Figure 1.1

Figure 4.1

Prescriptive Method

Engineered Method

S 1668.2

AS 1668.2—2002
(Incorporating Amendment Nos 1 and 2)

Australian Standard™

A2

The use of ventilation and airconditioning in buildings

Part 2: Ventilation design for indoor air contaminant control (excluding requirements for the health aspects of tobacco smoke exposure)

Standards Australia

This Australian Standard was prepared by Committee ME-062, Ventilation and Airconditioning. It was approved on behalf of the Council of Standards Australia on 29 April 2002 and published on 10 June 2002.

The following are represented on Committee ME-062:

Air Conditioning and Mechanical Contractors Association of Australia

Air Conditioning and Refrigeration Equipment Manufacturers Association of Australia

Australasian Fire Authorities Council

Australian Building Codes Board

Australian Institute of Building Surveyors

Australian Institute of Environmental Health

Australian Institute of Refrigeration, Air Conditioning and Heating

Chartered Institution of Building Services Engineers

Department of Contract and Management Services W.A.

FPA Australia

Institution of Refrigeration, Heating and Airconditioning Engineers New Zealand

Insurance Council of Australia

Metal Trades Industry Association of Australia

Plastics and Chemical Industries Association

Property Council of Australia

Thermal Insulation Contractors Association of Australia

National Environmental Health Forum

A1

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AS 1668.2—2002
(Incorporating Amendment Nos 1 and 2)

Australian Standard™

A2

The use of ventilation and airconditioning in buildings

Part 2: Ventilation design for indoor air contaminant control (excluding requirements for the health aspects of tobacco smoke exposure)

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PREFACE

This Standard was prepared by Standards Australia Committee ME-062, Ventilation and Airconditioning, to supersede AS 1668.2—1991, *The use of mechanical ventilation and air-conditioning in buildings*, Part 2: *Mechanical ventilation for acceptable indoor-air quality*.

*This Standard incorporates Amendment No. 1 (*November 2002*) and Amendment No. 2 (June 2003). The changes required by the Amendments are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.*

In accordance with the philosophy of adopting a performance approach to building regulations, the main technical change to the Standard is the introduction of Dilution Indices (DI). Within that approach the structure of the Standard has been revised to include mandatory simple but conservative requirements complemented by optional and more complex analytical and performance approaches. The main technical changes are summarized as follows:

(a) A methodology for the classification of systems by Dilution Indices has been included.

(b) Minimum outdoor airflow rates have changed.

(c) Requirements for natural ventilation systems have been included.

(d) Outdoor airflow rate calculations have been presented as prescriptive and engineered procedures.

(e) Minimum requirements for air filtration have been included.

(f) Requirements for kitchen exhaust hood design have been rationalized.

(g) Equations used for calculation of total airflow rates in car parks have been presented as prescriptive and engineered procedures.

(h) Requirements for staffed car parks have been included.

Consideration has been given to the incorporation of the Standard in building regulations. In its preparation consideration was given to many international and national Standards, design guides, technical papers, manuals and other publications.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

Statements expressed in mandatory terms in notes to Tables are deemed to be requirements of this Standard.

This Standard incorporates a Commentary on some clauses. The Commentary is set directly following the relevant clause and is designated by 'C' preceding the clause number and printed in italics in a panel. The Commentary is for information only and does not need to be followed for compliance with the Standard.

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FOREWORD

Requirements for the design of natural ventilation systems have been included in this document. This will allow building regulations to reference a single Standard for virtually all aspects of the ventilation of buildings. Where possible, this Standard is performance based and calculations are presented as prescriptive and performance procedures.

This Standard sets minimum permissible ventilation rates having consideration to health and ventilation amenity. Minimum ventilation rates specified are intended to maintain general contaminants (e.g., body odours, volatile organic compounds and the like) at concentrations below exposures that have the potential to cause adverse health effects to a substantial majority of occupants. Minimum ventilation rates specified may not ensure that specific contaminants (e.g., environmental tobacco smoke, fumes from unflued gas-fired devices and other fumes) are maintained at concentrations below exposures that have the potential to cause adverse health effects. When specific contaminants are present, alternative or additional control measures, other than dilution, may need to be implemented to achieve an equivalent level of health and amenity (see Clause 1.3).

A simple method of calculating ventilation rates to meet the minimum requirements is included. The method is based on a default multiple enclosure factor, with a design check step to verify that the underlying assumptions are incorporated. The Standard also includes a mechanism for designing ventilation systems that provide different levels of ventilation amenity above the minimum requirements. Its use will allow the rating of buildings, both new and existing, in terms of the amenity provided by the ventilation system. This rating system allows a Dilution Index (DI) to be calculated for any mechanical or natural ventilation system. Appropriate DI ratings for specific occupancies are suggested.

The sections on kitchen exhaust and car park ventilation have been revised in line with the general performance philosophy. A new section on health care enclosures has been developed. Air filters are now a mandatory requirement for most air-handling systems.

It is recognized that this Standard is likely to be used for occupational health and community health purposes thus its provision have been designed, to the extent possible, to community health criteria promulgated by peak health bodies. Implicit in this recognition is the possibility that the provisions of the Standard may, at least in part, be excessively conservative when applied in an occupational health context. The Standard has used a three-part approach to the setting of ventilation rates for health purposes, which comprises a general approach, a more specific approach where particular information is available and a particular approach to ventilation of enclosures in which smoking is not prohibited.

The principal health basis of the ventilation requirements for enclosures in which smoking is prohibited is in essence taken from previous editions of the Standard—editions prior to 1991. In smoking prohibited occupancies, minimum ventilation rates are generally lower than those given in the 1991 edition of the Standard. The 1991 edition did not discriminate between the requirements of smoking and non-smoking occupancies This represents acceptance with ventilation rates long in use in Australia for health purposes remain valid in circumstances where available information does not allow a more specific or scientific approach. Where there is reasonably predictable pollutant generation information and an authoritative community health exposure limit, then that information is used to set ventilation rates.

The Standard sets ventilation rates for enclosures in which smoking is not prohibited based on the amenity effects of environmental tobacco smoke (ETS). The Standard does not address the health aspects of ETS exposure.

Health authorities advise that ETS is associated with serious adverse health effects including ischaemic heart disease and lung cancer.

Users of the Standard are advised to consult relevant Government authorities for details of legislation that deals with public health and occupational health aspects of ETS exposure.

Users wanting to calculate an estimate of some of the health risks to occupants of an enclosure where smoking is not prohibited may also consult Appendix A of the Supplement to this Standard, AS 1668.2 Supp 1.

STANDARDS AUSTRALIA

Australian Standard

A2

The use of ventilation and airconditioning in buildings

Part 2: Ventilation design for indoor air contaminant control (excluding requirements for the health aspects of tobacco smoke exposure)

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out design requirements for natural ventilation systems and mechanical air-handling systems that ventilate enclosures. It sets minimum requirements for ventilation and specifies a methodology whereby enclosures served by air-handling systems may be assigned a Dilution Index (DI). Dilution Indices are based on needs for the control of odours and particulates. This Standard does not prescribe other requirements associated with comfort, such as temperature, humidity, air movement or noise. This Standard does not include requirements for the maintenance of ventilation and air-handling systems.

NOTE: A grading system for Dilution Indices is suggested in Appendix A.

This Standard includes requirements for the ventilation of car parks. Road tunnels are outside the scope of this Standard. This Standard does not address the health aspects of exposure to environmental tobacco smoke.

> ***C1.1*** *This Standard addresses the ventilation of buildings. Fire and smoke control aspects of air-handling systems are covered in* AS/NZS 1668.1. *Requirements for system design in respect of microbial control are given in* AS/NZS 3666.1
>
> *It is recommended that air-handling systems be designed, constructed and installed so that their use does not give rise to a noise or vibration nuisance. For guidance on noise and vibration control see* AS 1055.1 *and* AS 2107. *Information on thermal comfort conditions is given in* ISO 7730.

1.2 APPLICATION

1.2.1 General

This Standard is intended for use by regulatory authorities, building services designers, architects, equipment manufacturers and suppliers, installers, managers, owners and operating staff responsible for designing, air-handling systems. System selection (mechanical or natural) shall be in accordance with Section 2. Figure 1.1 provides a flow chart on the application of this Standard.

> ***C1.2.1*** *It is intended that this Standard be applied to new buildings at the design stage. Its application to some existing buildings may be inappropriate and in such instances alternative designs and solutions may be necessary.*

1.2.2 Ventilation system application

This Standard sets out design requirements for ventilation systems as follows:

(a) *Natural ventilation* Natural ventilation provisions shall comply with Section 3 for general enclosures and Section 7 for enclosures accommodating automotive vehicles with internal combustion engines.

(b) *Mechanical ventilation* For mechanical ventilation, system selection (supply or exhaust) shall be in accordance with Clause 2.3. The Standard sets out requirements for mechanical ventilation systems as follows:

 (i) Mechanical ventilation provisions for supply ventilation systems shall comply with Section 4.

 (ii) Mechanical ventilation provisions for exhaust ventilation systems for general enclosures shall comply with Section 5. Minimum exhaust air requirements shall be in accordance with Appendix B.

 (iii) Mechanical ventilation provisions for kitchens and other processes or enclosures requiring local exhaust ventilation shall comply with Section 5.

 (iv) Mechanical ventilation provisions for particular health care enclosures shall comply with Section 6.

 (v) Mechanical ventilation provisions for enclosures accommodating automotive vehicles with combustion engines shall comply with Section 7.

(c) *Combination ventilation systems* For combinations of natural and mechanical ventilation provisions, the provisions shall comply with the appropriate sections required by Clauses 1.2.2(a) and 1.2.2(b), and with the requirements of Clause 2.4.

(d) *Residual ventilation* Residual ventilation shall comply with Clause 2.5, and either with Clause 3.3.3 for residual ventilation by means of borrowed air, or with Section 4 (engineered procedure) for residual ventilation by means of transfer air.

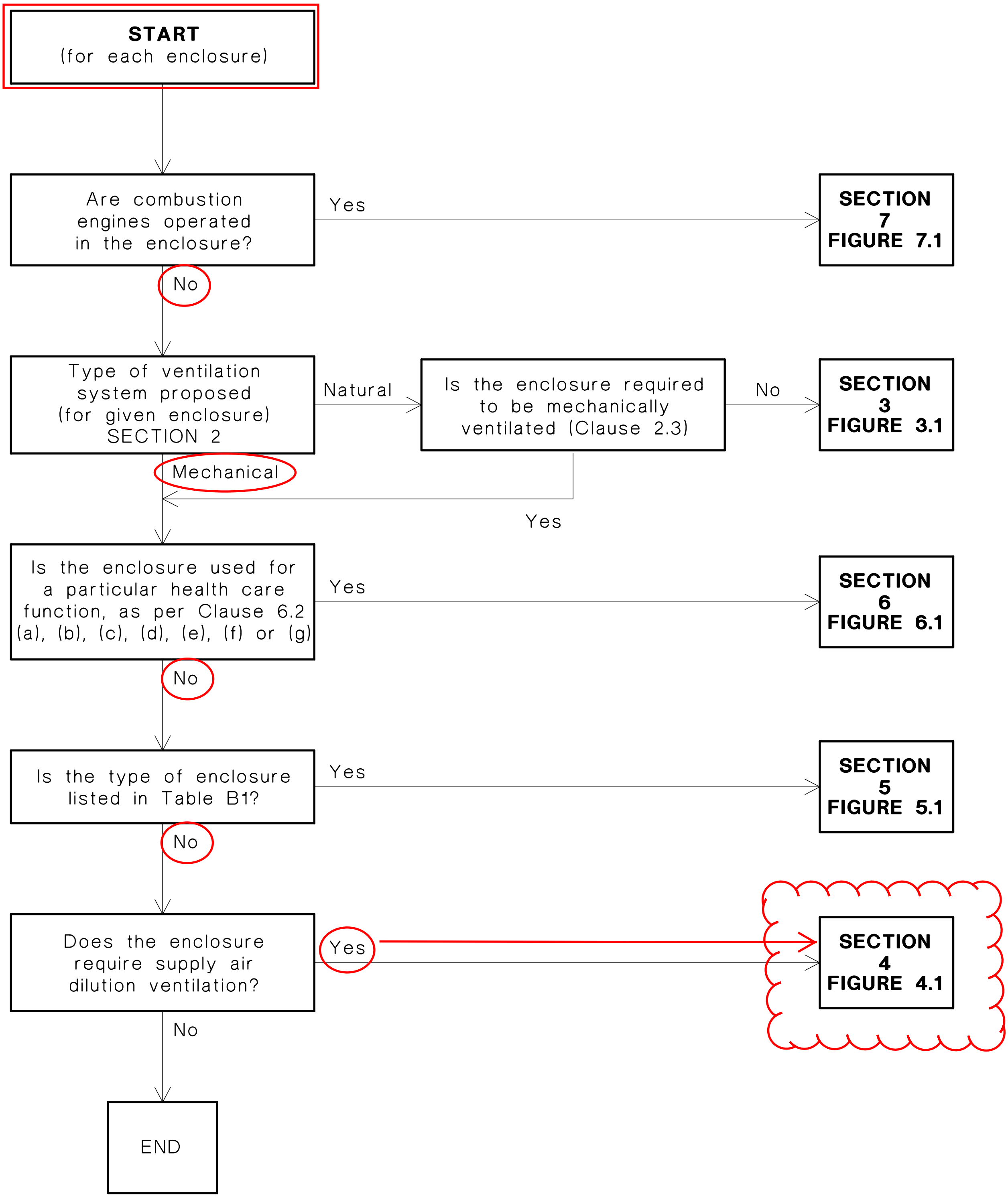


FIGURE 1.1 GENERAL GUIDE FOR APPLICATION OF THIS STANDARD

1.3 OBJECTIVE

The objectives of this Standard are to—

(a) specify minimum ventilation rates;

(b) provide a method for the calculation of the level of dilution provided by ventilation; and

(c) provide minimum requirements for the design of ventilation systems.

> ***C1.3*** *A comprehensive strategy for the control of contaminants in the indoor environment is ideally approached through a well accepted hierarchy of control measures as follows:*
>
> *(a) Elimination of the contaminant.*
>
> *(b) Substitution for the contaminant.*
>
> © *Enclosure of the contaminant.*
>
> *(d) Treatment of transmission path between the contaminant and the receptor.*
>
> *(e) Dilution ventilation.*
>
> *(f) Administrative measures.*
>
> *(g) Personal protective equipment.*
>
> *This Standard sets ventilation rates for enclosures in which smoking is not prohibited based only on the amenity effect of environmental tobacco smoke, and not health.*

1.4 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS	
1055	Acoustics—Description and measurement of environment noise
1055.1	Part 1: General procedures
1324	Air filters for use in general ventilation and airconditioning
1324.1	Part 1: Application, performance and construction
1324.2	Part 2: Methods of test
1482	Electrical equipment for explosive atmospheres—Protection by ventilation—Type of protection
1530	Methods for fire tests on building materials, components and structures
1530.1	Part 1: Combustibility test for materials
1668.2 Supp 1	The use of mechanical ventilation and air-conditioning in buildings—Ventilation design for indoor air contaminant control—Commentary (Supplement to AS 1668.2—2002)
1735	Lifts, escalators, and moving walks (all parts)
1940	The storage and handling of flammable and combustible liquids
2107	Acoustics—Recommended design sound levels and reverberation times for building interiors
2676	Guide to the installation and maintenance, testing and replacement of secondary batteries in buildings
2714	The storage and handling of hazardous chemical materials—Class 5.2 substances (organic peroxides)
3772	Fire protection of cooking areas

AS	
3780	The storage and handling of corrosive substances
4006	Software test documentation
4008	Software design description
4260	High efficiency particulate air (HEPA) filters—Classification, construction and performance
4332	The storage and handling of gases in cylinders
AS/NZS	
1668	The use of mechanical ventilation and airconditioning in buildings
1668.1	Part 1: Fire and smoke control in multi-compartment buildings
1677	Refrigerating systems
1677.2	Part 2: Safety requirements for fixed applications
2243	Safety in laboratories
2243.8	Part 8: Fume cupboards
3000	Electrical installations —(known as the Australian/New Zealand Wiring Rules)
3666	Air-handling and water systems of buildings—Microbial control
3666.1	Part 1: Design, installation and commissioning
ISO	
7730	Moderate thermal environments—Determination of the PMV and PPD indices and specification of the conditions for thermal comfort
BS	
5925	Code of practice for ventilation principles and designing for natural ventilation.
ABCB	
BCA	Building Code of Australia
NOHSC	Exposure Standards for Atmospheric Contaminants in the Workplace
ASHRAE	
Handbook	Fundamentals 1997

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

1.5 DEFINITIONS

For the purpose of this Standard, the definitions given in Figure 1.2, the Building Code of Australia and those below apply.

1.5.1 Airflow rate (herein referred to as 'flow rate')

The volumetric flow rate of air derived from the mass flow rate by dividing it by the density, normalized to 1.2 kg/m^3 (1.2 g/L).

NOTE: For buildings located at an altitude substantially differing from sea level, specified airflow rates should be adjusted.

1.5.2 Air-handling plant

A component part of an air-handling system that includes equipment that provides air movement, as well as equipment for the purpose of controlling the direction, rate of airflow, division of airflow and condition of air.

1.5.3 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.

1.5.4 Airlock

A room or compartment provided to disconnect a sanitary compartment or other enclosure from another room or space in the building.

1.5.5 Air outlet

Any opening through which air is delivered to an enclosure by an air-handling system of a building.

1.5.6 Borrowed air

Air that is borrowed from a naturally ventilated enclosure and used to ventilate an adjoining enclosure. It can be included in Dilution Index calculations for natural ventilation systems.

1.5.7 Competent person

A person who has had appropriate training or practical experience (or both) in the subject, sufficient to provide safe and satisfactory performance.

1.5.8 Dilution Index (DI)

The ratio of the rate of removal of a contaminant from an enclosure to the rate of generation of this contaminant within the enclosure.

NOTE: An enclosure with a higher Dilution Index represents a less contaminated enclosure. Dilution Indices are calculated for each contaminant generated within the enclosure and the lowest DI value applied.

1.5.9 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').

1.5.10 Effective aerodynamic area

The area of an equivalent aerodynamically perfect orifice, and equals the penetration area required by the natural ventilation device multiplied by the discharge coefficient determined under test.

1.5.11 Enclosure

An individual room, space or part thereof.

1.5.12 Exhaust air

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

1.5.13 Exhaust air intake

Any opening through which air is extracted from an enclosure by an air-handling system.

1.5.14 Exhaust outlet

An outlet from an air-handling system, discharging to atmosphere.

1.5.15 Exposure limit (EL)

For occupational exposure, values designated by NOHSC. For community exposure, values based on standards and goals set by NHMRC and NEPC.

1.5.16 General exhaust ventilation

Ventilation of an enclosure by the extraction of air from that enclosure, thereby allowing contaminants to be diluted by supply air or make-up air, the mixture being collected at exhaust-air intakes and discharged outside the building (see Figure 1.2).

1.5.17 General contaminants

Contaminants that are generated by occupants, the building or devices (e.g., body odours, volatile organic compounds, and the like) and found within most buildings.

1.5.18 Grease filter

A device that removes grease and lint from the airstream.

1.5.19 Hood

A component part of a local exhaust system intended for collecting effluent.

1.5.20 Indoor air

Air inside the enclosure under consideration (see Figure 1.2).

1.5.21 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).

1.5.22 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).

1.5.23 Local exhaust

Extraction of objectionable or hazardous effluent close to the source and discharging to atmosphere (see Figure 1.2).

1.5.24 Make-up air

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

1.5.25 May

Indicates the existence of an option.

1.5.26 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.

1.5.27 Outdoor air

Air outside the building (see Figure 1.2).

1.5.28 Outdoor air intake

Any opening through which outdoor air is admitted to an air-handling system of a building.

1.5.29 Plant room

A room that contains any items of plant or machinery (see Clause 4.3.2).

1.5.30 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.

1.5.31 Privacy lock

A room or compartment whose function is to provide a visual or acoustic barrier, and not provided to disconnect a sanitary compartment from another room or space through which persons pass to enter the sanitary compartment.

1.5.32 Recirculating air

Enclosure air that passes through a local air-cleaning unit and returns to the same enclosure.

1.5.33 Recycle air

That portion of indoor air removed by mechanical means from enclosures as return air and returned as part of the supply air (see Figure 1.2).

1.5.34 Relief air

Air that flows from an enclosure in a controlled manner by other than direct mechanical means (see Figure 1.2).

1.5.35 Required

A requirement of this Standard or building regulation.

NOTE: Building owners and managers, fire insurance underwriters and other bodies may have requirements in excess of those required by this Standard.

1.5.36 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).

1.5.37 Smoking prohibited enclosure

An enclosure that has been nominated not to provide for the occupants' smoking.

1.5.38 Smoking not prohibited enclosure

Not a smoking prohibited enclosure.

1.5.39 Shall

Indicates that a statement is mandatory.

1.5.40 Should

Indicates a recommendation.

1.5.41 Specific contaminants

Contaminants that are generated by occupants, the building or devices other than those generally found within most buildings (e.g., fumes from unflued gas devices and other fumes).

1.5.42 Spill air

That portion of return air that is not recycled (see Figure 1.2).

1.5.43 Supply air

Air introduced into an enclosure by mechanical means (see Figure 1.2).

1.5.44 Transfer air

Air that transfers between enclosures in an uncontrolled but predictable manner. It can be included in Dilution Index calculations for mechanical ventilation systems.

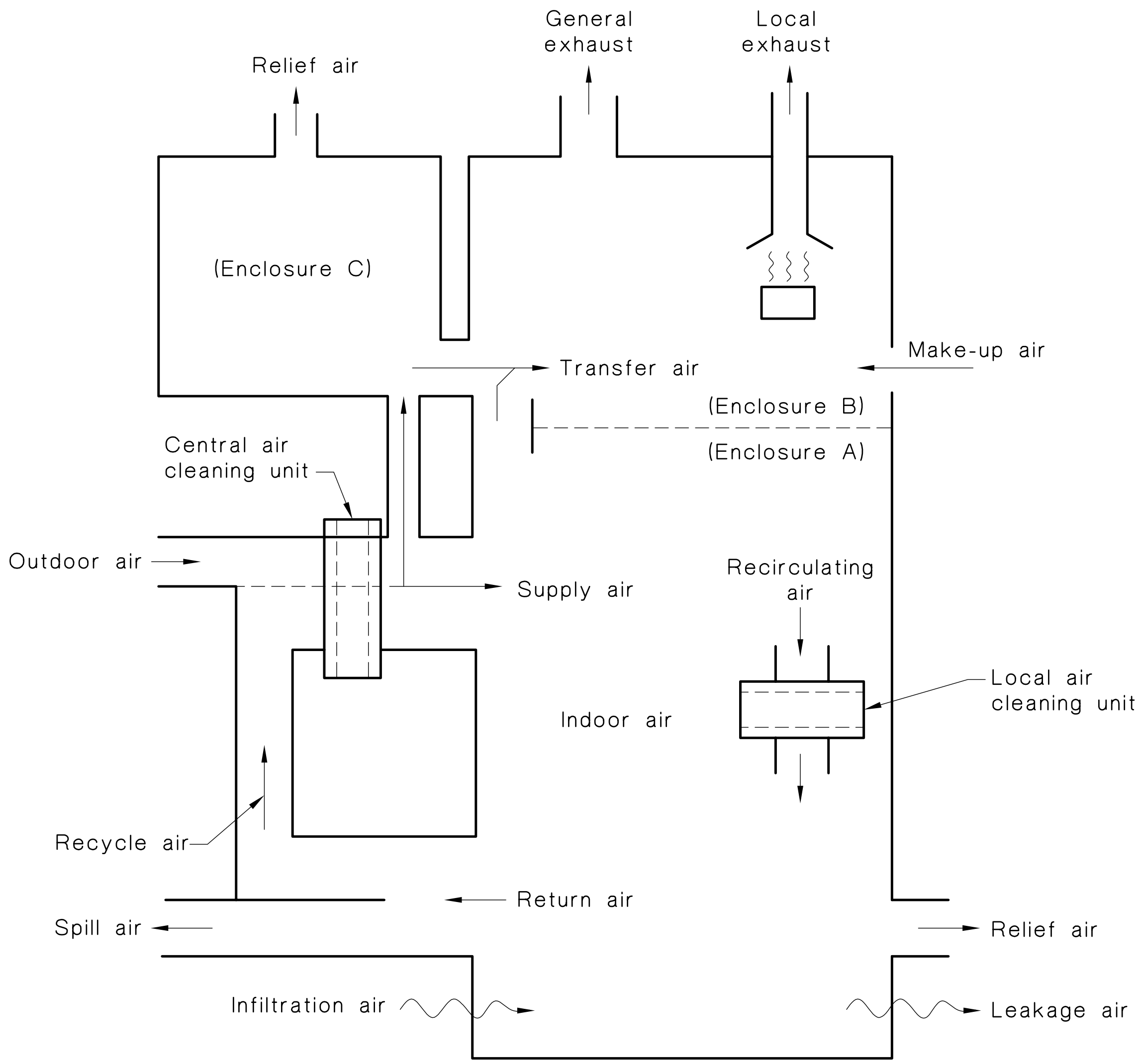


FIGURE 1.2 REPRESENTATION OF AIR-HANDLING TERMS

1.6 NEW DESIGNS AND INNOVATIONS

Any alternative materials, design, methods of assembly and procedures that do not comply with specific requirements of this Standard, or are not mentioned in it, but give equivalent results to those specified, are not necessarily prohibited.

SECTION 2 PRINCIPLES OF VENTILATION

2.1 SCOPE OF SECTION

This Section prescribes a means of determining whether an enclosure may be naturally ventilated or whether mechanical ventilation is necessary.

2.2 NATURAL VENTILATION

Natural ventilation is an appropriate means of providing ventilation to enclosures where the outdoor air needs no treatment such as particulate filtration, where air movement within the enclosures is unimpeded, where there is provision for wind and thermal effects to allow for varying atmospheric conditions and where there is some tolerance to transient lower airflow rates caused by adverse atmospheric conditions. It is mainly suitable for applications where there is low occupancy density but may also be suitable for applications of moderate occupancy density provided due allowance is made in the design. Where there is potential for a hazardous condition to arise within the enclosure through the release of contaminants, then adequate fixed external openings or mechanical ventilation shall be installed.

> ***C2.2*** *There is increased community interest in natural ventilation because of its lower energy consumption. However, the dynamics of these systems rely on very small pressure differentials caused by wind and air density, which makes the effect difficult and complex to predict. This Standard provides simplified solutions that are considered to satisfy the ventilation requirements for most applications but more complex empirical and modelling methods may be appropriate for special institutional, factory or office buildings where a full analysis is worthwhile. Also, as a result of energy conservation efforts, some buildings are now being sealed to a much greater degree than was the case in the past. This has reduced the ventilation benefit that infiltration of outdoor air has provided.*
>
> *Ventilation rates will vary significantly with atmospheric conditions, including wind speed, wind direction, thermal effects and outdoor air temperatures. Failure to ensure adequate outdoor air ventilation through the minimum permissible openable openings, at all times, and adequate air movement through the enclosure may result in contaminant levels reaching concentrations that may cause adverse health effects. This is particularly true for specific contaminants.*
>
> *High occupancy density, the need for filtration, the uncertainty of atmospheric conditions, and a high internal resistance to air movement such as internal partitions or deep floor plans, are all factors that may preclude the use of natural ventilation. Examples where natural ventilation should not be used for specific applications are given in Commentary C2.3.*

2.3 MECHANICAL VENTILATION

2.3.1 General

Mechanical ventilation shall be provided where it is required for a specific process, where the rate of air provided by natural ventilation cannot achieve the required ventilation rate or where needed for fire and smoke control.

