BUILDING PERFORMANCE

C

C Protection from Fire

Verification Method C/VM2

Framework for fire safety design

SECOND EDITION | EFFECTIVE 28 JULY 2025

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Te Kāwanatanga o Aotearoa
New Zealand Government

Preface

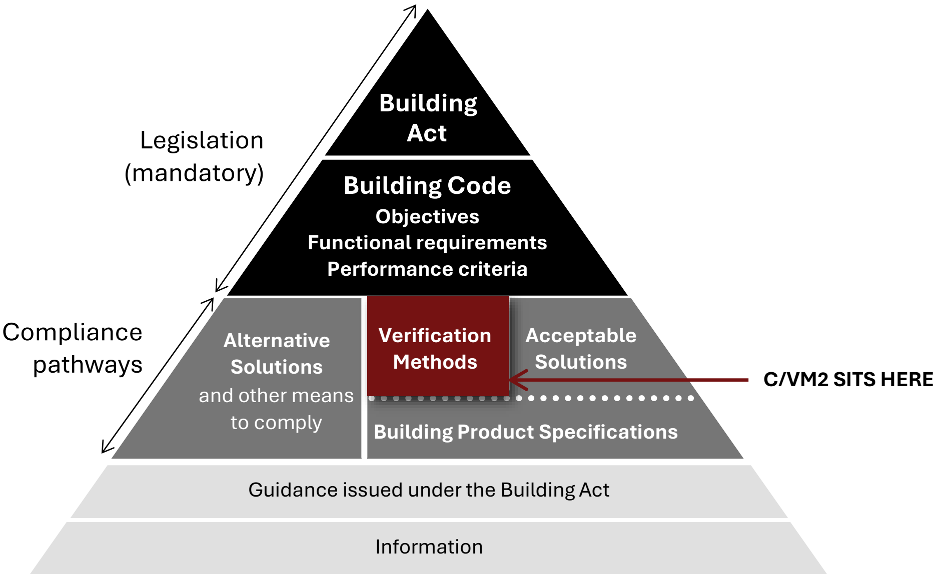
Document status

This document (C/VM2) is a verification method issued under section 22 (1) of the Building Act 2004 and is effective on 28 July 2025. It does not apply to building consent applications submitted before 28 July 2025. The previous Verification Method C/VM2 First Edition, as amended, can be used to show compliance until 31 July 2026 and can be used for building consent applications submitted before 1 August 2026.

Building Code regulatory system

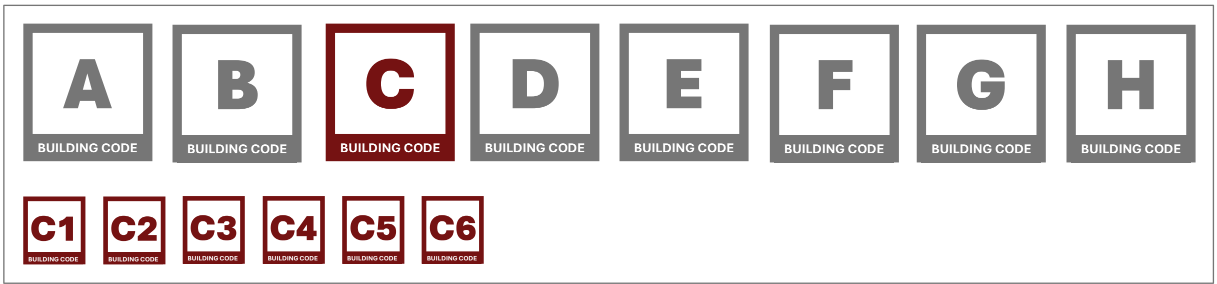
Each verification method outlines the provisions of the Building Code that it relates to. Complying with an acceptable solution or verification method are ways of complying with that part of the Building Code. Other options for establishing compliance are listed in section 19 of the Building Act.

Schematic of the Building Code system



A building design must take into account all parts of the Building Code. The Building Code is located in Schedule 1 of the Building Regulations 1992 and available online at www.legislation.govt.nz.

The part of the Building Code that this verification method relates to is clause C Protection from fire. Information on the scope of this document is provided in Part 1. General.



Further information about the Building Code, including objectives, functional requirements, performance criteria, acceptable solutions, and verification methods, is available at www.building.govt.nz.

Main changes in this version

This verification method is the second edition of C/VM2. The main changes from the previous version are:

- The layout has been revised to improve clarity. This includes using a common structure for headings and text throughout the verification method.
- Minor amendments have been made to correct typos, grammar, cross-references, punctuation, wording, and formatting of the document. This includes changes to headings, paragraphs, tables and figures, table and figure notes, and definitions. Additional comment boxes have been added to throughout the document based on text previously found in the separate Commentary document for C/VM2. These amendments do not affect the level of performance required in the document but may assist in the interpretation of the requirements.
- Occupant load factors have been relocated to Subsection 1.2.4.
- Provisions relevant to determining the available safe egress time (ASET) have all been merged into Section 2.1 and reorganised to provide a consistent structure the section.
- Provisions relevant for assessing fire separations have been merged into Section 2.2.
- The verification method now refers to the Building Product Specifications for smoke separations in Subsection 2.1.3, fire doors and smoke control doors in Subsection 2.1.4, fire resistance ratings in Paragraph 2.2.2.2, cladding materials and cladding systems in Subsections 4.5.5 and 4.6.2, surface linings in Section 4.7, and in the definitions for fire resisting glazing, Group Number, limited combustible, and non-combustible. As a consequence, references to building product standards have been removed from the verification method. This includes references to AS/NZS 3837, AS 1366, AS 1530, AS 4254, AS 5113, BS 8414, BS EN 13501, ISO 5660, ISO 9239, ISO 9705, ISO 13784, NFPA 285, and BRE 135. The previous fire testing appendices have been removed from the document with applicable specifications provided in the Building Product Specifications. More information on the Building Product Specifications is provided in Subsection 1.2.6.
- References have been revised to reflect the documents cited in this verification method in Appendix A.
- Definitions have been revised to reflect the terms used in this verification method in
- Tables for horizontal fire spread have been reorganised to display in landscape format and separated by the fire load in Appendix C.

People using this document should check for amendments on a regular basis. The Ministry of Business, Innovation and Employment may amend any part of any acceptable solution or verification method at any time. Up-to-date versions of acceptable solutions or verification methods are available from www.building.govt.nz.

Features of this document

- For the purposes of Building Code compliance, the standards and documents referenced in this verification method must be the editions, along with their specific amendments listed in Appendix A.
- Words in *italic* are defined at the end of this document in Appendix B.
- Hyperlinks are provided to cross-references within this document and to external websites and appear with a blue underline.
- Appendices to this verification method are part of, and have equal status to, the verification method. Figures are informative only and the wording of the paragraphs takes precedence. Text boxes headed 'COMMENT' occur throughout this document and are for guidance purposes only.
- A consistent number system has been used throughout this document. The first number indicates the Part of the document; the second indicates the Section in the Part; the third is the Subsection; and the fourth is the Paragraph. This structure is illustrated as follows:

2	Part
2.5	Section
2.5.3	Subsection
2.5.3.1	Paragraph
2.5.3.1(a)	Paragraph (as a portion of the relevant paragraph)
2.5.3.1(a)(i)	Paragraph (as a portion of the relevant paragraph)

Contents

Part 1. General

1.1 Introduction

1.1.1 Scope of this document

1.1.1.1 This verification method can be used for the specific design of *buildings* with:

a) simultaneous evacuation procedures where occupants evacuate immediately to the outside; and

b) typical *fire growth* rates.

1.1.2 Items outside the scope of this document

1.1.2.1 This verification method does not include *buildings* that:

a) do not have simultaneous evacuation schemes that evacuate immediately to the outside; or

b) require a managed evacuation; or

c) contain *fire* hazards that are not defined in Part 2. Rules and parameters for the design scenarios.

> COMMENT:
>
> 1. Additional *fire* safety precautions to those determined by this verification method may be necessary to meet the Fire and Emergency New Zealand (Fire Safety, Evacuation Procedures, and Evacuation Schemes) Regulations 2018.
> 2. Examples of *buildings* outside of the scope of this verification method include hospitals, care homes, stadia, principal transport terminals, large shopping malls (greater than 10,000 m^2 and contain mezzanine floors), tall *buildings* (greater than 60 metres or 20 storeys in height), or tunnels.
> 3. *Buildings* that are outside the scope of this document can demonstrate compliance with an alternative solution using the Fire Engineering Brief process described in Subsection 1.2.3 alongside other appropriate parts of this verification method.

1.1.2.2 The control of hazardous substances is not covered by this verification method and it does not provide for any use, storage or processing of hazardous substances. Compliance with Verification Method F3/VM1 and the Hazardous Substances and New Organisms Act 1996, and the Health and Safety at Work (Hazardous Substances) Regulations 2017 is required where applicable in addition to the requirements of this verification method.

1.1.3 Compliance pathway

1.1.3.1 This verification method is one option that provides a means of establishing compliance with the functional requirements and performance criteria in Building Code clause C Protection from Fire.

1.1.3.2 If this verification method cannot be followed in full, use an alternative means to demonstrate compliance.

> COMMENT: Varying the inputs and parameters in this verification method is considered to be an alternative solution. Where the design input is not described in this verification method (for example, boilers), these inputs should be identified as part of the Fire Engineering Brief process described in Subsection 1.2.3.
>
> More information on the use of an alternative solution for fire safety design is available on www.building.govt.nz.

1.2 Using this verification method

1.2.1 Knowledge of fire engineering modelling methods

1.2.1.1 This verification method is suitable for use by professional *fire* engineers who are proficient in the use of *fire* engineering modelling methods.

1.2.1.2 The *fire* modelling rules, *design fire* characteristic, and other parameters to be used in calculations are provided in Part 2. Rules and parameters for the design scenarios.

1.2.1.3 Calculations for the movement of people are provided in Part 3. Movement of people.

> COMMENT: Professional fire engineers are expected to apply appropriate judgment to the model inputs and results when demonstrating compliance using this document.

1.2.2 Determining the importance level

1.2.2.1 Importance levels of *building* are described in clause A3 of the Building Code.

1.2.3 Determining the fire safety requirements

1.2.3.1 Part 4. Design scenarios contains 10 *design scenarios* that must each be satisfied separately in order to demonstrate compliance with the Building Code. The *design scenarios* are summarised in Table 1.2.3.1.

> COMMENT:
>
> 1. The *design scenarios* are intended to provide a diverse range of *fire* events that will challenge the design and *fire safety systems* in the *building*. This includes life safety considerations along with *fire* spread to neighbouring property, external vertical *fire* spread, interior surface linings, and firefighting operations.
> 2. *ASET/RSET* analysis and other computational modelling is only required for a few of the *design scenarios*. Many can be satisfied by inspection or by providing certain features such as *fire separations* or automatic *fire* alarm systems with smoke detection. In many cases the location that is the most challenging and will provide the shortest *ASET/RSET* can be easily determined.

1.2.3.2 The concept *fire* design shall be trialled using *building* specific *fire* design requirements ascertained via a Fire Engineering Brief (FEB) process. This process involves analysing or testing the *fire* design against the design scenarios as applicable and undertaking *fire* modelling of specific scenarios. The Challenging Fire scenario may involve analysis of a number of different *fire* locations in the most challenging locations. An example of the process is illustrated in Figure 1.2.3.2.

> COMMENT: There are a number of internationally recognised documents describing the FEB process including the International Fire Engineering Guidelines and others published by British Standards and the Society for Fire Protection Engineers. More information on the International Fire Engineering Guidelines is available on www.building.govt.nz.

1.2.3.3 Communication relating to the FEB process will vary for each *building* and may include both written and verbal communication to collect stakeholder considerations and test options when preparing trial designs. Similarly, the form of FEB documentation will vary depending on the complexity and scale of the *building* and the design issues. The key feature of the FEB process is that the communication and documentation are unambiguous, complete, provided with appropriate context, and recorded in some form for later reference.

Table 1.2.3.1: Summary of design scenarios

Paragraph 1.2.3.1

Design scenario	Building Code objectives	Building Code performance criteria	Expected method to demonstrate compliance
4.1 BE: Fire blocks exit	C1(a)	C4.5	Evaluate whether a second exit is required or not
4.2 UT: Fire in normally unoccupied room threatening occupants of other rooms	C1(a)	C4.3, C4.4	*ASET/RSET* analysis, or provide *separating elements* or automatic *fire* suppression
4.3 CS: Fire starts in a concealed space	C1(a)	C4.3	Provide *separating elements,* automatic *fire* suppression, or a *fire* alarm system with automatic detection
4.4 SF: Smouldering fire	C1(a)	C4.3	Provide a *fire* alarm system and automatic smoke detection
4.5 HS: Horizontal fire spread	C1(a), C1(b)	C3.6, C3.7, C4.2	Calculate radiation from *unprotected areas* as specified
4.6 VS: External vertical fire spread	C1(a), C1(b)	C3.5	Use appropriate materials and *construction* features to limit vertical *fire* spread as required
4.7 IS: Rapid fire spread involving internal surface linings	C1(b)	C3.4	Use appropriate materials to limit *fire* spread
4.8 FO: Firefighting operations	C1(b), C1(c)	C3.8, C5.3, C5.4, C5.5, C5.6, C5.7, C5.8, C6.3	Provide access and safety for firefighting operations
4.9 CF: Challenging fire	C1(a)	C4.3, C4.4	*ASET/RSET* analysis
4.10 RC: Robustness check	C1(a), C1(b), C1(c)	C3.9, C4.5, C5.8, C6.2(d)	Modified *ASET/RSET* analysis

Figure 1.2.3.2: Example design process for demonstrating compliance using this verification method

Paragraph 1.2.3.2

Step 1. Concept design	Prepare a concept design using: • Occupant characteristics • Initial determination of active and passive *fire safety systems* that are preferred
Step 2. FEB	Communicate the concept design to stakeholders and include the following into the FEB documentation : • Inputs determined from this verification method • Locations and *design fires* for CF: Challenging Fire to use in analysis • *Fire load energy densities* • Occupant related data • Active system inputs (*fire* alarms and automatic *fire* suppression) Revise the FEB documentation if necessary to incorporate stakeholder considerations.
Step 3. Trial design	Prepare a trial design and evaluate the design against the ten *design scenarios* in this verification method. • If the design complies with all the scenarios proceed to Step 4. • If the design does not comply with one or more of the scenarios, revise the trial design and evaluate again. Repeat until all ten scenarios are satisfied. This may require a revision to the concept design and revised FEB documentation (Step 2).
Step 4. Design documents	Document the process and the *fire* design.

Notes:

(1) This figure is an example only and does not form part of the requirements in this verification method.

(2) The figure illustrates how this verification method fits into a general iterative *fire* design process. It assumes the design starts at a concept design stage. The process may vary when using this verification method for demonstrating compliance for existing *buildings*.

1.2.4 Determining occupant loads

1.2.4.1 The *occupant load* shall be determined for each space of the *building*. The *occupant load* may also need to be evaluated for:

a) a space or open floor area involving one or more activities; and/or

b) a floor containing one or more activities; and/or

c) any space bounded by *separating elements*; and/or

d) each floor within a space bounded by *separating elements*.

1.2.4.2 *Occupant loads* shall be calculated from the *occupant load* factors given in Table 1.2.4.2 based on the floor area of the part of the *building* containing the activity. These values already allow for a proportion of the floor area appropriate to the activity being occupied by furniture, partitions, *fixtures*, and associated equipment. If a *building* space has alternative activity uses, the activity having the greatest *occupant load* shall be used. If an activity is not specifically described in Table 1.2.4.2, the nearest reasonable description shall be used.

1.2.4.3 Duplication shall be avoided by:

a) ensuring that, where people may be involved in more than one activity, they are counted only once; and

b) not including an *occupant load* for:

   i) *exitways*, or

   ii) areas such as lift lobbies or sanitary facilities that are used intermittently by people already counted elsewhere in the *building*.

1.2.4.4 For fixed seating, the determination of *occupant loads* shall take account of the actual arrangement and number of seats. Where additional floor area abuts the fixed seating, additional occupants are permitted in that floor area based on standing space density provided the *escape route* is not obstructed.

1.2.4.5 For care and detention activities, the term ‘bed’ means the number of people that are under care or detention. It can include people on:

a) beds; or

b) recliner or lounge chairs; or

c) dentist chairs; or

d) treatment tables; or

e) any other furniture where an occupant may be for a period of treatment in care or detention.

1.2.4.6 If, in a particular situation, the *occupant load* derived from Table 1.2.4.2 is clearly more than that which will occur, the basis of any proposal for a lesser *occupant load* shall be substantiated to the *building consent authority*.

> COMMENT: Designing a *building* for a reduced *occupant load* can severely restrict future occupancy options and may involve significant expense in meeting the *means of escape from fire* provisions for increased numbers.

1.2.4.7 If the maximum *occupant load* is greater than that calculated from Table 1.2.4.2, the higher number shall be used as the basis for the *fire* safety design and will need to be justified to the *building consent authority*.

Table 1.2.4.2: Occupant load factors (continued on next page)

Paragraphs 1.2.4.2, 1.2.4.6, and 1.2.4.7

Activity	Occupant load factor
Aircraft hangars	50 m^2/person
Airport baggage areas	2 m^2/person
Airport waiting areas and check-in	1.4 m^2/person
Airport terminal space	10 m^2/person
Areas without seating or aisles	1 m^2/person
Art galleries and museums	4 m^2/person
Bar sitting areas	1 m^2/person
Bar standing areas	0.5 m^2/person
Bedrooms, bunkrooms, halls, and *wharenui*	Bed spaces
Bleachers, pews, or bench-type seating	0.45 linear m/person
Boiler rooms and plant rooms	30 m^2/person
Bulk storage including racks and shelves	100 m^2/person
Bulk retail (trading stores, supermarkets, and similar)	5 m^2/person
Call centres	7 m^2/person
Care and detention including wards in hospitals, operating theatres, detention quarters, and similar	Bed spaces as per Paragraph 1.2.4.5 and staff
Classrooms	2 m^2/person
Commercial kitchens	10 m^2/person
Commercial laboratories and laundries	10 m^2/person
Computer server rooms	25 m^2/person
Consulting rooms (doctors, dentists, beauty therapy)	5 m^2/person
Dance floors	0.6 m^2/person
Daycare centres	4 m^2/person
Dining, restaurant, and cafeteria spaces	1.25 m^2/person
Dormitories and hostels	Bed spaces and staff
Early childhood centres	Based on Education (Early Childhood Services) Regulations 2008 plus the number of staff
Exhibition areas and trade fairs	1.4 m^2/person
Fitness centres and weight rooms	5 m^2/person
Gaming and casino areas	1 m^2/person
Heavy industry	30 m^2/person
Indoor games areas and bowling alleys	10 m^2/person
Interview rooms	5 m^2/person
Library stack areas	10 m^2/person

Table 1.2.4.2: Occupant load factors (continued from previous page)

Paragraphs 1.2.4.2, 1.2.4.6, and 1.2.4.7

Activity	Occupant load factor
Library other areas	7 m^2/person
Lobbies and foyers	1 m^2/person
Mall areas used for assembly uses	1 m^2/person
Manufacturing and process areas	10 m^2/person
Meeting rooms	2.5 m^2/person
Office spaces	10 m^2/person
Parking buildings and garages	50 m^2/person
Personal service facilities	5 m^2/person
Reading or writing rooms and lounges	2 m^2/person
Reception areas	10 m^2/person
Retail spaces and pedestrian circulation areas including malls and arcades	3.5 m^2/person
Retail spaces for furniture, floor coverings, large appliances, building supplies, and Manchester	10 m^2/person
Showrooms	5 m^2/person
Sleeping non-institutional	Bed spaces
Space with fixed seating	Number of seats
Space with loose seating	0.8 m^2/person
Space with loose seating and tables	1.1 m^2/person
Sports halls	3 m^2/person
Stadiums and grandstands	0.6 m^2/person
Staff rooms and lunchrooms	5 m^2/person
Stages for theatrical performances	0.8 m^2/person
Standing space	0.4 m^2/person
Swimming pool water surface area	5 m^2/person
Swimming pool surrounds and seating	3 m^2/person
Teaching laboratories	5 m^2/person
Technology classrooms (for example: woodwork, metalwork, food science, and sewing)	10 m^2/person
Workrooms and workshops	5 m^2/person

1.2.5 Construction

1.2.5.1 Detailing during *construction* shall meet the requirements of the design as developed using this verification method.

