAPE’ CAR PARK



NOTE: If register spacing exceeds 6 m, part of the carpark between registers will be further than 3 m from direct air path.

DIMENSIONS IN METRES

FIGURE L2 EXHAUST VENTILATION OF A "SQUARE" CARPARK



DIMENSIONS IN METRES

FIGURE L3 EXHAUST VENTILATION VIA A SINGLE INTAKE

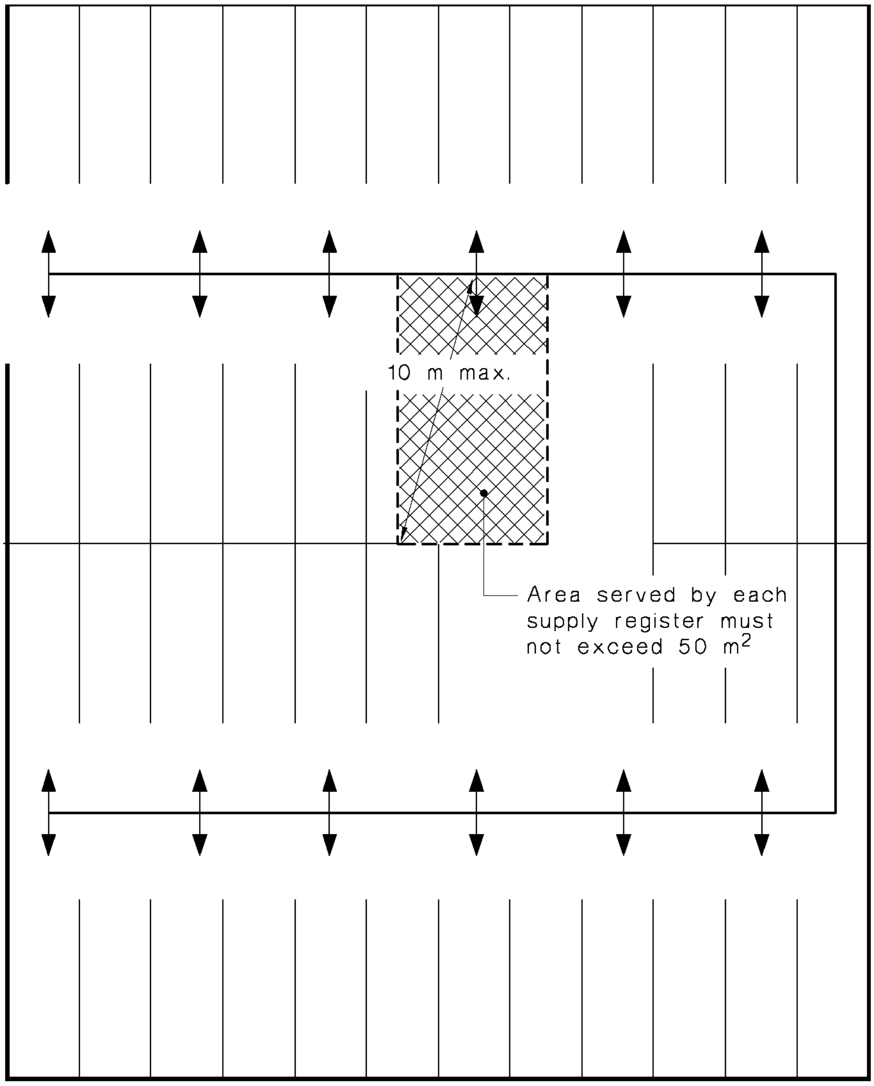


FIGURE L4 SUPPLY VENTILATION OF A "SQUARE" CARPARK

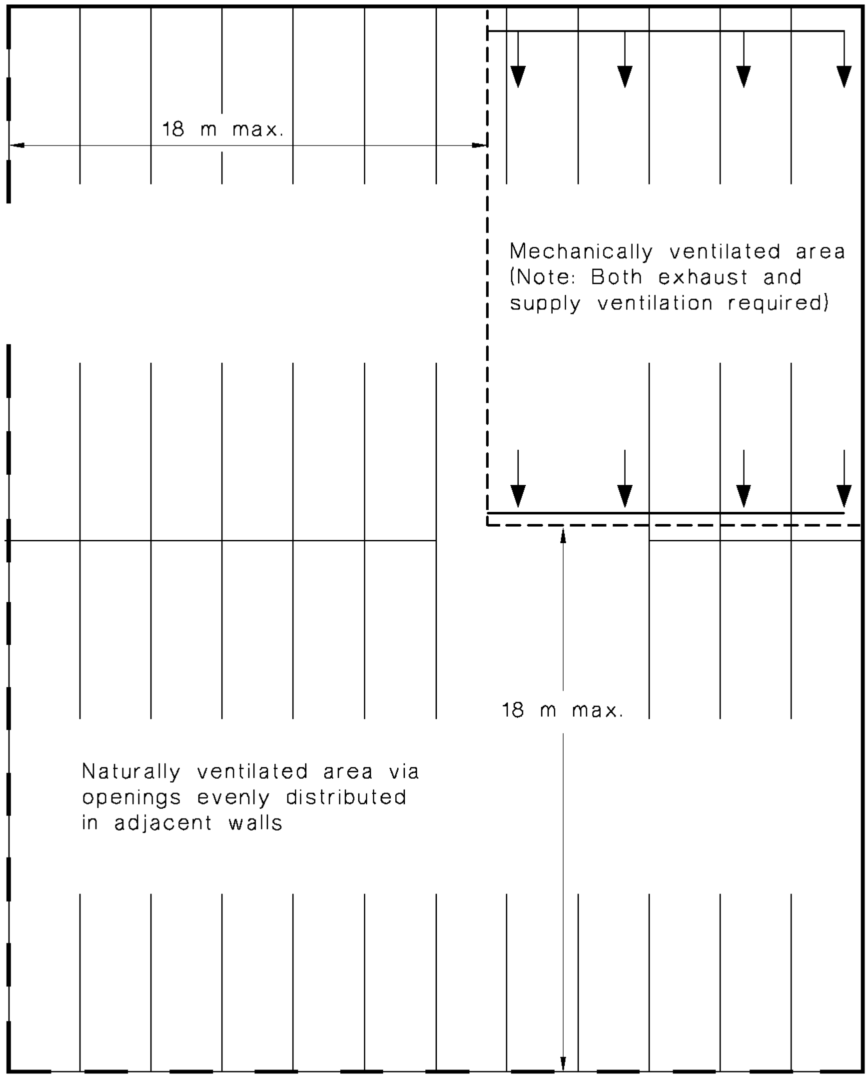


FIGURE L5 COMBINATION OF NATURAL AND EXHAUST/SUPPLY VENTILATION

APPENDIX M

AUTOMATIC MONITORING SYSTEMS FOR CARPARKS MARKING, COMMISSIONING, RELIABILITY AND RECORDS

(Informative)

M1 MARKING The supplier of the monitoring system should provide a durable label on the external surface of each cabinet containing an analyser to be fixed in a conspicuous position with—

(a) the words ‘service frequency’ in legible style upper case letters with a letter height of not less than 8 mm in a colour contrasting to the background; and

(b) a number indicating the service frequency in months. The number shall be legible, 20 mm high and clearly visible. The service frequency shall be that period which the supplier guarantees the system will, without maintenance, report analytical results in accordance with Clause 4.13.3(b).

M2 COMMISSIONING Every monitoring system should be commissioned in accordance with the manufacturer’s recommendations by a qualified person(s), and calibrated with calibration gas whose composition is certified by a NATA qualified laboratory.

M3 RELIABILITY Every monitoring system installed in enclosures should be operated and maintained so as to maintain its reliability.

Re-calibration should be effected by a qualified person(s) at frequencies not greater than the service frequency period (see Clause 4.13.7) using calibration gas certified by a NATA qualified laboratory.

M4 RECORDS All calibration, re-calibration and related test work should be recorded, with the dates and names of persons conducting the work and kept available at the operating site for inspection by approved persons.