Mechanical ventilation shall be provided in enclosures where specific health and ventilation amenity requirements cannot be adequately met by natural means.

***C2.3** Examples of enclosures that may need mechanical ventilation are as follows:*

(a) Industrial or other premises where it is essential to remove dust, toxic or noxious contaminants at, or near, their source (see Section 5).

(b) Those health care facilities where it is needed to control infection (e.g., operating theatres), or to control cross-infection (e.g., between isolation wards), see Section 6.

(c) Where unfavourable external environmental conditions exist, e.g., excessive noise, pollution or dust.

(d) Enclosed car parks, driveways and the like where it is necessary to dilute hazardous gases and fumes (see Section 7).

(e) Where there is a high density of continuing occupancy expected, e.g., auditoriums or clubs.

(f) Where high heat and vapour generation is likely, e.g., large commercial kitchens and laundries (see Section 5).

(g) Enclosures where specific contaminants are emitted at high levels.

2.3.2 Mechanical ventilation systems

Mechanical ventilation may be by means of combinations of mechanical supply and exhaust and natural relief and make-up as follows:

(a) Mechanical supply with mechanical exhaust.

(b) Mechanical supply with natural relief.

(c) Mechanical exhaust with natural make-up.

Mechanical exhaust ventilation may provide general exhaust, or may be required to provide local exhaust.

2.3.3 Mechanical ventilation systems selection

The following applies to the selection of mechanical ventilation systems:

(a) For processes or enclosures subject to Type A or B effluent, as described in Clause 5.3, local exhaust complying with Section 5 shall be provided.

(b) For enclosures accommodating automotive vehicles with combustion engines, mechanical supply or mechanical exhaust or both shall be provided as necessary to meet the requirements of Section 7.

(c) For processes or enclosures listed in Appendix B and similar enclosures, general exhaust complying with Section 5 shall be provided, except as follows:

    (i) Local exhaust air systems that can be demonstrated to be as effective in the removal of effluent as the required general exhaust system, which may be used in lieu of part of or whole of the general exhaust ventilation.

    (ii) For enclosures for which discharges are not deemed objectionable (see Table 5.3) mechanical supply air ventilation together with permanently open natural relief air openings may be provided in lieu of general exhaust ventilation, subject to any adjacent enclosure of different use being maintained at a higher pressure at all times.

(d) For processes or enclosures listed in Appendix A and similar enclosures, supply ventilation complying with Section 4 shall be provided, except that mechanical exhaust air ventilation together with permanently open natural make-up air openings may be provided in lieu of supply ventilation, subject to any adjacent enclosure of different use, as listed in Appendix B, is maintained at a lower pressure at all times.

2.4 COMBINATION VENTILATION SYSTEMS

Mechanical ventilation systems serving enclosures or parts of enclosures shall be arranged so that their operation does not interfere with natural ventilation systems serving remaining parts of the enclosure or other enclosures. Enclosures only provided with devices for the improvement of air movement within that enclosure shall be considered as being naturally ventilated.

Ventilation systems may be combined to meet the requirements of this Standard. Possible combinations are as follows:

(a) Mechanical supply with mechanical exhaust.

(b) Mechanical supply with natural relief (exhaust).

(c) Natural supply with mechanical exhaust.

(d) Natural supply with natural relief (exhaust).

> ***C2.4*** *The requirement that outdoor air be well distributed within the occupied zone of an enclosure is to ensure the elimination of pockets of stagnant air where pollutants could accumulate and to provide outdoor air to suit the building occupancy.*

2.5 RESIDUAL VENTILATION

Residual ventilation (i.e., borrowed or transfer air) may be used for areas of low or transient occupancy such as corridors or similar. Residual ventilation may be incorporated into the calculations of Dilution Index.

> ***C2.5*** *Allowance is made for the incorporation of residual ventilation in both natural (borrowed air) and mechanical (transfer air) ventilation systems. Where natural ventilation systems are assessed under the Dilution Index rating, borrowed air should be treated as transfer air in calculations.*

2.6 VENTILATION EFFECTIVENESS

The internal layout and partitioning of a building will have an impact on the air distribution across an enclosure. This Standard assumes a ventilation effectiveness factor of 0.8. Where the ventilation effectiveness factor of a space is expected to be less than this, the minimum outdoor airflow rates and Dilution Index, if applicable, calculated in accordance with Section 4 shall be appropriately adjusted.

NOTE: Information on ventilation effectiveness is given in the Supplement to this Standard.

2.7 SYSTEM OPERATION

Ventilation systems shall be designed to be operable to suit the building occupancy.

SECTION 3 NATURAL VENTILATION

3.1 SCOPE OF SECTION

This Section specifies the means of achieving the quantity of outdoor air required in a naturally ventilated enclosure. The provisions described include ventilation openings for the amenity of occupants. When the ventilation openings are open, general contaminants should be maintained at concentrations below exposures that have the potential to cause adverse health effects to a substantial majority of occupants. However, natural ventilation to this Standard may not ensure that specific contaminants are maintained at concentrations below exposures that have the potential to cause adverse health effects under all atmospheric conditions. Requirements for the natural ventilation of enclosures used by vehicles with combustion engines are given in Section 7. Figure 3.1 provides a flow chart on the application of this Section.

3.2 SYSTEM REQUIREMENTS

System requirements shall be achieved by providing natural ventilation openings determined by one of the following methods:

(a) The prescriptive opening size and location approach as given in Clause 3.4.

(b) Empirical calculations.

(c) Computer modelling.

NOTE: Some guidance on a performance approach to natural ventilation systems design is provided in the Supplement to this Standard.

Where a Dilution Index is calculated for a natural ventilation system it shall be based on the outdoor airflow rates achieved within the following design criteria:

(i) The mean wind speed for the location that is expected 50% of the time.

(ii) A temperature differential (outdoor/indoor) no greater than 6°C.

OR

(iii) A combination of Items (i) and (ii).

> ***C3.2*** *It is intended that outdoor airflow rates resulting from natural ventilation systems are capable of achieving the minimum outdoor airflow requirements of Clause 4.7.2 for the majority of the time. Prevailing atmospheric conditions will vary ventilation rates. However, the provisions of this Section are considered appropriate under most conditions for general contaminants. Guidance on the use of empirical calculations and computer modelling is given in the Supplement to this Standard. Where a source of contamination has the potential to create an unsafe condition, the particular requirements need to be determined and where continuity of ventilation is required, mechanical ventilation may be necessary.*

3.3 VENTILATION PROVISIONS

3.3.1 General

Natural ventilation shall be by systems, or a combination of systems, complying with Clauses 3.3.2 to 3.3.5.

3.3.2 Direct ventilation

Systems that ventilate individual enclosures with one or more openings in the external envelope of the enclosure are direct ventilation systems (see Figure 3.2).

Where the following and similar enclosures are naturally ventilated, they shall be designed as direct ventilation systems:

(a) Bathrooms, showers and the like.

(b) Enclosures containing sanitary fixtures.

(c) Laundries.

(d) Enclosures containing unflued gas appliances.

NOTE: Requirements for unflued gas appliances may be the subject of state and territory government legislation.

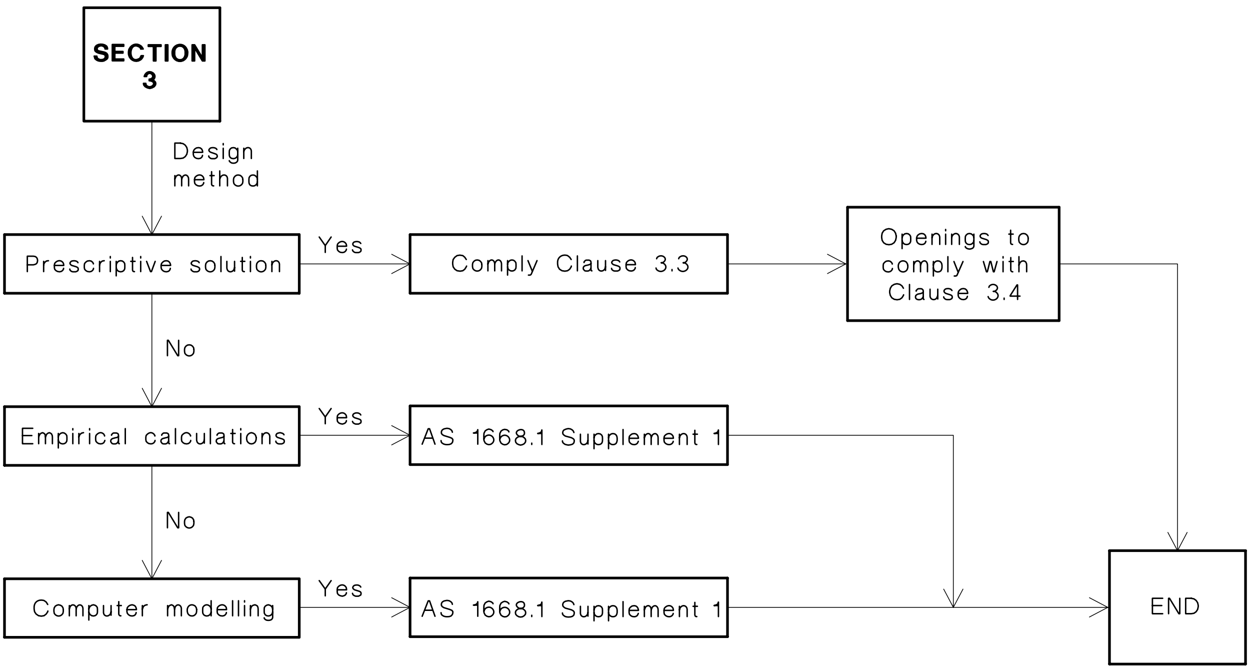


FIGURE 3.1 GENERAL GUIDE FOR APPLICATION OF SECTION 3

3.3.3 Borrowed ventilation

Borrowed ventilation (see Figure 3.2) may be applied to a particular enclosure by considering it as part of a second adjoining enclosure and so borrow air from, and return it to that adjoining enclosure provided that—

(a) the area of the openings between the enclosures are twice the requirements for external openings based on the area of the particular enclosure; and

(b) the adjoining enclosure has an external opening area based on the total areas of both enclosures.

The enclosures listed in Clause 3.3.2 shall not be used as the source for borrowed ventilation.

3.3.4 Flowthrough ventilation

Flowthrough ventilation (see Figure 3.2) may be applied to a series of enclosures and is designed to enter by one enclosure and leave by a different enclosure.

Flowthrough ventilation systems may be applied to enclosures provided that—

(a) the area of external openings is based on the total floor area of all enclosures and they are proportionately distributed;

(b) the flowthrough air does not pass through more than two enclosures and a corridor;

(c) the internal openings comply with Clause 3.4.4; and

(d) all parts of the enclosure being naturally ventilated shall be either—

(i) within 7 m; or

(ii) within a distance of twice the enclosure height of the shortest path between any two natural ventilation openings.

3.4 OPENINGS

3.4.1 General

Openings for natural ventilation shall be of a type, location and size as detailed in this Section. Where a combination of methods are used, the area of openings shall be determined on a proportional basis.

3.4.2 Type of openings

Openings shall either be fixed, such as wall or roof ventilators (with ducting where needed), or adjustable, such as windows or other openable devices including doors. Adjustable ventilation openings shall be operable by or on behalf of the enclosure occupants.

3.4.3 External openings

External openings shall be appropriately positioned to provide a reasonably even distribution of outdoor air. They shall also be positioned to minimize the entry of objectionable or noxious discharges. Obstacles shall not substantially reduce the minimum outdoor airflow through the openings.

The minimum total area of unobstructed openings, including natural ventilators, shall be proportional to the floor area and shall be in accordance with that required for occupant- and building-related contaminants as given Table 3.1.

For enclosures for which Table 3.1 requires an area of openable areas greater than 5% of floor area, and where the distribution of openable openings within the enclosure provides substantial cross ventilation (i.e., a minimum ratio of 1:4 opposite distribution of openings), then the required percentage of openable openings may be reduced to 5% of the floor area.

The unobstructed opening area of natural ventilators shall be taken as the effective aerodynamic area. Where the airflow is reduced by ducting being installed to a natural ventilator, the minimum area shall be increased appropriately unless it can be demonstrated that the performance requirements of Clause 3.2 can be achieved with a lesser area.

> ***C3.4.3*** *Positioning external openings on opposite or adjacent sides of the building should maximize the cross-ventilation benefit of wind effects. Positioning external openings at both high and low levels maximizes the benefits of thermal effects.*
>
> *Where concentrations of people are high, specific contaminants are present, hazardous gases are present or where combustion air is needed for plant, then larger openings or mechanical ventilation systems may be needed. Such enclosures may need to be analysed on a case-by-case basis.*

3.4.4 Internal openings

All internal openings along the air path shall be no less in effective area than the total area required for external openings based on the floor area of the enclosures along the air path.

TABLE 3.1

PERCENTAGE FLOOR AREA REQUIRED AS OPENABLE OPENINGS FOR OCCUPANT- AND BUILDING-RELATED CONTAMINANTS

Use of enclosure	Average adjusted metabolic rate Watts/occupant	Net floor area per occupant (m^2) (use highest applicable value)			
		<2	2 to 5	Over 5 up to 15	>15
Low activity	Up to 160	7.5%	5%	5%	2.5%
Medium activity	161–200	7.5%	5%	5%	2.5%
High activity	201–340	10%	7.5%	5%	5%
Very high activity	Over 341	15%	10%	7.5%	5%
Class 1 Class 2 Class 4	Any	5%			
Classroom (students under 16 years old)	Any	Multiply the percentage floor area required by 1.25			
Smoking not prohibited	Any	Multiply the percentage floor area required by 2.0 (does not apply to Class 1, Class 2 and Class 4 buildings)			

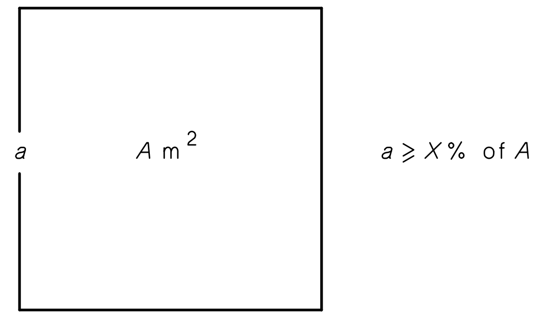
NOTES:

1 Information on metabolic rates/activity levels is given in Appendix A, Table A2.

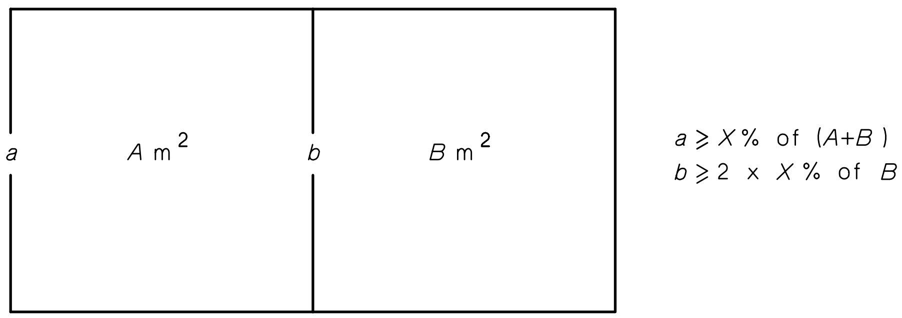
2 A description of building class is given in the Building Code of Australia.

3.5 PROHIBITION OF TRANSFERRED OR BORROWED AIR

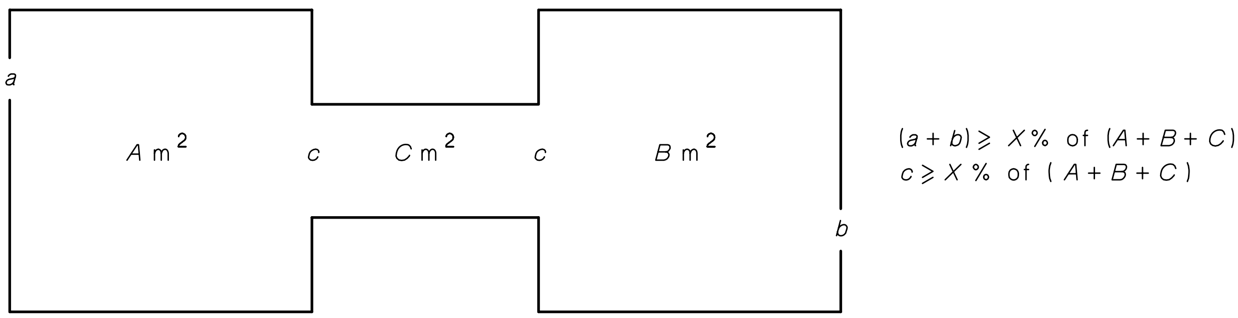
To the extent reasonably practicable, air shall not be transferred or borrowed from a smoking not prohibited enclosure to a smoking prohibited enclosure. This can be achieved by an appropriate barrier between enclosures or by the application of mechanical exhaust from the smoking not prohibited enclosure at a rate no less than 5 L/s per square metre of floor area.



(a) Direct ventilation



(b) Borrowed ventilation



(c) Flow through ventilation

Where:

A, *B*, *C* = floor area of enclosures, in m^2

a, *b*, *c* = area of openable opening(s) into enclosure, in m^2

x = percentage floor area of enclosure required as openable openings, from Table 3.1

FIGURE 3.2 TYPES OF NATURAL VENTILATION

SECTION 4 MECHANICAL VENTILATION— SUPPLY SYSTEMS

4.1 SCOPE OF SECTION

This Section prescribes general requirements for outdoor air supply and two methods of calculation of mechanical ventilation whereby indoor air contaminants are diluted by introducing outdoor air into the enclosure. Exhaust ventilation may be used as an alternative to supply systems in accordance with Clause 2.3. Figure 4.1 provides a flow chart on the application of this Section. The two methods are—

(a) a prescriptive procedure that incorporates minimum mandatory requirements for single enclosures and simple multiple enclosures (see Clause 4.8); and

(b) an engineered procedure based on the Dilution Index (DI) of the enclosure (see Clause 4.9).

> ***C4.1*** *The Standard allows two approaches to the supply air dilution procedure, a mandatory, simple but conservative approach (the prescriptive procedure), which addresses health and minimum ventilation amenity and an optional, complex but more accurate approach (the engineered or Dilution Index procedure), which addresses health and permits design to a specified amenity grade, which is deemed to comply with the minimum mandatory requirements of the prescriptive procedure.*

4.2 NOTATION AND DEFINITIONS

4.2.1 Notation

The following symbols are used in this Section.

A = the gross floor area of an enclosure served in square metres

a_b = the factor for building material and other non-occupant-related contaminants for an enclosure from Table 4.3

a_o = the factor for occupant-related contaminants in an enclosure from Table 4.2

a_u = the contamination rate/occupant for the contaminant under consideration from Table 4.5 or 4.6 as appropriate

C = the return air contamination rate for the system determined in accordance with Clause 4.10.2

DI = the Dilution Index of the enclosure under consideration

DI_t = the Dilution Index of the enclosure from which transfer air is drawn

k = the total contamination rate for an enclosure, as given in Clause 4.10.3

e_c = the fractional efficiency (percentage efficiency divided by 100) of the central air-cleaning unit for the contaminant under all operating conditions, determined in accordance with Clause 4.13

e_l = the fractional efficiency (percentage efficiency divided by 100) of a local recycle air-cleaning unit, if provided, for the contaminant under all operating conditions, determined in accordance with Clause 4.13

e_s = the fractional efficiency (percentage efficiency divided by 100) of a local supply air-cleaning unit, if provided, for the contaminant under all operating conditions, determined in accordance with Clause 4.13

N = the number of occupants, in all enclosures served, generating contaminants at a particular rate

n = the occupancy for the enclosure served as defined in Clause 4.2.2.

Q_f = the flow rate of outdoor air to the system, in litres per second

Q_r = the flow rate of return air drawn from all enclosures served by an air-handling system to be used as recycled air, in litres per second

Q_s = the flow rate of supply air to all enclosures served by an air-handling system, in litres per second

q_l = the rate at which air is recycled through a local air-cleaning unit, in litres per second

q_r = the flow rate at which return air to be used as recycle air is drawn from an enclosure, in litres per second

q_s = the flow rate of supply air to the enclosure, in litres per second

q_t = the flow rate of transfer air to the enclosure, in litres per second

r = the reduction in contamination rate by means of a local air-cleaning unit for an individual enclosure, determined in accordance with Clause 4.10.4

U = the used air fraction of supply air for dilution of contaminants determined in accordance with Clause 4.11.1

U_m = the maximum permissible used air fraction for supply air for all enclosures served, determined in accordance with Clause 4.12

V_e = the ventilation effectiveness of the ventilation system

4.2.2 Occupancy

The occupancy (n) of an enclosure shall be the greater of—

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

(b) one-third of the maximum number of occupants present in the enclosure at any time.

Where the occupants of a group of enclosures, served by a single air-handling system, move between enclosures, it is not necessary to treat the total occupancy as the sum of the maximum occupancies of each enclosure. Rather, the distribution of occupants that gives the highest required outdoor airflow rate shall be used.

The occupancy of the building is subject to building regulation and shall be nominated for the purposes of ventilation system design. For each enclosure the activity rates and the smoke status of the enclosure (smoking prohibited or smoking not prohibited) shall also be nominated. Where the smoking rate differs from that underlying Table 4.2, the particular smoking rate shall be nominated.

NOTE: In the absence of other information, the number of occupants should be not less than that estimated on the basis of floor area per person. Appendix A provides guidelines on maximum occupant density, activity/metabolic rates and suggested Dilution Indices for particular enclosures and grades of amenity.

> ***C4.2.2*** *The occupancy values given in Appendix A are conservative and it is recommended that actual values BE nominated for design purposes. In some cases, the occupancies used for the purposes of determination of outdoor airflow rates may differ in aggregate for a given floor from those used for egress provisions in the Building Code of Australia. This can arise as a result of the use of the maximum occupancy for each area with no account taken of movement of people from one area to another at different times during the period of occupancy. An example would be a conference room used substantially by the occupants of adjacent areas on the same floor.*

4.3 OUTDOOR AIR INTAKES

4.3.1 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 level significantly 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.

> ***C4.3.1*** *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, pre-treatment of the outdoor air may be needed. Information on the acceptability of outdoor air is given in AS 1668.2 Supp 1. Should the use of outdoor air not be acceptable for a particular location or a different means is proposed for ventilation, AS 1668.2 Suppl 1 also provides guidelines on a performance-based approach to mechanical ventilation system design. The removal of certain contaminants from the outdoor air may not be readily achievable using existing technologies.*
>
> *Chapter 15 of the 1997 ASHRAE Fundamentals Handbook addresses airflow around buildings, dispersion of building exhaust gases and design to minimize re-entry. Particularly critical cases may warrant wind tunnel testing of models. Attention is drawn to Clause 5.10 on the location of discharges.*

4.3.2 Passage of air

Outdoor air shall pass to the air-handling plant directly through a duct or plenum connected to the intake.

Enclosures used for storage of equipment, plant or materials likely to contaminate the air shall not be used as plenums. A plant room housing equipment or materials that do not contaminate the air may act as a plenum.

4.4 FILTRATION

Any individual mechanical supply air ventilation system incorporating heating/cooling coils or humidifiers, or both, shall incorporate an air filter rated to AS 1324.1 in accordance with Table 4.1. Such filters shall be positioned before supply air fans and any coils or humidifiers and both the outdoor and recycled air shall be filtered.

NOTE: This requirement does not preclude the use of additional filters in other parts of the air-handling system.

Whenever a filter is required by this Standard, essential mechanical ventilation system information shall be recorded on a permanent plaque installed in close proximity to the air-handling plant. This plaque shall record the following information:

(a) System design supply air and outdoor airflow rates.

(b) Design filter classification and efficiencies as appropriate.

C4.4 *Filters can assist in the following:*

(a) The removal of particulate contaminants from the air.

(b) The reduction of energy consumption through the reduction of dirt build-up on heat transfer equipment.

(c) The maintenance of design airflows and aerodynamic performance of system through the reduction of dirt build-up.

(d) The maintenance of the accurate response of control system components.

(e) The prevention of the malfunction of fire control equipment due to dust build-up reducing the ability of a system to respond to a fire event.

TABLE 4.1

MINIMUM FILTER RATING

System characteristics	Minimum filter rating (see AS 1324.1)
≥1500 L/s ducted	F4
≥1500 L/s non-ducted	G4
<1500 L/s non-ducted	NR
Evaporative coolers	NR

NR = no requirement

4.5 PROHIBITION OF RECYCLE AIR

Similar occupancies may be served by common recirculation systems. Except where the recycle air is treated in an acceptable manner, air-handling systems serving more than one enclosure shall not recycle air to dissimilar occupancies from any of the following enclosures:

(a) Any enclosure listed in Appendix B.

(b) Any enclosure of Types C, D, E, F, G or H as listed in Table 4.3.

(c) Any enclosure required to be ventilated by a general or local exhaust ventilation system.

Where air is recycled or transferred from a smoking not prohibited enclosure to another enclosure, both enclosures shall be treated as smoking not prohibited enclosures and contamination rates used for Dilution Index calculations shall be taken from Table 4.6. Air shall not be recycled or transferred from a smoking not prohibited enclosure to another enclosure in which smoking is prohibited.

NOTE: The Supplement to this Standard provides information on supplementary measures for the control of environmental tobacco smoke (ETS) or other contaminants including ventilation system design recommendations when it is designed to further segregate a smoking not prohibited enclosure into smoking and non-smoking areas.