> COMMENT: For example:
> 1. *Fire* rated closures including doors have to be tested in accordance with an internationally recognised standard to confirm the *FRR*.
> 2. *Fire separations* and *smoke separations* should be *fire stopped* with appropriate proprietary products for the orientation and be specific for use in that *separating element*.

1.2.6 Building Product Specifications

1.2.6.1 This verification method refers to the Building Product Specifications for *building* product standards and specifications in relation to their manufacture, fabrication, testing, quality control, physical properties, performance, installation, and/or maintenance.

1.2.6.2 The Building Product Specifications cannot be used in isolation to demonstrate compliance with any requirements of the Building Code. To comply with C/VM2, *building* products conforming to the Building Product Specifications must be used with the scope, limitations, and other applicable requirements set out in this verification method.

Part 2. Rules and parameters for the design scenarios

2.1 Fire modelling for life safety design

2.1.1 Overview

2.1.1.1 For some of the *design scenarios*, it must be demonstrated that the occupants have sufficient time to evacuate the *building* before being overcome by the effects of *fire*. The *available safe egress time (ASET)* must be greater than the *required safe egress time (RSET)*.

2.1.1.2 The *RSET* is to be determined in accordance with Section 3.1.

2.1.1.3 The *ASET* is to be determined:

a) through the use of *fire* modelling following the rules in this section; and

b) using a *design fire* as specified in Section 2.3.

2.1.1.4 The model to be used, and the spaces or volumes to be modelled, shall be established as part of the FEB process described in Subsection 1.2.3.

> COMMENT: The number of cases to check in the analysis depends on the size and complexity of the *building*. It should be agreed with the *building consent authority* as part of the Fire Engineering Brief process. Factors to consider when selecting the *design fire* include the likely *fire growth* rate, number of occupants exposed in the room of origin, other occupants outside the room of origin, and area and height of the spaces.

2.1.1.5 The volume of storage racking, furniture and other contents need not be subtracted from the gross volume.

2.1.2 Automatic detection and warning systems

2.1.2.1 Automatic detection and warning systems shall be installed and simulated in accordance with Section 3.2.

2.1.3 Fire separations and smoke separations

2.1.3.1 The trial design shall identify:

a) the type of separations for the *building* including *fire separations*, *smoke separations*, or non-*fire* rated *construction*; and

b) closures in the separations including *fire doors* and *smoke control doors*; and

c) which of the separations and closures are to be included in the analysis.

2.1.3.2 It is not necessary to include all separations in the analysis. Only those separations and closures forming the volumes required to demonstrate the safe evacuation of occupants need be considered in an *ASET* analysis.

2.1.3.3 *Smoke separations*, including glazing, that comply with Paragraph 8.2.2.1(a) of the Buildings Product Specifications for use as a smoke barrier are assumed to remain in place up to the rated temperature or the time at which *flashover* occurs, whichever is sooner.

2.1.3.4 *Smoke separations* that comply with Paragraph 8.2.2.1(b) of the Buildings Product Specifications (for example, non-*fire* rated but imperforate *construction*) are assumed to remain in place until the average upper layer temperature reaches 200°C.

COMMENT: *Smoke separations* can provide the benefit of containing the smoke within a desired location. *Smoke separations* typically do not have a *fire* rating and so cannot be relied on to prevent smoke spread beyond *flashover*. Therefore, they are assumed not to exist as a barrier to smoke transport. If a *smoke separation* complies with a relevant national or international standard, such as achieving an FRR of 10/10/- in a *standard test* method, then it can be assumed to continue to stay in place up to *flashover*. If the *smoke separation* is not designed in accordance with a relevant national or international standard, such as simply providing toughened glass, then the *smoke separation* is assumed to disappear once the average upper layer temperature reaches 200°C. Although the separation may actually stay in place, it can no longer be relied on to function as a *smoke separation*.

2.1.4 Doors

2.1.4.1 *Doorsets* that are required to be:

a) *fire doors* shall comply with Subsection 8.3.1 of the Building Product Specifications; and

b) *smoke control doors* shall comply with Subsection 8.3.2 of the Building Product Specifications; and

c) *fire doors* with smoke control capability shall comply with both Paragraphs 2.1.4.1(a) and 2.1.4.1(b).

2.1.4.2 *Fire doors* and *smoke control doors* with self-closers are assumed closed unless being used by occupants. During egress, when the *occupant load* is low, doors are assumed to be open for three seconds per occupant. However, when the *occupant load* is high and queuing is expected, the door is considered to be open for the duration of queuing.

COMMENT: A well-maintained *fire door* or *smoke control door* is expected to operate as intended. The opening time of three seconds accounts for occupants arriving at the door at different times during the evacuation phase. The three seconds allows for the occupant to open the door, travel through the opening, and leave the door to self-close.

When queuing is expected, it is assumed there is a continuous flow of people that will keep the door open. High *occupant load* conditions occur when the doorway flow time (t_{flow}) is greater than t_{trav} (refer to Section 3.5). The duration that the door is open should be taken as the shorter of the two methodologies in Paragraph 2.1.4.1.

2.1.4.3 *Smoke control doors* serving bedrooms in sleeping areas where care is provided and that do not have self-closers shall be considered closed once evacuation from the bedroom is complete, as per Part 3. Movement of people.

2.1.4.4 External doors and other closures such as roller shutters shall be simulated as closed unless explicitly designed to open in the event of *fire*.

2.1.4.5 All doors not described in Paragraphs 2.1.4.1, 2.1.4.3, and 2.1.4.4 shall be considered to be open during the analysis unless:

a) there is a high likelihood that the door will be closed for security or other functional reasons throughout the time period of analysis; and

b) the substantiated functional reason is established as part of the FEB process.

2.1.4.6 Doors being used for egress, when in the open position, are assumed to be halfwidth for smoke flow calculations.

> COMMENT: The half opening area is to allow for the fact that the door is rarely fully open to provide a full unobstructed area. The door is either in the process of being opened or closing, or the occupant is passing through the opening and impeding the flow.

2.1.5 Ventilation and leakage areas

2.1.5.1 Windows that are *fire resisting glazing* may be assumed to remain in place up to the rated time.

2.1.5.2 Exterior windows that are not *fire resisting glazing* are assumed to break (that is, the glass falls out to become completely open) at the sooner of either:

a) when the average upper layer temperature reaches 500°C; or

b) when the *fire* becomes limited by ventilation.

> COMMENT: The impact of the glass falling out and providing ventilation for the *fire* is twofold. First, the more ventilation, the larger the *fire* can grow. Second, venting combustion products to the outside reduces the hazard to the occupants.
>
> It is hard to reliably predict when glass falls out of a window. This verification method adopts a prudent approach to address the two most likely situations. If the *fire* can grow to *flashover* without causing the glass to fall out, then the window is assumed to stay in place up to 500°C. This results in the maximum amount of smoke distributed within the *building*. If there is not enough ventilation for *flashover*, the window may still fall out. This provides the ventilation needed for the *fire* to continue to grow. Both situations are valid and should be considered. The value of 500°C represents a rapid onset of *flashover* in the compartment.

2.1.5.3 Leakage area through non-*fire* rated walls shall be calculated according to Paragraph 2.1.5.5. The leakage area may be simulated as either:

a) a tall narrow slot from floor to ceiling with the width determined by the calculated area; or

b) in the case of *CFD* modelling, as two vents, one at floor level and one at ceiling level, to fit within the computational grid. If the required leakage vent area is smaller than a single grid cell, the leakage may be increased to fit within the computational grid. However, the combined area of the modelled leakage vents shall not exceed 5 times that of the calculated leakage area.

2.1.5.4 Where the leakage is from a room to the outside, it may also be simulated as a single vent at floor level. Where there is a permanent opening between two spaces, the leakage between those spaces may be ignored if the area of the permanent opening is at least five times the leakage area.

> COMMENT: Although the actual amount of leakage is never known for a space, a reasonable estimate should be included within the computer modelling. Within a zone model, the leakage is modelled as a vertical vent over the height of the *building*. This assumes that the leakage can be modelled as an equivalent area evenly distributed over the height of the space. For *CFD* modelling, the grid size is typically too large to include the leakage as a vertical slot. When the grid size is too coarse to include the leakage as a vertical slot, then the leakage can be modelled as two vents (one in the lowest grid cells of the space and one at the uppermost grid cells within the space). Two leakage vents (one high and one low in the space) are required to model the leakage for a space even if the grid size is large relative to the size of the vents required.

2.1.5.5 Leakage areas assumed for modelling shall be as follows:

a) *fire separations* and *smoke separations* (excluding doors) are considered to have zero leakage; and

b) *smoke control doors*, including doors that have both *fire* and smoke control capability, that comply Subsection 8.3.2 of the Building Product Specifications are assumed to have a 10 mm gap under the door; and

c) *fire doors* that are not *smoke control doors* are assumed to have a 10 mm gap over the height of the door; and

d) non-*fire* rated internal walls and *external walls* are assumed to have leakage areas that are proportional to the surface area of the walls. The leakage area is equal to the wall area multiplied by 0.001 m^2/m^2 (0.1%) for lined internal and *external walls* and 0.005 m^2/m^2 (0.5%) for unlined *external walls*.

COMMENT: *Fire* resistant *construction* is designed and installed to minimise the flow of *fire* gases from the fire space to the adjacent space. Therefore, the *construction* is assumed to be sealed and with no leakage except for around the doors. When a *smoke control door* is installed, it is assumed that the seals prevent leakage around the door except for the gap at the bottom of the door where seals are not fitted. *Fire doors* without smoke seals are assumed to have a 3 mm gap around the door that is modelled with an equivalent area vent of 10 mm over the height of the door.

2.1.6 Tenability criteria

2.1.6.1 The *ASET* is the time between ignition of the *design fire* and the time when the first tenability criterion is exceeded in a specified room within the *building*. The tenability parameters measured at a height of 2.0 m above floor level, as specified in Building Code clause C4.3, are:

a) *fractional effective dose* of carbon monoxide (FED_{CO}); and

b) *fractional effective dose* of thermal effects ($FED_{thermal}$); and

c) *visibility*.

2.1.6.2 Paragraphs 2.1.1.2(b) and 2.1.1.2(c) do not apply where it is not possible to expose more than 1000 occupants in a *firecell* protected with an automatic *fire* sprinkler system.

COMMENT: *Visibility* will generally be the first tenability criterion exceeded in the calculations unless any exception is applied.

2.1.6.3 FED_{CO} and $FED_{thermal}$ shall be calculated using the procedures described in ISO 13571. FED_{CO} shall include the contributions from CO, CO_2, and O_2 gases. $FED_{thermal}$ shall include radiative and convective effects.

2.1.6.4 The *fire* shall be located away from walls and corners to maximise entrainment of air into the *fire* plume. The base of the *fire* shall be located at a height of no more than 0.5 m above floor level.

COMMENT: The value of 0.5 m accounts for items such as desks, tables, chairs, beds and similar furniture items. The *fire* may be placed lower than 0.5 m, which may occur in CFD modelling where the grid is less than 0.5 m, but it is not permitted to place the *fire* any higher. When a *fire* is placed higher in the room, the detection would be faster and the upper layer would drop more slowly. This would lead to a longer *ASET* than when the *fire* is lower.

2.1.6.5 In most cases there will be a number of locations for the *fire* that could produce the lowest *ASET* for a given *escape route*. The limiting case is to be determined by checking a number of rooms.

2.1.6.6 For design scenario FO only, if *CFD* modelling is used, the layer height shall be defined from the *visibility* results arranged over a number of points throughout the space. The number and location of the points where the layer height is monitored and the criteria for defining the average layer height are described in Appendix C of the commentary.

2.1.6.7 Refer to Subsection 2.3.3 for guidance on modelling *post-flashover fires* when evaluating life safety on *escape routes* that are not in the room of *fire* origin.

2.2 Fire modelling for structural design and to determine the resistance of fire separations

2.2.1 Overview

2.2.1.1 *Fire* modelling for *fires* reaching full *burnout*, for structural design, and for assessing *fire* resistance required of *separating elements*, shall comply with:

a) the *fire* modelling rules in this section; and

b) the *design fire* as specified in Section 2.3.

2.2.2 Equivalent time of exposure

2.2.2.1 When elements of *construction* are required to resist *fully developed fires* for a specified period of time, their minimum *fire resistance rating* may be determined from one of the following (but not less than 20 minutes):

a) specifying a *fire resistance rating* equal to three times the time period for which the *construction* is required to perform; or

b) the equivalent time of exposure in a standard *fire* resistance test assuming full *burnout* as described in Subsection 2.3.4; or

c) the equivalent time of exposure in a standard *fire* resistance test having the same destructive potential for the element of construction as for the compartment *fire*; or

d) calculating the thermal/structural response applicable for the particular material or structural element as described in Subsection 2.3.4.

2.2.2.2 The maximum *fire resistance rating* determined using Subsection 8.2.1 of the Building Product Specifications need not exceed:

a) 240/240/240 for an unsprinklered *firecell*; or

b) 180/180/180 for a sprinklered *firecell*.

2.2.3 Car parking areas

2.2.3.1 The *design fire* severity for car parking areas incorporating a vehicle stacking system shall use the *FLED* specified in Table 2.3.3.4A.

2.2.3.2 The *design fire* severity for car parking areas with overlapping interconnected floors shall be based on the worst case (floor area and effective openings available for ventilation) for one of the overlapping floors or for the worst combination of two adjacent (overlapping) floors.

2.2.3.3 For car parking areas, the area of vertical opening ventilation available to the *fire* shall be the area available via permanent openings to the outside environment in the perimeter walls and access ramps to a car parking level above. Access ramp area shall be taken as the projection on the vertical plane at the point where the ramp meets the floor of the car park at the level under consideration.

2.2.4 Ventilation and effective openings

2.2.4.1 Only those areas of openings in *external walls* and roofs that can dependably provide airflow to the *fire* shall be used in calculating the *fire* severity. Such opening areas include windows containing non-*fire resisting glazing* and horizontal parts of a roof that are specifically designed to open or to melt rapidly in the event of exposure to *fully developed fire*.

2.2.4.2 An allowance can be made for air leakage through the *external wall* of the *building* envelope. The allowance for inclusion in the vertical openings area shall be no greater than 0.1% of the *external wall* area where the wall is lined internally and 0.5% where the *external wall* is unlined.

2.2.4.3 For single storey *buildings* or the top floor of multi-storey *buildings* where the structural system supporting the roof is exposed to view and has no dependable *fire* resistance (for example, a roof with *fire* resistance less than 10 minutes), the ratio of the horizontal openings in the roof to the floor area of the space (A_h/A_f) can be taken as 0.2.

2.2.4.4 For the purposes of calculating the total area of vertical windows and doors (A_v) in the full *burnout design fire*, it shall be assumed that doors in external walls are closed. Wall areas clad in sheet metal shall not be included in the area A_v.

2.3 Design fires

2.3.1 Overview

2.3.1.1 The *design fires* used in analysis are to be defined by one or more of the following parameters:

a) the *fire* growth rate; and

b) the peak *heat release rate*; and

c) the *fire load energy density (FLED)*; and

d) the species production including CO, CO_2, water, and soot; and

e) the *heat of combustion*; and

f) the heat flux; and

g) the time.

2.3.1.2 Parameters for the *design fires* are provided for:

a) the *fire* growth phase in Subsection 2.3.2; and

b) *fully developed fires* and the duration of the *fire* in Subsection 2.3.3; and

c) full *burnout design fires* in Subsection 2.3.4.

2.3.1.3 The individual *design scenarios* in Part 4. Design scenarios specify where these *design fires* are to be used.

> COMMENT: *Design fires* are intended to represent the worst credible scenarios that will challenge the *fire* safety design of the *building*. The details required for each *design fire* are dependent on the issues being addressed in the design.
>
> This verification method uses existing empirical correlations to develop the parameters used for the *design fires*. It assumes the *fire* follows an idealised *fire* growth consisting of pre-*flashover fire* development and the transition to a *fully developed fire* (usually after *flashover* occurs). This does not include analysis of the incipient phase of the *fire* that precedes the growth phase as this is considered to be too unpredictable to be included in design. Although all *fires* are different and have different *fire* characteristics, this follows the internationally recognised methodology for *fire* safety design.

2.3.2 Fire growth phase

2.3.2.1 The characteristics of the pre-*flashover design fire* are given in Table 2.3.2.1.

2.3.2.2 The *fire* is assumed to grow using the values in Table 2.3.2.1 until:

a) *flashover* occurs as defined in Paragraph 2.3.3.2; or

b) the *fire* reaches the peak *HRR* given in Table 2.3.2.1; or

c) the *fire* becomes ventilation limited as described in Paragraph 2.3.3.3; or

d) when determining *ASET* for life safety analysis in sprinklered *buildings*, the sprinklers activate based on the *RTI*, C-factor, and activation temperature specified in Table 3.2.2.2.

> COMMENT: For life safety analysis in sprinklered *buildings*, the *fire* is assumed to be controlled (with a constant *HRR*) after the sprinkler activates. Analysis of *separating elements* and structural design in Section 2.2 is based on the *burnout design fire* without sprinkler intervention except that the design *FLED* may be modified where sprinklers are installed (refer to Paragraph 2.3.4.3).

Table 2.3.2.1: Pre-flashover design fire characteristics

Paragraphs 2.3.2.1 and 2.3.2.2

Building use	Fire growth rate (kW)[(1)]	Pre-flashover species[(1)]	Radiative fraction	Peak HRR and HRR/m²
All *buildings,* except those described in rows below, including storage with a stack height of less than 3.0 m	$0.0469t^2$	Y_{soot} = 0.07 kg/kg Y_{CO} = 0.04 kg/kg ΔH_c = 20 MJ/kg Y_{CO2} = 1.5 kg/kg[(2)] Y_{H20} = 0.82 kg/kg[(2)]	0.35	20 MW 500 to 1000 kW/m²[(3)] 250 kW/m²[(4)]
Carparks (no stacking)	$0.0117t^2$	Y_{soot} = 0.07 kg/kg Y_{CO} = 0.04 kg/kg ΔH_c = 20 MJ/kg Y_{CO2} = 1.5 kg/kg[(2)] Y_{H20} = 0.82 kg/kg[(2)]	0.35	20 MW 500 to 1000 kW/m²[(3)] 250 kW/m²[(4)]
Capable of storage to a stack height of between 3.0 m and 5.0 m above the floor	$0.188t^2$	Y_{soot} = 0.07 kg/kg Y_{CO} = 0.04 kg/kg ΔH_c = 20 MJ/kg Y_{CO2} = 1.5 kg/kg[(2)] Y_{H20} = 0.82 kg/kg[(2)]	0.35	50 MW 1000 to 2500 kW/m²[(3)] 250 kW/m²[(4)]
Capable of storage to a stack height of more than 5.0 m above the floor and car parks with stacking systems	$0.00068t^3 \cdot H$	Y_{soot} = 0.07 kg/kg Y_{CO} = 0.04 kg/kg ΔH_c = 20 MJ/kg Y_{CO2} = 1.5 kg/kg[(2)] Y_{H20} = 0.82 kg/kg[(2)]	0.35	50 MW 1000 to 2500 kW/m²[(3)] 250 kW/m²[(4)]

Notes:

(1) t is the time in seconds. H is the height to which storage is capable of in metres. Y is the *yield* in kg/kg. ΔH_c is the *heat of combustion*.

(2) As an alternative to CO_2 + H_2O *yields* use generic fuel as $CH_2O_{0.5}$ and calculate *yields*.

(3) In a *CFD* model the *fire* is intended to be modelled as a plan area where the size is determined from the peak HRR/m². A range is provided for *HRR*/m² to accommodate different *HRR* and mesh sizes.

(4) For use in a zone model.

2.3.3 Fully developed fire and the duration of the fire

2.3.3.1 After the *fire growth* phase, the *fully developed fire* is assumed to burn at the constant maximum *heat release rate* for the applicable case described in Table 2.3.3.1.

> COMMENT: It may be necessary to first run the *fire* model to determine which of the cases apply and then re-run the model with the adjusted input *HRR*, species *yields*, and duration of burning.

2.3.3.2 *Flashover* is assumed to occur when the average upper layer temperature (T_{UL}) first reaches 500°C.

> COMMENT: *Flashover* marks the transition from a small *fire* to full room involvement. This transition typically occurs over a few seconds. Within this verification method, *flashover* is assumed to occur when the upper layer reaches 500°C, which is at the lower end of the expected temperature range from experiments.

2.3.3.3 The ventilation limit shall be taken as the *HRR* at the time when the predicted energy release first diverges from the *design fire* (given in Table 2.3.2.1) due to the lack of sufficient oxygen for complete combustion.