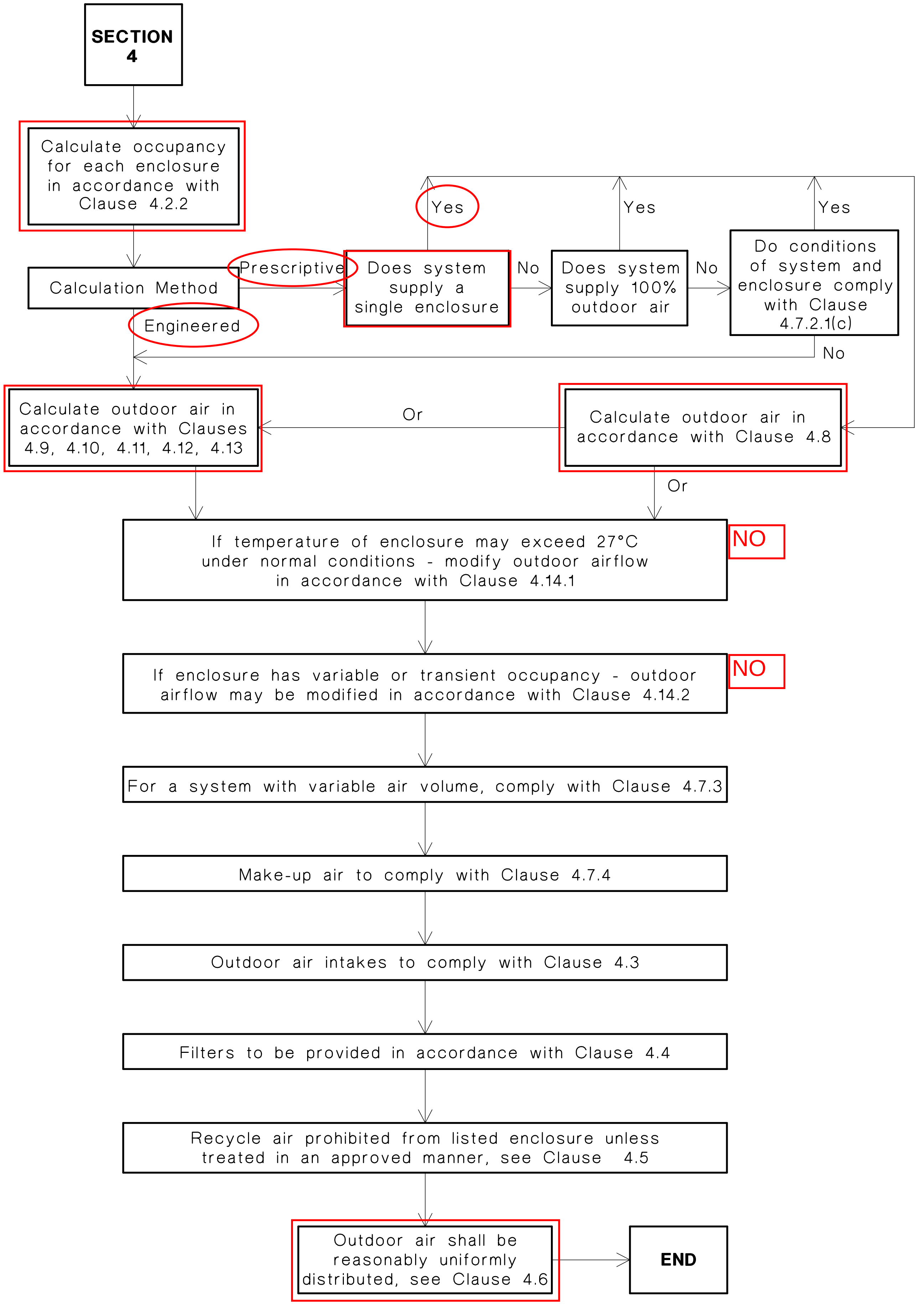


FIGURE 4.1 GENERAL GUIDE FOR APPLICATION OF SECTION 4

4.6 OUTDOOR AIR MIXING AND DISTRIBUTION

A reasonably uniform distribution of outdoor air shall be achieved throughout the occupied zones for each enclosure, irrespective of whether 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.

> ***C4.6*** *As it may not be practicable to measure the outdoor air content and its distribution in the air supply duct, the requirements of this Clause will be satisfied if the system design provides for minimum outdoor air to be carried at all times by the supply ducts from the air-handling plant to all enclosures and sufficient mixing of outdoor air with the recycle air in the air-handling plant to supply all enclosures with air of about the same ratio of outdoor to recycle air.*
>
> *It may be practical to express the aim of this clause in a particular enclosure by the introduction of ventilation air in a limited number of places, provided that the airflow in the enclosure is adequately arranged.*

4.7 OUTDOOR AIRFLOW RATES

4.7.1 General

The flow of mechanically provided outdoor air shall comply with Clauses 4.7.2 to 4.7.4.

> ***C4.7.1*** *Using the prescriptive procedure described in Clause 4.7.2.1 will result in an equal or higher minimum outdoor air requirement than using the engineered procedure described in Clause 4.7.2.2 which allows reduction in outdoor air requirements if recycle air-cleaning is provided, and which is based on calculated allowance for distributional effects for systems serving multiple enclosures. In all cases, provision of the outside airflow in accordance with Clause 4.7.2.2 meets the minimum outdoor air requirement.*

4.7.2 Minimum outdoor air requirement

4.7.2.1 *Prescriptive procedure*

The minimum flow rate required may be calculated using the prescriptive procedure in accordance with Clause 4.8 for air-handling systems that—

(a) supply a single enclosure;

(b) supply 100% outdoor air to single or multiple enclosures; or

(c) supply multiple enclosures for which variations in density of occupancy, type of use and rate of supply airflow allow the enclosure to comply with the following equation:

$$q_s > \frac{n \times a_o}{\dfrac{Q_f}{Q_s} + 0.33} \qquad \ldots 4(1)$$

For the purposes of Equation 4(1), a_0 shall be taken as the single enclosure values given in Table 4.2.

4.7.2.2 *Engineered procedure*

The minimum flow rate required may be calculated using the engineered procedure in accordance with Clause 4.9.

4.7.3 Variable air volume systems

For a system with variable supply airflow rate, provision shall be made to ensure that the minimum outdoor airflow rate complies with Clause 4.7.2 under all operating conditions. 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 be regarded as a single enclosure.

> ***C4.7.3*** *One way of satisfying the requirements of this Clause, is to introduce into the air-handling plant sufficient outdoor air. In this case the outdoor air content in the air supplied by the air-handling plant is determined by the use of the highest ratio of outdoor air to total supply air for any enclosure, applied to the total of air supplied to all enclosures. This solution satisfies the Standard but may not be economical since all enclosures with lower ratios are oversupplied with outdoor air.*
>
> *The Dilution Index calculation is based on the fact that air returned from enclosures oversupplied with outdoor air still has some potential to dilute pollutants to satisfactory levels when introduced into the supply duct from the air-handling plant to enclosures. It should be evident that further economies can be achieved by the grouping of enclosures with like ratios of outdoor air to total air on the same air-handling plant. This solution may not be possible or appropriate in many cases for a variety of reasons.*

4.7.4 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 5.8.

4.8 OUTDOOR AIRFLOW CALCULATION—PRESCRIPTIVE PROCEDURE

The minimum flow rate of outdoor air supplied by the air-handling system in litres per second, Q_f shall, for each contaminant considered, be the higher of—

(a) the total of occupant-related contaminants for all enclosures, given by—

$$\Sigma (n \times a_o); \text{ or} \quad \ldots 4(2)$$

(b) the total of building material and other non-occupant-related contaminants for all enclosures given by—

$$\Sigma (A \times a_b) \quad \ldots 4(3)$$

provided that the requirements of Clause 4.7.2.1 are complied with.

Where a_o and a_b are the highest applicable factor given in Tables 4.2 and 4.3.

TABLE 4.2

FACTOR FOR OCCUPANT-RELATED CONTAMINANTS

Use of enclosure	Average adjusted metabolic rate Watts/occupant	a_o (L/s per occupant))			
		Temperature maintained at or below 27°C in normal use		Temperature exceeds 27°C in normal use	
		Supplying 100% outdoor air or a single enclosure	Multiple enclosure system	Supplying 100% outdoor air or a single enclosure	Multiple enclosure system
Low activity	Up to 160	5	5	6	9
Medium activity	161–200	5	7.5	7	10.5
High activity	201–340	10	15	12	18
Very high activity	Over 340	15	22.5	17	25
Classrooms (students under 16 years old)	Any	Multiply above values by 1.25			
Smoking not prohibited	Any	10	15	10	15

NOTES:

1 Smoking not prohibited is based on a smoking rate of 1 cigarette per person per hour as an average for all occupants (smoking and non-smoking) of the enclosure. Where higher smoking rates are reasonably anticipated a higher contaminant factor (a_o), for the higher smoking rates, shall be calculated by multiplying the smoking not prohibited factor of Table 4.2 by the expected smoking rate (cigarettes per hour per occupant).

2 The single enclosure rate for light activity is not reduced from the corresponding rate for multiple enclosures to ensure that enclosures are not ventilated at low outdoor airflow rates without consideration of all factors using the engineered procedure.

3 Information on metabolic rates /activity rates is given in Appendix A, Table A2.

TABLE 4.3

FACTOR FOR BUILDING MATERIAL AND OTHER NON-OCCUPANT-RELATED CONTAMINANTS

	Type of enclosure	a_b (L/s per m^2)
A	General use enclosures, e.g., offices, residences, shops, stores, corridors, bars, theatres, switch and meter enclosures, computer enclosures, fire control enclosures, locker enclosures and warehouses (general use)	0.35
B	Critical activity use, e.g., air traffic control	As necessary to meet exposure standards but never less than 5
C	Equipment and store enclosures holding materials generating odours or noxious gases	5
D	Animal enclosures, pet shops, veterinary centres, kennels	5
E	Swimming pools, deck and pool and ancillary areas	3.5
F	Embalming enclosures, autopsy enclosures	See Section 6
G	Operating and delivery enclosures	See Section 6
H	Warehouses for products that give off odours or noxious gases, e.g., particleboard products (formaldehyde)	As necessary to meet exposure standards

4.9 OUTDOOR AIRFLOW CALCULATION—ENGINEERED PROCEDURE (DILUTION INDEX)

4.9.1 General

This Standard allows for the achievement of different levels of ventilation amenity represented by the calculation of a Dilution Index (DI) for each enclosure and each contaminant under consideration. Higher DI values represent a higher ventilation amenity. An enclosure for which the Dilution Indices, calculated in accordance with Clause 4.9.3, are not less than those given in Table 4.4 is deemed to comply with the minimum requirements of Clause 4.7.2.

NOTE: Appendix A provides guidelines on occupant density, activity/metabolic rates and recommended Dilution Indices for particular enclosures.

For enclosures subject to unusual contaminants or procedures, such as those listed as Type C, D, E, F, G or H in Table 4.3, Dilution Indices are not applicable.

C4.9.1 *This Clause provides a procedure allowing the designer to calculate a DI for each enclosure served separately for different contaminants and for different categories of occupants. Alternatively, the designer may choose Dilution Indices for each enclosure and calculate the required ventilation and air-cleaning parameters necessary to achieve these conditions. An enclosure, for which the Dilution Indices calculated for body odour and environmental tobacco smoke (particulates and odour) are not less than the applicable minimum DI from Table 4.4 (subject to the conditions of Clauses 4.9.2(a) and 4.9.2(b)), complies with Clause 4.7.2. The DI procedure is not suitable for some enclosures with unusual contaminants and the requirements of Sections 5 or 6 may be more appropriate (see Appendix A).*

4.9.2 Calculation

The minimum flow rate of outdoor air supplied by the air-handling system in litres per second (Q_f) shall be the highest of—

(a) $\Sigma\,(n \times 3.5)$; or . . . 4(4)

(b) $\Sigma\,(A \times a_b)$; or . . . 4(5)

(c) the outdoor airflow rate required so that, for each enclosure served, Dilution Indices calculated in accordance with this Clause and Clauses 4.9, 4.10, 4.11 and 4.12 are not less than those given in Table 4.4.

TABLE 4.4

MINIMUM DILUTION INDICES

Type of use	Contaminant		
	Body odours	Environmental tobacco smoke odours and gaseous irritants	Environmental tobacco smoke particulates
General	3.5	3.5	3.5
Enclosures in which occupants tolerate higher levels of odour, e.g., factories, dance halls, gyms	May be reduced to not less than 2.0	3.5	3.5
Enclosures in which occupants tolerate higher levels of environmental tobacco smoke odours and gaseous irritants, e.g., bars	3.5	May be reduced to not less than 2.0 provided the DI for particulates is increased to higher than 3.5 so that the average of Dilution Indices for environmental tobacco smoke odours and gaseous irritants and environmental tobacco smoke particulates is not less than 3.5	The greater of— (a) 3.5; or (b) the value required to ensure that the average of the dilution indices for environmental tobacco smoke and gaseous irritants and environmental tobacco smoke particulates is not less than 3.5
Enclosures in which occupants tolerate higher levels of body odour and environmental tobacco smoke odours and gaseous irritants, e.g., discos	May be reduced to not less than 2.0	May be reduced to not less than 2.0 provided the DI for particulates is increased to higher than 3.5 so that the average of Dilution Indices for environmental tobacco smoke odours and gaseous irritants and environmental tobacco smoke particulates is not less than 3.5	The greater of— (a) 3.5; or (b) the value required to ensure that the average of the Dilution Indices for environmental tobacco smoke odours and gaseous irritants and environmental tobacco smoke particulates is not less than 3.5

NOTE: The lower DI for body odours permitted for enclosures in which occupants may tolerate a lower level of ventilation amenity caused by higher levels of body odours, such as a gymnasium, allows the enclosure to be ventilated at a reduced outdoor airflow rate. For enclosures in which occupants may tolerate a lower level of ventilation amenity due to environmental tobacco smoke contaminants, such as a bar in which smoking is not prohibited, the Standard allows a reduction in the DI for environmental tobacco smoke odours and gaseous irritants, provided that there is an increase in the DI for environmental tobacco smoke particulates.

4.9.3 Procedure

Dilution Indices shall be calculated separately for each applicable contaminant, using contamination rates from Tables 4.5 and 4.6 or as appropriate. The DI for the enclosure shall be taken as the lowest of the indices calculated for applicable contaminants.

Either of two procedures may be used, as follows:

(a) To calculate the DI achieved for a selected outdoor airflow rate, first determine the contamination rates using Clause 4.10 and then calculate the DI from Clause 4.11.

(b) To calculate the outdoor airflow rate necessary to achieve a selected DI, first determine the contamination rates using Clause 4.10 and then calculate the necessary outdoor airflow rate using Clause 4.12.

NOTES:

1 The procedures provide for consideration of the effects of central and local recycle *air cleaning*, transfer air from other enclosures and exhaust air from particular enclosures if applicable.

2 Guidelines on activity/metabolic rates of enclosures and suggested grading of recommended Dilution Indices are given in Appendix A.

4.10 CALCULATION OF AIR CONTAMINATION

4.10.1 General

For all DI calculations the contamination rates for return air and for each enclosure shall be calculated in accordance with Clauses 4.10.2 and 4.10.3. Where local *air-cleaning* devices are installed, reduction in contamination rates may be calculated in accordance with Clause 4.10.4.

> ***C4.10.1*** *For a system that supplies a mixture of recycle air and outdoor air to enclosures, the used air fraction (U), for a particular contaminant is the fraction of supply air having no dilution ventilation capability for that contaminant. It is determined by the amount of contaminant emitted in the enclosures served, the amount of contaminant removed by air-cleaning, diversity that may be applied to contaminant emission rates and, for a system supplying air to multiple enclosures, the extent to which recycle air from enclosures with low contaminant generation rates is less contaminated than air from the enclosure with the highest requirement. For a system that supplies 100% outdoor air to enclosures, the used air fraction, U* = 0.

4.10.2 Return air contamination rate

The return air contamination rate shall be calculated as follows:

(a) If no recycle *air-cleaning* is provided and the flow rate of return air from each enclosure is proportional to the supply air to the enclosure, the return air contamination rate for the air-handling system (C) is the sum of the total contamination rates for each enclosure, given by—

$$C = \Sigma (N \times a_{\mathrm{u}}) \qquad \ldots 4(6)$$

(b) If recycle *air-cleaning* is provided, or if the flow rate of return air from each enclosure is not proportional to the supply air to the enclosure, the return air contamination rate for the air-handling system (C), is given by—

$$C = \frac{Q_s}{Q_r} \times \Sigma\left(\frac{q_{\mathrm{r}}}{q_{\mathrm{s}}} \times (n \times a_{\mathrm{u}} - r)\right) \qquad \ldots 4(7)$$

(c) For a system that supplies 100% outdoor air to enclosures, $C = 0$.

> ***C4.10.2*** *The return air contamination rate is reduced if air is exhausted from enclosures with lower than average Dilution Indices, so that air to be used as recycle air is drawn preferentially from enclosures with higher than average Dilution Indices.*
>
> *As the reduction in contamination rate resulting from local recycle air-cleaning (r) depends on the DI of the enclosure, for air-handling systems serving enclosure(s) with local recycle air-cleaning, an iterative procedure is necessary to calculate C. Alternatively, the reduction in contamination may be taken as nil (r = 0).*

4.10.3 Calculation of total contamination rate for the enclosure

The total contamination rate (k) for a single enclosure is the sum of the contaminants generated by the occupants at the contamination rates determined by the types of activity. This shall be calculated from the following equation:

$$k = \Sigma (n \times a_u) \qquad \text{. . . 4(8)}$$

4.10.4 Calculation of reduction in contamination rate by means of a local *air-cleaning* unit

The reduction in contamination rate by means of a local *air-cleaning* unit (r) is given by the lesser of Equations 4(9) and 4(10) as follows:

$$r = U \times q_s \times e_s + \frac{q_l \times e_l}{DI} \qquad \text{. . . 4(9)}$$

$$r = U \times q_s \times e_s + k \qquad \text{. . . 4(10)}$$

TABLE 4.5

CONTAMINATION RATES/OCCUPANT FOR GENERAL CONTAMINANTS (a_u)

Type of activity	Temperature maintained at or below 27°C in normal use	Temperature exceeds 27°C in normal use
Low activity (average adjusted metabolic rate up to 160 W per occupant)	1	1.6
Classrooms	1.5	2.4
Medium, high and very high activity (average adjusted metabolic rate over 160 W per occupant)	$\frac{(\text{Met rate} - 60)}{100}$	$\frac{\text{Met rate}}{100}$

TABLE 4.6

CONTAMINATION RATES/OCCUPANT FOR ENVIRONMENTAL TOBACCO SMOKE CONTAMINANTS (a_u)

Level of tobacco smoking	Particulates	Odours and gaseous irritants
Smoking prohibited	0	0
Smoking not prohibited	2.8	2.8

NOTE: Smoking not prohibited is based on a smoking rate of one cigarette per person per hour as an average for all occupants (smoking and non-smoking) of the enclosure. Where higher smoking rates are reasonably anticipated, a higher contamination rate (a_u), for the higher smoking rates, shall be calculated by multiplying the smoking not prohibited rate of Table 4.6 by the expected smoking rate (cigarettes per hour per occupant).

4.11 CALCULATED DILUTION INDEX FOR A SELECTED OUTDOOR AIRFLOW RATE

4.11.1 Calculation of used air fraction for a system

The used air fraction of a system shall be calculated as follows:

(a) If central recycle *air-cleaning* is not provided, the used air fraction for the supply air stream (U) shall be calculated from the following equation:

$$U = C \times \left(\frac{1}{Q_f} - \frac{1}{Q_s} \right) \qquad \text{. . . 4(11)}$$

(b) If central recycle *air-cleaning* is provided, the used air fraction for the supply air stream (U) shall be calculated from the following equation:

$$U = C \times \left(1 - \frac{Q_\text{S} \times e_c}{Q_\text{S} \times e_c + Q_\text{f} \times (1 - e_c)}\right) \times \left(\frac{1}{Q_\text{f}} - \frac{1}{Q_\text{S}}\right) \quad \ldots 4(12)$$

4.11.2 Calculation of DI

The DI shall be calculated as follows:

(a) For enclosures for which supply air is introduced into the enclosure by registers or diffusers so that supply air is mixed with indoor air:

(i) If no local *air-cleaning* unit is provided, and if there is no ventilation by means of transfer air, the DI for the enclosure shall be calculated from the following equation:

$$DI = \frac{q_\text{s}}{k + U \times q_\text{s}} \quad \ldots 4(13)$$

(ii) If a local *air-cleaning* unit is provided, or if there is ventilation by means of transfer air, the DI for the enclosure shall be calculated from the following equation:

$$DI = \frac{q_\text{s} + q_t + q_\text{l} \times e_\text{l}}{k + U \times q_\text{s} \times (1 - e_\text{s}) + \dfrac{q_\text{t}}{DI_\text{t}}} \quad \ldots 4(14)$$

(b) For an enclosure for which displacement ventilation is provided, by supplying air into the enclosure at low level and at low velocity so that supply air does not significantly mix with indoor air, and so that convection airflow at occupants entrains contaminants upwards to return to relief or exhaust openings, without passing through the breathing zone of other occupants, shall be calculated from the following equation:

$$DI = \frac{q_\text{s}}{\dfrac{0.8 \times k}{V_\text{e}} + U \times q_\text{s} \times (1 - e_\text{s})} \quad \ldots 4(15)$$

NOTES:

1 If items such as transfer air or local *air-cleaning* are included in the design, Equation 4(15) should be appropriately modified; however, these items may be incompatible with this type of ventilation system due to air mixing that can occur.

2 Information on ventilation effectiveness is given in AS 1668.2 Supp 1.

4.12 CALCULATED OUTDOOR AIRFLOW RATE FOR A SELECTED DI

4.12.1 Calculation of maximum permissible used air fraction for supply to enclosure for a selected DI

The maximum permissible used air fraction shall be calculated as follows:

(a) For enclosures for which supply air is introduced into the enclosure by registers or diffusers so that supply air is mixed with indoor air:

(i) If no local *air-cleaning* unit is provided, and if there is no ventilation by means of transfer air, the maximum permissible used air fraction for supply air (U_m) for the system shall be calculated from the following equation:

$$U_{\mathrm{m}} = \frac{1}{DI} - \frac{k}{q_{\mathrm{s}}} \qquad \ldots 4(16)$$

(ii) If a local *air-cleaning* unit is provided, or if there is ventilation by means of transfer air, the maximum permissible used air fraction for supply air (U_{m}) for the system shall be calculated from the following equation:

$$U_{\mathrm{m}} = \frac{1}{q_{\mathrm{s}} \times (1 - e_{s})} \times \left(\frac{q_{\mathrm{s}} + q_{\mathrm{t}} + q_{\mathrm{l}} \times e_{\mathrm{l}}}{DI} + \frac{q_{\mathrm{t}}}{DI_{\mathrm{t}}} - k \right) \qquad \ldots 4(17)$$

(b) For enclosure for which displacement ventilation is provided, by supplying air into the enclosure at low level and at low velocity so that supply air does not mix with indoor air, and so that convection airflow at occupants entrains contaminants upwards to return to relief or exhaust openings, without passing through the breathing zone of other occupants, shall be calculated from the following equation:

$$U_{m} = \frac{1}{q_{s} \times (1 - e_{s})} \times \left(\frac{q_{s}}{DI} - \frac{k}{V_{e}} \right) \qquad \ldots 4(18)$$

NOTES:

1 If items such as transfer air or local *air-cleaning* are included in the design, Equation 4(18) should be appropriately modified; however, these items may be incompatible with this type of ventilation system due to air mixing that can occur.

2 Information on ventilation effectiveness is given in AS 1668.2 Supp 1.

4.12.2 Calculation of outdoor airflow rate for a system for a maximum permissible used air fraction

Outdoor airflow rates shall be calculated as follows:

(a) If central recycle *air-cleaning* is not provided, the required outdoor airflow rate (Q_{f}) shall be calculated from the following equation:

$$Q_{\mathrm{f}} = Q_{\mathrm{s}} \times \frac{C}{Q_{\mathrm{s}} \times U_{\mathrm{m}} + C} \qquad \ldots 4(19)$$

(b) If central recycle *air-cleaning* is provided, the required outdoor airflow rate (Q_{f}) shall be calculated from the following equation:

$$Q_{\mathrm{f}} = Q_{\mathrm{s}} \times \left(1 - \frac{Q_{\mathrm{s}} \times U_{\mathrm{m}}}{(Q_{\mathrm{s}} \times U_{\mathrm{m}} + C) \times (1 - e_{\mathrm{c}})} \right) \qquad \ldots 4(20)$$

4.13 EFFICIENCIES OF AIR-CLEANING UNITS

4.13.1 General

The efficiency of air-cleaning units shall be determined using a test method that accurately assesses the performance of the air-cleaning unit for the contaminant concerned. Particulate removal efficiencies used in Dilution Index calculations are fractional efficiencies as given in Table 4.7.

4.13.2 Test methods for odours

The efficiency of the air-cleaning unit for odours shall be determined by a suitable test.

NOTE: At time of publication, Standards Australia was not aware of suitable test specifications for the determination of this efficiency.

4.13.3 Test methods for environmental tobacco smoke particulate contaminants

The efficiency of the air-cleaning unit for particulates shall be as given in Table 4.3 determined in accordance with either—

(a) AS 1324.2 using Test Dust No. 1 and average efficiencies; or

(b) AS 4260.

TABLE 4.7

FILTER PARTICULATE EFFICIENCIES—BY CLASS

AS 1324.1 performance rating	Percentage average efficiency (E_m)	Fractional efficiency for the purpose of Dilution Index calculations
F4	$20 < E_m < 40$	0.20
F5	$40 < E_m < 60$	0.40
F6	$60 < E_m < 80$	0.60
F7	$80 < E_m < 90$	0.80
F8	$90 < E_m < 95$	0.90
F9	$95 < E_m$	0.95
AS 4260 performance rating	**Percentage efficiency**	**Fractional efficiency for the purpose of DI calculations**
Grade 1	99.97	0.9997
Grade 2	99.99	0.9999
Grade 3	99.999	0.99999
Grade 4	99.999	0.99999

4.13.4 Test methods for environmental tobacco smoke odours and gaseous irritants

The efficiency of the air-cleaning unit for odours and gaseous irritants of environmental tobacco smoke, under all operating temperatures, shall be determined by means of a suitable test.

NOTE: At time of publication, Standards Australia was not aware of suitable test specifications for the determination of this efficiency.

4.14 OUTDOOR AIRFLOW ADJUSTMENT

4.14.1 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 similar) to the flow rate that would be appropriate if the enclosures were not subject to temperatures exceeding 27°C in normal operation. Adjustment may be controlled manually or automatically.

C4.14.1 *It is well recognized that additional body odour is generated at elevated temperatures and/or that the perception of body odours is enhanced under these conditions. Where temperatures in excess of 27°C occur under normal operation, rates should be adjusted upwards to compensate for increase in body odour generation or perception by occupants (see Tables 4.2 and 4.3).*

4.14.2 Systems serving enclosures with transient or variable occupancy

During periods of low occupancy, the outdoor airflow rate may be adjusted (by dampers or similar) 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 the following conditions:

(a) The lag time between increases in occupancy and the adjustment shall not exceed that determined in Figure 4.2.

(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 appropriate location.

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

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

Where specific 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 4.3.

NOTE: Rationale for lag or lead time for transient occupancies is provided in AS 1668.2 Supp 1.