> COMMENT: The ventilation limit is determined using *fire* modelling.

2.3.3.4 Where *flashover* occurs or the *fire* becomes ventilation limited (refer to cases 3, 4, and 5 in Table 2.3.3.1), the following post-*flashover* species *yields* shall apply after that time:

a) Y_{soot} = 0.14 kg/kgfuel; and

b) Y_{CO} = 0.40 kg/kgfuel.

2.3.3.5 The *fire* is to burn until all the fuel is exhausted. The total *fire load* is to be determined using the design *FLED* specified in Table 2.3.3.4A for the activities within *buildings* and may be modified by multiplying the design *FLED* by the applicable F_m factor from Table 2.3.3.4B.

Table 2.3.3.1: Maximum heat release rate for different cases

Paragraphs 2.3.3.1 and 2.3.3.4

Case	Description	Maximum heat release rate
1	The *fire* reaches the peak *HRR* given in Table 2.3.2.1 before the average upper layer temperature reaches 500°C.	The peak *HRR* given in Table 2.3.2.1
2	Sprinklers activate before the *fire* reaches the peak *HRR* given in Table 2.3.2.1.	The *HRR* at sprinkler activation
3	The average upper layer temperature reaches 500°C before the *fire* reaches the peak *HRR* given in Table 2.3.2.1 and the *fire* is not ventilation limited.	After *flashover* occurs (T_{UL} reaches 500°C), ramp the *fire* up to the peak *HRR* given in Table 2.3.2.1 over a period of 15 s
4	The average upper layer temperature reaches 500°C and the *fire* is ventilation limited	After *flashover* occurs (T_{UL} reaches 500°C), ramp the *fire* up to 1.5 times the ventilation limit *HRR* over a period of 15 s
5	The *fire* is ventilation limited before the average upper layer temperature reaches 500°C.	When the ventilation limit is reached, ramp the *fire* up to 1.5 times the ventilation limit *HRR* over a period of 15 s

COMMENT:

1. The 15 second transition period in Table 2.3.3.1 for *flashover* is based on experimental observations and the numerical capabilities of existing *fire* models.
2. In some of the cases presented, the input *HRR* is to be 1.5 times the ventilation limited *HRR*, after *flashover* or after the ventilation limit is reached. For these cases, growth to the peak in Table 2.3.2.1 would not be realistic and could result in an excessive amount of unburned fuel being generated in the model which may cause numerical problems within the model.

Table 2.3.3.4A: Design fire load energy densities (FLEDs) for use in fire modelling

Paragraphs 2.2.3.1, 2.3.3.5, and 2.3.4.3

<table>
<tr><th>Activities in the space or room</th><th>Examples</th><th>Design FLED (MJ/m²)</th></tr>
<tr><td>1. Display or other large spaces; or other spaces of low fire hazard where the occupants are awake but may be unfamiliar with the building</td><td>Art galleries, auditoriums, bowling alleys, churches, clubs, community halls, court rooms, day care centres, gymnasiums, indoor swimming pools</td><td rowspan="5">400</td></tr>
<tr><td>2. Seating areas without upholstered furniture</td><td>School classrooms, lecture halls, museums, eating places without cooking facilities</td></tr>
<tr><td>3. All spaces where occupants sleep</td><td>Household units, motels, hotels, hospitals, residential care institutions</td></tr>
<tr><td>4. Working spaces and where low fire hazard materials are stored</td><td>Wineries, meat processing plants, manufacturing plants</td></tr>
<tr><td>5. Support activities of low fire hazard</td><td>Car parks, locker rooms, toilets and amenities, service rooms, plant rooms with plant not using flammable or combustible fuels</td></tr>
<tr><td>6. Spaces for business</td><td>Banks, personal or professional services, police stations (without detention), offices</td><td rowspan="3">800</td></tr>
<tr><td>7. Seating areas with upholstered furniture, or spaces of moderate fire hazard where the occupants are awake but may be unfamiliar with the building</td><td>Nightclubs, restaurants and eating places, early childhood centres, cinemas, theatres, libraries</td></tr>
<tr><td>8. Spaces for display of goods for sale (retail, non-bulk)</td><td>Exhibition halls, shops and other retail (non bulk)</td></tr>
<tr><td>9. Spaces for working or storage with moderate fire hazard</td><td>Manufacturing and processing moderate fire load. Storage up to 3.0 m high other than foamed plastics</td><td rowspan="2">1200</td></tr>
<tr><td>10. Workshops and support activities of moderate fire hazard</td><td>Maintenance workshops, plant and boiler rooms other than those described elsewhere</td></tr>
<tr><td>11. Spaces for multi-level car storage</td><td>Car stacking systems. The design floor area over which the design FLED applies is the total actual car parking area</td><td>400/tier of car storage</td></tr>
<tr><td>12. Spaces for working or storage with high fire hazard</td><td>Chemical manufacturing and processing, feed mills, flour mills. Storage over 3.0 m high of combustible materials, including temperature controlled storage</td><td rowspan="2">800/m height, with a minimum of 2400</td></tr>
<tr><td>13. Spaces for display and sale of goods (bulk retail)</td><td>Bulk retail (over 3.0 m high)</td></tr>
</table>

Table 2.3.3.4B: Modification factors (F_m) to be applied to the FLED

Paragraphs 2.3.3.5 and 2.3.4.3

Application	F_m for a sprinklered firecell	F_m for an unsprinklered firecell
Determining the *fire* duration[(1)]	0.5	1.00
Fire resistance of all non-structural elements[(2)]	0.5	1.00
Fire resistance of structural elements not covered by the description in the row below	0.5	1.00
Fire resistance of structural elements in a structural system that is unable to develop dependable deformation capacity under post-*flashover fire* conditions[(3)]	1.00	1.25

Notes:

(1) Life safety calculations of the duration of the fire (the duration of burning) may use the *FLED* as modified by the F_m factor in the table.

(2) This table does not prescribe that all non-structural elements require *fire* resistance based on the *fire* duration. However, where calculation of *fire* resistance of non-structural elements is based on the *fire* duration, this table gives the F_m value to be applied to the *FLED*.

(3) This factor accounts for impact of non-uniform *fire load* and/or ventilation and hence local increase in actual structural *fire* severity on a structural system which has less resilience to accommodate variations from the calculated *fire* severity. For this purpose the structural system comprises the individual members and the connections between these members.

2.3.4 Full burnout design fires

2.3.4.1 The full *burnout design fire* for structural design and for assessing *fire* resistance of *separating elements* shall be based on complete *burnout* of the *firecell* with no intervention.

2.3.4.2 To model the full *burnout design fire*, use one of the following:

a) the time-equivalent formula described in Paragraph 2.3.4.5 to calculate the equivalent *fire* severity and specify *building elements* with a *fire resistance rating* not less than the calculated *fire* severity. If the calculated *fire* severity is less than 20 minutes, a minimum equivalent *fire* severity of 20 minutes shall be used; or

b) a parametric time versus gas temperature formula to calculate the thermal boundary conditions (time/ temperature) for input to a structural response model; or

c) an *HRR* versus time structural *design fire*. Then, taking into account the ventilation conditions, use a *fire* model or energy conservation equations to determine suitable thermal boundary conditions (time/temperature/flux) for input to a structural response model.

> COMMENT:
>
> 1. A common approach to use with this verification method is the equivalent *fire* severity method. This allows the equivalent time of exposure to the *standard test* for *fire* resistance to be estimated based on the compartment properties, *FLED*, and available ventilation given complete *burnout* of the *firecell* with no intervention.
> 2. For Paragraph 2.3.4.2(c), the peak *HRR* should be established and justified as part of the FEB process.

2.3.4.3 For assessing the *fire* resistance of structural and non-structural elements, the *FLED* from Table 2.3.3.4A shall be modified by multiplying the design *FLED* by the applicable F_m factor from Table 2.3.3.4B.

2.3.4.4 Where a space contains interconnected floors, separate calculations shall be made to determine the structural *fire* severity, first by considering the total floor area of the space and then by considering the interconnected floor at each level. The greatest magnitude of structural *fire* severity shall be applied to all levels, unless the structural system supporting floors is designed to dependably prevent collapse during the *fire*.

2.3.4.5 The time equivalence formula shall be taken from Annex E of Eurocode DD ENV 1991-2-2 as given in Equation 2.1 and Equation 2.2.

Equation 2.1: $t_e = e_f \cdot k_b \cdot k_m \cdot w_f$

Equation 2.2: $w_f = \left(\frac{6.0}{H}\right)^{0.3}\left[0.62 + \frac{90(0.4 - \alpha_v)^4}{1 + b_v\alpha_h}\right]$ for $w_f \geq 0.5$

where:

t_e is the time equivalence (minutes); and

e_f is the *FLED* determined in accordance with Paragraph 2.3.4.3; and

k_b is the conversion factor to account for the thermal properties of the material as specified in Paragraph 2.3.4.7; and

k_m is the modification factor for the structural material as specified in Paragraph 2.3.4.6; and

w_f is the ventilation factor. When $w_f < 0.5$, then w_f is equal to 0.5; and

$\alpha_v = {}^{A_v}/_{A_f}$ for $0.025 \leq \alpha_v \leq 0.25$; and

$b_v = 12.5\ (1 + 10\ \alpha_v - \alpha_v^2) \geq 10.0$; and

$\alpha_h = {}^{A_h}/_{A_f}$; and

A_f is the floor area of the space (m^2); and

A_v is the total area of vertical windows and doors (refer to Subsection 2.2.4) (m^2). If $A_v < 0.025A_f$ then $Av = 0.025A_f$ shall be used for the purpose of this calculation. If $A_v > 0.25A_f$ then $A_v = 0.25A_f$ shall be used for the purpose of this calculation; and

A_h is the area of horizontal openings in the roof (refer to Subsection 2.2.4) (m^2); and

H is the average height of the space (m). For pitched roofs, use the average value for H.

2.3.4.6 The value of k_m shall be as follows:

a) for reinforced concrete, protected steel, timber, and a mix of unprotected and protected steel, k_m is equal to 1.0

b) for unprotected steel, k_m is to be determined in accordance with Equation 2.3 which is applicable over the range $0.02 \leq A_v\sqrt{h_{eq}}/A_t \leq 0.20$.

Equation 2.3: $k_m = 13.7\ A_v\sqrt{h_{eq}}/A_t \geq 1.0$

where:

k_m is the modification factor for the structural material; and

A_v is the total area of vertical windows and doors (refer to Subsection 2.2.4) (m^2); and

h_{eq} is the weighted average height of all of the openings (m); and

A_t is the total internal surface area of the enclosure (walls, floors, and ceilings including the openings)(m^2).

2.3.4.7 The value of k_b shall be determined from Table 2.3.4.7. To account for different thermal properties of the walls, ceiling and floor it is permissible to calculate an effective thermal property from Equation 2.4 and determine the k_b factor by interpolation from the table. Where a surface comprises multi-layers with different materials, it is only the first few centimetres on the *fire* exposed side that relevant for the purposes of the calculation.

Table 2.3.4.7: Conversion factor k_b for various lining materials

Paragraph 2.3.4.7

Typical values for $\sqrt{k\rho c}$ ($J/m^2s^{0.5}K$)(1)	Construction materials	k_b
400	Very light highly insulating materials	0.10
700	Plasterboard ceilings and walls	0.09
1100	Light weight concrete ceilings	0.08
1700	Normal weight concrete ceilings	0.065
> 2500	Thin sheet steel roof and any wall systems	0.04

Notes:

(1) k is the thermal conductivity (W/mK), ρ is the density (kg/m^3), and c is the specific heat (J/kgK).

Equation 2.4: $\sqrt{k\rho c} = \left(\sum\left(b_j A_j\right)\right) / (A_t - A_v)$

where:

$\sqrt{k\rho c}$ is the effective thermal property ($J/m^2s^{0.5}K$); and

A_j = area of the enclosed surface j not including openings (m^2); and

b_j = thermal property ($\sqrt{k\rho c}$) of enclosure surface j ($J/m^2s^{0.5}K$); and

A_t is the total internal surface area of the enclosure (walls, floors, and ceilings including the openings)(m^2); and

A_v is the total area of vertical windows and doors (refer to Subsection 2.2.4) (m^2).

Part 3. Movement of people

3.1 Required safe egress time (RSET)

3.1.1 Overview

3.1.1.1 The *required safe egress time (RSET)* is the calculated time available between ignition of the *design fire* and the time when all the occupants in the specified room/location have left that room/location.

3.1.1.2 The simple hydraulic model for *RSET* is given in Equation 3.1.

Equation 3.1: $RSET = (t_d + t_n + t_{pre}) + (t_{trav} \text{ or } t_{flow})$

where:

t_d is the *detection time* determined from deterministic modelling (refer to Section 3.2); and

t_n is the time from detection to notification of the occupants (refer to Section 3.3); and

t_{pre} is the time from notification until evacuation begins (refer to Section 3.4); and

t_{trav} is the time spent moving toward a place of safety (refer to Section 3.5); and

t_{flow} is the time spent in congestion controlled by flow characteristics (refer to Section 3.5).

3.1.1.3 When calculating the flow from the room of origin, the occupants are assumed to be evenly distributed in the space. Therefore, the egress time is determined by the greater of the travel time to the exit (t_{trav}) and the queuing time (t_{flow}).

> COMMENT: This verification method defines the minimum analysis required to demonstrate that the *building* meets the required performance criteria. For more information on how to calculate *RSET*, refer to the SFPE Handbook of Fire Protection Engineering, Section 3 Chapter 13.

3.1.1.4 *Occupant loads* shall be determined in accordance with Subsection 1.2.4.

3.1.1.5 Additional requirements apply for:

a) *buildings* with delayed evacuation strategies in Section 3.6; and

b) occupants exposed to radiation along *egress routes* in Section 3.7.

3.2 Detection time

3.2.1 Fire alarm system

3.2.1.1 *Buildings* must have a *fire* alarm system installed to NZS 4512 to alert the occupants to a *fire*.

3.2.1.2 The *detection time* shall be determined using:

a) deterministic modelling for automatic detection of the *fire* or activation of a sprinkler system in accordance with Subsection 3.2.2; or

b) manually activation of the *fire* alarm system in accordance with Subsection 3.2.3.

> COMMENT: Calculating the *RSET* requires accurate, predictable, and reliable means of alerting the occupants to a *fire*. Thus, a means of automatically alerting the occupants is required to use this verification method. Manual activation of the *fire* alarm is permitted for a *building* such as a warehouse where the *occupant load* is low and the ceiling is high. For these *buildings*, the high ceiling allows the smoke layer to traverse the entire length of the *building* before the smoke can threaten the occupants. This provides time for the few occupants in the *building* to see the smoke travelling across the ceiling and evacuate before the onset of hazardous conditions.

3.2.2 Automatic detection

3.2.2.1 The *detection time* for an automatic warning system shall be determined using *fire* modelling with:

a) an algorithm that includes a ceiling jet correlation; or

b) a *CFD* model that solves for the velocity, temperature, and smoke/soot concentration directly.

3.2.2.2 Detectors shall be simulated using the values in Table 3.2.2.2 regardless of the actual make/model and installation parameters of the detection device specified to be installed in the *building*.

3.2.2.3 For very high sensitivity air sampling smoke detectors, this type of detector requires specialised design. The response depends on a range of factors including air flow rates, sampling tube length, and alarm threshold levels. The response criteria in Table 3.2.2.2 shall be used in the analysis.

Table 3.2.2.2: Criteria for detector and sprinkler activation

Paragraphs 2.3.2.2, 3.2.2.2, and 3.2.2.3

Detector criteria	Sprinkler activation criteria
Heat detector *RTI* = 30 $m^{1/2}s^{1/2}$ T_{act} = 57°C Radial distance = 4.2 m Distance below ceiling not less than 25 mm	**Extended coverage sprinkler** *RTI* = 50 $m^{1/2}s^{1/2}$ C = 0.65 $m^{1/2}s^{1/2}$ T_{act} = 68°C Radial distance = 4.3 m (maximum) Distance below ceiling not less than 25 mm
Smoke detectors including ionisation or photoelectric spot detectors, or air sampling smoke detectors *Optical density of smoke* at alarm = 0.097 m^{-1} Radial distance = 7.0 m Distance below ceiling not less than 25 mm	**Standard response sprinkler** *RTI* = 135 $m^{1/2}s^{1/2}$ C = 0.85 $m^{1/2}s^{1/2}$ T_{act} = 68°C Radial distance = 3.25 m Distance below ceiling not less than 25 mm
Project beam smoke detectors *Optical density of smoke* at alarm to be determined based on beam path length and the design setting for the total obscuration for alarm	**Quick response sprinkler** *RTI* = 50 $m^{1/2}s^{1/2}$ C = 0.65 $m^{1/2}s^{1/2}$ T_{act} = 68°C Radial distance = 3.25 m Distance below ceiling not less than 25 mm

(1) When a space is small than the radial distance quoted above it is permitted to use the maximum spacing distance appropriate to the dimensions of the space in compliance with the appropriate standard.

(2) If a higher activation temperature is required by the chosen sprinkler standard this shall be used as T_{act}.

COMMENT:

1. Smoke *optical density of smoke* at alarm of 0.097 m^{-1} is used for design purposes and would correspond to a detector with a normal level of sensitivity.
2. For projected beam smoke detectors, response sensitivities are typically in the range of 20% to 70% total obscuration (OBS) and I/Io = 0.3 to 0.8.

   Based on design inputs for the beam path length and the response sensitivity, and assuming a uniform *optical density of smoke* along the path length of the beam, the *optical density of smoke* at alarm is calculated as:

   $$OD = -\frac{1}{L}\log_{10}\left(\frac{I}{I_o}\right) \text{ and } \left(\frac{I}{I_o}\right) = \frac{100 - OBS}{100}$$

   where:
   OB = *optical density of smoke* (1/m)
   L = path length of beam (m)
   I = intensity at receiver with smoke
   I_o = intensity at receiver without smoke, and
   OBS = total obscuration (%).

   For example, if the beam path length is 10 m and the total obscuration for alarm is set at 50%, then:

   $$OD = -\frac{1}{L}\log_{10}\frac{100 - OBS}{100} = -\frac{1}{10}\log_{10}\frac{100 - 50}{100} = 0.030 \text{ m}^{-1}$$

   In practice, the *optical density of smoke* along the path length may not be uniform such as when a plume intercepts a beam. If desired, to account for this, the path length can be divided into smaller sections and the *optical density of smoke* (OD/m x length of section) summed over all sections.

3.2.3 Manual activation of an alarm

3.2.3.1 Manual activation of an alarm system shall only be permitted in spaces where the average ceiling height is 5 m or more, the occupants of the *building* are awake and familiar with their surroundings, and the *occupant load* is fewer than 50 persons. In all other situations automatic detection is required.

3.2.3.2 Where only manual systems are installed, occupants are assumed to be aware of the *fire* when the ceiling jet flow has traversed the entire length of the space from a *fire* at the opposite end of the space. No additional *pre-travel activity times* need be included. The time required for the ceiling jet to completely traverse the ceiling can be determined using:

a) *CFD* modelling; or

b) Equation 3.2 if zone modelling is used.

Equation 3.2:

For storage height ≤ 5.0 m (ultrafast *fire* growth):

$t_d = 10 + 2.4L$ when $L \leq 1.4w$, and

$t_d = 10 + w + 1.7L$ when $1.4w < L \leq 4w$; and

For storage height > 5.0 m (rack growth):

$t_d = 25 + 1.7L$ when $L \leq 1.4w$, and

$t_d = 25 + w + L$ when $1.4w < L \leq 4w$

where: w is the width of the space in metres (shortest dimension); and
L is the length of the space in metres (longest dimension).

> COMMENT: Predicting the activation of an alarm by manual call points can be problematic because it relies on human interaction to trigger the alarm. This approach assumes that the *fire* is seen and manual alarm activated. It is based on the transport time for smoke to travel the length of the *building* as the time delay between ignition and activation of the alarm. No other *pre-travel activity time* or alarm notification time is included. Manual call point systems are simple systems and are expected to activate immediately after the call point is activated. The application of this methodology is intended for large spaces such as warehouses.

3.2.3.3 If the space with a high ceiling has *intermediate floor(s)*, the manual activation will be permitted to apply if the *intermediate floors* are open and the occupants will be fully aware of a *fire* located in the warehouse.