> ***C4.14.2*** *It should be recognized that although a system may be turned off during periods of non-occupancy, a period of post-purging by natural or mechanical means may be needed after departure of occupants to clear pollutants generated by the occupants. Also a period of pre-purging may be required before entry of occupants to clear accumulation of pollutants generated by furnishings, other materials, and the like, within the space.*

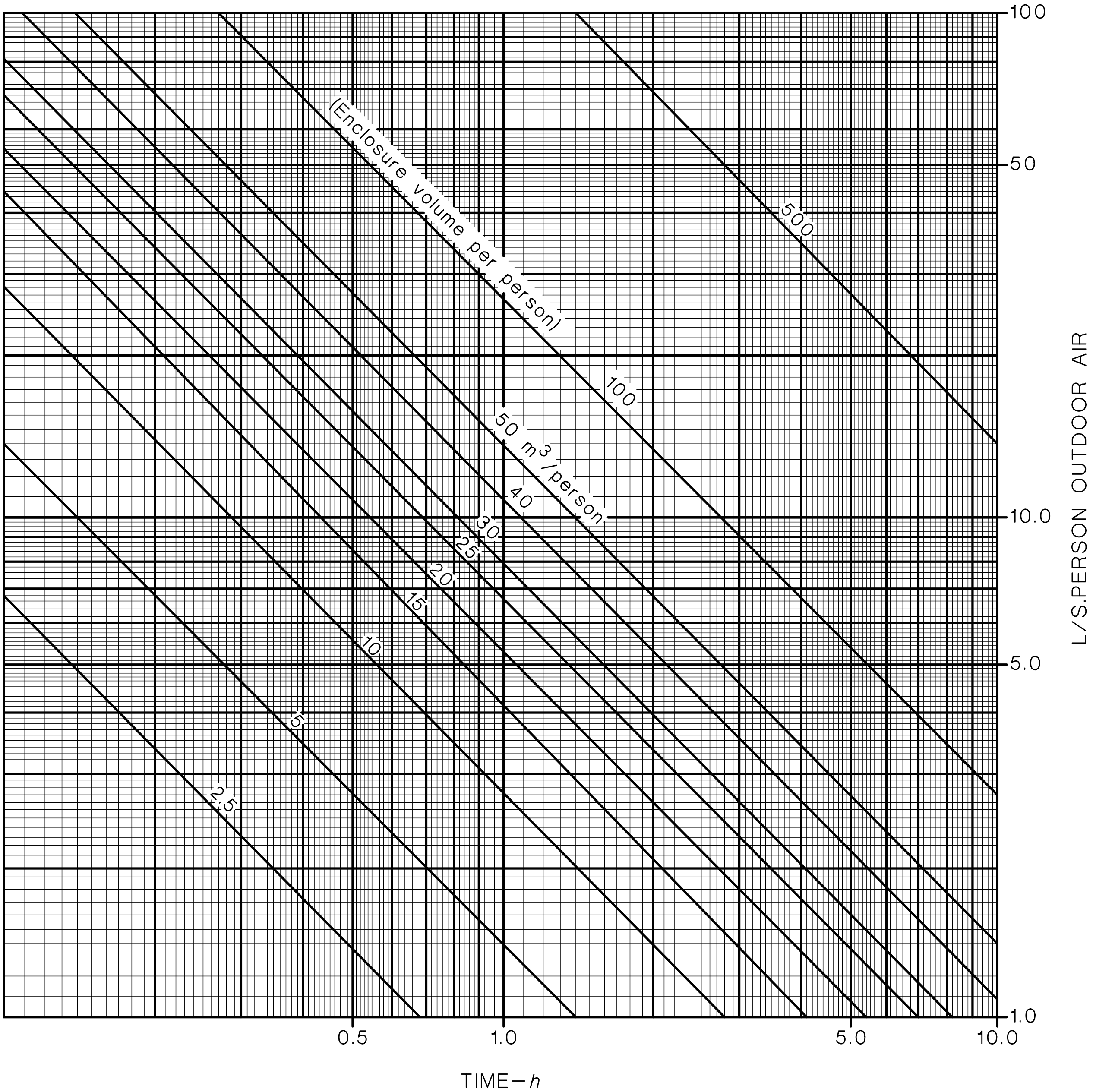


FIGURE 4.2 PERMISSIBLE LAG TIME—HOURS

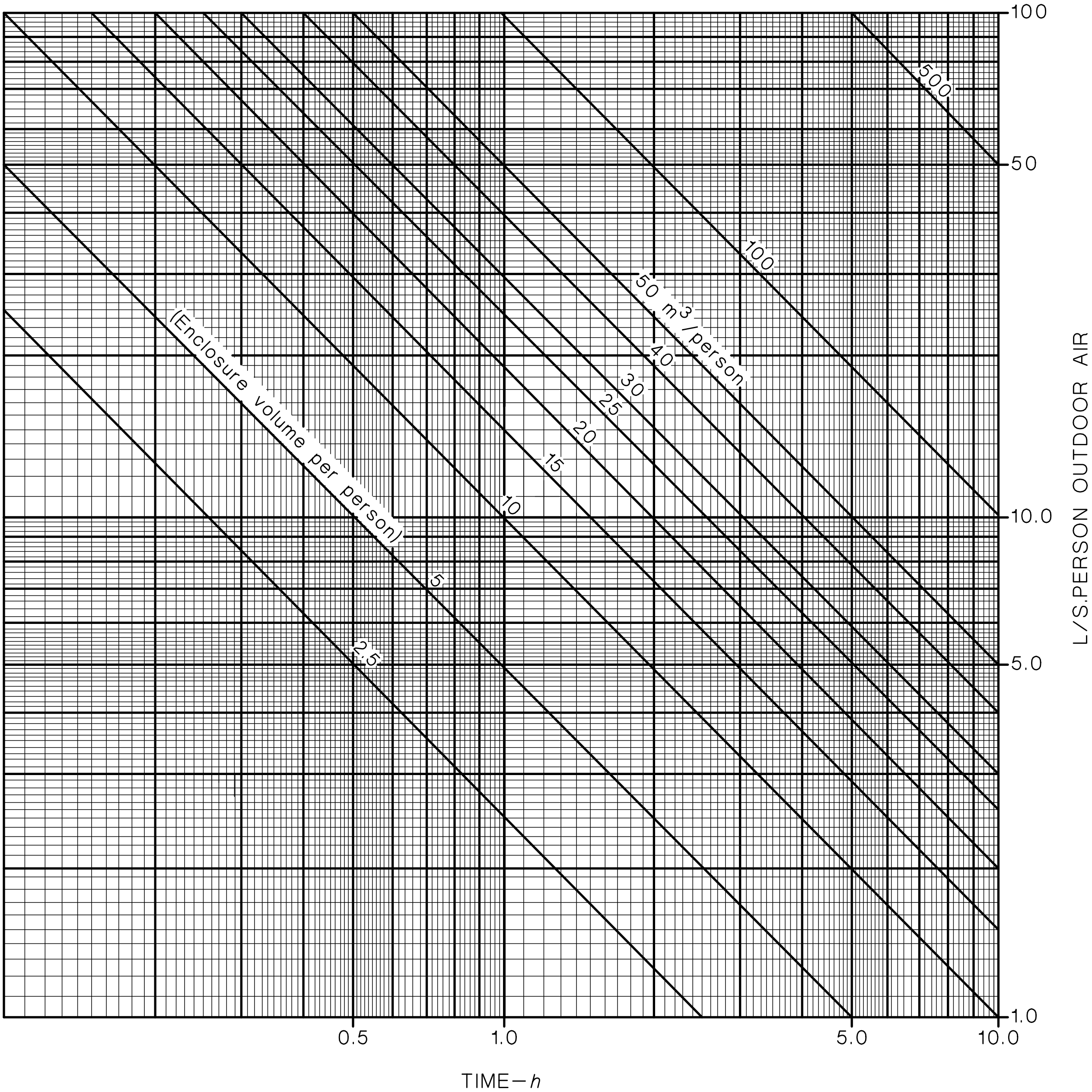


FIGURE 4.3 REQUIRED LEAD TIME—HOURS

SECTION 5 MECHANICAL VENTILATION— EXHAUST SYSTEMS

5.1 SCOPE OF SECTION

This Section prescribes exhaust ventilation requirements for enclosures in which contaminants are generated or contained, whereby indoor air contaminants are diluted by exhausting adequate amounts of indoor air and providing make-up air. Supply air ventilation may be used as an alternative to exhaust air systems in accordance with Clause 2.3.3. Figure 5.1 provides a flow chart on the application of this Section.

This Section of the Standard does not apply to the control of environmental tobacco smoke.

NOTE: For enclosures used by vehicles with combustion engines, see Section 7.

> ***C5.1*** *This Standard allows two approaches to exhaust air dilution, general or local exhaust. Where enclosures contain processes that generate contaminants of a type or concentration deemed to be objectionable or that may have adverse health effects (defined in Clause 5.3.1(a)), it is specified that these be removed directly from the enclosure by a separate exhaust system and not be recirculated through the supply air system. It is also required that the exhaust airflow rate be adequate to dilute the contaminants and be arranged to discharge them outside the building in such a manner that no danger or nuisance results to people outside the building.*

5.2 GENERAL EXHAUST VENTILATION

5.2.1 General

Unless ventilated by natural means in accordance with Section 3 enclosures listed in Appendix B require general exhaust ventilation. Exhaust airflow rates shall be as specified in Appendix B.

NOTE: Local exhaust air systems that can be demonstrated as being effective in the removal of effluent may be used in lieu of part or whole of the general exhaust ventilation (see Clause 2.3.2).

> ***C5.2.1*** *Appendix B of this Standard specifies rates for general exhaust ventilation. These rates are deemed adequate except for such applications as bathrooms, laundries and hospital sterilizing rooms where excessive heat or steam is generated, or sanitary compartments where excess odours are generated. In kitchens, local exhaust should be used in addition to the specified general exhaust, where the size of cooking apparatus exceeds the limits stated.*

5.2.2 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.

5.2.3 Enclosures served by both supply and general exhaust systems

Where the enclosure is served by both a supply air system and a general exhaust system required by this Section, the exhaust airflow rate shall exceed the supply airflow rate by at least 10%, unless means are provided to maintain any adjacent enclosure, of a different use, at a higher pressure at all times.

C5.2.3 *The aim of the requirement for the general exhaust rate to exceed the supply rate (where used) by 10% is to ensure that effluent cannot flow to adjacent enclosures. This requirement for general exhaust to exceed supply may be waived where mechanical ventilation is used to produce pressure differentials between enclosures or where a specified general exhaust is replaced by a local exhaust system.*

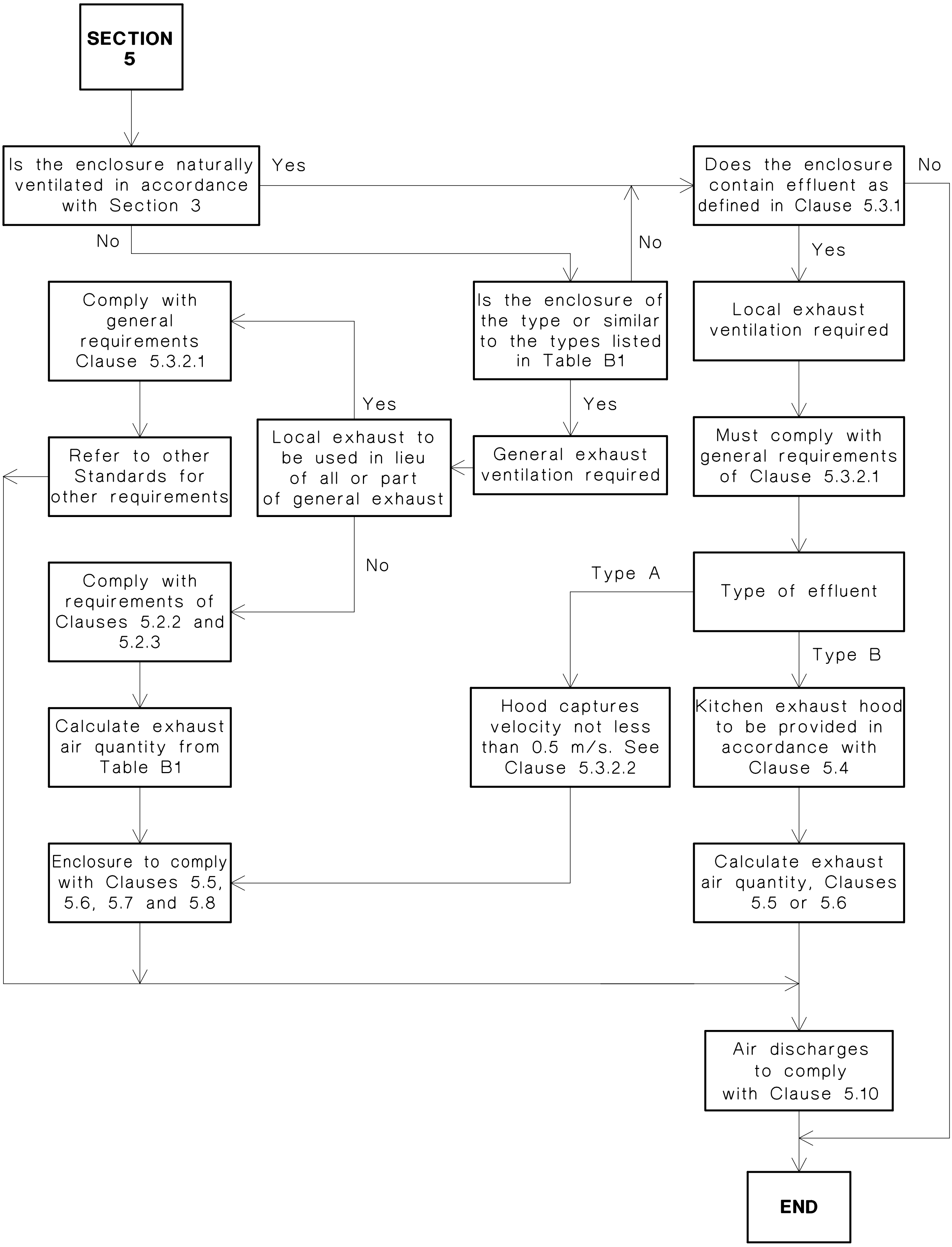


FIGURE 5.1 GENERAL GUIDE FOR APPLICATION OF SECTION 5

5.3 LOCAL EXHAUST

5.3.1 Types of effluent requiring local exhaust

Effluent having any one or more of the following properties shall be removed by local exhaust in accordance with Clause 5.3.2.

(a) *Type A*: Significant localized sources of toxic, irritant, asphyxiant, offensive, flammable or explosive gases, dusts, fumes or vapours, excluding effluent arising from cooking processes and contaminants controlled in accordance with Section 4, Section 7 (excluding direct ducting from tail pipes in accordance with Clause 7.6.3.2), or Appendix B.

(b) *Type B*: Heated air with or without water or grease vapour produced by cooking equipment employed for the preparation of food for commercial or institutional purposes and having a total maximum input exceeding 8 kW for an electrical appliance, or total gas input 29 MJ/h for a gas appliance, or any deep fryer appliance.

Microwave cookers and similar low-power cooking equipment used for commercial purposes, which are used infrequently or used solely for the purposes of reheating food, shall be exempted from this requirement. Apparatus used specifically for space heating, apparatus in plant enclosure, apparatus used solely for domestic purposes and apparatus that does not cause objectionable conditions in the enclosure shall also be exempted.

C5.3.1 *The Clause formally sets out the definition of a Type A effluent. Typically, Type A effluents are emitted by welding processes, chemical and microbiological reactions, degreasing tanks, acid tanks and certain woodworking operations. For the purposes of this Standard, Type A effluents do not include environmental tobacco smoke contaminants. Type B effluents are more of a nuisance than dangerous, and the most common application would relate to kitchen exhaust hoods.*

5.3.2 Effluent removal

5.3.2.1 *General requirements*

The removal of effluent by means of local exhaust shall be as follows:

(a) The effluent shall be collected as it is being produced, as close as practicable to the source of generation, using special surroundings, hoods, surface-mounting exhaust-air intakes, and the like. The airflow rates shall be such as will ensure positive capture and removal of the effluent.

(b) Local exhaust airflow rates shall be in accordance with the relevant Australian Standards.

NOTE: At present, relevant Australian Standards are AS 1482, AS 2676 and AS/NZS 2243.8. In the absence of relevant Australian Standards, the current recommendations that appear in the American Conference of Governmental Industrial Hygienists Industrial Ventilation manual should be adopted.

(c) Local exhaust may complement general exhaust and may be a substitute for the general exhaust where the total contaminant level is maintained at a level equal to or less than that achieved by the general exhaust system.

(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 ventilated apparatus.

(e) 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.

> ***C5.3.2.1*** *Apart from establishing requirements for local exhaust, the Standard does not attempt to prescribe the form, capture velocities or airflow rates of hoods or other means used for local exhaust of effluents with the exception of kitchen exhaust. Australian Standards for the design of laboratories should be referred to in regard to local exhaust and make-up air provisions in such applications.*

5.3.2.2 *Type A effluent removal*

In addition to the requirements of Clause 5.3.2.1, the velocity of air as it enters the hood, special surrounding or exhaust air intake used in the removal of Type A effluent shall be not less than 0.5 m/sec averaged across the opening.

5.3.2.3 *Type B effluent removal*

Hoods for the collection of Type B effluent shall be provided. Where the apparatus specified in Clause 5.3.1(b) is a cooking appliance, a kitchen exhaust hood complying with Clause 5.4 shall be installed above the appliance.

5.4 KITCHEN EXHAUST HOODS

5.4.1 General

Requirements for low velocity air-filtered kitchen exhaust hoods are set out in this Clause for the four common types and configurations of hoods that apply to the five most common types of cooking processes. Clause 5.5 sets out a prescriptive procedure for hood design and Clause 5.6 sets out an engineered procedure for hood design. Required kitchen exhaust hoods shall comply with Clause 5.5 or 5.6, and Appendix C. Appendix C sets out construction and installation requirements for these hoods.

Alternative exhaust hood designs including proprietary designs and specialized (application specific) designs may be used provided that it can be established that the performance of such hoods is at least equivalent to the hoods described in this Section.

> ***C5.4.1*** *This Clause sets out two procedures for hood design, a prescriptive procedure and an engineered procedure. The prescriptive procedure does not allow for cooking process diversity and the entire hood is required to be designed on the worst case cooking process type under the hood. The engineered procedure does allow for cooking process diversity and each section of hood may be individually calculated using the appropriate cooking process factors. Where the hood being designed does not incorporate cooking process diversity, the engineered procedure may produce a higher ventilation requirement than the prescriptive procedure. The prescriptive procedure should be used in these cases.*

5.4.2 Hood and cooking process types

5.4.2.1 *General*

The four common types and configurations of hoods and the five types of cooking processes are defined in Clauses 5.4.2.2 and 5.4.2.3.

5.4.2.2 *Hood type nomenclature*

Hood type nomenclature is as follows:

(a) *Hood Type 1* Low sidewall (see Figure C3)—where the canopy does not extend at least 150 mm beyond the edge of the cooking surface.

(b) *Hood Type 2* Corner-mounted (see Figure C4)—subject to a maximum length to width ratio of 2:1.

(c) *Hood Type 3* Sidewall (see Figure C5).

(d) *Hood Type 4* Island (see Figure C6).

NOTE: See Appendix C for typical sketches of hood types.

5.4.2.3 *Cooking process type nomenclature*

Cooking process type nomenclature is as follows:

(a) *Process Type 1*—Non-grease producing equipment and void spaces under the hood, which serve to ventilate other cooking equipment.

(b) *Process Type 2*—Low-grease, medium-heat producing equipment such as griddles, ranges, conventional fryers, tilting skillets, steam kettles and gas ovens.

(c) *Process Type 3*—High-grease, low-heat producing equipment such as electric deep-fat fryers, grooved griddles, hot tops and hot top ranges.

(d) *Process Type 4*—High-grease, medium-heat producing equipment such as countertop barbecues and gas-fired deep fat fryers.

(e) *Process Type 5*—High-grease, high-heat producing equipment such as woks, salamanders, and open flame charcoal equipment utilizing solid fuel.

5.4.3 Dishwashing hoods

Where an exhaust hood is located over a dishwashing machine, air filtration is not required and the exhaust airflow rate shall provide a hood face velocity of not less than 0.3 m/s.

5.4.4 Proprietary exhaust allowance

Where kitchen appliances are provided with proprietary exhaust systems, that is, exhaust spigots ready for connection to an exhaust system, the exhaust airflow rate shall be in accordance with the manufacturer's requirements. Separate exhaust hoods may not be required in this case (see Clause 5.4.1).

5.4.5 Charcoal and solid fuel appliances

All hoods and associated exhaust systems for use over charcoal and solid fuel appliances shall be provided with separate systems, and shall not be combined with a system serving grease- or oil-generating or oil-heating appliances.

NOTE: Where the exhaust air is likely to significantly pollute the outdoor air, the exhaust discharge may be required to be treated to reduce the concentration of contaminants. Reference to pollution control authorities is recommended for requirements relating to the quality and concentration of discharge contaminants.

5.5 KITCHEN EXHAUST HOOD AIRFLOW—PRESCRIPTIVE PROCEDURE

The exhaust airflow rate (Q) for a hood shall be calculated using one of the equations set out in Table 5.1. The particular equation used in calculating the exhaust airflow rate shall be dependent on the worst case. For example, where a Type 4 cooking process is located under the same hood as a Type 2 cooking process, the equation applicable to the Type 4 cooking process shall be used for the entire hood. The calculated exhaust airflow rate shall never be less than 300 L/s per square metre of cooking surface.

NOTE: For oven applications, the cooking surface area is deemed to be equivalent to the oven door area.

The equations of Table 5.1 are based on a minimum overhang, beyond the edge of the cooking surface or point (location) of discharge of effluent if not from cooking surface, of 150 mm for cooking process Types 1 to 4 and 300 mm for cooking process Type 5. The face of Type 1 hoods shall not exceed a maximum horizontal setback of 300 mm from the leading edge of the kitchen appliance. The length of the hood shall not be less than the length of the kitchen appliance.

NOTE: Fan-forced cooking appliances may require more detailed consideration of overhang due to the increased penetration of the effluent into the enclosure.

TABLE 5.1

CALCULATION OF MINIMUM HOOD EXHAUST AIRFLOW RATE

Hood type	Cooking process			
	Type 1 and Type 2	**Type 3**	**Type 4**	**Type 5**
Hood Type 1 Low sidewall	$Q = 400 \times L$	$Q = 600 \times L$	$Q = 800 \times L$	$Q = 800 \times L$
Hood Type 2 Corner mounted Hood Type 3 Sidewall Hood Type 4 Island	$Q = 190 \times P \times H$	$Q = 250 \times P \times H$	$Q = 375 \times P \times H$	$Q = 375 \times P \times H$

LEGEND:

Q = exhaust airflow rate, in litres per second

L = length of hood, in metres

P = inside perimeter of hood over all exposed sides, in metres

H = height of hood above cooking appliance, in metres

5.6 KITCHEN EXHAUST HOOD AIRFLOW—ALTERNATIVE PROCEDURE

NOTE: The alternative procedure should only be applied to cases where two or more cooking appliances are grouped together under one exhaust hood. Where a single appliance is provided with a dedicated hood, the prescriptive procedure should be applied.

5.6.1 Low sidewall hoods (Hood Type 1)

The minimum design criteria for systems utilizing low sidewall (backshelf) type exhaust hoods may be calculated as follows:

(a) 500 L/s.m^2 of cooking surface for cooking process Types 1 and 2.

(b) 750 L/s.m^2 of cooking surface for cooking process Types 3 and 4

(c) 1000 L/s.m^2 of cooking surface for cooking process Type 5.

5.6.2 Corner, sidewall and island hoods (Hood Types 2, 3 and 4)

The minimum design criteria for exhaust air quantities of island and sidewall type hoods may be calculated using the following equation:

$$Q = V_f PH \qquad \ldots 5$$

where

Q = exhaust airflow rate, in litres per second

V_f = velocity factor of each cooking appliance

P = inside perimeter of hood over all exposed sides of each piece of equipment, in metres

H = vertical distance from the top of cooking appliance to the lower edge of the hood, in metres

Velocity factors shall be used as applicable to each cooking appliance under the hood see Table 5.2:

TABLE 5.2

VELOCITY FACTORS APPLICABLE TO EACH COOKING APPLIANCE UNDER A HOOD

Velocity factors V_f	Cooking process type
150	1
250	2
375	3
500	4
750	5

5.7 AIR FROM ENCLOSURES HAVING EXHAUST AIR REQUIREMENTS

5.7.1 General requirements

Air from an enclosure ventilated by a required general or local exhaust system shall not be recycled to other enclosures of different use.

5.7.2 Air pressures

The air pressure of enclosures served by a required general exhaust system shall be less than that of adjacent enclosures not served by required exhaust systems, during normal operation of the system.

NOTE: This may be evidenced by net airflow from the higher pressure to the lower pressure combined with no significant transfer of air into the high-pressure area.

5.8 REPLENISHMENT OF EXHAUST AIR

5.8.1 Source

The air exhausted from enclosures shall be replenished by outdoor air or by make-up air of an acceptable quality from an adjacent enclosure. Make-up air shall not be drawn from an enclosure ventilated by a required exhaust system or from an adjacent car park. Make-up air from an enclosure ventilated by a required exhaust system may be acceptable for unoccupied enclosures, for example, make-up air from a car park for a garbage room exhaust system. Where desired, or where make-up air is not available, a supply-air ventilation system complying with Section 4 may be provided. Where the make-up air is drawn from outside the building, the intake shall comply with Clause 4.3.

Make-up air from an enclosure served by a non-required exhaust system in conjunction with a mechanical supply or natural ventilation system is not prohibited.

5.8.2 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, as necessary, to accommodate the amount of make-up air required for the exhaust ventilation system.

5.8.3 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 between enclosures does not exceed 12 Pa.

5.8.4 Electrical interlocking of exhaust and make-up

When a local exhaust system requires a mechanical supply air system for its make-up air, the system shall be interlocked so that the supply system will always run when the exhaust system is operated.

5.9 COMBINATION OF EXHAUST SYSTEMS

Exhaust-air systems that serve different types of enclosures shall be kept separate unless they are of a similar nature. Enclosures that are similar in nature may be served by common exhaust systems, and are grouped in Table 5.2.

> ***C5.9*** *It should be understood that duct connections between enclosures in different groupings may present a problem when the exhaust system is not in operation. It may also be unacceptable to combine process exhausts or exhausts from laboratory fume cupboards during system operation.*

TABLE 5.2

ENCLOSURES THAT MAY BE SERVED BY A COMMON EXHAUST SYSTEM

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

NOTES:

1 Where an airlock 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 airlock or privacy lock. Make-up air and relief openings should comply with Clause 5.8. An airlock or privacy lock need not be exhausted separately.

2 Table 5.2 is not intended to be an exhaustive list of possible enclosures.

5.10 AIR DISCHARGES

5.10.1 General

All exhaust 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. For the purpose of this Standard, any of the discharges at the flow rates specified in Table 5.3 shall be deemed to contain objectionable effluent.

Discharges that are not deemed to contain objectionable effluent shall comply with Clause 5.10.2 and discharges that are deemed to contain objectionable effluent shall comply with Clause 5.10.3.

TABLE 5.3

OBJECTIONABLE EFFLUENT DISCHARGES

Exhaust-air discharge	Flow rate
Type A effluent as defined in Clause 5.3.1(a)	Any flow rate
Type B effluent as defined in Clause 5.3.1(b)	> 1000 L/s (see Clause 5.10.3)

5.10.2 Discharges not deemed objectionable

Air discharges that are not deemed to contain objectionable effluent (see Clause 5.10.1) 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 the distance given in Table 5.4 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, to the extent practicable, a danger to health or a nuisance will not occur; and

(d) not less than the distance given in Table 5.4 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 roof subject to regular traffic are not recommended. Where discharge extends less than 3 m above a pedestrian thoroughfare, the discharge should not create a nuisance.

2 Where large, relatively clean or high velocity discharges are soundly engineered, separations less than specified in Table 5.4 may be acceptable if it can be proved that any such engineered discharge does not significantly pollute the outdoor air.

TABLE 5.4

MINIMUM SEPARATION DISTANCES FROM DISCHARGES TO INTAKES, BOUNDARY OR NATURAL VENTILATION DEVICE

Airflow rate L/s	Minimum distance m
< 200	1
< 400	2
< 600	3
< 800	4
< 1000	5
≥ 1000	6

5.10.3 Discharges deemed objectionable

Air discharges that are deemed to contain objectionable effluent (see Clause 5.10.1) shall be in accordance with Clause 5.10.2 and—

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

(b) for a Type A effluent (see Clause 5.3.1 which excludes cooking effluents), be situated—

  (i) at least 3 m above the roof at point of discharge;

  (ii) above any part of the building (or adjacent building) that is within 15 m (horizontally) or the discharge point; and

  (iii) at least 3 m above a thoroughfare or roof subject to regular traffic, but within 15 m of the discharge point.

  In the case of a pitched roof, at least 1 m above the ridge.

(c) located not less than 6 m from a property boundary, any outdoor air intake opening or any natural ventilation device or opening; and

(d) treated to reduce the concentration of contaminants when required.

Where it can be demonstrated that special filtration processes will remove the contaminants from the cooking process exhaust gas and prevent exhaust operation if filters are not in place, horizontal discharge of kitchen exhaust of flow rates greater than 1000 L/s may be acceptable. In these cases, the flow rate may be taken as the actual flow rate multiplied by the lowest fractional efficiency of the filtration process.

NOTE: Where the outdoor air is liable to be significantly polluted, Item (d) may be invoked. Reference to pollution control authorities is recommended for control requirements relating to concentration of contaminants.

5.10.4 Non-required discharges

Spill air and relief air shall be discharged to atmosphere is such a manner as not to cause nuisance to occupants in the building, occupants of neighbouring buildings or members of the public.

Where air that has ventilated enclosures within the building is discharged from the building, it may re-enter the ventilation system provided that the net inflow of uncontaminated outdoor air is not less than that required by Section 4.

> ***C5.10.4*** *This provision allows a non-required air discharge point to be located closer to an outdoor air intake point than would be allowed for a required exhaust air discharge point and would apply to non-required design provisions such as those applied to an economy air cycle.*

SECTION 6 MECHANICAL VENTILATION OF ENCLOSURES USED FOR PARTICULAR HEALTH CARE FUNCTIONS

6.1 SCOPE OF SECTION

This Section applies to the mechanical ventilation requirements of particular types of health care enclosures, which differ from those of other mechanically ventilated enclosures. These particular enclosures are conventionally known as operating rooms, sterile stores/set-up rooms, isolation rooms, recovery rooms, autopsy rooms and dirty utility rooms.

NOTE: The need for the segregation of systems serving operating rooms should be assessed on a case by case basis.

6.2 APPLICATION OF SECTION

Requirements of this Section apply to the minimum mechanical ventilation requirements for particular types of health care enclosures, as follows:

(a) For operating rooms, Clause 6.3 shall apply.

(b) For sterile store and set-up rooms, Clause 6.4 shall apply.

(c) For infectious isolation rooms, Clause 6.5 shall apply.

(d) For protective isolation rooms, Clause 6.6 shall apply.

(e) For recovery rooms, Clause 6.7 shall apply.

(f) For autopsy rooms, Clause 6.8 shall apply.

(g) For dirty utility rooms, Clause 6.9 shall apply.

Figure 6.1 provides a flow chart on the application of this Section.

6.3 OPERATING ROOMS

6.3.1 General

Operating rooms shall be mechanically ventilated in accordance with Clauses 6.3.2 to 6.3.7.

6.3.2 Air change rate

The supply air rate shall be not less than that calculated to achieve 20 air changes per hour in the operating room.

6.3.3 Recirculation air rate

Recirculated air rate shall not be greater than 50% of the supply air rate.

Air supplied to operating theatres and sterile store and set-up rooms shall not be recirculated from any other enclosure type.

6.3.4 Outdoor air rate

The minimum outdoor airflow rate shall be 20 L/s per person at an occupancy of 5 m^2 per person or that resultant from Clause 6.3.3, whichever is greater.

6.3.5 Supply air filtration

The supply air shall be filtered, using high efficiency particulate air (HEPA) filters in accordance with AS 4260 Type 1 Class A Grade 2 with a minimum efficiency of 99.99%.

NOTE: HEPA filters should, where possible, be located in a terminal position, that is, close to or at the supply air register in the operating room.

6.3.6 Exhaust grille location

Exhaust and recirculation air shall be drawn from the room via grilles with not less than 50% of the exhaust and recirculation air being drawn through low level grilles, the bottom of which shall not be more than 300 mm above floor level.

6.3.7 Room air pressure

The air pressure within the operating room shall be maintained at a higher rate than that in adjacent enclosures other than sterile store and set-up rooms, which are required to have a room air pressure greater than that in the operating room.

Pressure differentials across doors shall be such that—

(a) the force to open any door against the combined effect of the air pressure differential and any self-closing mechanism does not exceed 110 N at the door handle; and

(b) doors are not prevented from closing and latching, that is, the force due to air pressure on the door leaf does not exceed the force of the self-closing or automatic-closing device and latching device.

6.4 STERILE STORE AND SET-UP ROOMS

6.4.1 General

Sterile store and set-up rooms shall be mechanically ventilated in accordance with Clauses 6.4.2 to 6.4.4.

6.4.2 Outdoor air rate

The minimum outdoor airflow rate delivered to the isolation room shall be the greater of 10 L/s per person and 2 L/per square metre.

Air supplied to sterile store and set-up rooms and operating rooms shall not be recirculated from any other enclosure type.

6.4.3 Supply air filtration

The supply air shall be filtered, using high efficiency particulate air (HEPA) filters in accordance with AS 4260 Type 1 Class A Grade 2 with a minimum efficiency of 99.99%.

NOTE: HEPA filters, where possible, should be located in a terminal position, i.e., close to or at the supply air register in the sterile store or set-up room.

6.4.4 Room air pressure

The air pressure within the sterile store and set-up enclosures shall be maintained higher than that in adjacent enclosures. Pressure differentials shall comply with the door opening limitations of Clause 6.3.7.

6.5 INFECTIOUS ISOLATION ROOMS

6.5.1 General

Infectious isolation rooms shall be mechanically ventilated in accordance with Clauses 6.5.2 to 6.5.5.

6.5.2 Recirculation air rate

Air shall not be recirculated from infectious isolation rooms to any other enclosure.

6.5.3 Outdoor air rate

The minimum outdoor airflow rate delivered to the infectious isolation room shall be the greater of 10 L/s per person and 2 L/s per square metre.

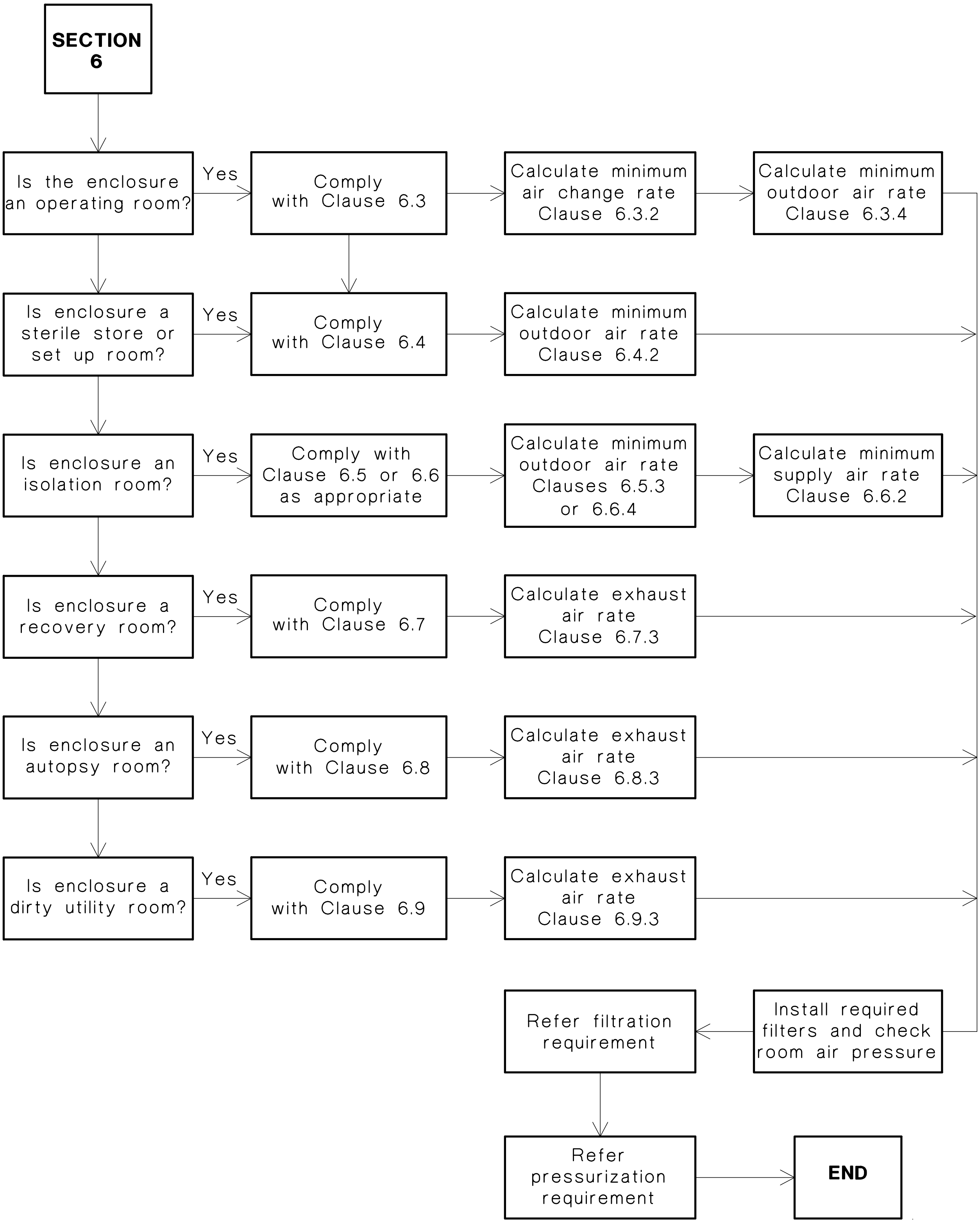


FIGURE 6.1 GENERAL GUIDE FOR APPLICATION OF SECTION 6

6.5.4 Exhaust air rate

Infectious isolation rooms shall be mechanically exhausted to atmosphere as a Type A effluent at a rate not less than six air changes per hour.

NOTE: Filtering of exhaust air may be necessary.

6.5.5 Room air pressure

Infectious isolation rooms (for example, isolation rooms used to isolate patients suffering from 'droplet infection' diseases) shall have controlled room air pressure that is lower than that of adjacent enclosures. The differential pressure between the isolation room and adjacent enclosures shall be automatically controlled and shall comply with the door opening limitations of Clause 6.3.7.

6.6 PROTECTIVE ISOLATION ROOMS

6.6.1 General

Protective isolation rooms shall be mechanically ventilated in accordance with Clauses 6.6.2 to 6.6.5.

6.6.2 Supply air rate

Supply air shall be delivered to a protective isolation room to provide not less than 15 air changes per hour.

6.6.3 Recirculation air rate

Supply air delivered to a protective isolation room shall not be recirculated to any other room (indirect recirculation of air leaked from the positively pressurized room is acknowledged) unless the air has been filtered using HEPA filters in accordance with AS 4260 Type 1 Class A Grade 2 with a minimum efficiency of 99.99%.

6.6.4 Outdoor air rate

The minimum outdoor airflow rate delivered to the isolation room shall be the greater of 10 L/s per person and 2 L/per square metre.

6.6.5 Room air pressure

Protective isolation rooms used to isolate patients shall have controlled room air pressure that is higher than that of adjacent enclosures. The differential pressure between the isolation room and adjacent enclosures shall be automatically controlled and shall comply with the door opening limitations of Clause 6.2.7.

6.7 RECOVERY ROOMS

6.7.1 General

Recovery rooms shall be mechanically ventilated in accordance with Clauses 6.7.2 and 6.7.3.

> ***C6.7.1*** *The exhalation of anaesthetic gases by patients may present a hazard in inadequately ventilated recovery rooms.*

6.7.2 Recirculated air

Air shall not be recirculated from the recovery room to any other enclosure.

6.7.3 Exhaust air rate

Recovery rooms shall be mechanically exhausted to atmosphere at a minimum airflow rate of the greater of 10 L/s per person, 10 air changes per hour and 4 L/s per square metre.

6.8 AUTOPSY ROOM

6.8.1 General

Autopsy rooms shall be mechanically ventilated in accordance with Clauses 6.8.2 to 6.8.4.

6.8.2 Recirculation air

Air shall not be recirculated from the autopsy room to any other enclosure.

6.8.3 Air change rate

Air shall be exhausted from the enclosure at a rate of not less than 12 air changes per hour.

6.8.4 Exhaust location

Exhaust air shall be drawn from the room via grilles, not less than 50% of the exhaust air being drawn through low level grilles, the bottom of which shall be not more than 300 mm above floor level and discharged to atmosphere as a Type A effluent (see Section 5).

6.8.5 Room air pressure

The air pressure within the autopsy room shall be less than that in adjacent enclosures. Pressure differentials shall comply with the door opening limitations of Clause 6.3.7.

6.9 DIRTY UTILITY ROOMS

6.9.1 General

Dirty utility rooms are enclosures in which contaminated linen, utensils and instruments are located in preparation for cleaning. Dirty utility rooms shall be mechanically ventilated in accordance with Clauses 6.9.2 and 6.9.3.

6.9.2 Recirculation air

Air shall not be recirculated from the dirty utility room to any other enclosure.

6.9.3 Air change rate

The mechanical exhaust rate shall be sufficient to provide not less than 10 air changes per hour.

6.9.4 Room air pressure

The air pressure within dirty utility rooms shall be less than that in adjacent enclosures achieved by the mechanical exhaust system. Pressure differentials shall comply with the door opening limitations of Clause 6.3.7.

SECTION 7 VENTILATION OF ENCLOSURES USED BY VEHICLES WITH COMBUSTION ENGINES

7.1 SCOPE OF SECTION

This Section applies to all enclosures in which vehicles powered by combustion engines are parked, serviced or operated, e.g., car parks, 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. Requirements for specific occupancies located within these enclosures are also given.

> ***C7.1*** *This Standard requires provision of natural or mechanical ventilation to enclosures intended to minimize the potential for adverse health effects from contaminants generated by combustion engines. The amount of ventilation needed depends on the type and quantity of vehicles using the enclosures, the time for which vehicles' engines operate, and the time that occupants spend in the enclosure. Higher ventilation airflow needs to be provided for car parks for which occupants' exposure is of extended duration (e.g., parking attendant).*

7.2 APPLICATION OF SECTION

7.2.1 General application

Requirements of this Section shall be applied as follows:

(a) For car parks, Clauses 7.3 to 7.5 and 7.7 to 7.14 shall apply.

(b) For enclosures other than car parks, Clauses 7.6 to 7.12 shall apply.

(c) For enclosures within car parks Clause 7.2.3 shall apply.

Figure 7.1 provides a flow chart on the application of this Section.

7.2.2 Performance application

The ventilation system shall ensure that concentrations of atmospheric contaminants within the enclosure do not exceed occupational or community exposure limits listed in this Clause. Ventilation shall be provided to satisfy the minimum ventilation requirements by any of the following means:

(a) Natural ventilation via openings complying with Clause 7.4.1 with prescriptive openings in accordance with Clause 7.4.2 or provided via openings for which the equivalent ventilation flow rate calculated in accordance with Clause 7.4.4 is not less than the minimum ventilation requirement calculated in accordance with Clause 7.5.4.

(b) Mechanical ventilation by means of supply air, exhaust air or a combination of supply and exhaust air via openings complying with Clause 7.5.2 with a flow rate not less than the minimum ventilation requirement calculated in accordance with Clause 7.5.4.

(c) A combination of natural ventilation and mechanical ventilation. Those areas provided with natural ventilation shall comply with Clause 7.4. Those areas provided with mechanical ventilation shall comply with Clause 7.5 and shall be provided with mechanical supply and exhaust. Both the supply and exhaust ventilation rates shall be not less than the required ventilation rate calculated in accordance with Clause 7.5.4.

(d) Any other arrangement that is demonstrated to limit the CO concentration, between 900 mm and 2500 mm above the floor, everywhere to—

(i) 60 ppm 1 h maximum average;

(ii) 100 ppm peak value; and

(iii) 30 ppm (TWA) 8 h.

C7.2.2 *This Section recognizes the need to protect the health of both the general public and the workers. In its preparation, the recommendations of authorities such as the National Occupational Health and Safety Commission (NOHSC), the National Environment Protection Council (NEPC) and the National Health and Medical Research Council (NHMRC) were considered. Ventilation rates are calculated on the following exposure criteria available at the time of publication. NOHSC has set an 8 h time-weighted average exposure limit of 30 ppm (34 mg/m^3) for CO. The NEPC and NHMRC has set a 9 ppm exposure limit for 8 h. This exposure limit is approximately equivalent to a predicted 5% COHb level, which relates to a 60 ppm exposure limit for an hour or a 100 ppm exposure limit for 30 min (both equivalent to a predicted COHb level of 2%). The NHOHSC ambient CO level over 8 h is equivalent to a COHb level considered to be the current acceptable risk that workers may be exposed to over a working lifetime of exposure (see AS 1668.2 Supp 1).*

Systems designed in accordance with this Standard are based on a 9 ppm ambient CO level and a 51 ppm rise in CO for non-occupied car parks or on a 3 ppm 8 h average ambient CO level and a 27 ppm rise in CO for attendant parking or other occupied situations.

This Section assumes an ambient CO level of 9 ppm. Where data from the relevant EPA or from site monitoring indicates a consistently lower ambient value, then that value may be used in calculations.

For enclosures for which a combination of natural ventilation and mechanical ventilation is used, the effective mechanical airflow rate is the lesser of the supply airflow rate and the exhaust airflow rate, as excess make-up air drawn from naturally ventilated areas may be fully loaded with contaminants, and excess supply air may reduce the effectiveness of the natural ventilation openings. Typical car park ventilation layouts are given in AS 1668.2 Supp 1.

7.2.3 Other occupancies

Other occupancies located within the car park area (e.g., offices, retail premises, mechanics shops, tyre shops, or similar), including fixed locations in the enclosure where car park staff are located, (e.g., pay booth) shall be provided with outdoor air supply that is in accordance with Section 4, and—

(a) sufficient to ensure the outflow of air from these areas/occupancies to be at a velocity of not less than 0.5 m/s when doors and other openings that are normally open in the conduct of the business of the area/occupancy, are open;

(b) outdoor supply of this area/occupancy is the greater of 30 L/s per square metre of floor area and 500 L/s;

(c) sufficient to ensure that the CO concentration in the area/occupancy does not exceed 30 ppm (8 h TWA).

(d) air so supplied may (upon leaving the area or occupancy) be used as supply air to the associated car park.

7.3 NOTATION

7.3.1 Notation

The following notation is used in this Section.

A = the area of the zone or level, in square metres (see Clause 7.5.3)

a = the free area of each opening (see Clause 7.4.4)

C = the contaminant generation rate for the zone or level determined in accordance with Clause 7.5.4.1

CF = cycle factor, dimensionless (2 for 2-stroke, 4 for 4-stroke) (see Clause 7.6.3.4)

c_v = the ventilation coefficient for the opening from Table 7.1 (see Clause 7.4.4)

c_{av} = average value of c_v for all openings (see Clause 7.4.4)

c_f = cross-ventilation coefficient from Table 7.2 (see Clause 7.4.4)

D = the extent of unobstructed space from a required ventilation opening (see Figure 7.7 and Table 7.1.

d_1 = the average driving distance, in metres, within the zone or level under consideration for the exit of a car parked there (see Clause 7.5.4.1)

d_2 = 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 under consideration, but excluding any part of the exit route designated as queuing areas and ventilated in accordance with Clause 7.6 (see Clause 7.5.4.1)

E = the staff exposure factor determined from Table 7.5

FF = fuel factor, dimensionless (1.08 to be used for C1 petrol and heavier, e.g., diesel fuels) (see Clause 7.6.3.4)

F = the staff usage factor determined from Table 7.5

FR = full VR (see Clause 7.13.4.4)

L = engine capacity, in litres (see Clause 7.6.3.4)

MR = minimum VR (see Clause 7.13.4.5)

n_1 = the number of parking spaces in the zone of level under consideration (see Clause 7.3.2)

n_2 = the number of parking spaces situated in other parts of the car park, having exit routes passing through the zone or level under consideration

n_L = number of parking spaces per exit lane

P = the parking usage factor determined from Table 7.3

PM = manifold pressure, in kilopascals absolute (see Clause 7.6.3.4)

PA = atmospheric pressure, in kilopascals absolute (see Clause 7.6.3.4)

R = engine speed, in revolutions per min (see Clause 7.6.3.4)

T = the vehicle type factor determined from Table 7.4

TA = engine aspiration air temperature, degrees centigrade, downstream of all superchargers, turbochargers, intercoolers, aftercoolers and the like (see Clause 7.6.3.4)

TE = exhaust gas temperature, in degrees centigrade, at tailpipe (see Clause 7.6.3.4)

V = flowrate, in litres per second (see Clause 7.6.3.4)

VE = engine volumetric efficiency, dimensionless (0.9 to be used, unless engine specific date is available) (see Clause 7.6.3.4)

V_o = the total equivalent ventilation rate for all openings (see Clause 7.4.4)

v_o = the equivalent ventilation rate for a single opening (see Clause 7.4.4)

VR = ventilation rate, in litres per second (see Clause 7.13.4.3)

X = the aggregate effective area of openings in the wall having the larger area of openings (see Table 7.2)

Y = the aggregate effective area of openings in the wall having the smaller area of openings (see Table 7.2)

Z = concentration of CO, expressed as a fraction of the ES

7.3.2 Number of car spaces

The number of car parking spaces in an enclosure shall be nominated (n_1). If this information is not shown on the design drawings, the nominated value shall be taken as one-twenty-third (1/23) of floor area of the enclosure 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 7.6.

7.4 CAR PARKS—NATURAL VENTILATION

7.4.1 General

Natural ventilation of car parks is permitted subject to the following conditions:

(a) The lowest point of the floor of the car park being considered shall be not more than 1.2 m below the ground level of the required outdoor clear space, having the permanent ventilation openings along at least one side. For Type 3 in Figure 7.2 this may be achieved on a sloping site by excavation down to a level of within 1.2 m of the lowest car park floor over the required outdoor clear space area (see Figure 7.6).

(b) Outdoor areas immediately outside the required permanent ventilation openings of a car park shall be free of vegetation or other obstructions to the required free flow of air to and from the car park for the minimum distances shown in Figures 7.3, 7.4, 7.5, and 7.6 as appropriate, and extending upwards from a level 1.2 m above the lowest car park floor.

(c) The parking areas shall be free of internal permanent obstructions except as shown in Figure 7.2(b) and (c).

(d) The minimum area of openings provided is calculated in accordance with either Clause 7.4.3 or 7.4.4.

7.4.2 Natural ventilation openings

For natural ventilation openings, the following conditions apply:

(a) For an opening to be considered as unobstructed, there shall be a minimum of 3 m unobstructed space outside the opening (see Figure 7.2).

(b) An opening in the roof or ceiling may be considered to provide cross-ventilation for an opening in a wall, but shall not be considered for another opening in the roof or ceiling.

(c) If an opening, or part thereof, has been allocated to provide ventilation to a part of a car park, then that opening, or part thereof, shall not be considered as contributing to the ventilation of another part of the car park.

(d) All parts of the car park shall be either—

(i) within 20 m of a natural ventilation opening; or

(ii) within 30 m of two natural ventilation openings on separate walls; or

(iii) within 7 m of the shortest path(s) between any natural ventilation opening and any other natural ventilation opening.

7.4.3 Prescriptive procedures

Certain areas of car parks may be naturally ventilated by the provision of a minimum area of fixed openings in accordance with the following:

(a) Areas, other than queuing 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.

(b) Areas, other than queuing 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 7 m from any such opening (see Figure 7.2(a)).

(c) Areas, other than queuing areas, situated within 18 m from either a perimeter that is open to the outside or a perimeter wall having uniformly distributed unobstructed openings of minimum 2 m^2 per car parking space (see Figure 7.2(b)).

Where the permanent ventilation openings are located in adjacent walls, the maximum allowable depth of the car park may be increased as depicted in Figure 7.2(d) with uniformly distributed unobstructed openings of 1.0 m^2 per car parking space on each wall.

(d) Areas, other than queuing areas, situated between opposite perimeter 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 0.5 m^2 per car parking space on each wall (see Figure 7.2(c)).

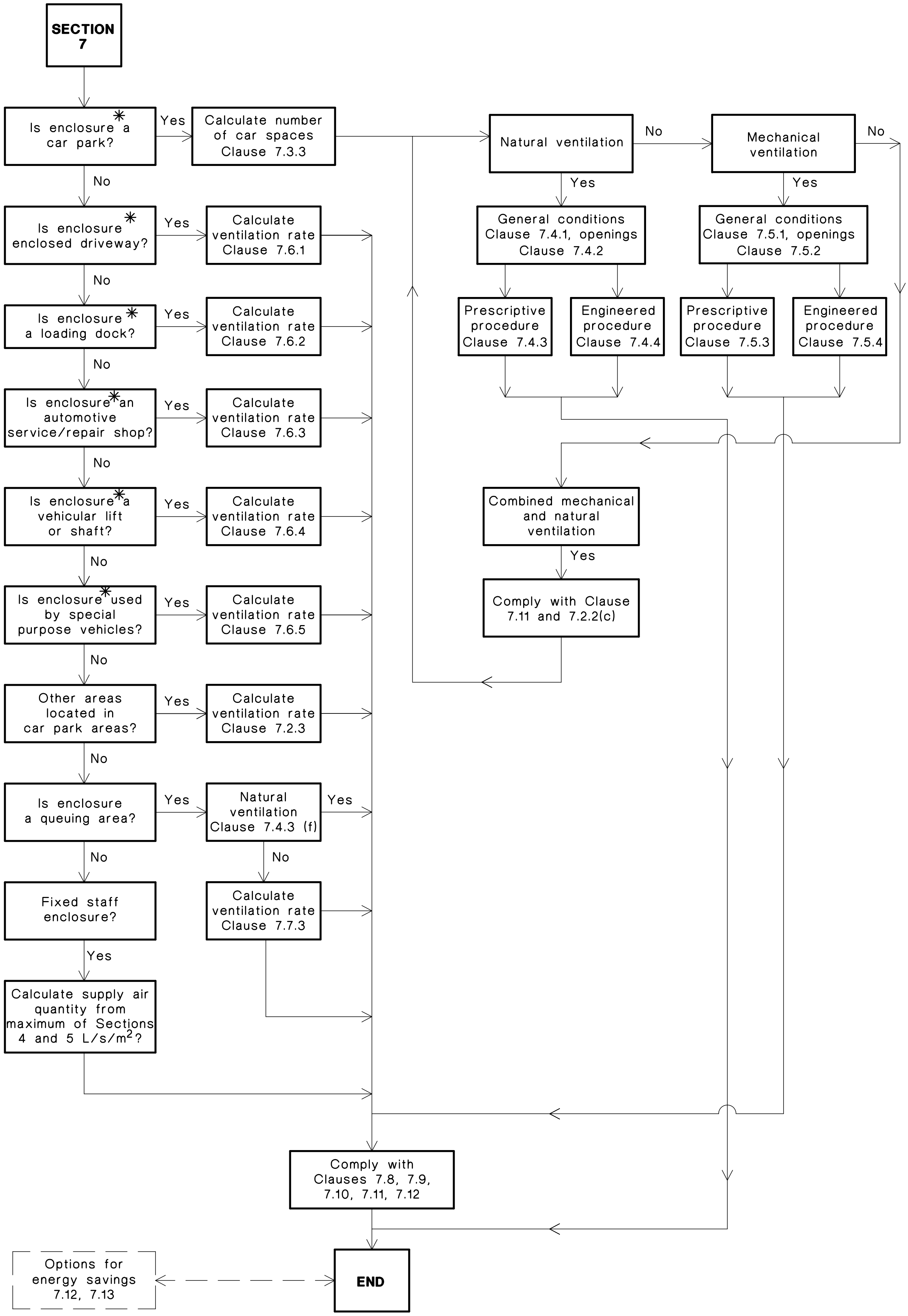
Where the permanent ventilation openings are in opposite walls that are of unequal length, each part shall be treated separately as shown in Figure 7.3.