3.2.3.4 If there are *occupied spaces* that are separated from the space with a high ceiling such as offices in warehouses, the methodology may be used and the following criteria apply to the small *occupied space*:

a) *pre-travel activity time* of 60 s for the occupants of the small *occupied space* after manual activation; and

b) maximum area of the space 500 m^2; and

c) the area must be located on the ground floor of the space with a high ceiling; and

d) there must be an *escape route* directly from the *occupied space* to the outside without the need to enter the space with a high ceiling.

3.2.3.5 If the criteria in Paragraph 3.2.3.4 are not met, the adjacent office areas must have a *detection time* in accordance with Subsection 3.2.2 and a notification time in accordance with Subsection 3.3.1. Automatic detection must be installed within the adjacent office.

3.2.3.6 An exception is a very small isolated area within the space with a high ceiling such as washrooms or offices each being no larger than 30 m^2 located on the ground floor. The maximum aggregate *occupant load* of these spaces is 10 persons. The *pre-travel activity time* of 60 s shall be applied for egress from these spaces.

3.3 Notification time

3.3.1 Overview

3.3.1.1 For standard evacuation strategies, take the notification time as 30 seconds.

3.3.1.2 For non-standard evacuation strategies (for example, management investigating sole activation), take account of the extended notification time.

3.4 Pre-travel activity time

3.4.1 Overview

3.4.1.1 *Pre-travel activity times* shall be determined using the values in Table 3.4.1.1.

Table 3.4.1.1: Pre-travel activity times

Paragraph 3.4.1.1

Description of occupants	Examples of buildings	Alarm signal	Pre-travel activity time for occupants in the enclosure of origin (s)	Pre-travel activity time for occupants remote from the enclosure of origin (s)
Awake, alert and familiar with the *building*	Offices, warehouses not open to the public	Any	30	60
Awake, alert and unfamiliar with the *building*	Retail shops, exhibition spaces, restaurants	Standard alarm signal	60	120
		Voice alarm signal	30	60
Sleeping and familiar with the *building*	Apartments	Standard alarm signal	60	300
Sleeping and unfamiliar with the *building*	Hotels and motels	Standard alarm signal	60	600
		Voice alarm signal	60	300
Awake and under the care of trained staff	Dental office, clinic	Any	60	120
Children under the care of trained staff	*Early childhood centres*	Any	60 s for staff to respond to alarm then 60 s per child per staff[1]	120
Sleeping and under the care of trained staff	Hospitals and rest homes	Any	60 s for staff to respond to alarm then 120 s per patient per 2 staff[2]	1800[3]
Sleeping and detained under the care of trained staff	Prisons	[4]	[4]	[4]
Focused on an activity	Cinemas, *theatres* and stadiums	Any	0[5]	Refer to other values above as relevant

Notes:

(1) This assumes staff will respond to the room of *fire* origin. It allows 60 s to move each child from their location to the *place of safety* on the same floor and then to return to evacuate another child.

(2) This assumes staff will respond to the room of *fire* origin. It allows 120 s to move each patient from their room to the next adjacent *firecell*. This includes time for staff to prepare the patient and transport them to the adjacent *firecell*, and then to return to evacuate another patient. It is expected that three teams each of 2 staff members is a realistic maximum limit that can shuttle patients from their ward/bedroom to a *place of safety*. The commentary document for this verification method gives details of staff to patient ratios.

(3) Where occupants are unable to be moved due to the procedure or other factors, the *pre-travel activity time* shall be based on the specific requirements for the procedure or 1800 s, whichever is the greater.

(4) The values for analysis are to be established as part of the FEB process.

(5) Within the space of origin, occupants are assumed to start evacuation travel immediately after detection and notification time or when *fire* in their space reaches 500 kW, whichever occurs first.

Movement of people

COMMENT:

1. There are many factors that influence the *pre-travel activity time* of occupants within a *building* including, but not limited to: age, gender, training, familiarity, activity, family grouping, density of occupants, physical abilities of occupants, the type of warning system, and the spatial complexity of the *building*. The *pre-travel activity times* in Table 3.4.1.1are intended to take into account these factors to the degree necessary for design purposes. The incipient phase of the *fire* growth has not been considered in the design *fire* which provides an inherent safety factor for the *pre-travel activity times* in Table 3.4.1.1.
2. Shorter *pre-travel activity times* may be assumed for occupants in the enclosure of *fire* origin due to the presence of additional cues that are not available to remote occupants. These cues can prompt a faster recognition of danger and a more immediate evacuation response. These cues may be:
   a. direct, such as seeing flames or smoke, or smelling smoke. These are typically limited to occupants in the room of origin or, in some cases, to open-plan floors directly above the *fire* and connected by vertical voids; or
   b. indirect, such as being alerted by others or observing others evacuating. Indirect cues may be assumed where the space operates as a single use with a reasonable degree of occupant interaction. Examples include:
      i. retail areas within the same tenancy, and
      ii. office spaces under single management, and
      iii. dormitory-style accommodation.
   Indirect cues should not be assumed in spaces with limited interaction, such as:
      i. apartments, or
      ii. hotels, or
      iii. separate office tenancies, even if located on the same floor.
   For indirect cues, occupants must be able to alert others. The assumption of indirect cues should be limited to the general area of the *fire* and typically within the same floor and no more than one room removed from the room of origin. This recognises that people may raise the alarm while evacuating but are unlikely to actively seek out others in remote areas. There is a decreasing likelihood of occupants receiving cues as their distance from the *fire* increases.
   Where direct or indirect cues can be reasonably assumed, the *pre-travel activity time* may be taken as that for the enclosure of origin. In all other cases, occupants should be treated as remote, and a longer *pre-travel activity time* should be applied.
   Pre-travel activity times for occupants within or remote from the enclosure of origin should be established as part of the Fire Engineering Brief process.
3. The evacuation of hospital ward areas with the 2 min/patient time assumes that there is an adjacent enclosure available for horizontal evacuation. If this is not available, the *pre-travel activity time* may need to be increased.
4. When people are in a focused activity, such as a *theatre* or sports arena, it is expected that a *fire* within that area would be obvious to the occupants and that they would start to evacuate when the *fire* gets to 500 kW.

3.5 Travel time

3.5.1 Overview

3.5.1.1 Travel time within a space is governed by:

a) the time taken to travel to the doorway (t_{trav}) as determined in accordance with Subsection 3.5.2; or

b) the time for all the occupants to flow through a restriction, typically a doorway, when queueing is necessary (t_{flow}) as determined in accordance with Subsection 3.5.3.

3.5.1.2 The greater of these two times is the *evacuation time* from the space.

3.5.1.3 Doors on *escape routes* shall be hung to open in the direction of escape and, where escape may be in either direction, doors shall swing both ways. This does not apply where the number of occupants of spaces with egress using the door is no greater than 50. Manual sliding doors are permitted where the relevant number of occupants is no more than 20.

> COMMENT: This applies to standard, manual, self-closing side-hinged doors, and not to automatic sliding doors.

3.5.1.4 Where a primary entrance can be identified, the primary entrance shall be designed to egress 50% of the total *occupant load* of the space with the remaining occupants evenly distributed in proportion to the number of exits. Where there is no primary entrance, the *occupant load* shall be distributed to the available exits with no more than 50% to one exit.

3.5.2 Time to reach a doorway

3.5.2.1 For horizontal travel through corridors, aisles, ramps, or doorways, the travel time (t_{trav}) shall be calculated by using Equation 3.3.

Equation 3.3: $t_{trav} = L_{trav}/S$

where:

t_{trav} is the travel time (s); and

L_{trav} is the *travel distance* (m); and

S is the horizontal travel speed (m/s).

3.5.2.2 Horizontal travel speed (S) shall be:

a) calculated using Equation 3.4; or

b) if the calculated travel speed exceeds 1.2 m/s, taken as 1.2 m/s.

Equation 3.4: $S = k - akD$

where:

S is the horizontal travel speed (m/s); and

D is the occupant density of the space (persons/m^2); and

k is 1.4 for horizontal travel; and

a is 0.266.

> COMMENT: If the calculated travel speed is less than 1.2 m/s, then the calculated value is to be used in Equation 3.3.

3.5.2.3 The maximum horizontal *travel distance* (L_{trav}) shall be determined by:

a) adding together the length of orthogonal *travel distance* to the nearest exit; or

b) if the location of fixed obstructions is known, measuring the *travel distance* around the fixed obstructions.

3.5.2.4 For vertical travel, the travel speed is to be determine using Table 3.5.2.4 as calculated using Equation 3.4 based on the stair riser, stair tread, and corresponding k value.

Table 3.5.2.4: Vertical travel speeds based on the stair riser and stair tread size

Paragraph 3.5.2.4 and Equation 3.5

Stair riser (mm)	Stair tread (mm)	k	Travel speed (m/s)
191	254	1.00	0.85
178	279	1.08	0.95
165	305	1.16	1.00
165	330	1.23	1.05

3.5.3 Time if flow governs

3.5.3.1 The flow time (t_{flow}) shall be calculated using the flow rate in Equation 3.5 and the number of occupants to flow through a restriction. Refer to Paragraph 3.5.1.4 for the distribution of occupants where multiple exits are available.

Equation 3.5: $F_c = (1 - aD)k \cdot D \cdot W_e$

where:

F_c is the calculated flow (persons/s); and

a is 0.266; and

D is the occupant density near the flow constriction and is 1.9 persons/m^2 for doors; and

k is 1.4 for horizontal travel and determined from Table 3.5.2.4 for vertical travel; and

W_e is the effective width of the component being traversed (m).

> COMMENT: This verification method does not provide a comprehensive guide to egress analysis, but highlights the level of rigour expected in the egress calculations. Refer to the SFPE Handbook of Fire Protection Engineering, Section 3 Chapter 13, for further details regarding egress calculation procedures, including flow transitions.
>
> The egress analysis should be undertaken for the entire length of the *escape route* ensuring that the flow of occupants is not restricted at some point closer to the *final exit*.

3.5.3.2 The effective width (W_e) is equal to the measured width minus the boundary layer. The thickness of the boundary layer is given in Table 3.5.3.2.

Table 3.5.3.2: Boundary layer width for calculating the effective width of an exit component

Paragraph 3.5.3.2

Exit route element	Boundary layer on each side (m)
Stairway – walls or side tread	0.15
Railing or *handrail*	0.09
Theatre chairs, stadium bench	0.00
Corridor wall and ramp wall	0.20
Obstacle	0.10
Wide concourse, passageway	0.46
Door, archway	0.15

> COMMENT: Equation 3.5 is most commonly used for doorway flows to estimate the queuing times. However, it is useful in many situations, as shown by the variety of exit route elements listed in Table 3.5.3.2.

3.5.3.3 For doorway flows, the maximum flow rate is limited to 50 people per minute for each standard door leaf that has a self-closing device fitted. If there is no self-closing device, Equation 3.5 shall be used with no upper limit on the flow rate.

> COMMENT:
>
> 1. The maximum flow rate of 50 people per minute corresponds to a door of 0.95 m wide with a boundary layer each side of 0.15 m and a total effective width of 0.65 m. The cap on the doorway flow rate is due to the impact of the door interfering with the egressing occupants. If the door is somehow held open, or does not have a self-closer, then the flow through the opening is calculated using Equation 3.5 with the appropriate effective width. For the case of double doors where both doors have self-closers, the maximum possible flow would be 50 persons/min/leaf and therefore 100 persons/min in total. This is the maximum flow through a double door with or without a mullion.
> 2. In the case of automatic sliding doors, the effective width of the opening may be used in Equation 3.5 from the time when the doors are opened and remain open. The same applies to manual sliding doors. They may be assumed to remain fully open once the first occupant has passed through the door.

3.6 Delayed evacuation strategies

3.6.1 Places of safety

3.6.1.1 *Buildings* and parts of *buildings* that have occupants that are required to stay in place or where evacuation is to a *place of safety* inside the *building* (for example, where occupants may either be detained or undergoing treatment such as in an operating theatre, hyperbaric chamber or dialysis unit) must comply with the definition of *place of safety*.

> COMMENT: As these spaces usually have a climate controlled environment, special care should be taken with the design of smoke detection and air handling system smoke control.

3.7 Exposure to radiation along escape routes

3.7.1 Overview

3.7.1.1 When occupants located within an *exitway* or on an external *escape route* must egress past a window opening or glazed panel, they must not be exposed to a radiation level which will cause pain while evacuating. The time to onset of pain (t_p) must be longer than the exposure time (t_{exp}).

3.7.1.2 The limitations for the analysis are as follows:

a) the analysis requires that all occupants must have evacuated past the window opening or glazed panel within 10 minutes after ignition unless *fire resisting glazing* is used; and

b) the maximum allowable radiation level that an occupant can be exposed to is 10 kW/m^2; and

c) the analysis described here is only applicable for a single window. Multiple windows require more detailed analysis on the time to pain calculations where the time-dependent cumulative effect of the radiation can be accounted for (such procedures can be found in the SFPE Engineering Guide – Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation); and

d) analysis is not appropriate where occupants are likely to be mobility-impaired.

e) radiation through uninsulated *fire resisting glazing* can be reduced by 50% (refer to k = 0.5 in Equation 3.7); and

f) analysis is not required where an alternative *escape route* is available; and

g) analysis is not required where insulated glazing with a *fire* resistance of not less than -/30/30 is used; and

h) analysis is not required for sprinklered *buildings* with window wetting sprinklers located on the same side of the window as the *fire* and designed and installed for that specific purpose; and

i) analysis is not required during the period prior to *ASET* for the room of *fire* origin; and

j) any part of the window or glazed panel that is openable must be fitted with a self-closer or other device that automatically closes the opening on detecting smoke or heat.

> COMMENT: For Paragraph 3.7.1.2(h), wall wetting sprinkler heads and system listed and approved by a qualified agency for this purpose are considered to provide protection equivalent to a *fire separation* provided they are installed to the specific requirements of the listing.

3.7.2 Time to onset of pain

3.7.2.1 The time to onset of pain shall be determined using Equation 3.6.

Equation 3.6: $t_p = \left(\frac{35}{\dot{q}_r''}\right)^{1.33}$

where:

t_p is the time required for pain (s); and

$\dot{q}_r''$ is the maximum incident thermal radiation (kW/m^2).

3.7.3 Radiation from a window to an egressing occupant

3.7.3.1 The maximum incident thermal radiation occurs opposite the centre of the window or glazing, at a height of 2.0 m or mid-height of the glazing whichever is the lower height, and can be calculated using Equation 3.7.

Equation 3.7: $\dot{q}_r'' = F_W \varepsilon k \dot{q}_W''$

where:

$\dot{q}_r''$ is the maximum incident thermal radiation (kW/m^2); and

F_w is the view factor from a window or glazing to a point opposite the centre of the window or glazing, at a height of 2.0 m or mid-height of the glazing whichever is the lower height, and at a distance corresponding to the nearest part of the required *escape route*; and

ε is the emissivity of the fire gases taken as 1.0; and

k is the glazing factor equal to 0.5 for *fire resisting glazing* and 1.0 for all other glazing; and

$\dot{q}_W''$ is the design emitted heat flux from the window taken as 83 kW/m^2 for *FLED* ≤ 400 MJ/m^2, 103 kW/m^2 for *FLED* between 400 and 800 MJ/m^2, and 144 kW/m^2 for FLED greater than 800 MJ/m^2.

3.7.3.2 For sprinklered *buildings*, the maximum incident thermal radiation may instead be determined from Subsection 3.7.5 and Equation 3.9 assuming the *fire* point source is located mid-width of the window or glazing at a height of 2.0 m, and at a horizontal distance of 2.0 m from the window or glazing.

3.7.3.3 The sprinkler controlled *heat release rate* may be used in Equation 3.9.

3.7.4 Exposure time

3.7.4.1 The exposure time (t_{exp}) is determined by calculating the distance (D) the occupant must travel while exposed to radiation from the window or glazed panel and assuming a travel speed of 1.0 m/s. The occupant is assumed to be exposed as long as their exposure to the incident thermal radiation is greater than 2.5 kW/m^2. The exposure time for the occupant is the travel distance required to pass the window, divided by the walking speed as shown in Equation 3.8

Equation 3.8: $t_{exp} = \left(\frac{D}{V}\right)$

where:

t_{exp} is the time an occupant is exposed to the radiation (s); and

V is the travel speed of 1 m/s; and

D is the distance the occupant must travel while exposed to incident thermal radiation of at least 2.5 kW/m^2 from the window or glazing (m).

3.7.5 Radiation from a burning object to an egressing occupant

3.7.5.1 Radiation calculations from a burning object can be approximated using the point source model with fixed radiation fraction as given in Equation 3.9.

Equation 3.9: $\dot{q}_r'' = \frac{0.45\,\dot{q}_{Fire}}{4\pi r^2}$

where:

$\dot{q}_r''$ is the radiation flux at a distance r from the fire occupant (kW/m^2); and

$\dot{q}_{fire}''$ is the total heat release rate from the *fire* (kW); and

r is the radial distance from the *fire* to the egressing occupant (m).

3.7.5.2 To use this equation, the average upper layer temperature within the *fire* compartment must not have exceeded 150°C.

Part 4. Design scenarios

4.1 BE: Fire blocks exit

Criteria	Description
Scenario in brief	A *fire* starts in an *escape route* and can potentially block an exit.
Code objective	C1(a) Safeguard people from an unacceptable risk of injury or illness caused by *fire*
Performance criteria that must be satisfied	C4.5 by providing *escape routes* for *building* occupants in the event of *fire*
Required outcome	Demonstrate that a viable *escape route* (or multiple routes where necessary) has been provided for *building* occupants.

4.1.1 Scenario description

4.1.1.1 This *design scenario* addresses the concern that, due to proximity of the *fire source*, a *fire* may block an *escape route* and prevent occupants from being able to evacuate. The number of exits and total exit width must be sufficient for the number of occupants.

4.1.1.2 This scenario applies to *escape routes*:

a) serving more than 50 people; or

b) with a single direction of travel.

4.1.1.3 This scenario does not apply to vertical stair enclosures that are *fire separated* from all other parts of a *building* that serve not more than:

a) 150 people if the *building* is unsprinklered; or

b) 250 people if the *building* is sprinklered.

> COMMENT: For an unsprinklered *building* with up to 50 people per level, the maximum number of storeys able to be served by a single stair is four (assuming the ground floor occupants do not use the stair). If the same *building* is sprinklered, the maximum number of storeys would increase to six.

4.1.1.4 Single *escape routes* are permitted to serve up to 50 people.

4.1.1.5 In order to be regarded as alternative *escape routes*, the *escape routes* shall be separated from each other and shall remain separated until reaching a *final exit*. Separation shall be achieved by diverging (from the point where two *escape routes* are required) at an angle of no less than 90° until separated by:

a) a distance between closest parts of the openings of:

  i) at least 8.0 m when up to 250 occupants are required to use the *escape routes*, or

  ii) at least 8.0 m when more than 250 occupants are requiring escape through more than two *escape routes*, or

  iii) at least 20 m when more than 250 occupants are required to escape through only two *escape routes*; or

b) *smoke separations* and *smoke control doors*.

4.1.1.6 For each room/space accommodating more than 50 people within the *building*, assume that the *fire source* is located near the primary *escape route* or exit and that it prevents occupants from leaving the *building* by that route. The *fire* in the *escape routes* can be the result of a deliberately lit *fire* or an accidental *fire*.

> COMMENT: The *fire* source locations must be considered that prevent the use of exits in *escape routes*. However, *fire* characteristics and analysis need not be considered in this scenario as the *fire* is assumed to physically block the exit. It is assumed that occupant tenability criteria cannot be met where *fire* plumes and flame block an exit.

4.1.1.7 Active and passive *fire* safety systems in the *building* shall be assumed to perform as intended by the design.

4.1.2 Method

4.1.2.1 If the *escape routes* serve more than 50 people, demonstrate whether or not a second exit is required.

4.1.2.2 If there is an *escape route* with a single direction of travel, the maximum length of that single direction shall be not greater than:

a) 50 m if occupants are familiar with the *building*; or

b) 40 m if occupants are not familiar with the *building*.

4.2 UT: Fire in normally unoccupied room threatening occupants of other rooms

Criteria	Description
Scenario in brief	A fire starts in a normally unoccupied room and can potentially endanger a large number of occupants in another room.
Code objective	C1(a) Safeguard people from an unacceptable risk of injury or illness caused by *fire*.
Performance criteria that must be satisfied	C4.3 and C4.4 for any *buildings* with rooms or spaces that can hold more than 50 people. This may require analysis.
Required outcome	Demonstrate ASET>RSET for any rooms or spaces that can hold more than 50 people given a *fire* occurs in the normally unoccupied space. Solutions might include the use of *separating elements* or *fire* suppression to confine the *fire* to the room of origin.