Where it is not possible to provide cross-ventilation of car parks in excess of 18 m depth in the manner described in Figure 7.2(c), relocation of the required permanent ventilation openings on one side of the car park to the car park roof, as depicted in Figure 7.4, is acceptable.

(e) Areas, other than queuing areas, where the car park can be deemed to be a combination of Types in Figure 7.2 and those shown in Figures 7.4 and 7.5, parts of the combination shall be treated individually in accordance with relevant type.

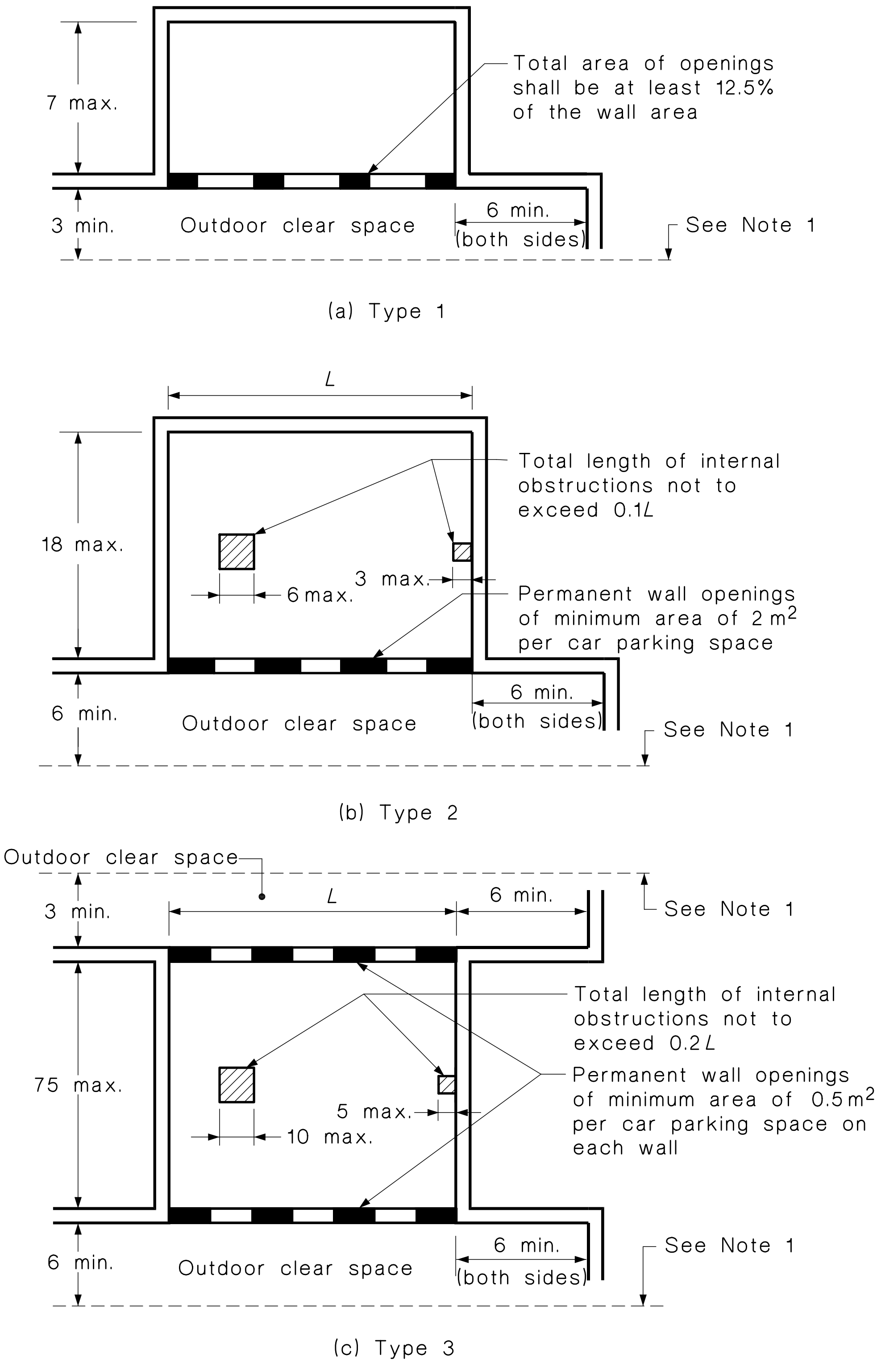
(f) Queuing areas situated within 10 m from either a perimeter that is open to the outside or a perimeter wall having evenly distributed openings at least 2 m high for at least 90% of the full length of the queuing area.

In general, enclosures that are naturally ventilated in accordance with these requirements are deemed to comply with Clause 7.2.2.



* Enclosure or part thereof as appropriate.

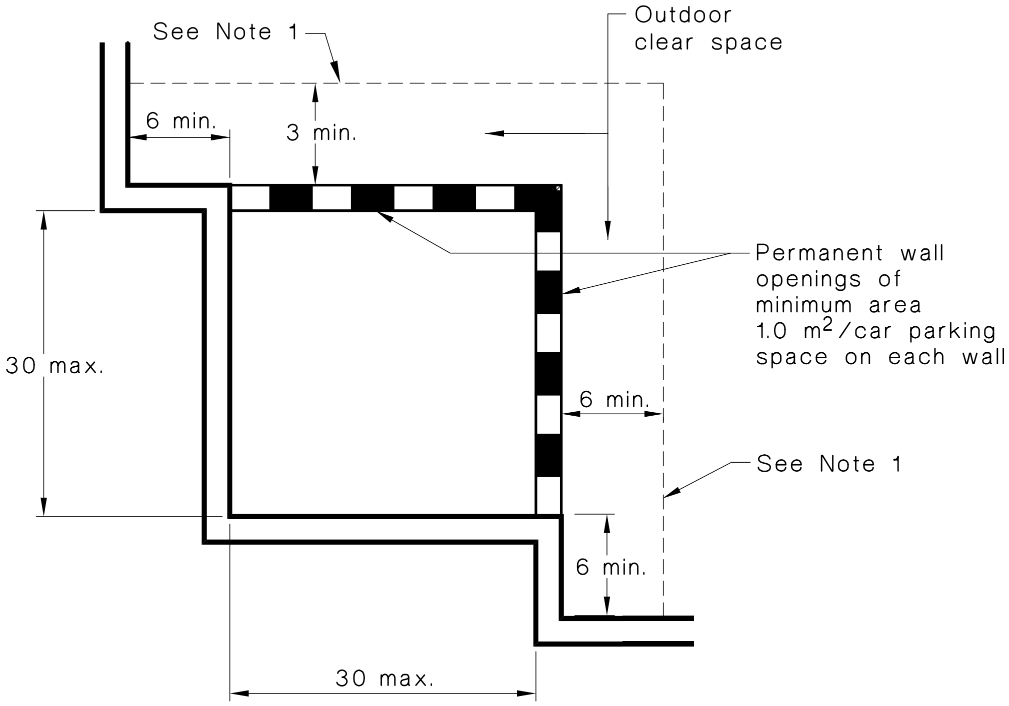
FIGURE 7.1 GENERAL GUIDE FOR APPLICATION OF SECTION 7



DIMENSIONS IN METRES

NOT TO SCALE

FIGURE 7.2 (in part) NATURAL VENTILATION OF CAR PARKS



(d) Type 4

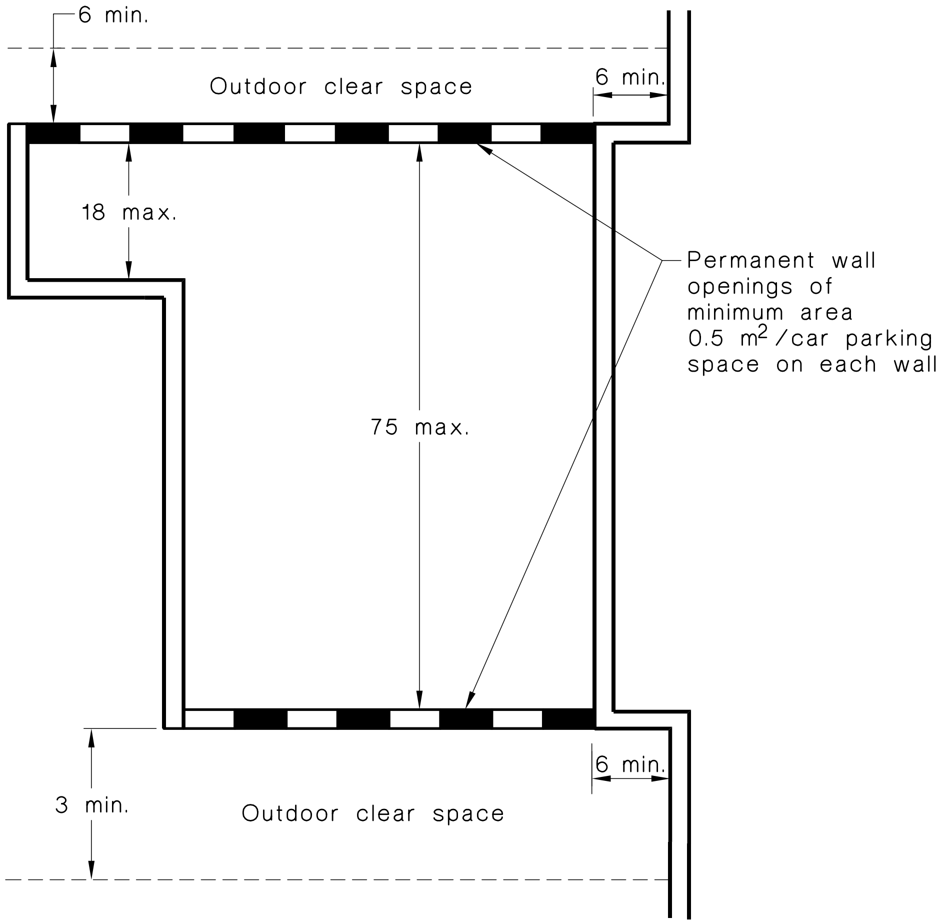
NOTES:

1 Adjacent building or permanent vertical obstruction to horizontal airflow. The outdoor clear space between the car park and this obstruction to be free of vertical obstructions, such as awnings, extended upper floors, and the like, unless appropriately increased.

2 Total length of internal obstructions such as stairs, lifts, switchrooms, and columns greater than 1.2 m width shall not exceed 10 m. Separation between adjacent obstructions shall be at least the one half length of the larger obstruction.

DIMENSIONS IN METRES

FIGURE 7.2 (in part) NATURAL VENTILATION OF CAR PARKS



DIMENSIONS IN METRES

FIGURE 7.3 PERMANENT OPENINGS IN UNEQUAL WALLS

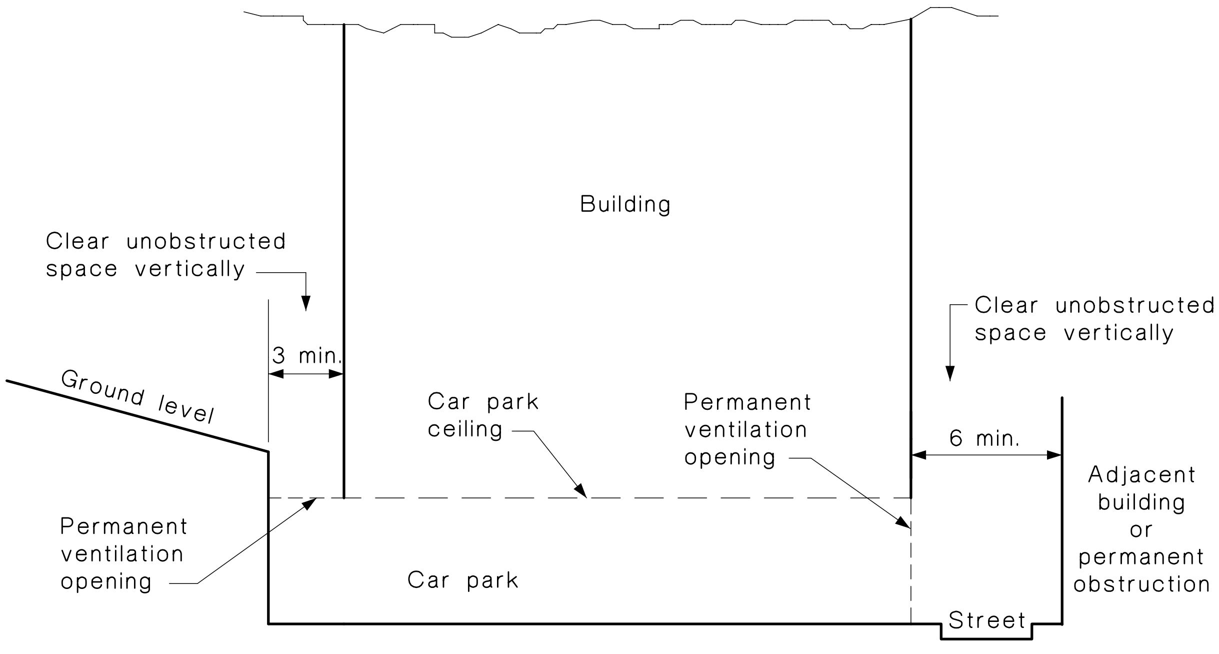


FIGURE 7.4 ELEVATION OF TYPE 3 CAR PARK–ROOF OPENINGS

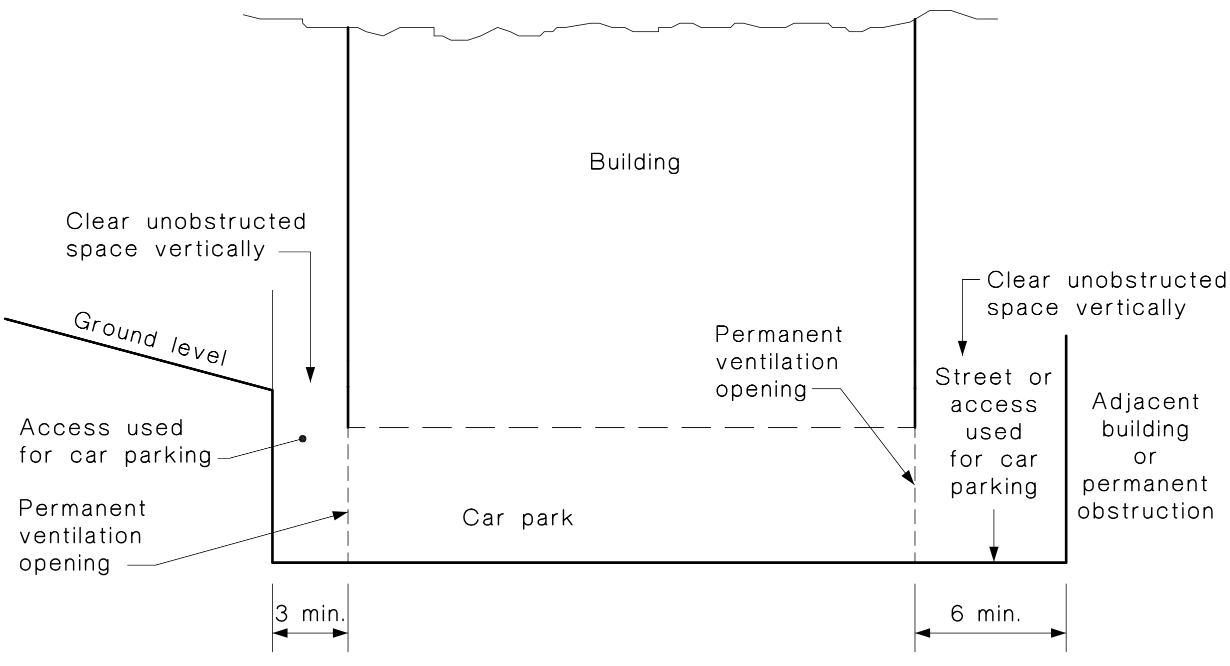
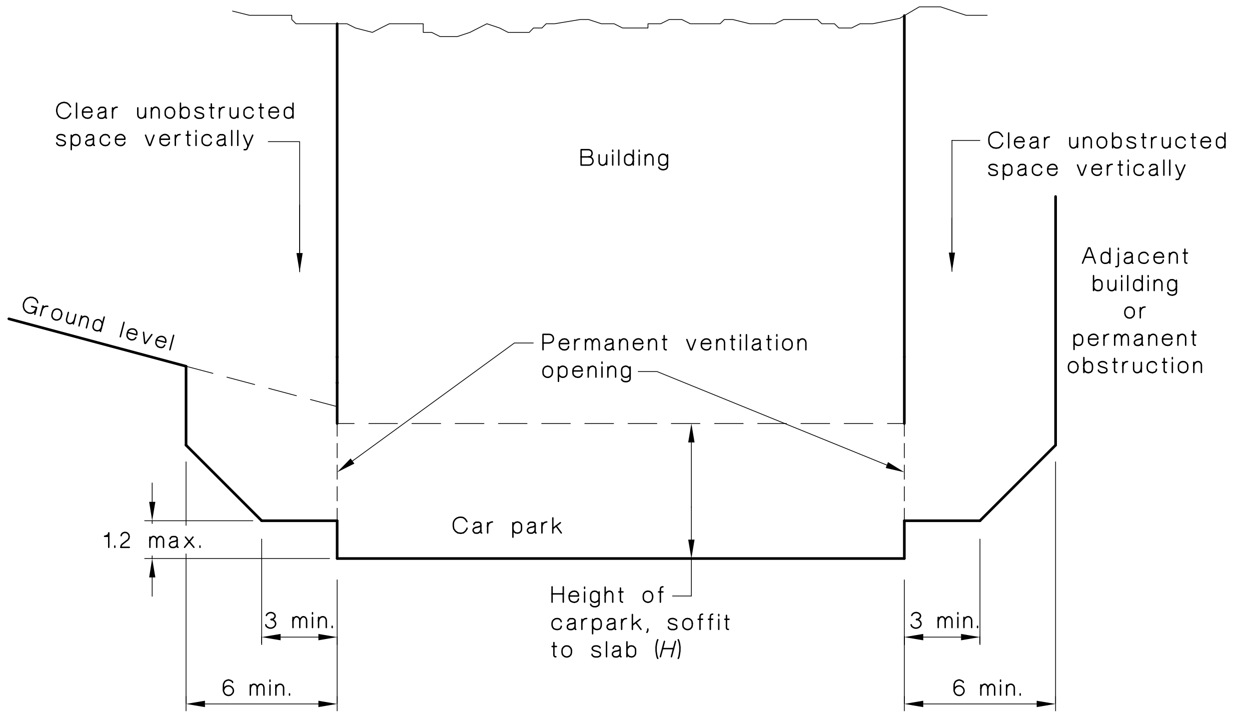


FIGURE 7.5 ELEVATION OF TYPE 3 CAR PARK–CLEAR SPACE USED FOR ACCESS AND PARKING



DIMENSIONS IN METRES

FIGURE 7.6 ELEVATION OF TYPE 3 CAR PARK WITH RECESSED FLOOR LEVEL

7.4.4 Engineered procedure

As an alternative to the prescriptive requirements of Clause 7.4.3, the area of required natural ventilation openings may be calculated based on the equivalent ventilation rate provided by the natural ventilation openings proposed.

The equivalent ventilation rate for the natural ventilation openings (V_o), in litres per second, shall be the aggregate of the equivalent ventilation rates for each natural ventilation opening (v_o), given by:

(a) For each unobstructed opening with no cross-ventilation openings:

$$v_o = 50 \times a \times c_v \quad \ldots 7(1)$$

(b) For each unobstructed opening having cross-ventilation openings in an opposite wall within 75 m or in a sidewall within 30 m:

$$v_o = 50 \times c_f \times c_{av} \times a \times c_v \quad \ldots 7(2)$$

The total equivalent ventilation rate is then given by:

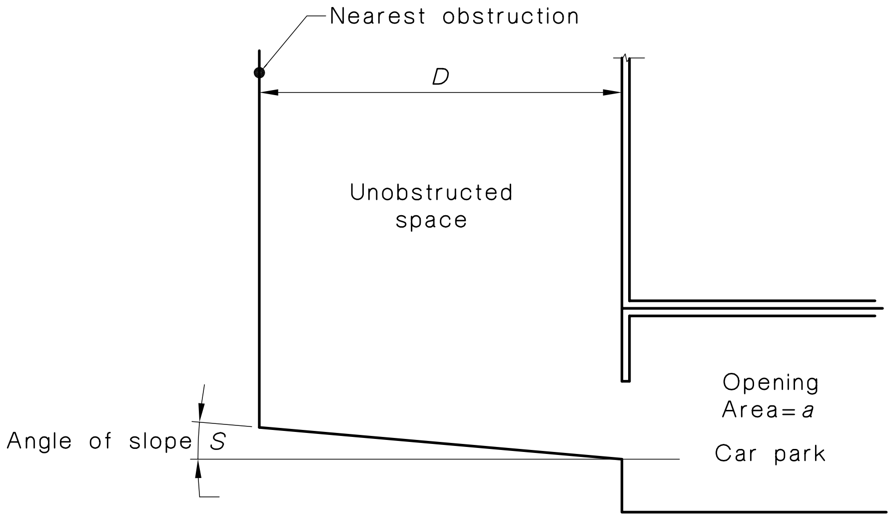
$$V_o = \Sigma v_o \quad \ldots 7(3)$$

TABLE 7.1

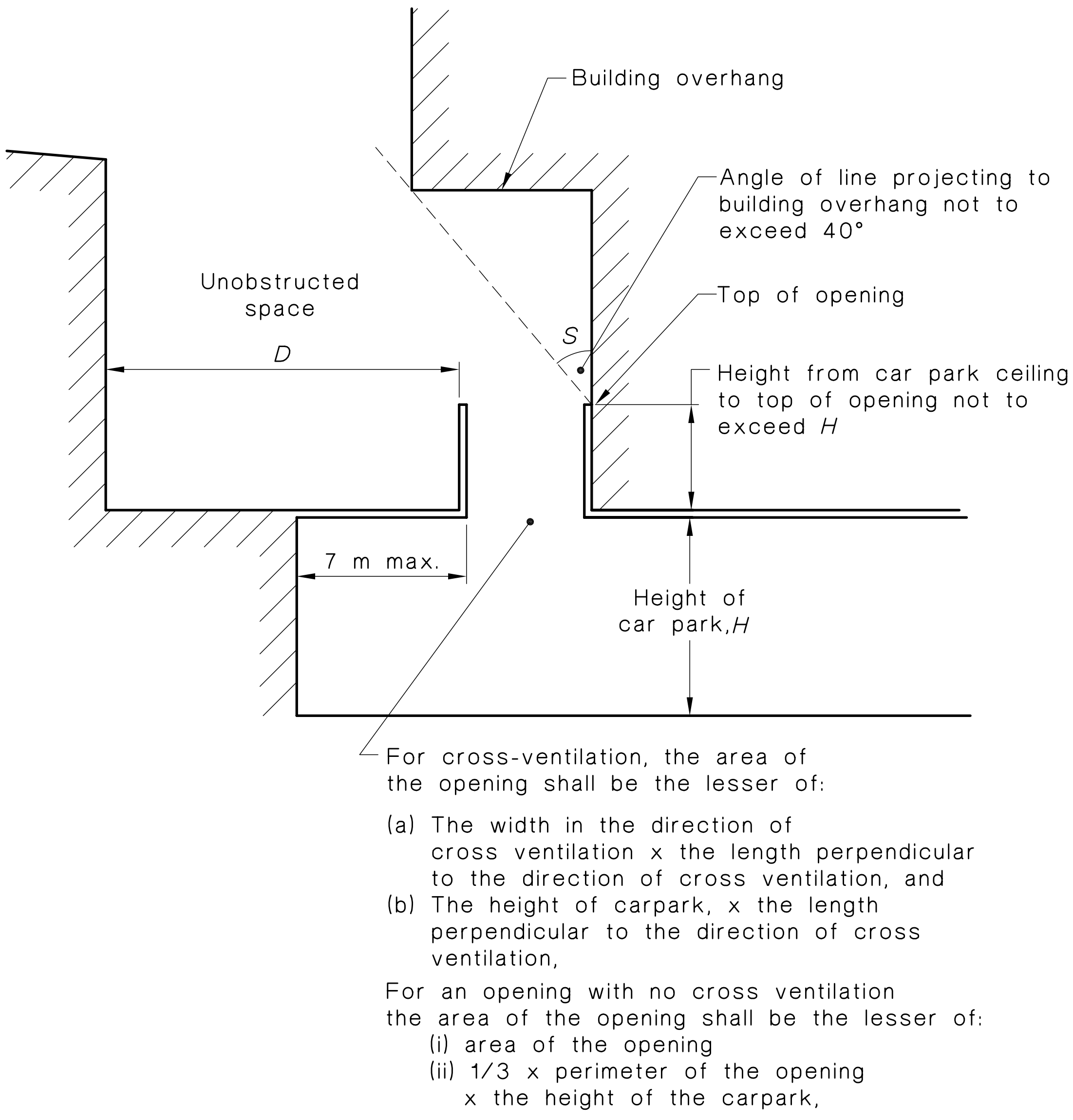
VENTILATION COEFFICIENTS FOR OPENINGS
(see Figure 7.7)

Vertical opening angle of slope(s)	Ventilation coefficient (c_v)		
	D >3	D >6	D >10
0°	0.5	0.75	1
10°	0.44	0.63	0.88
20°	0.38	0.5	0.75
30°	0.31	0.44	0.63
40° (max.)	0.25	0.38	0.5
Horizontal opening	0.25	0.38	0.5

NOTE: Interpolation of ventilation coefficient for intermediate angles and distances is permissible. Extrapolation of coefficient is not allowed.



(a) Vertical opening



(b) Horizontal opening

FIGURE 7.7 SLOPES AND WIDTHS

TABLE 7.2

CROSS-VENTILATION COEFFICIENTS FOR GROUPS OF OPENINGS

Cross-ventilation coefficient for openings in opposite walls	
Ratio of X to Y (r_w)	c_f
1	8.5
2	7.1
3	5.7
4	4.6
Cross-ventilation coefficient for other arrangements of groups of openings	
For walls and openings with ratio of X to Y = r_w and at angle to each other of θ degrees Note: θ = 0° for walls opposite each other θ = 90° for walls at right angles to each other	$c_f = \dfrac{24\cos\left(\dfrac{\theta}{2}\right)}{\sqrt{\left(1+r_w^2\right)\times\left(1+\dfrac{1}{r_w}\right)^{-2}}}$

LEGEND:

X = the aggregate effective area of openings in the wall having the larger area of openings

Y = the aggregate effective area of openings in the wall having the smaller area of openings

7.5 CAR PARKS—MECHANICAL VENTILATION

7.5.1 General

Car parks not naturally ventilated in accordance with Clause 7.4 shall be mechanically ventilated by a combination of general exhaust with flow rates in accordance with Clause 7.5.3 or 7.5.4, as applicable, and supply with flow rates required to comply with Clause 7.9, subject to the following variations:

(a) The mechanical supply-air system may be omitted provided that each zone and level of the car park has openings directly to outside in compliance with Clause 7.5.2.

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

  (i) the floor is no more than 1.2 m below the external ground level adjacent to the relief air openings;

  (ii) the car park has relief openings directly to the outside in compliance with Clause 7.5.2;

  (iii) the supply-airflow rate complies with Clause 7.5.3 or 7.5.4;

  (iv) 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; and

  (v) any adjacent occupied enclosure is at a pressure higher than the car park.