4.2.1 Scenario description

4.2.1.1 This *design scenario* addresses the concern of a *fire* starting in a normally unoccupied room that grows to a significant size and spreads to other areas where large numbers of people may be present.

4.2.1.2 This *design scenario* applies to *buildings* with rooms or spaces that can hold more than:

a) 50 occupants when only a manual *fire* alarm system is installed; or

b) 150 occupants when an automatic *fire* detection and alarm system is installed.

4.2.1.3 This *design scenario* only applies where occupants could be threatened by a *fire* occurring in another normally unoccupied space. It does not need to be satisfied for any other rooms or spaces in the *building*.

> COMMENT: *Building* rooms or spaces that can be considered normally unoccupied are those spaces where people are not usually found. These can include store rooms, plant rooms, other *building* services rooms, and cleaners' utility cupboards. They do not include rooms such as kitchenettes, toilets, staff rooms or meeting rooms.

4.2.1.4 The analysis shall assume that the target space containing the people is filled to capacity under normal use with a *design fire* as described in Part 2. Rules and parameters for the design scenarios for the applicable occupancy.

4.2.1.5 Active and passive *fire safety systems* in the *building* shall be assumed to perform as intended by the design.

4.2.2 Method

4.2.2.1 To demonstrate compliance with this *design scenario,* either:

a) carry out *ASET/RSET* analysis in accordance with Sections 2.1 and 3.1 to show that the occupants within target spaces are not exposed to untenable conditions; or

b) include *separating elements* or an automatic *fire* suppression system to confine the *fire* to the room of origin. If separating elements are used, the *separating elements* shall comply with either Paragraphs 4.2.2.2 or 4.2.2.3.

> COMMENT: An automatic *fire* suppression system includes any automatic system that controls or extinguishes the *fire* such as automatic sprinklers, gas flooding, or oxygen depletion systems.

4.2.2.2 If no automatic *fire* detection is installed in the space of *fire* origin, *separating elements* used to comply with Paragraph 4.2.2.1 shall have *fire* resistance to withstand a full *burnout fire* (see Section 2.2 and Subsection 2.3.4)

4.2.2.3 If an automatic *fire* detection is installed in the space of *fire* origin, *separating elements* used to comply with Paragraph 4.2.2.1 shall either:

a) have a *fire resistance rating* of not less than 60 minutes (-/60/60); or

b) be demonstrated to be effective for the period from ignition to the time when the *occupied space* (target space) is evacuated.

> COMMENT: If the unoccupied space is not *fire separated*, it will be necessary to show that the *ASET* for occupants in rooms/spaces holding more than 50 occupants is greater than the *RSET*. Automatic detection in the unoccupied space may be needed to ensure *ASET* > *RSET*. When calculating the *RSET* in an analysis for this scenario, manual methods for detection for the *fire* in the room of origin cannot be relied on. If the unoccupied space is not *fire separated* from the target space, at minimum an automatic *fire* detection system is required for the unoccupied space.

4.3 CS: Fire starts in a concealed space

Criteria	Description
Scenario in brief	A *fire* starts in a *concealed space* that can potentially endanger a large number of people in another room.
Code objective	C1(a) Safeguard people from an unacceptable risk of injury or illness caused by *fire*.
Performance criteria that must be satisfied	For any *buildings* with rooms holding more than 50 people and with *concealed spaces*, ensure that *fire* spread via *concealed spaces* will not endanger the *building* occupants. This will not require analysis.
Required outcome	Demonstrate that *fire* spread via *concealed spaces* will not endanger occupants located in rooms/spaces holding more than 50 people. This scenario is deemed to be satisfied by the use of *separating elements*, automatic detection, or suppression.

4.3.1 Scenario description

4.3.1.1 This *design scenario* addresses the concern of a *fire* starting in a *concealed space* that can develop undetected and spread into any room within the *building* to endanger a large number of people.

> COMMENT: *Fires* spreading in concealed spaces may also compromise the ability of firefighters to assess the threat while undertaking rescue and firefighting operations.

4.3.1.2 This *design scenario* applies to *buildings* with rooms holding more than 50 occupants and with *concealed spaces*. It does not apply if:

a) the *concealed space* has no *combustibles* (other than timber framing); and

b) the *concealed space* has no more than two dimensions (length, width, or depth) greater than 0.8 m.

> COMMENT: *Concealed spaces* can occur in a range of sizes and types. They include floor plenums for IT cables, ceiling plenums, service shafts and curtain wall cavities. There are also a range of possible ignition sources and fuel types.

4.3.1.3 Active and passive *fire safety systems* in the *building* shall be assumed to perform as intended by the design.

4.3.2 Method

4.3.2.1 Due to the difficulty in modelling *fire* spread within *concealed spaces*, to demonstrate compliance with this *design scenario,* either:

a) use *separating elements* (*cavity barriers*) or an automatic *fire* suppression system to confine the *fire* to the *concealed space*; or

b) include automatic detection of heat or smoke to provide early warning of *fire* within a *concealed space*.

4.3.2.2 *Separating elements* (*cavity barriers*) in *concealed spaces* without a means of automatic *fire* detection shall have a *fire resistance rating* of not less than 30 minutes (-/30/30) and the *concealed space* shall not have an area greater than 500 m^2.

4.4 SF: Smouldering fire

Criteria	Description
Scenario in brief	A *fire* is smouldering in close proximity to a sleeping area.
Code objective	C1(a) Safeguard people from an unacceptable risk of injury or illness caused by *fire*.
Performance criteria that must be satisfied	For *buildings* with a sleeping use, ensure that there are automatic means of smoke detection and alarm for occupants who may be sleeping.
Required outcome	Provide an automatic smoke detection and alarm system throughout the *building*.

4.4.1 Scenario description

4.4.1.1 This *design scenario* addresses the concern of a slow, smouldering fire causing a threat to sleeping occupants.

4.4.1.2 Active and passive *fire safety systems* in the *building* shall be assumed to perform as intended by the design.

4.4.2 Method

4.4.2.1 To demonstrate compliance with this *design scenario*, provide an automatic *fire* detection and alarm system throughout the *building* including smoke detection in sleeping areas, designed and installed to NZS 4512. No further analysis is expected.

> COMMENT: This scenario considers the incipient phase of the *fire* and ensures that, where occupants are sleeping, automatic smoke detection is provided.

4.5 HS: Horizontal fire spread

Criteria	Description
Scenario in brief	A fully developed *fire* in a *building* exposes the *external walls* of a neighbouring *building* or *firecell*.
Code objective	C1(b) Protect other property from damage caused by *fire*.
Performance criteria that must be satisfied	C3.6 and C3.7. This will require calculation. Functional requirement C4.2 is also to be considered in relation to horizontal *fire* spread across a *notional boundary* to sleeping occupancies and *exitways* in *buildings* under the same ownership.
Required outcome	Demonstrate that the criteria in C3.6 and C3.7 are not exceeded by calculating the radiation from *unprotected areas* in the *external wall* to the closest point on an adjacent boundary and at 1.0 m beyond an adjacent boundary, and specifying exterior cladding materials with adequate resistance to ignition. Control horizontal *fire* spread across a *notional boundary* to sleeping occupancies and *exitways* in *buildings* under the same ownership.

4.5.1 Scenario description

4.5.1.1 This scenario addresses the concern that a *fully developed fire* in a *building* leads to high levels of radiation heat exposure potentially:

a) leading to horizontal *fire* spread across a *relevant boundary* to *other property*; and/or

b) leading to horizontal fire spread across a *notional boundary* to sleeping occupancies and *exitways*; and/or

c) igniting the *external walls* of a neighbouring *building*.

4.5.1.2 It requires compliance with the following performance clauses of the Building Code:

C3.6 *Buildings* must be designed and constructed so that in the event of *fire* in the *building* the received radiation at the *relevant boundary* of the property does not exceed 30 kW/m^2 and at a distance of 1 m beyond the *relevant boundary* of the property does not exceed 16 kW/m^2.

C3.7 External walls of *buildings* that are located closer than 1 m to the *relevant boundary* of the property on which the *building* stands must either:
(a) be constructed from materials which are not *combustible building materials*, or
(b) for *buildings* in importance levels 3 and 4, be constructed from materials that, when subjected to a radiant flux of 30 kW/m^2, do not ignite for 30 minutes, or
(c) for *buildings* in Importance Levels 1 and 2, be constructed from materials that, when subjected to a radiant flux of 30 kW/m^2, do not ignite for 15 minutes.

4.5.1.3 For demonstrating compliance with clause C3.6, this *design scenario* applies to:

a) *fire* spread across a *relevant boundary* to *other property*; and

b) *fire* spread across a *notional boundary* across to sleeping occupancies and *exitways* in *buildings* under the same ownership.

4.5.1.4 There are four considerations for the methods in this scenario:

a) to comply with clause C3.6, limit *fire* spread from:

i) *external walls* in Subsection 4.5.2; and

ii) roofs in Subsection 4.5.3; and

iii) canopies in Subsection 4.5.4; and

b) to comply with clause C3.7, specify *external wall* cladding materials to resist ignition to protect against *fires* that may occur in an adjacent *building* in Subsection 4.5.5.

4.5.1.5 There are no restrictions on the amount of *unprotected area* and the performances specified in Building Code clause C3.6 are deemed to be achieved if:

a) the *external wall* is more than 1.0 m of the *relevant boundary*; and

b) the *firecell* does not contain a storage occupancy with a capability to store to more than 3.0 m; and

c) the *building* is provided with a sprinkler system complying with either:

i) NZS 4541 with a Class A or Class B2 water supply, or

ii) NZS 4541, as amended by Appendix D of C/AS2, with a Class A or Class B2 water supply.

> COMMENT: It is considered that a *fire* sprinkler system with two independent supplies, but only one of which may be dependent on a town's main, has a very high degree of reliability so that the sprinkler system alone can be relied upon to satisfy clause C3.6.

4.5.1.6 The *design fire* for this scenario comprises an assumed emitted radiation flux from *unprotected areas* in *external walls* of the *fire* source *building* (assuming no intervention). This shall be as follows:

a) for unsprinklered *firecells*:

i) 83 kW/m^2 for *FLED* ≤ 400 MJ/m^2, and

ii) 103 kW/m^2 for *FLED* > 400 to ≤ 800 MJ/m^2, and

iii) 144 kW/m^2 for *FLED* > 800 MJ/m^2; and

b) for sprinklered *firecells*:

i) 58 kW/m^2 for *FLED* ≤ 400 MJ/m^2, and

ii) 72 kW/m^2 for *FLED* > 400 to ≤ 800 MJ/m^2, and

iii) 101 kW/m^2 for *FLED* > 800 MJ/m^2; and

c) the emissivity of *fire* gases shall be taken as 1.0.

> COMMENT: The *design fire* assumes that firefighter intervention will be available after some period of time to prevent *fire* spread to neighbouring property.

4.5.1.7 *Unprotected area* shall include both non-*fire* rated *external wall construction* as well as any non-*fire* rated window/door assemblies and other openings. Areas of the *external wall* that are not designated as *unprotected area* shall have a *fire resistance rating* meeting the *integrity* criteria sufficient to resist the *full burnout design fire* described in Subsection 2.3.4 and with *insulation* sufficient to meet Building Code clause C3.7.

4.5.1.8 The structural system supporting those parts of the *external wall* that are not permitted to be unprotected must also provide *structural adequacy* sufficient to keep the *external wall* in place for the full duration of the *fire*.

4.5.1.9 If a sprinklered unit-titled *building* is subdivided, the protection between any title and areas in common need not be *fire* rated for the protection of *other property* unless required:

a) for separation of *escape routes*; or

b) to separate sleeping occupancies; or

c) to demonstrate compliance with the Section 4.8 FO: Firefighting operations.

4.5.1.10 *Unprotected areas* are not permitted within 1.0 m of a *relevant boundary*, except for a combination of small *unprotected area* and/or *fire resisting glazing* as determined using Appendix C.2 or Acceptable Solution C/AS2 Subsection 5.2.3.

4.5.2 Method for horizontal fire spread from external walls

4.5.2.1 Compliance can be achieved by:

a) complying with Paragraph 4.5.1.5; or

b) limiting small openings and using *fire resisting glazing* in accordance with Paragraph 4.5.1.10; or

c) limiting *unprotected areas* in *external walls* or separating by distance using the tabulated values from:

   i) Appendix C. Design scenario HS horizontal fire spread tables, or

   ii) Acceptable Solution C/AS2 Appendix E. Horizontal fire spread tables; or

d) limiting *unprotected areas* in *external walls* or separating by distance as demonstrated using the calculation method in Paragraph 4.5.2.3.

4.5.2.2 When using the tables in Appendix C. Design scenario HS horizontal fire spread tables:

a) for *external walls* at an angle more than 10° to the *relevant boundary*, appropriate calculations shall be undertaken to demonstrate that the performance criteria are achieved and minimum dimensions shall be specified for return and/or wing walls as necessary or use tables as provided in Appendix C.5; and

b) in all *firecells* protected with an automatic sprinkler system, the maximum permitted *unprotected area* obtained from the tables for an unsprinklered space can be doubled.

4.5.2.3 When using calculations:

a) calculate the radiation from *unprotected areas* in the *external wall* to the closest point on an adjacent boundary and at 1.0 m beyond an adjacent boundary; and

b) take into account:

   i) the distance to the boundary, and

   ii) the size and shape of the *unprotected area* in the *external walls*, and

   iii) the assumed emitted radiation flux for the *design fire* specified in Paragraph 4.5.1.6 for the applicable *FLED* range; and

c) only one *fire separated* space needs to be considered at a time as a potential source of thermal radiation; and

d) for unsprinklered *buildings*, the width of the enclosing rectangle need be:

   i) the actual width of the enclosing rectangle if it is less than 20 m, or

   ii) no greater than 20 m for *FLED* up to and including 800 MJ/m^2, or

   iii) no greater than 30 m for *FLED* greater than 800 MJ/m^2; and

e) the *unprotected area* calculated using the emitted radiation flux for sprinklered *firecells* is not permitted to be doubled; and

f) in a *firecell* not containing a storage occupancy or a storage occupancy with a capability to store to more than 3.0 m, and which is protected with an automatic sprinkler system, the calculation for maximum permitted *unprotected area* may use:

   i) the emitted radiation flux for sprinklered *firecells* for the appropriate *FLED*, and

   ii) the height of the enclosing rectangle as the vertical distance between the floor and the ceiling level beneath which the sprinklers are installed in the area adjacent to the external wall facing the *relevant boundary*, and

iii) the width of the enclosing rectangle as the least of the square root of the design maximum area of sprinkler operation or the actual width of the enclosing rectangle or 20 m.

4.5.3 Method for horizontal fire spread from roofs

4.5.3.1 For unsprinklered *buildings* where the average *fire load* exceeds 1200 MJ/m^2 and the *building* is located within 1.0 m of a *relevant boundary*, horizontal *fire* spread via a non-*fire* rated roof shall be resisted. This requirement can be satisfied by undertaking one of the following:

a) *fire* rating (for *fire* exposure from below) that part of the roof within 1.0 m of a *relevant boundary*. The *FRR* shall be based on the *burnout fire* determined in Section 2.2 and Subsection 2.3.4. The determined *FRR* needs to meet with *structural adequacy* and *integrity* criteria as a minimum; or

b) extending the wall, being a *fire separation* along or adjacent to the *relevant boundary*, no less than 450 mm above the roof to form a parapet; or

c) undertaking specific calculation to demonstrate that the resultant incident radiation 1.0 m beyond the relevant boundary due to *fire* breaking through a non-*fire* rated roof does not exceed 16 kW/m^2.

4.5.4 Method for horizontal fire spread from canopies

4.5.4.1 The potential for any space to expose *other property* shall be evaluated. The area beneath a canopy *roof* does not need to be assessed as a source of external *fire* spread if all the following conditions apply:

a) the nearest distance between any part of the canopy and the *relevant boundary* is not less than 1.0 m; and

b) the average *FLED* applying to the area beneath the canopy is not greater than 800 MJ/ m^2; and

c) the canopy has at least 50% of the perimeter area open to the outside.

4.5.5 Method for external wall cladding materials

4.5.5.1 Cladding materials shall be specified in accordance with Subsection 8.4.1 of the Building Product Specifications.

4.5.5.2 To demonstrate compliance with clause C3.7 of the Building Code,

a) where *external walls* are located less than 1.0 m from a *relevant boundary*, cladding materials shall be *non-combustible*, *limited combustible*, or Type A materials; and

b) for *buildings* containing sleeping care or sleeping detention uses, where *external walls* are located more than 1.0 m from a *relevant boundary*, cladding materials shall be *non-combustible, limited combustible*, Type A, or Type B materials.

4.6 VS: External vertical fire spread

Criteria	Description
Scenario in brief	A *fire* source exposes the *external wall* and leads to significant vertical fire spread
Code objective	C1(a) Safeguard people from an unacceptable risk of injury or illness caused by *fire*. C1(b) Protect *other property* from damage caused by *fire*.
Performance criteria that must be satisfied	The performance criteria of C3.5 (that is, if *buildings* are taller than 10 m or have upper floors that are *other property* or contain people sleeping, *fire* shall be prevented from spreading more than 3.5 m vertically) so that: (a) tenable conditions are maintained on *escape routes* until the occupants have evacuated, and (b) vertical *fire* spread does not compromise the safety of firefighters working in or around the *building*.
Required outcome	Demonstrate that the *building*'s external claddings do not contribute to excessive vertical *fire* spread using one of the methods described.

4.6.1 Scenario description

4.6.1.1 This design scenario addresses the concern of external vertical *fire* spread.

4.6.1.2 This *design scenario* applies to:

a) all multi-level buildings with a *building height* of more than 10 m; and

b) any other multi-level *buildings* with upper floors:

- i) where people sleep, or
- ii) are defined as *other property*, or
- iii) that have external *exitways* with an *external wall*; and

c) where there is a lower roof exposure to a higher *external wall* within the same or an *adjacent building*, where *firecells* behind the higher *external wall* house sleeping occupancies, *exitways*, or *other property*.

> COMMENT:
> 1. This scenario is not concerned with horizontal *building*-to-*building fire* spread across a relevant boundary, as this is addressed in Section 4.5 HS: Horizontal fire spread.
> 2. Multi-level *buildings* include:
>   a. *buildings* with more than one full floor; or
>   b. *buildings* that have more than one intermediate floor and the *escape height* of the uppermost intermediate floor is greater than 10 m (for example, a multi-storey office with an atrium).

4.6.1.3 There are three considerations for the methods in this scenario to prevent :

a) for multi-level *buildings* with a *building height* of more than 10 m, prevent façade cladding materials from contributing to significant external vertical *fire* spread over the cladding materials and within the *external wall* cladding system in Subsection 4.6.2; and

b) for multi-level *buildings* with a *building height* greater than 10 m where people sleep, have external *exitways* or *exitways* with an *external wall*, or that are defined as *other property,* prevent *fire* plumes spreading *fire* vertically up the *external wall* via openings and *unprotected areas* in Subsection ; and

c) exposure to external *exitways* or a higher *external wall* within the same or an *adjacent building*, where spaces behind the higher *external wall* are sleeping occupancies or *other property, prevent fire* plumes spreading *fire* from a lower *firecell* through an unprotected lower roof to an adjacent higher *external wall* via *unprotected areas*.

> COMMENT: Subsection 4.6.2 addresses concerns regarding the contribution of the *external wall* cladding system to vertical *fire* spread. Subsections 4.6.3 and 4.6.4 look at the use of aprons, spandrels, *fire* rated lower roofs, *fire* rated *external walls*, or sprinklers to prevent external *fire* spread between openings at different levels in the *building*. For Subsection 4.6.4, vertical *fire* spread via an unprotected lower roof to an *adjacent building* also needs to be considered.

4.6.2 Method for external vertical fire spread over facade materials

4.6.2.1 This subsection applies to all multi-level *buildings* with a *building height* of more than 10 m.

4.6.2.2 The *design fire* shall:

a) be a *fire source* that is either:

i) in close contact with the façade (such as in a rubbish container/skip) that could ignite and spread *fire* vertically to higher levels in the *building*, or

ii) adjacent to an *external wall*, such as a *fire* plume emerging from a window opening or from an *unprotected area* of the wall burning; and

b) expose the façade cladding materials to a radiant flux of:

i) 50 kW/m^2 impinging on the façade for 15 minutes for *buildings* in importance levels 2 and 3, or

ii) 90 kW/m^2 impinging on the façade for 15 minutes for *buildings* in importance level 4.

4.6.2.3 The intention is to prevent façade cladding materials from contributing to significant flame spread propagation beyond the area initially exposed. Some damage to the area initially exposed is expected.