> ***C7.5.1*** *Using the prescriptive procedure described in Clause 7.5.3 will result in an equal or higher ventilation flow rate than using the engineered procedure described in Clause 7.5.4. In all cases, provision of airflows in accordance with Clause 7.5.4 meets the minimum ventilation requirement.*
>
> *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 car park supply system. Relief openings within 6 m of a thoroughfare where people congregate, e.g., a bus stop, may not be acceptable.*

7.5.2 Mechanical ventilation air openings

For mechanical ventilation provided by supply or exhaust systems with make-up air or relief air openings, the following conditions apply:

(a) Airflow rates at each supply air or exhaust air opening shall ensure that the quantity of air passing across areas of the enclosure is in approximate proportion to the number of vehicle spaces through which the air passes.

(b) All relief or make-up air openings shall be sized so that the pressure difference across the relief opening does not exceed 12 Pa.

(c) For enclosures with exhaust ventilation only, all parts of the car park shall be within 7 m of the shortest path(s) between any exhaust air or relief air opening and any make-up air or supply air opening and not more than 10% of the area within the enclosure shall be further than 3 m from the shortest path(s) between any exhaust air or relief air opening and any make-up air. Alternatively, the following conditions apply:

    (i) All parts of the car park shall be within 10 m of a supply air opening and 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.

    (ii) The location of relief air openings including car vehicle entries and exits shall be not less than 6 m away from any outdoor air intake or natural ventilation opening.

    (iii) Any adjacent occupied enclosure shall be provided with supply air to maintain it at a higher pressure than the car park. This may be achieved by providing a pressurized disconnecting compartment, which may be supplied by the car park supply air system.

> ***C7.5.2*** *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, the ability of such an 'engineered' system to effectively dilute polluted air in all parts of the car park should be demonstrated.*
>
> *Where make-up air sources are subject to high ambient carbon monoxide levels and the make-up openings are located within 3 m of ground level, the use of supply air ventilation from an alternative source of outdoor air may be needed.*
>
> *For enclosures provided with exhaust only, or with supply only, the specified pressure difference (12 Pa) will normally be achieved when the air velocity through relief or make-up air openings does not exceed 1 m/s. For enclosures with supply only, air openings should not be within 6 m of a thoroughfare where people congregate, e.g., a bus stop. Example layouts complying with this Clause are shown in AS 1668.2 Supp 1.*

7.5.3 Prescriptive procedure for small car parks

As an alternative to Clause 7.5.4, for car parks with 50 or fewer car spaces with no special vehicle population and no attendant parking, the airflow rate in L/s may be taken as the greatest of—

(a) $400\ n_1 P$; . . . 7(1)

(b) 2000; or . . . 7(2)

(c) $3.0 \times A$ . . . 7(3)

7.5.4 Engineered procedure

7.5.4.1 *Contaminant generation rate*

For each car park enclosure, calculate the contaminant generation rate (C), in litres used per second, given by the following equation:

$$C = P \times \left(100 \times n_1 + n_1 \times d_1 + n_2 \times d_2\right) \qquad \ldots 7(4)$$

NOTES:

1 A distance equal to one half of the perimeter of the car park, in metres, may be used as the value of d_1 or d_2.

2 The basis for the contaminant generation rate equation is provided in AS 1668.2 Supp 1.

7.5.4.2 *Airflow rate*

For car parks, the airflow rate in L/s shall be calculated separately for each zone or level, and shall be not less than the greatest of—

(a) $0.85\ C \times E \times T$; . . . 7(5)

(b) $2000 \times F \times T$; or . . . 7(6)

(c) $3.0 \times A$ . . . 7(7)

TABLE 7.3

PARKING USAGE FACTOR

Use of car park	Parking usage factor (P)
Residential	0.3
Commercial	0.5
Retail/food and drink services	0.7
Entertainment/sports centres	1.0
Vehicle depots (see Note)	2.4

NOTE: This provides for areas where vehicles are left idling for a significant period of time. In other circumstances, a lower figure may apply.

TABLE 7.4

VEHICLE TYPE FACTOR

Types of vehicles	Special vehicle usage factor (T)
No special vehicle population	1.0
Diesel vehicles	2.4
LPG vehicles	1.0
CNG vehicles	1.0
Electric powered vehicles	0.1
Motorcycles	0.25

TABLE 7.5
STAFF USAGE/EXPOSURE FACTORS

Parking procedure	Staff exposure factor (E)	Staff usage factor (F)
No special procedure (self parking), any staff in separate enclosure ventilated in accordance with Clause 7.12	1	1
Self parking stack parking, any staff in separate enclosure ventilated in accordance with Clause 7.12	1	2 + 0.1 × No. of car spaces without immediate access to driveway
No special procedure (self parking), staff located in car parking enclosure	1.8	2
Self parking stack parking, staff located in car parking enclosure	1.8	4 + 0.25 × No. of car spaces without immediate access to driveway
Attendant parking no stack parking	1.8	2.5 × No. of attendants
Attendant parking stack parking	1.8	3.5 × No. of attendants
Mechanical stack parking	1.8	2 × No. of cars engines operating at any one time

NOTE: The staff exposure factor (E) addresses the need for lower CO concentrations if staff have an occupational exposure. The staff usage factor (F) addresses the effect on number of engines operating resulting from different management arrangements, combined with staff exposure considerations.

7.6 ENCLOSURES OTHER THAN CAR PARKS

7.6.1 Enclosed driveways associated with buildings

Enclosed driveways giving access to areas in buildings, including loading docks, car parks and servicing facilities, shall be ventilated by an air-handling system. The 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.

7.6.2 Loading docks

Loading docks, in which the rear of the docked vehicle may be located at a distance greater than 10 m from an external wall with appropriate ventilation openings, shall be ventilated by an exhaust system. The 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.

7.6.3 Automotive service and repair shops

7.6.3.1 *General*

Automotive service bays, repair shops and the like, extending more than 10 m from the external wall having natural ventilation opening shall be ventilated, unless provision is made for directly ducting engine exhaust fumes as prescribed in Clause 7.6.3.2, at a flow rate being the greater of 600 L/s per car space or 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.

7.6.3.2 *Direct ducting from tailpipes*

Where provisions are made for direct ducting of engine exhaust fumes to outside, the exhaust ducts shall be designed to slip over the engine tailpipe and shall be connected to an exhaust ventilation system having minimum exhaust airflow rates calculated in accordance with Clause 7.6.3.3 or 7.6.3.4.

7.6.3.3 *Direct ducting—Prescriptive procedure*

Minimum exhaust airflow rate shall be in accordance with Table 7.6

TABLE 7.6

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

Type of vehicle	Minimum exhaust airflow rate per tailpipe L/s
Vehicles up to 150 kW N.E.P.*	50
Petrol engine vehicles over 150 kW N.E.P	100
Diesel engine vehicles over 150 kW N.E.P.	200

* Net engine power, in accordance with Australian Design Rules.

7.6.3.4 *Direct ducting—Engineered procedure*

The volumetric flowrate into the exhaust duct (the sum of engine tailpipe emissions and ambient air entry into the end of the duct) shall be not less than 1.5 times the volumetric exhaust flow from the tailpipe.

The volumetric exhaust flow rate (V), from the tailpipe shall be determined, for reciprocating engines, as follows:

$$V = L \times R \times (1/60) \times VE \times FF \times (2/CF) \times [(273 + TE)/(273 + TA) \times (PM/PA)] \quad \ldots 7(8)$$

C7.6.3.4 The calculation applies to spark ignition engines and may be applied to compression ignition engines (with results up to approximately 8% conservative). The fuel factor (volumetric ratio of exhaust products L/s to aspirated air L/s, both at STP) may be as high as 1.21 for hydrogen or methanol, the value for hydrocarbon fuels is generally lower than this. Engine volumetric efficiency may be expressed as a function of manifold pressure and RPM, 0.5 to 0.9 is a reasonable range for a spark ignition engine. Manifold pressure (generally, atmospheric pressure minus engine vacuum) is depressed below atmospheric pressure by aspiration air path pressure losses. Manifold pressure may be increased above atmospheric pressure by operation of superchargers and turbochargers. For naturally aspirated engines with minimally heated intake air path, TA may be taken as the ambient air temperature. Exhaust gas temperature, though engine specific, may typically be in the range of 400°C to 1100°C at manifold (increasing with speed and load) for spark ignition engines at stable operating temperature. Exhaust gas temperatures, though engine specific, may typically be in the range of 350°C to 650°C at manifold (increasing with load) for compression ignition engines at stable operating temperature.

7.6.3.5 *Dynamometer engine testing*

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

(a) have engine exhausts directly ducted away at a rate calculated in accordance with Clause 7.6.3.4; or

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

7.6.4 Vehicular lifts and shafts

7.6.4.1 *Exhaust ventilation of vehicular lifts*

Lifts used for transporting vehicles within a building shall be ventilated. The airflow rate shall be not less than 2000 L/s to allow for undisturbed airflow through the lift. Lifts with open sides and no ceiling may be exempted from the exhaust requirement, provided that the lift shaft complies with Clause 7.6.4.2.

7.6.4.2 *Exhaust ventilation of vehicular lift shafts*

Vehicular lift shafts shall be ventilated by a mechanical air-handling system at a flow rate of not less than 2000 L/s.

7.6.5 Areas used by special-purpose vehicles

Areas within buildings, where special-purpose vehicles (e.g., forklift trucks) operate, shall be ventilated. The ventilation airflow rates given in Table 7.7 shall apply. Make-up or relief air shall be provided by means of uniformly distributed natural ventilation openings or a mechanical air-handling system. The vehicle engines shall not exceed 45 kW.

Where the above conditions are not met, the flow rates in Table 7.7 shall be adjusted proportionally.

NOTE: A sign should be displayed in a conspicuous position, stating the maximum number of vehicles that may be operated in order to keep emissions within design levels.

TABLE 7.7

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

Fuel used by vehicle	Minimum 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

7.7 QUEUING AREAS

7.7.1 General

Enclosures where vehicles queue up with engines operating for any purpose, including parcel pick-up, purchasing, payment at exits or awaiting entry or exit, shall be mechanically ventilated in accordance with Clauses 7.7.2 and 7.7.3 or naturally ventilated in accordance with Clause 7.4.3(f).

7.7.2 Queuing length

The length of a queue shall be stated by the owner of the building.

C7.7.2 Several factors influence the length of queues, including use of the enclosure, number and location of entry and exit points and external traffic conditions. Car parks associated with entertainment and sporting venues tend to have longer queues than other car parks. Tables 7.8 and 7.9 may be referred to for guidance in determining queue lengths.

TABLE 7.8

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

NOTE: Rationale for information contained in this Table is provided in AS 1668.2 Supp 1.

TABLE 7.9

LENGTH OF QUEUES AT EXIT POINTS

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

NOTE: Rationale for information contained in this Table is provided in AS 1668.2 Supp 1.

7.7.3 Airflow rate and distribution of air

The exhaust-airflow rate shall be—

(a) 225 L/s per metre length of each exit lane queue; and

(b) 150 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.

NOTE: The derivation of airflow rates for queuing areas is provided in the Supplement to this Standard.

7.8 AIR PRESSURE

Air pressure in an enclosure ventilated by an exhaust-air system shall comply with Clause 5.7.2.

7.9 MAKE-UP OF EXHAUST AIR

Clause 5.8 shall apply generally for the make-up of exhaust air. Where a supply ventilation system for make-up air is provided, it shall have a flow rate of not less than 75% and not more than 100% of the exhaust airflow rate.

7.10 EXHAUST-AIR DISCHARGE

Exhaust-air discharge shall be in accordance with Clause 5.10.2.

7.11 COMBINATION SYSTEMS

Where a combination of natural and mechanical ventilation systems are used, the systems shall be considered separately. Air from a naturally ventilated portion shall not be used as make-up for the mechanically exhausted portion.

7.12 ENERGY SAVING MEASURES

The following energy-saving measures may be adopted:

(a) Where all vehicles remain parked with engines remaining unoperated 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 detection devices that continuously monitor the concentration of atmospheric contaminants in the enclosure in accordance with Clause 7.13.

(c) Automatic operation of systems controlled by detection devices that continuously monitor the concentration of atmospheric contaminants in the enclosure in accordance with Clause 7.13. When the monitored condition is below the determined maximum concentration, the mechanical exhaust system may be stopped. However, the system shall operate intermittently to provide a minimum of 0.5 air changes per hour (ACH) during any 24 h period, or an equivalent supplementary natural ventilation system shall be provided.

(d) Where all vehicles remain parked with engines remaining unoperated and the space is unoccupied for periods in excess of 2 h, the system may be shut down. Provision shall be made to automatically restart the system should the space become occupied. Where the space is to be used for storage of materials, a supplementary exhaust system shall be provided to operate during shutdown to exhaust 0.35 L/s of air per square metre of the total gross floor area of the car park.

7.13 MONITORING OF ATMOSPHERIC CONTAMINANTS

7.13.1 General

Where the operation of mechanical ventilation is automatically controlled by an atmospheric contaminant monitoring system(s), the calculated air quantity may be varied, subject to the requirements of this Clause. The atmospheric contaminant to be monitored shall be carbon monoxide (CO).

> ***C7.13.1*** *Advice from health authorities indicate that monitoring of CO is optimum for contaminant monitoring systems for enclosures used by vehicles with combustion engines. Although NO_2 is produced by some combustion engines monitoring results have indicated that CO levels exceed the exposure standard (ES) before NO_2 levels.*

7.13.2 System requirements

A CO 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 analog or digital display;

(b) operate continuously and effectively whenever motor vehicles are present in the enclosure in accordance with Clause 7.13.3;

(c) under any fault condition automatically activate an alarm and operate the mechanical ventilation in the enclosure in accordance with Clause 7.13.6;

(d) be clearly marked to indicate servicing and calibration requirements in accordance with Clause 7.13.7; and

(e) analyse the air—

  (i) at all sampling points continuously, and simultaneously and automatically operate the mechanical ventilation system in accordance with Clauses 7.13.4.2; or

(ii) from all sampling points intermittently, at least twice every 4 min and automatically operate the mechanical ventilation in accordance with Clauses 7.13.4.1 and 7.13.4.2.

C7.13.2 This Standard permits CO monitoring systems that incorporate sampling and detection devices that analyse the air at sampling points and transmit signals to a central reporting station as well as CO monitoring systems that draw samples of air from sampling points to a central analyser that transmits signals to a central reporting station.

7.13.3 Operation and accuracy of CO monitors

The monitoring system shall be selected to—

(a) operate 24 h per day or be automatically activated at a time that will ensure it accurately analyses 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 CO to within 10% of the exposure limit (EL) for measurements in the range between 10% and 120% of the EL, and to within 10% of the full range deflection of the monitoring system for measurements over 120% of the EL.

C7.13.3 The exposure limit is set by NOHSC, NHMRC or NEPC as applicable, see Commentary C7.2.2 and AS 1668.2 Supp 1.

7.13.4 Analysis of CO and operation of mechanical ventilation

7.13.4.1 *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; and

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

7.13.4.2 *Response time of monitoring systems*

When a system detects—

(a) an increase in CO above a set point, reaction of the system to the increase above the value calculated in accordance with Clause 7.13.4.3 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 CO below a set point, reaction of the system to the decrease below the value calculated in accordance with Clause 7.13.4.3 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.

7.13.4.3 *Set points*

A mechanical ventilation system that is controlled by one or more CO monitoring system(s) shall—

(a) operate at the full ventilation rate in accordance with Clause 7.13.4.4, when the concentration of the CO in the enclosure is 80% or more of the EL;

(b) operate at not less than the minimum ventilation rate in accordance with Clause 7.13.4.5, when the concentration of the CO in the enclosure is 50% or less of the EL; and

(c) operate at a rate not less than determined by the following equation—

$$VR = MR + \left[\frac{(Z - 0.5)}{0.3}\right] \times (FR - MR) \quad \ldots 7(9)$$

when the concentration of the CO in the enclosure is between 50% and 80% of the EL.

NOTE: Set points will vary depending on the occupancy of the car park (i.e., staffed or unstaffed) and reference should be made to Commentary C7.2.2 and AS 1668.2 Supp 1.

7.13.4.4 *Full ventilation rate (FR)*

The full ventilation rate of a mechanical ventilation system shall be not less than that calculated in accordance with Clause 7.5 according to the enclosure being ventilated.

7.13.4.5 *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).

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

(a) concentration of CO dropping below 15% of the EL;

(b) response time specified in Clause 7.13.4.2(b); and

(c) availability of supplementary ventilation, adequate to control low concentrations of pollutants (see Clause 7.12(d)).

7.13.4.6 *Make-up air*

Make-up air for each zone or level shall be maintained in accordance with Clause 7.9 to suit minimum, maximum and all intermediate ventilation rates of the mechanical ventilation systems.

7.13.5 Sampling points

7.13.5.1 *Number*

The number and distribution of sampling points required for an enclosure shall be such that no point in the enclosure is greater than 25 m away from a sampling point. Sampling shall also be provided in areas where people congregate, such as a waiting area for drivers or passengers of motor vehicles, which is not within a separate pressurized ventilated area.

7.13.5.2 *Location*

Sampling points shall be located—

(a) between 900 mm and 2500 mm above the floor surface in positions that will allow samples to be fully representative of the local atmosphere;

(b) 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.

7.13.5.3 *Enclosure area*

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

7.13.6 Monitor failure

7.13.6.1 *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.

7.13.6.2 *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 appropriate 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).

7.13.7 Marking, commissioning, reliability and records

In order to ensure the extended reliability of monitoring systems and the evidence of that reliability, service markings shall be provided and records shall be kept.

NOTE: Guidance is supplied in AS 1668.2 Supp 1.

APPENDIX A

GUIDELINES ON NET FLOOR AREA PER OCCUPANT, ACTIVITY RATES AND DILUTION INDICES FOR PARTICULAR ENCLOSURES

(Informative)

A1 ENCLOSURE GUIDELINES

Table A1 provides guidelines on occupant density and grades of Dilution Indices for particular enclosures. These values are necessary for system design and should be nominated (see Clause 4.2.2). In many of these enclosures smoking may be prohibited. Net floor area per occupant figures is necessarily conservative and system design should be calculated on actual occupancy numbers where possible. Three grades of ventilation amenity are provided with recommended dilution indices. The higher the grade of ventilation amenity achieved the higher the likelihood for occupant satisfaction.

TABLE A1

ENCLOSURE GUIDELINES

Enclosure type*	Net floor area per occupant † m^2	Recommended Dilution Index			Comments
		Grade 1 amenity	Grade 2 amenity	Grade 3 amenity	
Amusement centres				Minimum value as per Tables 4.3 and 4.4.	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 needed for laundries to satisfy exhaust air requirements
Commercial	10	5	3.5		Refer to the requirements of Section 5
Coin-operated dry cleaning	5	7.5	5		
Coin-operated laundries	5	7.5	5		
Pick-up areas	3.5	5	3.5		
Storage areas	3.5	3.5	3.5		
Education					
Classrooms serving occupants up to 16 years of age	2	7.5	5		Special case for activity (see Table 4.5)
Classrooms serving occupants over 16 years of age	2	7.5	5		Value of DI 3.5 may be acceptable in severe climatic conditions

(*continued*)

TABLE A1 (*continued*)

Enclosure type*	Net floor area per occupant † m^2	Recommended Dilution Index			Comments
		Grade 1 amenity	Grade 2 amenity	Grade 3 amenity	
Laboratories	3.5	7.5	5	Minimum value as per Tables 4.3 and 4.4.	Special contaminant control systems may be required for processes or functions including laboratory animal occupancy
Libraries	5	7.5	5		
Locker rooms	2	7.5	5		
Lounges	1.5	7.5	5		
Music rooms	2	7.5	5		
Training shops	3.5	7.5	5		
Food and drink services					
Bars	1	5	3.5		
Cabarets	1.5	5	3.5		
Cafeterias	1	7.5	5		
Cocktail lounges	1	5	3.5		
Dining rooms	1.5	7.5	5		
Fast food outlets	1	7.5	5		
Food preparation, serving and storage	3.5	5	3.5		For cooking, see Section 5
Funeral parlours					
Chapels	0.6	7.5	5		
Embalming rooms	5	N/A	N/A		Air not to be recirculated into spaces
Reception rooms	1	7.5	5		
General areas					General requirements (applies to all forms, unless separately listed)
Corridors		5	3.5		
Dressing rooms	2	7.5	5		
Fire control room		3.5	3.5		
Foyers		7.5	5		
Lobbies		7.5	5		
Locker rooms	2	7.5	5		
Pedestrian tunnels		5	3.5		
Ramps		5	3.5		
Rest rooms	1	7.5	5		
Stairs		5	3.5		For stairs, passageways, etc., used as a means of egress, see AS/NZS 1668.1
Switch & meter rooms		3.5	3.5		
Utility rooms		3.5	3.5		

(*continued*)

TABLE A1 (*continued*)

Enclosure type*	Net floor area per occupant † m^2	Recommended Dilution Index			Comments
		Grade 1 amenity	Grade 2 amenity	Grade 3 amenity	
Health care				Minimum value as per Tables 4.3 and 4.4.	Applies to convalescent homes, dentists, doctors, hospitals, nursing homes, and the like. For special requirements for particular enclosures, see Section 6
Amphitheatres	0.6	7.5	5		
Autopsy rooms	5	N/A	N/A		
Consultation rooms	3.5	7.5	7.5		Procedure generating contaminations may require higher rates, laminar flow or dedicated systems
Delivery rooms	5	N/A	N/A		
Intensive care rooms	5	N/A	N/A		
Operating rooms	10	N/A	N/A		
Patient rooms	10	7.5	5		
Recovery rooms	5	N/A	N/A		
Waiting areas	1.5	7.5	5		
Hotels, motels, resorts					
Assembly rooms (large)	1	7.5	5		
Bedrooms (single, double)	10	7.5	5		
Conference rooms (small)	2	7.5	5		
Dormitories		7.5	5		
Gambling casinos	1.5	5	3.5		
Living rooms (suites)	5	7.5	5		
Lobbies	3.5	7.5	5		
Laundries					See dry cleaners
Merchandising					General requirements (apply to all forms unless separately listed)
Arcades	5	7.5	5		
Dispatch areas	10	5	3.5		
Fitting enclosures	1	7.5	5		
Kiosks	1	7.5	5		
Malls	5	7.5	5		
Receiving areas	10	5	3.5		
Sales floors or showrooms					
Basement and street floors	3.5	7.5	5		
Upper floors	5	7.5	5		

(*continued*)

TABLE A1 (*continued*)

Enclosure type*	Net floor area per occupant † m^2	Recommended Dilution Index			Comments
		Grade 1 amenity	Grade 2 amenity	Grade 3 amenity	
Storage areas (serving sales and storerooms)	10	3.5	3.5	Minimum value as per Tables 4.3 and 4.4.	
Warehouses	20	N/A	N/A		See Clause 7.6.5
Motels					See hotels
Museums					
Exhibit halls	1.5	7.5	5		
Warehouses	20	N/A	N/A		
Offices					
Art rooms	5	7.5	5		
Boardrooms	1	10	7.5		
Committee rooms	1	7.5	5		
Computer rooms	25	7.5	5		
Conference rooms	1	7.5	5		
Drafting rooms	5	7.5	5		
Office areas	10	7.5	5		
Waiting areas	2	7.5	5		
Prisons					
Cell blocks	5	7.5	5		
Eating halls	1.5	7.5	5		
Guard stations	2.5	7.5	5		
Residential					
Private dwellings					Private dwelling places, multiple or single high or low rise
Bedrooms	10	7.5	5		
Living areas and general	10	7.5			
Other dwellings					
Boarding houses		7.5	5		See hotels
Guest houses		7.5	5		See hotels
Hostels		7.5	5		See hotels
Mobile homes		7.5	5		
Resorts					See hotels
Schools					See education
Speciality services					
Animal rooms		N/A	N/A		Special case
Barber shops	4	7.5	5		
Beauty salons	4	7.5	5		
Broadcasting studios	1.5	7.5	5		

(*continued*)

TABLE A1 (*continued*)

Enclosure type*	Net floor area per occupant † m^2	Recommended Dilution Index Grade 1 amenity	Grade 2 amenity	Grade 3 amenity	Comments
Electrical meter, switch rooms				Minimum value as per Tables 4.3 and 4.4.	
Exercise rooms	5	5	3.5		
Florists	10	7.5	5		
Greenhouses	100	7.5	5		
Hairdressers	4	7.5	5		Special case
Health spas	5	N/A	N/A		Special case
PABX rooms		N/A	N/A		Special case
Pet shops		N/A	N/A		Special case
Press booths, lounges	1	7.5	5		
Radio booths	1.5	7.5	5		
Reducing salons	5	7.5	5		
Saunas		N/A	N/A		Special case
Shoe repair shops (combined workrooms trade areas)	10	7.5	5		
Steam rooms		N/A	N/A		Special case
Survival shelters	1	N/A	N/A		Special case
Telephone main distribution frame (MDF) rooms	10	7.5	5		
Television booths	1.5	7.5	5		
Sports and amusement centres					When internal combustion engines are operated for maintenance of playing surfaces, or any other purpose, exhaust ventilation may be needed (see Section 7)
Ballrooms	1.5	5	3.5		
Bowling alleys (see areas)	1.5	5	3.5		
Discotheques	1.0	5	3.5		
Games rooms	1.5	7.5	5		Amusement machines, billiards, cards, and the like
Brothels	5	7.5	5		
Locker rooms	2	7.5	5		
Playing floors	3.5	5	3.5		Cricket, gymnasiums, ice skating, roller skating, squash, tennis, and the like
Spectator areas (general)	0.6	7.5	5		
Swimming pools, deck and pool areas	3.5	5	3.5		Ventilation may be needed for humidity control

(*continued*)

TABLE A1 (*continued*)

Enclosure type*	Net floor area per occupant † m^2	Recommended Dilution Index			Comments
		Grade 1 amenity	Grade 2 amenity	Grade 3 amenity	
Spectator areas (pool)	1.5	7.5	5	Minimum value as per Tables 4.3 and 4.4.	
Temples					
Theatres					
Auditoriums	0.6	7.5	5		
Concert halls	0.6	7.5	5		
Foyers	0.6	7.5	5		
Green rooms	5	7.5	5		
Lecture halls	0.6	7.5	5		
Lobbies	0.6	7.5	5		
Opera halls	0.6	7.5	5		
Stages and studios	1.5	7.5	5		Special ventilation will be needed to eliminate special effects, e.g., dry ice vapours, mists, and the like, used in stage or studio productions
Ticket booths		7.5	5		
Transportation centres					
Baggage areas	1.5	7.5	5		
Concourses	0.6	7.5	5		
Corridors	1.5	3.5	3.5		
Gate areas	1.5	7.5	5		
Hangars	50	5	3.5		
Platforms	0.6	7.5	5		
Ticket areas	1.5	7.5	5		
Waiting rooms	2	7.5	5		
Air traffic control		10	7.5		5 L/s per m^2 required
Veterinary centres					
Kennels		N/A	N/A		Special case
Operating rooms		N/A	N/A		Special case
Reception rooms		7.5	5		Special case
Stalls		N/A	N/A		Special case
Workrooms					This requirement covers continuous occupancy. When occupancy is intermittent, infiltration may provide sufficient natural ventilation
Bank vaults	10	7.5	5		Emergency provisions may be needed
Industrial process		N/A	N/A		Special case
Meat processing	10	N/A	N/A		Special case

(*continued*)

TABLE A1 (*continued*)

Enclosure type*	Net floor area per occupant † m^2	Recommended Dilution Index			Comments
		Grade 1 amenity	Grade 2 amenity	Grade 3 amenity	
Pharmacists	5	7.5	5	Minimum value as per Tables 4.3 and 4.4.	
Photography		7.5	5		Installed equipment may required exhaust, to control contamination
Camera rooms	10	7.5	5		
Darkrooms	10	7.5	5		
Duplicating rooms	3.5	7.5	5		
Printing rooms	3.5	7.5	5		
Refrigerated rooms		N/A	N/A		Special case
Strongrooms		7.5	5		Same as bank vaults
Voucher storerooms		7.5	5		Same as bank vaults

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

† This column applies where the number of occupants is not nominated, see Clause 4.2.2.