4.6.2.4 This can be achieved by limiting the extent of the vertical flame spread distance of the *external wall* cladding system above the *fire source*.

4.6.2.5 For all *buildings* where this scenario applies, the entire *external wall* cladding system shall:

a) be *comprised of non-combustible* or *limited combustible* materials; or

b) meet the acceptance criteria in Subsection 8.4.2 of the Building Product Specifications for one or more of the testing or classification methods stated.

4.6.2.6 The spread of *fire* through cavities in an *external wall* shall be avoided by providing *cavity barriers* at each floor level. *Cavity barriers* shall comply with the requirements in Subsection 4.11.2 of Acceptable Solution C/AS2.

4.6.2.7 The requirements given in Acceptable Solution C/AS2 Paragraphs 5.5.1.4, 5.5.2.1, 5.5.3.1 are an acceptable means of demonstrating compliance with this subsection for *buildings* with an importance level not higher than 3.

4.6.3 Method for external vertical fire spread via openings and unprotected areas

4.6.3.1 This subsection applies to multi-level *buildings* with a *building height* greater than 10 m where people sleep, have external *exitways* or *exitways* with an external wall, or that are defined as *other property*.

4.6.3.2 The intention is to prevent *fire* spread in unsprinklered *buildings* from projecting *fire* plumes to *unprotected areas* on upper floors where they are within 1.5 m vertically of a projecting plume *fire source*.

4.6.3.3 This can be achieve by either:

a) installing an automatic sprinkler system in accordance with an approved standard; or

b) limiting external vertical *fire* spread using *fire* rated construction on certain areas of the *external wall* to prevent a *fire* plume extending from a lower opening or *unprotected area* and re-entering the *building* via an opening or *unprotected area* at a higher level. Compliance can be demonstrated by using:

i) the requirements of Acceptable Solution C/AS2 Section 5.4 and providing *construction* features such as aprons and/or spandrels, or

ii) calculations of the effect of the radiation from *fire* plumes projected from openings or *unprotected areas* in the *external wall*. The *fire* plume characteristics and geometry shall be derived from the *design fires* described in Section 2.3 for the applicable occupancy and geometry.

4.6.4 Method for lower roof exposure

4.6.4.1 This subsection applies if there is a lower roof exposure to external *exitways* or a higher *external wall* within the same or an *adjacent building*, where spaces behind the higher *external wall* are sleeping occupancies or *other property*.

4.6.4.2 The design fire exposure is a fire plume spreading through a lower non-*fire* rated roof to an adjacent higher *external wall* and spreading vertically via openings and *unprotected areas* in the same or *adjacent building*.

4.6.4.3 The intention is to prevent *fire* from spreading from unsprinklered *buildings* due to a *fire* that has initiated below a non-*fire* rated lower roof that could spread to *unprotected areas* or openings that are located in a higher *external wall*.

4.6.4.4 The lower roof exposure risk is to be addressed where compartments behind the higher *external wall* contain sleeping or *other property*, for the same *building* or an *adjacent building* on the same site. The exposure risk needs also to be assessed for *buildings* on *other property* that have an *external wall* that is higher than the lower roof exposure.

4.6.4.5 This can be achieved by using the requirements of Acceptable Solution C/AS2 Section 5.4 and either:

a) installing an automatic sprinkler system in accordance with an approved standard throughout the space below the roof; or

b) *fire* rating the underside of any part of the lower roof that is within 5.0 metres of the higher *external wall* in order to prevent a *fire* plume extending through the lower roof. The *fire resistance rating* to be applied over the rated area of the lower roof shall be based on the *burnout fire* determined in Subsection 2.3.4 for the space below the roof; or

c) *fire* rating all parts of the *external wall* that are within 9.0 metres vertically of any area of unprotected lower roof that is within 5.0 metres horizontally of the higher *external wall*. This is to prevent the *fire* plume that has passed through the non-*fire* rated lower roof spreading into the higher levels. The *fire resistance rating* to be provided over the required area of the *external wall* shall be based on the *burnout fire* determined in Subsection 2.3.4 for the space below the roof.

4.7 IS: Rapid fire spread involving internal surface linings

Criteria	Description
Scenario in brief	Interior surfaces are exposed to a growing fire that potentially endangers occupants.
Code objective	C1(a) Safeguard people from an unacceptable risk of injury or illness caused by *fire*
Performance criteria that must be satisfied	C3.4 for materials used as internal surface linings in the relevant *building* areas
Required outcome	Demonstrate that *surface finishes* comply with the performance requirements

4.7.1 Scenario description

4.7.1.1 This *design scenario* addresses the concern of *fire* spread along surface linings that have the potential to contribute to rapid *fire* spread and smoke development beyond what is considered in other scenarios.

4.7.1.2 The performance criteria required for *surface linings* will depend on their location within a *building*, the use of the *building*, and the importance level of the *building*.

4.7.1.3 *Surface finish* requirements do not apply to:

a) small areas of non-conforming product within a space with a total aggregate surface area not more than 5.0 m^2;

b) electrical switches, outlets, cover plates and similar small discontinuous areas; or

c) pipes and cables used to distribute power or services; or

d) *handrails* and general decorative trim of any material such as architraves, skirtings and window components, including reveals, that do not exceed 5% of the area of the surface to which it is attached; or

e) *damp-proof courses*, seals, caulking, flashings, thermal breaks, and ground moisture barriers; or

f) timber joinery and structural timber *building elements constructed* from solid wood, glulam or laminated veneer lumber. This includes heavy timber columns, beams, portals and shear walls not more than 3.0 m wide, but does not include exposed timber panels or permanent formwork on the underside of floor/ceiling systems; or

g) individual *doorsets*; or

h) continuous areas of permanently installed openable wall partitions not more than 3.0 m high and having a surface area of not more than 25% of the divided room floor area or 5.0 m^2, whichever is less; or

i) marae *buildings* using traditional Māori construction materials (for example, tukutuku and toetoe panels); or

j) uniformly distributed *roof* lights where:

  i) the total area does not exceed 15% of the ceiling area (in plan), and

  ii) the minimum floor to ceiling height is not less than 6.0 m, and

  iii) the roof lights achieve a *Group Number* not greater than 3.

4.7.1.4 The smoke production rate criteria do not need to apply for sprinklered *buildings*.

4.7.1.5 Material *Group Numbers* apply to the exposed surface of the interior wall or ceiling lining.

4.7.2 Method

4.7.2.1 Wall lining materials, ceiling lining materials, and the surfaces of ducts and pipe insulation must comply with the maximum permitted *Group Numbers* specified in Table 4.7.2.1.

4.7.2.2 The material *Group Number* must be determined in accordance with Section 8.5 of the Building Product Specifications.

4.7.2.3 Floor surface materials meet the performance criteria specified in Table 4.7.2.3.

4.7.2.4 The critical radiant flux for floor coverings must be determined in accordance with Subsection 8.1.2 of the Building Product Specifications.

4.7.2.5 Suspended flexible fabrics used as underlay to exterior cladding or roofing, when exposed to view in all *occupied spaces* excluding *household units*, shall have a *flammability index* of no greater than 5.

4.7.2.6 Suspended flexible fabrics and membrane structures must have a *flammability index* of no greater than 12 in the following locations:

a) *exitways* from spaces where people sleep; and

b) all *occupied spaces* within crowd uses.

4.7.2.7 The *flammability index* of suspended flexible fabrics and membrane structures must be determined in accordance with Subsection 8.1.3 of the Building Product Specifications.

Table 4.7.2.1: Maximum permitted Group Number for internal surface finishes

Paragraph 4.7.2.1

Location in the building	Maximum permitted Group Number for spaces not protected with an automatic fire sprinkler system	Maximum permitted Group Number for spaces protected with an automatic fire sprinkler system
Wall/ceiling materials in sleeping areas where care or detention is provided Wall/ceiling materials in *exitways* Wall/ceiling materials in all *occupied spaces* in importance level 4 *buildings* Internal surfaces of ducts for *HVAC* systems	1-S	2
Ceiling materials in crowd and sleeping uses but not *household units* or where care or detention is provided	1-S	2
Wall materials in crowd and sleeping uses except *household units* or where care or detention is provided	2-S	3
Wall/ceiling materials in *occupied spaces* in all other locations in *buildings*, including *household units*(1) External surfaces of ducts for *HVAC* systems Acoustic treatment and pipe insulation within air-handling plenums in sleeping uses	3	3

Notes:

(1) There is no requirement for *detached dwellings* or within *household units* in *multi-unit dwellings*.

Table 4.7.2.3: Minimum required critical radiant flux for flooring (kW/m^2)

Paragraph 4.7.2.3

Location in the building	Minimum critical radiant flux for buildings not protected with an automatic fire sprinkler system	Minimum critical radiant flux for buildings protected with an automatic fire sprinkler system
Sleeping areas and *exitways* in *buildings* where care or detention is provided	4.5 kW/m^2	2.2 kW/m^2
Exitways in all other *buildings*	2.2 kW/m^2	2.2 kW/m^2
Firecells accommodating more than 50 persons	2.2 kW/m^2	1.2 kW/m^2
All other *occupied spaces* except *household units*	1.2 kW/m^2	1.2 kW/m^2

COMMENT:

1. Performance criteria for surface linings depend on:
   a. the relative contribution expected by the linings compared to other contents of a room; and
   b. the importance of the room/space to the *means of escape from fire*.
   For example, *fire* properties of surface linings within *exitways* are given greater emphasis as they are potentially the greatest source of *fire load* within those spaces as well as being critical paths for escape.
   Performance criteria also depend on the type of occupancy, the ability of occupants to self-evacuate, and the presence or otherwise of a sprinkler system.
2. *Group Number* 1 materials include *non-combustible* materials or materials with limited combustibility. Examples are plasterboard and similar low hazard materials. *Group Number* 2 materials include many *fire retardant* treated timbers. *Group Number* 3 materials include ordinary timber products and similar materials. *Group Number* 4 materials include exposed polyurethane foams or similar products. *Group Number* 4 materials are hazardous when installed as room linings and are not acceptable in occupied spaces.
3. A higher critical flux corresponds to better *fire* performance. Typically, wood products would be expected to have a CRF of greater than 2.2 kW/m^2, and in some cases greater than 4.5 kW/m^2, depending on product density, thickness, and treatments.

4.8 FO: Firefighting operations

Criteria	Description
Scenario in brief	This scenario provides for the safe operation of firefighters in a *building*.
Code objective	C1 b) Protect other property from damage caused by fire C1(c) Facilitate firefighting and rescue operations.
Performance criteria that must be satisfied	C3.8, C5.3, C5.4, C5.5, C5.6, C5.7, C5.8, and C6.3
Required outcome	Show that the performance requirements are satisfied.

4.8.1 Scenario description

4.8.1.1 This *design scenario* has been designed to test the safe operation of firefighters in the event of a *fire* in the *building*.

4.8.1.2 This *design scenario* requires compliance to be demonstrated with the following performance clauses of the Building Code:

C3.8 *Firecells* located within 15 m of a *relevant boundary* that are not protected by an automatic *fire* sprinkler system, and that contain a *fire load* greater than 20 TJ or that have a floor area greater than 5000 m^2 must be designed and constructed so that at the time that firefighters first apply water to the *fire*, the maximum radiation flux at 1.5 m above the floor is no greater than 4.5 kW/m^2 and the smoke layer is no less than 2 m above the floor.

C5.3 *Buildings* must be provided with access for fire service vehicles to a *hard-standing* from which there is an unobstructed path to the building within 20 m of:
(a) the firefighter access into the *building*, and
(b) the inlets to automatic fire sprinkler systems or fire hydrant systems, where these are installed.

C5.4 Access for fire service vehicles in accordance with Clause C5.3 shall be provided to more than 1 side of *firecells* greater than 5 000 m^2 in floor area that are not protected by an automatic fire sprinkler system.

C5.5 *Buildings* must be provided with the means to deliver water for firefighting to all parts of the *building*.

C5.6 *Buildings* must be designed and constructed in a manner that will allow firefighters, taking into account the firefighters' personal protective equipment and standard training, to:
a) reach the floor of fire origin,
b) search the general area of *fire* origin, and
c) protect their means of egress.

C5.7 *Buildings* must be provided with means of giving clear information to enable firefighters to:
a) establish the general location of the *fire*,
b) identify the *fire safety systems* available in the *building*, and
c) establish the presence of *hazardous substances* or process in the *building*.

C5.8 Means to provide access for and safety of firefighters in *buildings* must be designed and *constructed* with regard to the likelihood and consequence of failure of any *fire safety systems*.

C6.3 Structural systems in *buildings* that are necessary to provide firefighters with safe access to floors for the purpose of conducting firefighting and rescue operations must be designed and *constructed* so that they remain stable during and after *fire*.

4.8.2 Method

4.8.2.1 To comply with this *design scenario*, demonstrate that the performance criteria in Building Code clauses C3.8, C5.3, C5.4, C5.5, C5.6, C5.7, C5.8, and C6.3 have been satisfied.

4.8.2.2 For the purposes of clause C3.8,

a) when measuring the distance between a *firecell* and a *relevant boundary* and when determining the *fire load*, the area beneath a canopy roof may be ignored if all the following conditions apply:

   i) the nearest distance (in plan) between any part of the canopy and the *relevant boundary* is greater than 1.0 m; and

   ii) the average *FLED* applying to the area beneath the canopy is not greater than 800 MJ/m^2; and

   iii) the canopy has at least 50% of the perimeter area open to the outside; and

b) the time until firefighters first apply water to the *fire* can be taken as either:

   i) 1200 seconds; or

   ii) 1000 seconds if there is an automatic *fire* detection and alarm system and direct connection to a *remote receiving centre*; or

   iii) some other time as determined and supported by the application of a *fire* brigade intervention model; and

c) use the *design fire* described in Section 2.3 for the applicable occupancy. This can be modified to account for ventilation conditions; and

d) where *fire separations* are specified to create *firecells* of area not more than 5000 m^2, the full *burnout design fire* defined in Subsection 2.3.4 shall be used to determine the required *fire* resistance of the *fire separation*.

> COMMENT: Building Code clause C3.8 is designed to provide a secondary means of limiting *fire* spread to *other property*. *Design scenario* HS: Horizontal fire spread provides the primary means. Where the *fire load* is high and *firecells* are in the vicinity of a *relevant boundary*, it is intended that firefighters should be provided with a reasonable opportunity to be effective in managing the *fire* and preventing further spread to *other property*. This is only required where the *fire* could become very large and potentially threaten *other property*. Clause C3.8 sets out when this is required and what design criteria must be satisfied.
>
> In the event that the *firecell* area is not limited, firefighter tenability limits need only be met at the time when firefighters are ready to first apply water to the fire. Firefighter operations beyond that time will dependent on the conditions faced at the time.
>
> The *design fire* to satsify clause C3.8 is the same as used in the *design scenario* CF: Challenging fire for the occupancy of interest and may be modified to account for ventilation effects.

4.8.2.3 For the purposes of clause C5.5, water shall be provided from either:

a) a pumping appliance parked close to the *building* such that any point within the *building* may be reached within 75 m (approximately 3 hose lengths) of the pumping appliance; or

b) an internal hydrant designed and installed to NZS 4510 or as approved by the National Commander of Fire and Emergency New Zealand.

4.8.2.4 In relation to clause C6.3, firefighters are provided with the means of conducting search and rescue operations by giving them safe access to the *fire* floor with *building construction* that will not collapse during the *fire*. Derive the *fire* resistance of the structure or separating *construction* needed to achieve this by reference to the full *burnout design fire* defined in Subsection 2.3.4 and by meeting the requirements in Paragraphs 4.8.2.5, 4.8.2.6, 4.8.2.7, 4.8.2.7, and 4.8.2.8.

4.8.2.5 For *buildings* with an *escape height* greater than 10 m:

a) provide firefighters with access to all floors within the *building* that are not directly accessible from street level by having *stairway(s)* designed as *exitways*, *fire separated* from all other parts of the *building*, that are designed to resist *fire* spread until *burnout*; and

b) protect firefighters and others at ground level and within the *building* by designing the load-carrying structure and floor systems (excluding *intermediate floors*) to resist collapse and prevent *fire* spread between floor levels until *burnout*; and

c) design *intermediate floors* and supporting structure to resist collapse until *burnout*. This is unless the *intermediate floor* has an *occupant load* less than or equal to 100 people and an *escape height* no more than 4.0 m and the area below the floor is open to the *firecell*; in which case the *intermediate floor* may be designed to resist collapse for not less than 30 minutes. Such collapse shall not cause consequent collapse of any other part of the structural system that is required to resist *burnout* in accordance with Paragraphs 4.8.2.5(a) and 4.8.2.5(b).

4.8.2.6 For *buildings* with an *escape height* less than or equal to 10 m:

a) provide firefighters with *stairways fire separated* from all other parts of the *building* allowing them access to all floors within the *building* that are not directly accessible from street level either for a period of 60 minutes (from ignition) or to resist collapse until *burnout*; and

b) protect firefighters and others at ground level and within the *building* by designing the floor systems (excluding *intermediate floors*) and supporting structure to resist collapse and prevent *fire* spread between floor levels for a period of at least 30 minutes; and

c) design *intermediate floors* and supporting structure to resist collapse for a period of at least 30 minutes.

COMMENT:

1. In the case of *intermediate floors* In Paragraphs 4.8.2.5 and 4.8.2.6, access to the *intermediate floor* can be taken as being achieved if:
   a. The distance between the most remote point on the *intermediate floor* and a hydrant located within a *safe path* is no more than 40 m. This corresponds to approximately 2 hose lengths with some allowance for a non-direct path; or
   b. The furthest point on the *intermediate floor* is able to be reached within 3 hose lengths to satisfy the requirement of Building Code clause C5.5 to provide water to all points of the *building*.
2. Paragraph 4.8.2.6 is intended to permit search and rescue operations, and attempts to avoid unexpected or sudden collapse that would endanger firefighters within the *building*. An FRR of 30/30/- may be used to comply with Paragraphs 4.8.2.6(b) and 4.8.2.6(c).

4.8.2.7 For intermediate floors, if the total floor area of *intermediate floors* exceeds 40% of the floor area of the *firecell*, the *intermediate floors* shall be rated for *integrity*, *insulation* and *structural adequacy* to resist collapse to comply with the requirements of Paragraph 4.8.2.5 or 4.8.2.6.

4.8.2.8 Catwalks used intermittently in industrial plants, platforms for retractable seating, flytowers over stages, and similar structures do not need to be *fire* rated.

4.9 CF: Challenging fire

Criteria	Description
Scenario in brief	A *fire* starts in a normally *occupied space* and presents a challenge to the *building's fire safety systems*, threatening the safety of its occupants.
Code objective	C1(a) Safeguard people from an unacceptable risk of injury or illness caused by fire
Performance criteria that must be satisfied	C4.3 and C4.4
Required outcome	Demonstrate *ASET* > *RSET* for design *fires* in various locations within the *building*.

4.9.1 Scenario description

4.9.1.1 This *design scenario* is intended to represent credible worst case scenarios in normally occupied spaces that will challenge the *fire safety systems* of the *building*.

4.9.1.2 This scenario requires the use of *design fires* in various locations within the building. The *ASET* need not be determined for occupants of the space of *fire* origin for the following *fire* locations:

a) any room with a floor area less than 2.0 m^2; or

b) sanitary facilities adjoining an *exitway*; or

c) any room or space of *fire* origin other than *early childhood centres* on an upper level and sleeping areas where care or detention is provided that has all of the following:

   i) a total floor area, including *intermediate floors*, of less than 500 m^2, and

   ii) more than one direction of travel or a single direction of travel that is less than 25 m,

   iii) an *occupant load* of less than 150 people for the room or less than 100 people for any intermediate floor; or

d) any room where care is provided which has no more than 4 occupants undergoing treatment.

> COMMENT: Rooms specified in Paragraph 4.9.1.2(d) may include areas providing *direct support functions* such as security desks or kiosks, nurse stations, tea bays and sanitary facilities essential to the operation of the treatment room.

4.9.1.3 For Paragraph 4.9.1.2(c), it is not necessary to demonstrate that tenability is maintained for occupants within the enclosure of *fire* origin. However, it must be demonstrated that the challenging *fire* in this space does not threaten occupants in the rest of the *building*.

4.9.1.4 It must be demonstrated that the *structural adequacy*, *integrity* and *insulation* of floors, stairs and walkways forming *escape routes* and the *fire separations* and *smoke separations* protecting these *escape routes* is maintained sufficiently to protect the occupants in the rest of the *building* for the duration of their *RSET*.