NOTES:

1 Enclosure types listed are typical. Omission of an applicable enclosure from the Table does not obviate the need to comply, in principle, with this Standard (see Clause 4.1).

2 The values of net floor area per occupant are approximate and conservative.

3 The tabulated values are a consensus judgment of the minimum dilution indices necessary to meet the community's expectations for high, medium and low specification buildings, based on normally bathed, cleanly clothed occupants. Where unusual occupation or hygiene is expected, some appropriate increases should be made. In general, the values are in excess of the requirement needed to ensure healthy breathing or maintain acceptable levels of oxygen, carbon dioxide and the like.

4 In some cases, the area per occupant is greater than existing regulation for determination of exits and similar since ventilation needs are based on a time integrated requirement.

A2 METABOLIC RATES

Table A2 provides guidelines on metabolic rates applicable for different activities.

TABLE A2
METABOLIC RATES FOR DIFFERENT ACTIVITIES

Activity	Average adjusted metabolic rate Watts/occupant	Examples
Resting	80	
Seated, relaxed	100	Theatre, cinema
Sedentary activity	120	Office, dwelling, school
Standing, light activity	160	Shopping, laboratory
Standing medium activity	200	Domestic work
Light factory work	170	Light assembly lines, sewing, machining
Heavy factory work	280	Heavy assembly work, hammering, manually lifting/handling goods
Labouring	390	Sawing, shovelling, carrying heavy goods
Intense labouring	500	Climbing stairs/ ladders, intense shovelling
Moderate dancing	250	Dance hall
Energetic dancing	500	Discotheque
Vigorous exercise	600	Aerobic classes, gyms

NOTE: Metabolic rates are based on the average of rates for male and female persons. For further information on metabolic rates, refer to ISO 8996.

APPENDIX B

MINIMUM MECHANICAL EXHAUST AIR REQUIREMENTS BASED ON USE OF ENCLOSURE

(Normative)

B1 APPLICATION

This Appendix shall be read in conjunction with Section 5.

B2 GENERAL EXHAUST FOR ENCLOSURES

Exhaust for enclosures shall be in accordance with Table B1. The exhaust rates shown are minimum values.

TABLE B1

MINIMUM EXHAUST VENTILATION FLOW RATES

Enclosure type	Quantity	Unit	Comments
Automotive vehicle			See Section 7
Battery charging			See AS 2676
Document copying process that emits obnoxious effluent	5	L/s.m^2 floor	
Drycleaning (solvent)	20	L/s.m^2 floor	
Garages			See Section 7
Garbage room and service compartment	5	L/s.m^2 floor	100 L/s min.
Gas meter	5	L/s.m^2 floor	
Grease arrester	5	L/s.m^2 floor	100 L/s min.
Hospital sterilizing	20	L/s.m^2 floor	May be 5 L/s.m^2 of floor when local exhaust provided over sterilizers (see Clause 5.3)
Kitchen			
Commercial	5	L/s.m^2 floor	
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

(*continued*)

TABLE B1 (*continued*)

Enclosure type		Quantity	Unit	Comments
Sanitary compartment				
Bath, Shower, Urinal, Water closet		10 *or* 25	$L/s.m^2$ floor; L/s per listed fixture	Greater value shall be taken. For calculation purposes; floor area per fixture shall be no greater than 2.5 m^2; 0.6 m length of urinal shall be equivalent to one fixture. Sanitary compartments subject to high level of use, e.g., airports, entertainment venues, and similar, may require an increased ventilation rate
Bathroom, Toilet	Private dwellings and attached to bedroom of hotels, motels resorts, private hospital rooms and the like	25	L/s per room	May include bath, shower, water closet and handbasin in one compartment. Rate is independent of room size (see Note 2)
Sewage ejection		100	L/s	Minimum
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
Plant room/storage room		5	$L/s.m^2$ floor	Enclosures used for storage of equipment, plant or materials likely to contaminate the air will need special consideration, see Paragraph B2
Lifts				Lift car and motor room ventilation, see AS 1735
Refrigeration				See AS/NZS 1677.2

NOTES:

1 Enclosure uses in Table B1 are typical. Omission of an applicable enclosure from this Table does not obviate the need to comply, in principle, with this Standard (see Section 5).

2 Where a bathroom is combined with a laundry, the higher of the two applicable ventilation rates may be used.

3 Unit '$L/s.m^2$ floor' to be read as 'L/s per square metre of floor area'.

B3 ALTERNATIVE REQUIREMENTS

Table B2 provides a list of some Standards that also include requirements for exhaust systems for areas used for the storage of materials.

TABLE B2
APPLICABLE STANDARDS

Material property	Applicable Standard
Flammable liquid	AS 1940
Corrosive material	AS 3780
Hazardous chemical	AS 2714
Compressed gas	AS 4332
Electrical equipment	AS 1482
Batteries	AS 2676

APPENDIX C

KITCHEN EXHAUST HOODS

(Normative)

C1 SCOPE

This Appendix sets out requirements for the construction and installation of kitchen exhaust hoods where their provision is required under Clause 5.4.

C2 APPLICATION

Where a kitchen exhaust hood is required, it shall comply with Paragraphs C3, C4, and C9, and, where grease vapour is present, it shall also comply with Paragraphs C5 or C6 and Paragraph C7.

C3 HOOD CONSTRUCTION

C3.1 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.

C3.2 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 appropriate 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 that are in compression at the joint.

C3.3 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 that permit access into the exhaust plenum for cleaning purposes (refer to Figure C4); 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.

C3.4 Internal surface

C3.4.1 *Sloping*

All surfaces of hoods exposed to the appliance being ventilated shall be sloped at an angle not greater than 40° from the vertical (see also Paragraph C5), unless the design and performance of hoods prevent the formation of any condensate on such surfaces.

C3.4.2 *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 in accordance with AS 3772.

C3.4.3 *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 low sidewall hoods, grease may be drained into removable collection containers.

C3.4.4 *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 for cooking process Types 1 to 4 and 300 mm for cooking process Type 5, except on sides adjoining a wall.

C3.4.5 *Internal lights*

Where fitted, internal light fittings shall be flush mounted.

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

C4 HOOD INSTALLATION

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 and no higher than 1.2 m above the cooking appliance.

C5 KITCHEN EXHAUST HOODS INCORPORATING GREASE-ARRESTING FILTERS

Hoods shall incorporate a device that will impede the process of grease within the airstream in accordance with the following:

(a) Filter media and 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) Filters shall be installed so as to prevent significant leakage of air around their perimeter.

(d) The faces of filters shall be either vertical or sloped at an angle not greater than 30° 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 (for example, filter support channel designed to collect and convey grease into hood gutter).

(f) The filters and the filter retaining devices shall be flush mounted to comply with Paragraph C3.4.2.

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

C6 KITCHEN EXHAUST HOODS INCORPORATING GREASE-REMOVAL DEVICES

Kitchen exhaust hoods incorporating grease removal devices other than those in Paragraph C5 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 C5.

C7 DISTANCE FROM GREASE-ARRESTING DEVICE TO HEAT SOURCE

C7.1 General

Unless otherwise reduced (see Paragraph C7.2), the distance between the lowest edge of a grease-arresting device and the cooking surface shall be not less than—

(a) 1350 mm—for charcoal and similar type of open fires, including where food is typically ignited during the cooking process;

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

(c) 600 mm—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).

C7.2 Reduction of distances

In variation to Paragraph C7.1 the distance of grease-arresting filters from the heat source given in Paragraph C7.1 may be reduced where the kitchen exhaust system is provided with a 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.

C8 ALTERNATIVE AIR FLOW—EXAMPLES

C8.1 Sidewall hood calculation example

To calculate the required air quantity for the hood shown in Figure C1, use the equation $Q = V_f PH$. Velocity factors are as follows:

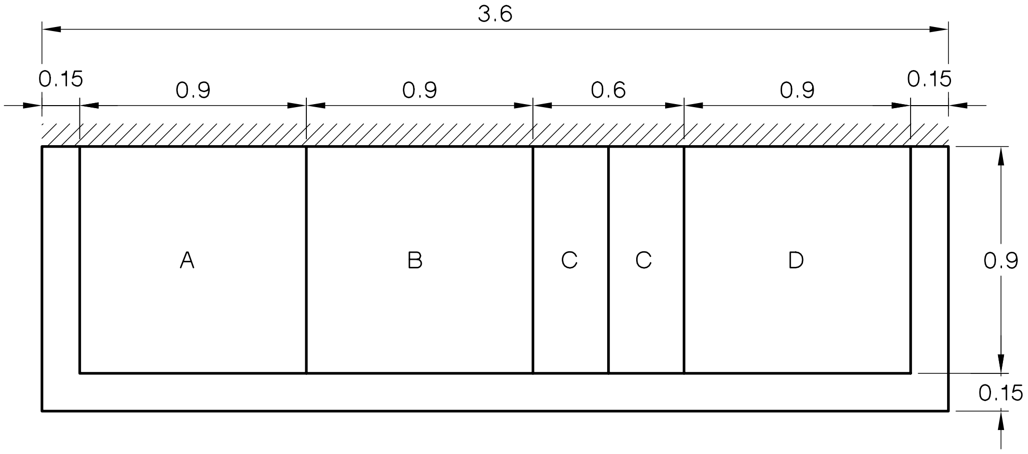
Kitchen equipment	Velocity factor (V_f)
A Range	250
B Gas barbecue	500
C Deep fryer	375
D Steamer	150

For the purpose of this example, the distance (H) from the cooking appliance to the bottom of the hood is 1.2 m. The following air quantities are calculated:

Kitchen equipment	Air quantity
A Range	250 × 2.1 × 1.2 = 630
B Gas barbecue	500 × 0.9 × 1.2 = 540
C Deep fryer	375 × 0.6 × 1.2 = 270
D Steamer	150 × 2.1 × 1.2 = 378
	Q = 1818 L/s

If side skirts or adjacent walls are used, the length of the exposed sides (perimeter) and, therefore, the air quantity may be reduced as follows:

Kitchen equipment	Air quantity
A Range	250 × 1.05 × 1.2 = 315
B Gas barbecue	500 × 0.9 × 1.2 = 540
C Deep fryer	375 × 0.6 × 1.2 = 270
D Steamer	150 × 1.05 × 1.2 = 189
	Q = 1314 L/s



DIMENSIONS IN METRES

FIGURE C1 PLAN OF KITCHEN EQUIPMENT UNDER SIDEWALL HOOD

C8.2 Island hood calculation example

To calculate the air quantity for the hood shown in Figure C2 use the equation $Q = V_f P H$. Velocity factors are as follows:

Kitchen equipment	Velocity factor (V_f)
A Range	250
B Deep fryer	375
C Hot top range	375
D Charcoal barbecue	750
E Steam kettle	150
F Work table	150
G Oven	150

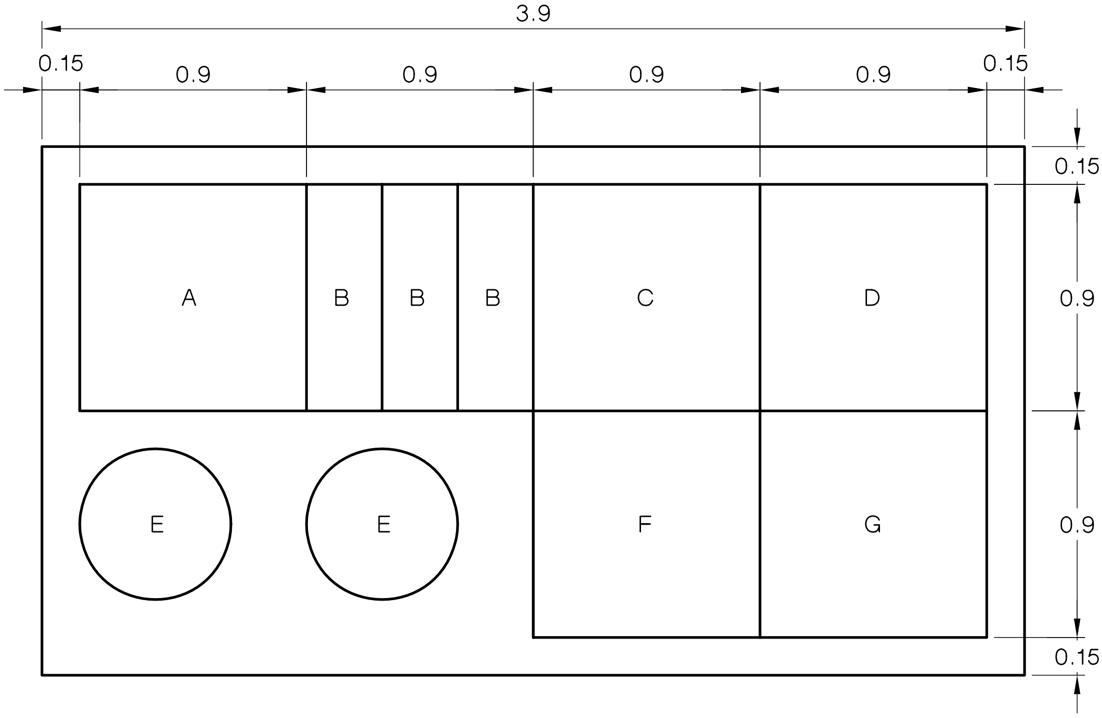
NOTE: Charcoal barbecue is required to have a separate exhaust system and hood.

For the purpose of this example, the distance (H) from the cooking appliance to the bottom of the hood is 1.2 m. The following air quantities are calculated:

Kitchen equipment	Air quantity		
A Range	250 × 2.1 × 1.2 =	630	
B Deep fryer	375 × 0.9 × 1.2 =	405	
C Hot top range	375 × 0.9 × 1.2 =	405	
D Charcoal barbecue*	750 × 2.1 × 1.2 =		1890
E Steam kettle	150 × 3.0 × 1.2 =	540	
F Work table	150 × 0.9 × 1.2 =	162	
G Oven	150 × 2.1 × 1.2 =	378	
	Q_1 =	2520 L/s	
	Q_2 =		1890 L/s

NOTE: Charcoal barbecue is required to have a separate exhaust system and hood.

If side skirts are used, the length of the exposed sides (perimeter) and, therefore, the air quantity may be reduced.

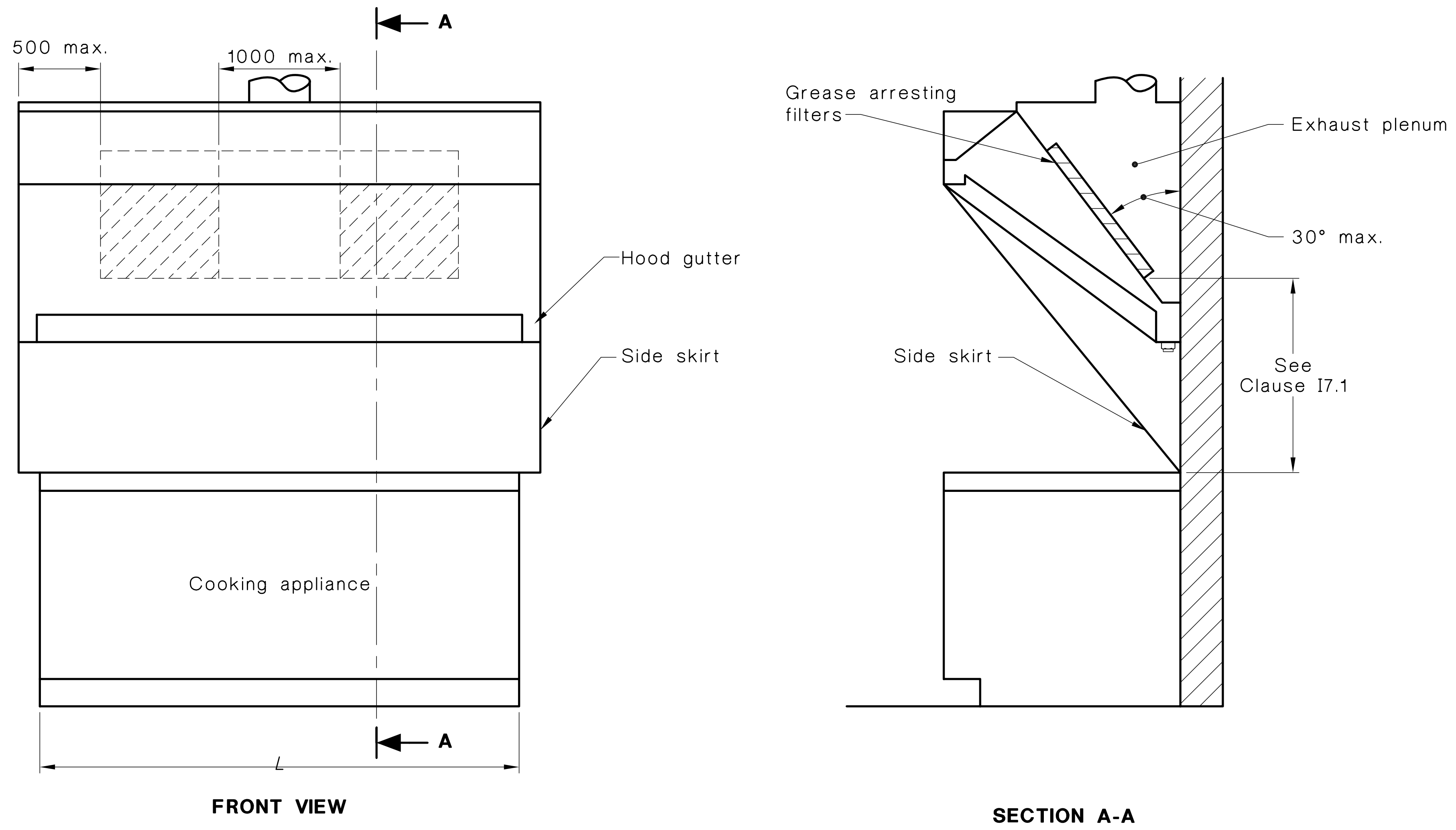


DIMENSIONS IN METRES

FIGURE C2 PLAN OF KITCHEN EQUIPMENT UNDER ISLAND HOOD

C9 HOOD TYPE NOMENCLATURE

Indicative sketches for common hood types are given in Figures C3, C4, C5 and C6.



DIMENSIONS IN MILLIMETRES

FIGURE C3 TYPICAL LOW SIDEWALL (BACK SHELF) TYPE HOOD INCORPORATING

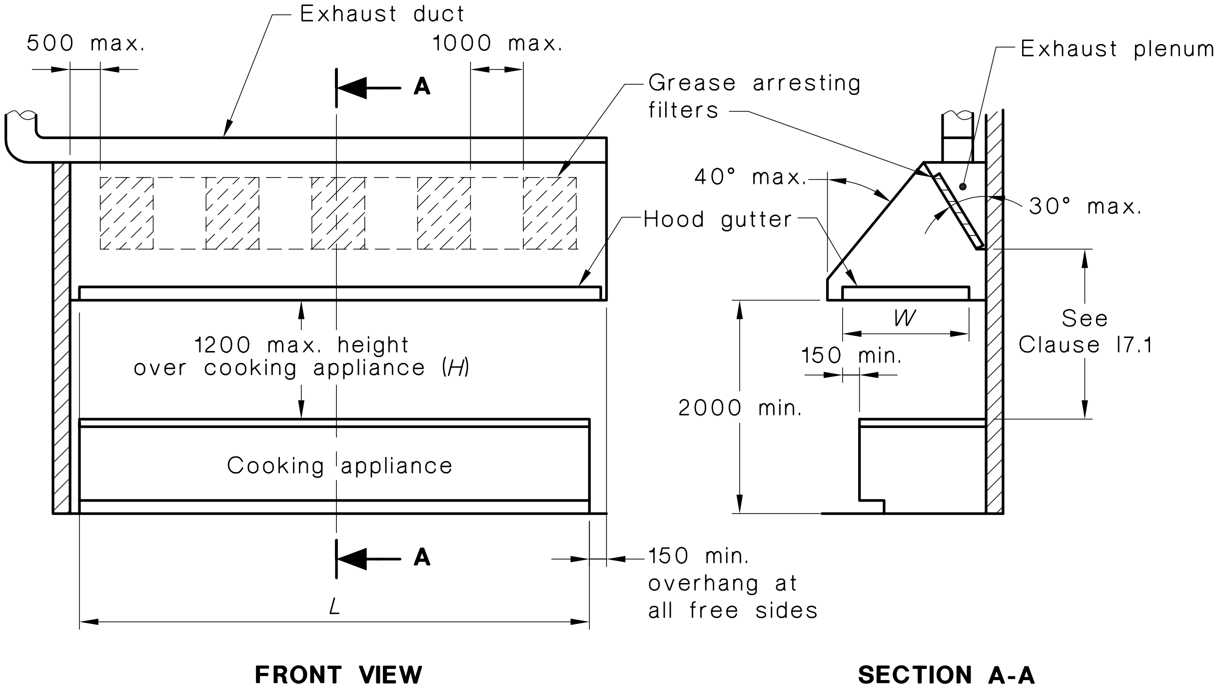
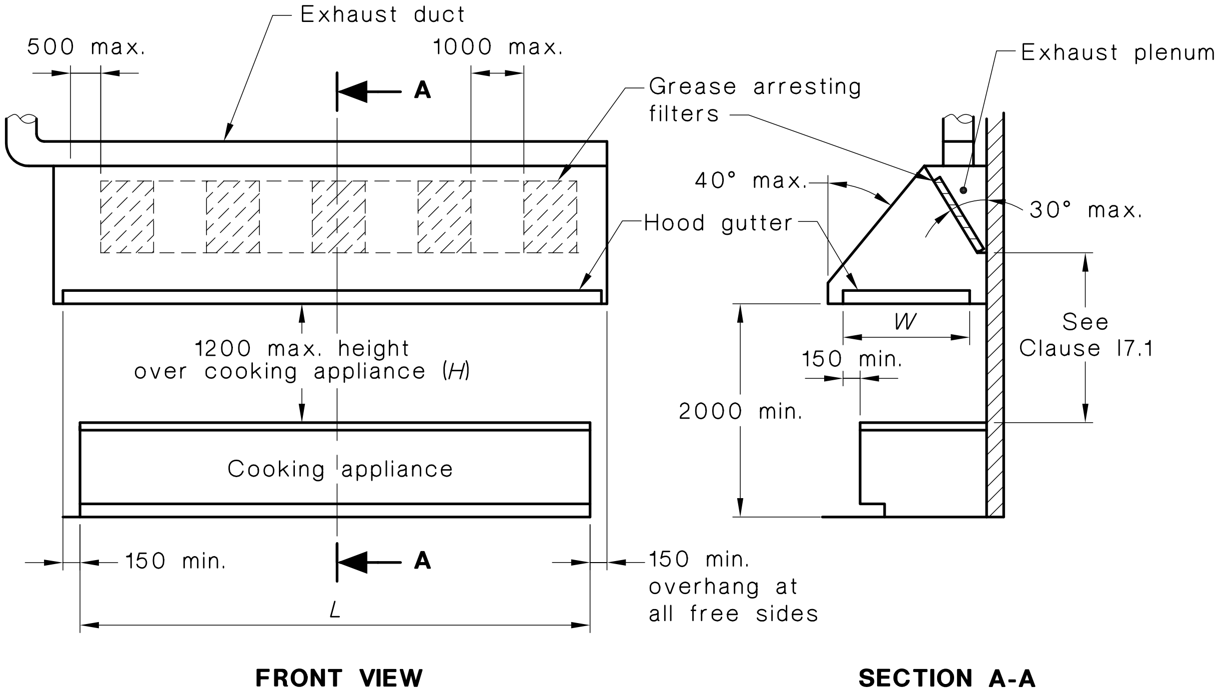
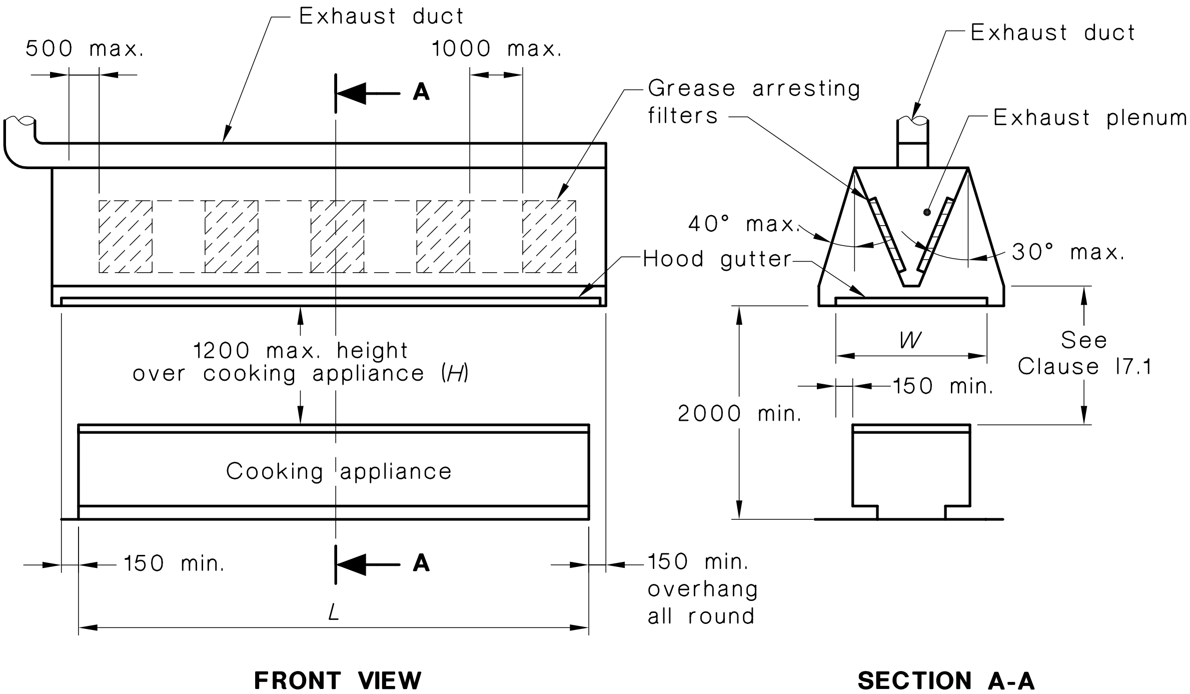


FIGURE C4 TYPICAL CORNER-MOUNTED HOOD



DIMENSIONS IN MILLIMETRES

FIGURE C5 TYPICAL CANOPY-TYPE SIDEWALL HOOD INCORPORATING GREASE FILTERS



DIMENSIONS IN MILLIMETRES

FIGURE C6 TYPICAL ISLAND-TYPE CANOPY HOOD INCORPORATING GREASE FILTERS

AMENDMENT CONTROL SHEET

AS 1668.2—2002

Amendment No. 1 (2002)

CORRECTION

SUMMARY: This Amendment applies to the List of Interested Parties, Inside Front Cover.

Published on 22 November 2002.

Amendment No. 2 (2003)

REVISED TEXT

SUMMARY: This Amendment applies to the Title of this Standard.

Published on 5 June 2003.

NOTES

NOTES

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