4.9.1.5 Where occupants in the rest of the *building* use *escape routes* protected from the effects of *fire* (such as *exitways*), the effect of sprinklers to control the *fire* (with constant *HRR*) shall be ignored for assessing the performance required of the *construction* protecting the *escape routes*.

4.9.1.6 For each location of the challenging *fire*, use a single *fire* source to evaluate the *building's* protection measures.

4.9.1.7 The *design fires* shall be characterised with a *fire* growth rate, peak *HRR*, *FLED*, and *yields* for CO, CO_2, and soot as specified in Section 2.2. Hydrogen cyanide production need not be considered.

4.9.1.8 The *design fires* are intended to represent free-burning *fires*. However, they shall be modified during an analysis (depending on the methodology used) to account for *building* ventilation and the effects of automatic *fire* suppression systems (if any) on the *fire*.

4.9.1.9 The impact of the fire must be considered for occupants who may be using *escape routes* external to the *building* as well as internal routes (refer to Section 3.7).

4.9.1.10 Active and passive *fire safety systems* in the *building* shall be assumed to perform as intended by the design.

4.9.2 Method

4.9.2.1 To demonstrate compliance with this *design scenario*:

a) carry out *ASET/RSET* analysis in accordance with Sections 2.1 and 3.1; and

b) analyse the impact on all *building* occupants from *design fires* in various locations within the *building*, except for those rooms or spaces excluded in Subsection 4.9.1.

4.9.2.2 Tenability is to be assessed:

a) in the *escape routes* over the period of time the occupants are required to escape; and

b) at the location of the occupants in the *building* throughout the evacuation.

4.9.2.3 To assess tenability, the *fire* model and calculations must be appropriate for the complexity and size of the *building* and space.

4.10 RC: Robustness check

Criteria	Description
Scenario in brief	The *fire* design will be checked to ensure that the failure of a critical part of the *fire safety system* will not result in the design not meeting the objectives of the Building Code.
Code objective	C1(a) Safeguard people from an unacceptable risk of injury or illness caused by *fire*. C1(b) Protect *other property* from damage caused by *fire*. C1(c) Facilitate firefighting and rescue operations.
Performance criteria that must be satisfied	This scenario contributes to compliance with performance criteria of C3.9, C4.5, C5.8 and C6.2(d). Where tenability criteria are evaluated, these criteria only need to be assessed based on FED_{CO}.
Required outcome	Demonstrate that if a single *fire safety system* fails, where that failure is statistically probable, the *building* as designed will allow people to escape and *fire* spread to *other property* will be limited.

4.10.1 Scenario description

4.10.1.1 This *design scenario* considers the consequences of key *fire safety system* not operating as anticipated and is intended to provide a level of redundancy and robustness in the design.

4.10.1.2 This scenario applies where failure of a key *fire safety system* could potentially expose to untenable conditions:

a) more than 150 people; or

b) more than 50 people in a sleeping occupancy where the occupants are neither detained or undergoing some treatment or care; or

c) more than 20 people detained, or undergoing treatment or care, or children in *early childhood centres*.

> COMMENT: Undergoing treatment or care is not restricted to people in operating theatres or procedure rooms, but also those in recovery and recuperative wards and rooms.

4.10.1.3 For this scenario, key *fire safety systems* include:

a) smoke management systems (other than permanent natural/passive ventilation features that do not rely on the activation of any mechanical or electronic component); and

b) *fire doors* and/or *smoke control doors* or similar *fire* closures; and

c) any other feature or system required as part of the *fire* safety design that relies on a mechanical or electronic component to be activated during the *fire*, except that:

i) *fire* sprinkler systems and automatic *fire* alarms installed to a recognised national or international standard, can be considered to be sufficiently reliable that they are exempt from this robustness scenario, and

ii) in sprinklered *buildings*, *fire doors* and *smoke control doors* fitted with automatic *hold open devices* that are designed and installed to BS 7273.4 or another recognised national or international standard and are activated by the operation of the *fire* alarm system can be considered to be sufficiently reliable that they are exempt from this robustness scenario.

4.10.1.4 This scenario focuses on the *ASET/RSET* analysis of *design fires* assessed in Section 4.9 CF: Challenging fire. The robustness of the design shall be tested by considering the *design fires* with each key *fire safety system* rendered ineffective in turn.

> COMMENT: It is only necessary to consider the impact of one system or feature not working at any time and not multiple system failures unless they have a single common cause.

4.10.2 Method

4.10.2.1 For this *design scenario*:

a) assume the failure of each key *fire safety system* in turn; and

b) carry out *ASET/RSET* analysis of the *design fires* except, when determining the *ASET*, only assess the tenability criteria for FED_{CO}; and

c) if *ASET* cannot be shown to be greater than *RSET* when each key *fire safety system* fails, then alter the design until this scenario can be satisfied.

4.10.2.2 If a design does not require a key *fire safety system* for demonstrating that *ASET* > *RSET*, there is no system to fail and a further robustness check is not required.

4.10.2.3 In addition to the above, a robustness check applies to sprinklered sleeping occupancies as follows:

a) for a *building* served by a single vertical *escape route*, *visibility* in the vertical *escape route* shall not be less than 5.0 m for the period of the *RSET*; and

b) for a *building* where the vertical *escape routes* serve more than 250 people in a sleeping occupancy, *visibility* shall not be less than 5.0 m in more than one vertical *escape route* for the period of the *RSET*.

4.10.2.4 For Paragraph 4.10.2.2, this check assumes that all *fire* safety systems are operating as designed.

Appendix A. References

For the purposes of Building Code compliance, the standards and documents referenced in this verification method must be the editions, along with their specific amendments, listed below.

Standards New Zealand		**Where quoted**
NZS 4510:2008	Fire hydrant systems for buildings Amendment 1	4.8.2.3(b)
NZS 4512:2021	Fire detection and alarm systems in buildings	3.2.1.1, Definitions
NZS 4515:2009	Fire sprinkler systems for life safety in sleeping occupancies (up to 2000 m^2)	Definitions
NZS 4541:2020	Automatic fire sprinkler systems	4.5.1.5, Definitions

These standards can be accessed from www.standards.govt.nz.

British Standards Institution		**Where quoted**
BS 7273-4:2007	Code of practice for the operation of fire protection measures - Actuation of release mechanisms for doors	4.10.1.3

This standard can be accessed from www.standards.govt.nz.

European Committee for Standardisation		**Where quoted**
Eurocode DD ENV 1991 – 2.2:1996	Eurocode 1: basis of design and actions on structures – Part 2.2 Actions on structures exposed to fire	2.3.4.5

This standard can be accessed from www.standards.govt.nz.

International Standards Organisation		**Where quoted**
ISO 13571:2007	Life-threatening components of fire Guidelines for the estimation of time available for escape using fire data.	2.1.6.3

This standard can be accessed from www.standards.govt.nz.

New Zealand Legislation	**Where quoted**
Education (Early Childhood Services) Regulations 2008	Table 1.2.4.2
Fire and Emergency New Zealand (Fire Safety, Evacuation Procedures, and Evacuation Schemes) Regulations 2018	1.1.2.1 Comment
Hazardous Substances and New Organisms Act 1996	1.1.2.2, Definitions
Health and Safety at Work (Hazardous Substances) Regulations 2017	1.1.2.2
Local Government Act 1974	Definitions
Railways Act 2005	Definitions

These documents can be accessed from www.legislation.govt.nz

References

Other publications		Where quoted
IFEG 2005	Australian Building Codes Board, International Fire Engineering Guidelines (IFEG), 2005. Available from: www.abcb.gov.au.	1.2.3.2 Comment
Society of Fire Protection Engineers, The Handbook of Fire Protection Engineering, 4th Edition, National Fire Protection Association, Quincy, M.A, USA, 2008. Gwynne, S.M.V, and Rosenbaum, E.R, "Employing the Hydraulic Model in Assessing Emergency Movement", Section 3 Chapter 13. Available from: www.sfpe.org		3.1.1.3 Comment, 3.5.3.1 Comment
SFPE Engineering Guide to Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation, 2000. Available from: www.sfpe.org		3.7.1.2(c)

Appendix B. Definitions

These definitions are specific to this verification method. Other defined terms italicised within the definitions are provided in clause A2 of the Building Code.

Term	Definition
Adjacent building	A nearby *building*, including an adjoining *building*, whether or not erected on *other property*.
Allotment	Has the meaning given to it by section 10 of the Building Act 2004.
Available safe egress time (ASET)	Time available for escape for an individual occupant. This is the calculated time interval between the time of ignition of a *fire* and the time at which conditions become such that the occupant is estimated to be *incapacitated* (that is, unable to take effective action to escape to a *place of safety*).
Boundary	Any *boundary* that is shown on a survey plan that is approved by the Surveyor-General and deposited with the Registrar-General of Land, whether or not a new title has been issued.
Building	Has the meaning given to it by sections 8 and 9 of the Building Act 2004. For the purposes of this verification method and notwithstanding the definition of *building*, a number of separated *buildings* cannot be taken as a single *firecell*.
Building consent	Means a consent to carry out *building* work granted by a *building consent authority* under section 49 of the Building Act 2004.
Building consent authority	Has the meaning ascribed to it by section 7 of the Building Act 2004.
Building element	Any structural and non-structural component or assembly incorporated into or associated with a *building*. Included are *fixtures*, services, *drains*, permanent mechanical installations for access, glazing, partitions, ceilings and temporary supports.
Building height	The vertical distance between the floor level of the lowest *occupied space* above the ground and the top of the highest occupied floor, but not including spaces located within or on the roof that enclose *stairways*, lift shafts, or machinery rooms.
Burnout	Means exposure to *fire* for a time that includes *fire growth*, full development, and decay in the absence of intervention or automatic suppression, beyond which the *fire* is no longer a threat to *building elements* intended to perform loadbearing or *fire separation* functions, or both.
Cavity barrier	A *construction* provided to close openings within a *concealed space* against the passage of *fire*, or to restrict the spread of *fire* within such spaces.
Combustible	Material that is neither *non-combustible* nor *limited combustible*.
Computational fluid dynamics (CFD)	Calculation method that solves equations to represent the movement of fluids in an environment.
Concealed space	Any part of the space within a *building*, excluding *protected shafts*, that cannot be seen from an *occupied space*.
Construct	In relation to a *building*, includes to design, build, erect, prefabricate, and relocate the *building*; and construction has a corresponding meaning.
Damp-proof course	A strip of durable vapour barrier placed between *building elements* to prevent the passage of moisture from one element to another.

Definitions

Term	Definition
Dead end	That part of an *open path* where escape is possible in only one direction.
Design fire	Quantitative description of assumed *fire* characteristics within the *design scenario*.
Design scenario	A specific scenario on which a deterministic *fire safety engineering* analysis is conducted.
Detection time	Time interval between ignition of a *fire* and its detection by an automatic system or manual activation of a *fire* alarm system.
Direct support function	Activities that provide support to the primary use of a space that are open areas of low risk and fire load which may include but are not limited to reception desks, nurses' stations, kiosks, tea bays, sanitary facilities which may be enclosed to provide appropriate privacy, and mailboxes.
Doorset	A complete assembly comprising a door leaf or leaves including any glazed or solid panels adjacent to or over the leaves within the door frame including hardware or other inbuilt features; and a door frame, if any, with its fixings to the wall and, for a sliding or tilting door, all guides and their respective fixings to the lintel, wall or sill.
Early childhood centre (ECC)	Premises used regularly for the education or care of three or more children (not being children of the persons providing the education or care, or children enrolled at a school being provided with education or care before or after school) under the age of six years old: a) by the day or part of a day; but b) not for any continuous period of more than seven days. This does not include home based early childhood services.
Escape height	The height between the floor level in the *firecell* being considered and the floor level of the required *final exit* which is the greatest vertical distance above or below that *firecell*. Where the *firecell* contains *intermediate floors*, or upper floors within *household units* the escape height shall be measured from the floor having the greatest vertical separation from the *final exit*.
Escape route	A continuous unobstructed route from any *occupied space* in a *building* to a *final exit* to enable occupants to reach a *safe place*, and shall comprise one or more of the following: *open paths,* and *safe paths*.
Evacuation time	Time interval between the time of warning of a *fire* being transmitted to the occupants and the time at which the occupants of a specified part of a *building* or all of the *building* are able to enter a *place of safety*.
Exitway	All parts of an *escape route* protected by *fire* or *smoke separations*, or by distance when exposed to open air, and terminating at a *final exit*.
External wall	Any exterior face of a *building* (including a roof) within 30° of vertical, consisting of *primary* and/or *secondary elements* intended to provide protection against the outdoor environment, but which may also contain *unprotected areas*.
Final exit	The point at which an *escape route* terminates by giving direct access to a *safe place*.
Fire	The state of combustion during which flammable materials burn producing heat, toxic gases, or smoke or flame or any combination of these.

Definitions

Term	Definition
Firecell	Any space including a group of contiguous spaces on the same or different levels within a *building*, which is enclosed by any combination of *fire separations*, *external walls*, roofs, and floors. Floors, in this context, include ground floors and those in which the underside is exposed to the external environment (when cantilevered). Note that internal floors between *firecells* are *fire separations*.
Fire decay	The stage of *fire* development after a *fire* has reached its maximum intensity and during which the *heat release rate* and the temperature of the *fire* are decreasing.
Fire door	A doorset, single or multi-leaf, having a specific *fire resistance rating*, and in certain situations a smoke control capability, and forming part of a *fire separation*. The door, in the event of *fire*, if not already closed, will close automatically and be self-latching.
Fire hazard	The danger of potential harm and degree of exposure arising from – a) the start and spread of *fire*; and b) the smoke and gases that are generated by the start and spread of *fire*.
Fire growth	The stage of *fire* development during which the *heat release rate* and the temperature of the *fire* are increasing
Fire load	The quantity of heat that can be released by the complete *combustion* of all the combustible materials in a volume, including the facings of all bounding surfaces (Joules).
Fire load energy density (FLED)	The *fire load* per unit area (MJ/m^2)
Fire resisting glazing	Fixed or openable glazing completed with frame and fixings, mullions, transoms, and glazing beads, with a specified *FRR* and complying with Subsection 8.3.3 of the Building Product Specifications.
Fire resistance rating (FRR)	The term used to describe the minimum *fire* resistance required of *primary* and *secondary elements* as determined in the *standard test* for *fire* resistance, or in accordance with a specific calculation method verified by experimental data from standard *fire* resistance tests. It comprises three numbers giving the time in minutes for which each of the criteria *structural adequacy*, *integrity* and *insulation* are satisfied, and is presented always in that order.
Fire retardant	A substance or a treatment, incorporated in or applied to a material, which suppresses or delays the combustion of that material under specified conditions.
Fire safety engineering	Application of engineering methods based on scientific principles to the development or assessment of designs in the built environment through the analysis of specific *design scenarios* or through the quantification of risk for a group of *design scenarios*.

Definitions

Term	Definition
Fire safety systems	The combination of all active and passive protection methods used in a *building* to— a) warn people of an emergency; and b) provide for safe evacuation; and c) provide for access by, and the safety of, firefighters; and d) restrict the spread of *fire*; and e) limit the impact of *fire* on *structural stability*.
Fire separation	Any *building element* that separates *firecells* or *firecells* and *safe paths*, and provides a specific *fire resistance rating*.
Fire stop	A material or method of *construction* used to restrict the spread of *fire* within or through *fire separations*, and having a *FRR* no less than that of the *fire separation*. *Fire stops* are mainly used to seal around *penetrations*, but can also be used to seal narrow gaps between *building elements*.
Flashover	The stage of *fire* transition to a state of total surface involvement in a *fire* of *combustible* materials within an enclosure.
Flammability index (FI)	That index number for flammability, which is determined according to the *standard test* method for flammability of thin flexible materials.
Foamed plastics	*Combustible* foamed plastic polymeric materials of low density (typically less than 100 kg/m^3) and classified as cellular polymers which are manufactured by creating a multitude of fine void (typically 90 to 98%) distributed more or less uniformly throughout the product. Examples of *foamed plastics* are latex foams, polyethylene foams, polyvinyl chloride foams, expanded or extruded polystyrene foams, phenolic foams, ureaformaldehyde foams, polyurethane foams and polychloropene foams.
Fractional effective dose (FED)	The fraction of the dose (of carbon monoxide (CO) or thermal effects) that would render a person of average susceptibility incapable of escape.
Fully developed fire	The state of total involvement of *combustible* materials in a *fire*.
Group Number	The classification number for a material used as a finish, surface, lining, or attachment to a wall or ceiling within an *occupied space* and determined according to the *standard test* methods for measuring the properties of lining materials. The methods for determining a Group Number are provided in Section 8.5 of the Building Product Specifications.
Hard-standing	Means a hard-surfaced area that is sufficiently stable to carry a fire truck, and includes a *road*.
Hazardous	Creating an unreasonable risk to people of bodily injury or deterioration of health.
Hazardous substance	Has the meaning ascribed to it by section 2 of the Hazardous Substances and New Organisms Act 1996.
Heat of combustion	Thermal energy produced by combustion of unit mass of a given substance (kJ/g).
Heat release	Thermal energy produced by combustion (Joules).
Heat release rate (HRR)	Rate of thermal energy production generated by combustion (kW or MW).

Definitions

Term	Definition
Household unit	a) means a *building* or group of *buildings*, or part of a *building* or group of *buildings*, that is— i) used, or intended to be used, only or mainly for residential purposes; and ii) occupied, or intended to be occupied, exclusively as the home or residence of not more than 1 household; but b) does not include a hostel, boarding house, or other specialised accommodation.
HVAC	An abbreviation for heating, ventilating and air-conditioning.
Incapacitated	The state of physical inability to accomplish a specific task.
Insulation	In the context of *fire* protection, the time in minutes for which a prototype specimen of a *fire separation*, when subjected to the *standard test* for *fire* resistance, has limited the transmission of heat through the specimen.
Integrity	In the context of *fire* protection, the time in minutes for which a prototype specimen of a *fire separation*, when subjected to the *standard test* for *fire* resistance, has prevented the passage of flame or hot gases. The precise meaning of *integrity* depends on the type of *building elements* being treated and how it is defined in the *standard test* being used.
Intended use	In relation to a *building* – a) includes any or all of the following: i) any reasonably foreseeable occasional use that is not incompatible with the intended use; ii) normal maintenance; ii) activities undertaken in response to *fire* or any other reasonably foreseeable emergency; but b) does not include any other maintenance and repairs or rebuilding.
Intermediate floor	Any upper floor within a *firecell* which because of its configuration provides an opening allowing smoke or *fire* to spread from a lower to an upper level within the *firecell*.
Limited combustible	Material that is not *non-combustible* and meets the criteria for a limited combustible material in Section 8.1 of the Building Product Specifications.
Means of escape from fire	In relation to a *building* that has a floor area— a) means continuous unobstructed routes of travel from any part of the floor area of that *building* to a *place of safety*; and b) includes all active and passive protection features required to warn people of *fire* and to assist in protecting people from the effects of *fire* in the course of their escape from the *fire*.
Multi-unit dwelling	Applies to a *building* or use which contains more than one separate household or family.
Non-combustible	Material that meets the criteria for a non-combustible material in Section 8.1 of the Building Product Specifications.

Definitions

Term	Definition
Notional boundary	The *boundary* which for *fire* safety purposes, is assumed to exist between two *buildings* on the same property under a single land title. The *notional boundary* is not permitted to be located any closer than 1.0 metre to any unprotected areas within the external wall of the *buildings* that is receiving the radiation where orientated at less than 90°.
Occupant load	The greatest number of people likely to occupy a particular space within a *building*. It is determined by: a) dividing the total floor area by the m^2 per person for the activity being undertaken; or b) for sleeping areas, counting the number of sleeping (or care) spaces; or c) for fixed seating areas, counting the number of seats.
Occupied space	Any space within a *building* in which a person will be present from time to time during the *intended use* of the *building*.
Open path	That part of an *escape route* (including *dead ends*) within a *firecell* where occupants may be exposed to *fire* or smoke while making their escape.
Open space	Land on which there are, and will be, no *buildings* and which has no roof over any part of it other than overhanging eaves.
Optical density of smoke	A measure of the attenuation of a light beam passing through smoke expressed as the logarithm to the base 10 of the *opacity of smoke*.
Opacity of smoke	The ratio of incident light intensity to transmitted light intensity through smoke under specified conditions.
Other property	Any land or *buildings* or part of any land or *buildings*, that are: a) not held under the same *allotment*; or b) not held under the same *ownership*; and includes any *road*.
Owner	In relation to land and any *buildings* on the land— a) means the person who— i) is entitled to the rack rent from the land; or would be so entitled if the land were let to a tenant at a rack rent; and b) includes— i) the *owner* of the fee simple of the land; and ii) for the purposes of Building Act sections 32, 44, 92, 96, 97, and 176(c), any person who has agreed in writing, whether conditionally or unconditionally, to purchase the land or any leasehold estate or interest in the land, or to take a lease of the land, and who is bound by the agreement because the agreement is still in force.
Penetration	A *building element* passing through an opening in a *fire separation*. A *penetration* may include, but is not limited to: pipes, cables, ducts, hoses, drains, cable trays, ropes, data outlets, power outlets, hatches, glazing, structural bracing etc.

Definitions

Term	Definition
Place of safety	Either: a) a *safe place*; or b) a place that is inside a *building* and meets the following requirements: i) the place is constructed with *fire separations* that have *fire* resistance sufficient to withstand burnout at the point of the *fire* source, and ii) the place is in a *building* that is protected by an automatic *fire* sprinkler system that complies with NZS 4541 or NZS 4515 as appropriate to the *building*'s use, and iii) the place is designed to accommodate the intended number of persons, and iv) the place is provided with sufficient *means of escape* to enable the intended number of persons to escape to a *safe place* that is outside a *building*.
Pre-travel activity time	The time period after an alarm or *fire* cue is transmitted and before occupants first travel towards an exit.
Primary element	A *building element* providing the basic loadbearing capacity to the structure, and which if affected by fire may initiate instability or premature structural collapse.
Protected shaft	A space, other than a *safe path*, enclosed by *fire separations* or *external walls* used to house *building* services, lifts, or conveyors which pass from one *firecell* to another.
Railway line	Has the meaning ascribed to it by section 4 of the Railways Act 2005.
Relevant boundary	The boundary of an *allotment* that is *other property* in relation to the *building* in question and from which is measured the separation between the *building* and that *other property*; and for the *external wall* of any *building*, the *relevant boundary* is the nearest of— a) a *boundary* of a freehold *allotment*, except that if the other property is a *road*, railway line, or public *open space*, the *relevant boundary* is the *boundary* on the far side of that *other property*; or b) a *boundary* of a cross-lease or a company lease or a licence, except that if the *other property* is *open space* to which the lessee or licencee of the *building* in question has an exclusive right of access and occupation or to which 2 or more occupiers of the *building* in question have rights of access and occupation, the *relevant boundary* is the *boundary* on the far side of that *other property*; or c) a *boundary* shown on a unit plan (but excluding a *boundary* between a principal unit and its accessory unit), except that if the *other property* is *open space* and is common property, the *relevant boundary* is the *boundary* on the far side of that *other property*. Refer also to *notional boundary* for *buildings* on the same property under a single land title.
Remote receiving centre	A *fire* alarm monitoring centre service provider that transmits *fire* alarm signals to summon Fire and Emergency New Zealand in case of *fire* and complies with NZS 4512.

Definitions

Term	Definition
Required safe egress time (RSET)	The time required for escape. This is the calculated time period required for an individual occupant to travel from their location at the time of ignition to a *place of safety*.
Response Time Index (RTI)	The measure of the reaction time to a *fire* phenomenon of the sensing element of a *fire safety system*.
Road	Has the meaning ascribed to it by section 315 of the Local Government Act 1974 and includes a public place and also includes a motorway.
Safe path	That part of an *exitway* which is protected from the effects of *fire* by *fire separations*, *external walls*, or by distance when exposed to open air.
Safe place	A place, outside of and in the vicinity of a single *building* unit, from which people may safely disperse after escaping the effects of a *fire*. It may be a place such as a street, *open space*, public space or an *adjacent building* unit.
Secondary element	A *building element* not providing load bearing capacity to the structure and if affected by *fire*, instability or collapse of the *building* structure will not occur.
Separating element	A barrier that exhibits fire *integrity, structural adequacy*, thermal *insulation*, or a combination of these for a period of time under specified conditions (in a *fire* resistance test).
Smoke control door	A *doorset*, single or multi-leaf, having smoke control capability and forming part of a *smoke separation*.
Smoke production rate	The amount of smoke produced per unit time in a *fire* or *fire* test.
Smoke separation	Any *building element* able to prevent the passage of smoke between two spaces.
Stability	In the context of *fire* protection is the support provided to a *building element* having a *FRR*, intended to avoid premature failure due to structural collapse as a result of applied load, dead and live loads or as a result of any additional loads caused by *fire*.
Standard test	A test method that is recognised as being appropriate for the *fire* protection properties being assessed.
Stairway	A series of steps or stairs with or without landings, including all necessary *handrails* and giving access between two different levels.
Structural adequacy	In the context of the *standard test* for *fire* resistance, is the time in minutes for which a prototype specimen has continued to carry its applied load within defined deflection limits. The *fire* design load should be as specified in B1/VM1.
Surface finish	The combination of a surface coating and substrate material on surfaces of *building elements* exposed to view. It can be an applied decorative coating or the uncoated *building element* itself. For interior surfaces the requirements are evaluated in terms of a *Group Number*.
Surface spread of flame	Flame spread away from the source of ignition across the surface of a liquid or a solid.
Theatre	A place of assembly intended for the production and viewing of performing arts, and consisting of an auditorium and stage with provision for raising and suspending stage scenery above and clear of the working area.

Definitions

Term	Definition
Travel distance	The distance that is necessary for a person to travel from any point within a built environment to the nearest exit, taking into account the layout of walls, partitions and fittings.
Unprotected area	In relation to an *external wall* of a *building*, means: a) any part of the *external wall* which is not *fire* rated or has less than the required *FRR*, and b) any part of the *external wall* which has *combustible* material more than 1.0 mm thick attached or applied to its external face, whether for cladding or any other purpose. *Unprotected areas* include non-*fire* rated windows, doors, or other openings, and non-*fire* rated *external wall construction*.
Visibility	The maximum distance at which an object of defined size, brightness and contrast can be seen and recognised.
Wharenui	A communal meeting house having a large open floor area used for both assembly and sleeping in the traditional Māori manner.
Yield	The mass of a combustion product generated during combustion divided by the mass loss of the test specimen.

Appendix C. Design scenario HS horizontal fire spread tables

C.1 Horizontal fire spread from external walls

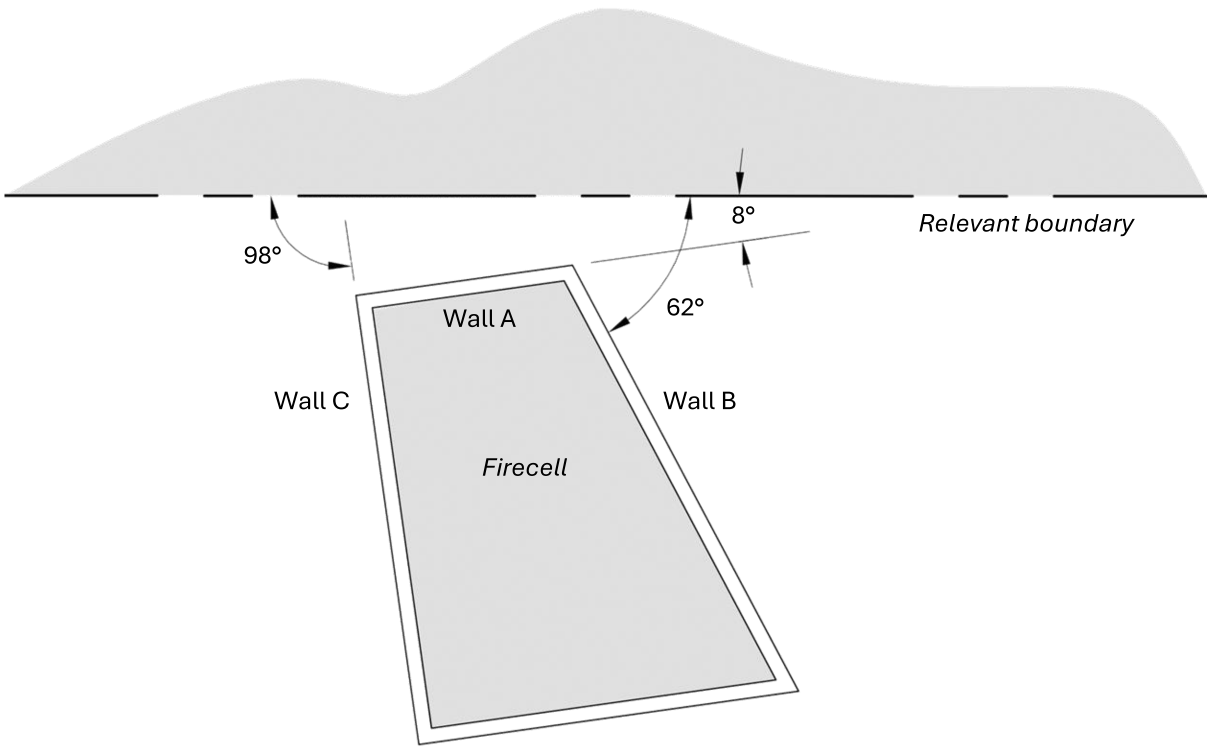
C.1.1 Overview

C.1.1.1 This appendix contains tabular data that can be used to satisfy Method B of design scenario HS: Horizontal fire spread. The requirements in this appendix depend on the intersection angle of the *external wall* and the *relevant boundary*.

C.1.1.2 The intersection angle is the angle produced between two horizontal lines with one being the line projected along the exterior face of a space bounded by *separating elements*, and the other being the *relevant boundary* (see Figure C.1.1.2). Where *external walls* are parallel to one another, or to a *relevant boundary*, the intersection angle is zero degrees.

Figure C.1.1.2: Measuring intersection angle in external walls adjacent to a relevant boundary

Paragraph C.1.1.2



Notes:

(1) This figure illustrates the situation where each of the methods 1, 2, 3 and 4 are used to restrict the size and/or location of *unprotected areas* in *external walls* close to the *relevant boundary* with *other property*.

(a) Wall A has an intersection angle of 10° or less (shown as 8° in the figure). If any part of the *external wall* is within 1.0 m of the *relevant boundary,* use method 1. If the *external wall* is 1.0 m or more from the *relevant boundary*, use method 2.

(b) Wall B has an intersection angle between 10° and 80° (shown as 62° in the figure) and method 3 applies for *buildings* that are irregular or non-parallel to the *relevant boundary*.

(c) Wall C has an intersection angle from 80° to 135° (shown as 98° in the figure) and method 4 applies for return walls and wing walls.

C.1.1.3 Protection shall be achieved by using one of the following approaches depending on the intersection angle:

a) for angles ≤ 10°, apply method 1 in Section C.2 or method 2 in Section C.3; or

b) for angles > 10° to < 80° or for *buildings* of irregular shape, apply method 3 in Section C.4; or

c) for angles ≥ 80° to < 135°, apply method 4 in Section C.5; or

d) for angles of 135° or greater, an *unprotected area* of 100% is permitted for the *external wall*.

C.1.1.4 For *buildings* on the same property, the words *relevant boundary* shall be interpreted as *notional boundary* for the application of this appendix.

C.2 Method 1 – Small openings and fire resisting glazing

C.2.1 Application

C.2.1.1 This method shall be applied to *external walls* of *buildings* that are parallel to or angled at no more than 10° to the *relevant boundary* when any part of the *external wall* is within 1.0 m of the *relevant boundary*.

C.2.2 Small unprotected areas and fire resisting glazing

C.2.2.1 *External wall construction* shall meet the following requirements:

a) small *unprotected areas* no greater than 0.1 m^2 and areas of *fire resisting glazing* shall be located to comply with Figure C.2.2.1; and

b) the remainder of the wall is *fire* rated equally for exposure to *fire* on both sides.

C.2.2.2 The *fire resisting glazing* shall be rated for *integrity* and the *FRR* of both the glazing and *external wall* shall be derived from the full *burnout design fire* as described in Subsection 2.3.4.

C.2.2.3 Areas of *fire resisting glazing* shall be no greater than the values in:

a) Table C.2.2.3A for unsprinklered *firecells*; or

b) Table C.2.2.3B for sprinklered *firecells*.

C.2.2.4 There is no limitation on the spacing between small *unprotected areas* and areas of *fire resisting glazing* that occur in different spaces bounded by *separating elements*. Within a space bounded by *separating elements* the following requirements shall apply:

a) small *unprotected areas* shall be no closer, both vertically and horizontally, than 1.5 m to another small *unprotected area or* areas of *fire resisting glazing*; and

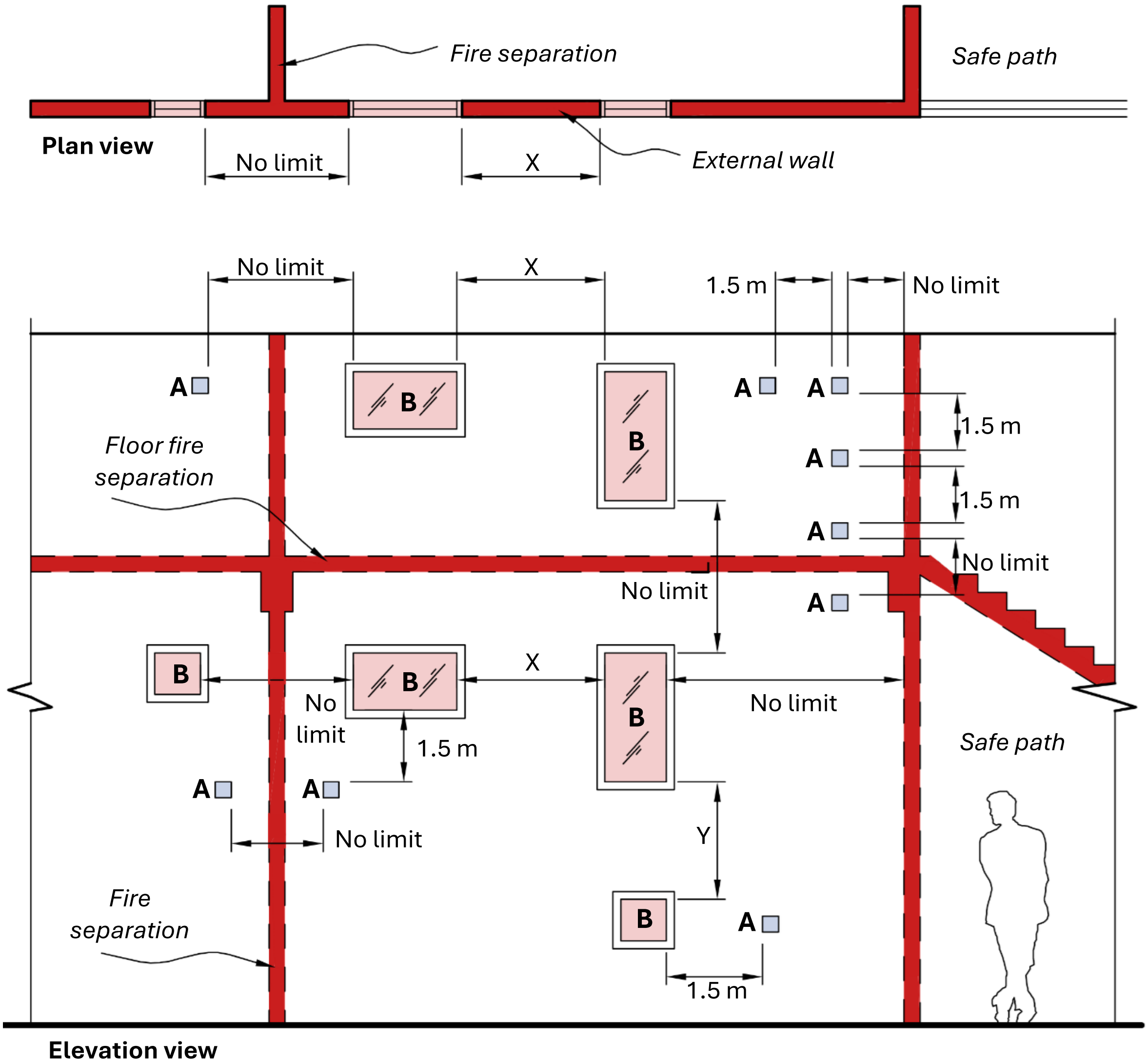
b) areas of *fire resisting glazing* shall be no closer to one another, vertically or horizontally, than the dimensions X or Y shown on Figure C.2.2.1.

c) where areas of *fire resisting glazing* are staggered, rather than being aligned vertically or horizontally, the shortest distance, in any direction, between adjacent areas shall be no less than the greater of the X and Y measurements.

> COMMENT: To determine dimensions X and Y, measure the width and height of both the adjacent areas of *fire resisting glazing*. The minimum value for X is the greater of the two widths, and for Y the greater of the two heights.

Figure C.2.2.1: Permitted small unprotected areas and fire resisting glazing

Paragraphs C.2.2.1 and C.2.2.4 b)



Notes:

(1) A is a small *unprotected area* no greater than 0.1 m².

(2) B is an area of *fire resisting glazing* that must comply with Paragraph C.2.2.3.

(3) Dimensions shown are the minimum distances between A and B. No limit means there is no limitation on spacing between the areas.

(4) Dimension X must be no less than the greater of the widths of the two areas of *fire resisting glazing* being considered.

(5) Dimension Y must be no less than the greater of the heights of the two areas of *fire resisting glazing* being considered.

Table C.2.2.3A: Maximum permitted areas of fire resisting glazing for unsprinklered firecells (m^2)

Paragraph C.2.2.3

Minimum distance to relevant boundary (m)	≤ 400 MJ/m^2 (m^2)	> 400 to ≤ 800 MJ/m^2 (m^2)	> 800 MJ/m^2 (m^2)
0.0	1.0	1.0	1.0
0.1	1.0	1.0	1.0
0.2	1.0	1.0	1.0
0.3	1.0	1.0	1.0
0.4	1.0	1.0	1.0
0.5	1.5	1.0	1.0
0.6	2.0	1.0	1.0
0.7	3.0	1.5	1.0
0.8	3.5	2.0	1.0
0.9	5.0	3.0	1.5
1.0	6.0	3.5	1.5
1.1	7.5	4.5	2.0
1.2	8.5	5.5	2.5
1.3	10.0	7.0	3.0
1.4	12.0	8.0	3.5
1.5	13.0	8.5	4.0
1.6	14.0	9.5	5.0
1.7	15.0(1)	10.0	5.5
1.8	Unlimited(1)	10.0	6.0
1.9	Unlimited(1)	11.0	6.5
2.0	Unlimited(1)	12.0	7.0
2.1	Unlimited(1)	13.0	7.5
2.2	Unlimited(1)	14.0	8.0
2.3	Unlimited(1)	15.0(2)	8.5
2.4	Unlimited(1)	15.0(2)	9.0
2.5	Unlimited(1)	15.0(2)	9.5
2.6	Unlimited(1)	15.0(2)	10.0
2.7	Unlimited(1)	15.0(2)	11.0
2.8	Unlimited(1)	15.0(2)	11.0
2.9	Unlimited(1)	15.0(2)	12.0
3.0	Unlimited(1)	15.0(2)	12.0
3.1	Unlimited(1)	15.0(2)	13.0
3.2	Unlimited(1)	15.0(2)	14.0
3.4	Unlimited(1)	15.0(2)	15.0(2)

Notes:

(1) For *firecells* with a *FLED* ≤ 400 MJ/m^2, there is no limit on the permitted area of *fire resisting glazing* at distances greater than 1.7 m from the *relevant boundary*.

(2) For *firecells* with a *FLED* > 400 MJ/m^2, the maximum permitted area of *fire resisting glazing* is 15 m^2.

Table C.2.2.3B: Maximum permitted areas of fire resisting glazing for sprinklered firecells (m^2)

Paragraph C.2.2.3

Minimum distance to relevant boundary (m)	≤ 400 MJ/m^2 (m^2)	> 400 to ≤ 800 MJ/m^2 (m^2)	> 800 MJ/m^2 (m^2)
0.0	Unlimited(1)	5.0	1.0
0.1	Unlimited(1)	6.5	1.0
0.2	Unlimited(1)	7.5	1.0
0.3	Unlimited(1)	9.0	1.0
0.4	Unlimited(1)	10.0	1.5
0.5	Unlimited(1)	11.0	2.5
0.6	Unlimited(1)	13.0	3.5
0.7	Unlimited(1)	14.0	5.0
0.8	Unlimited(1)	15.0(2)	6.5
0.9	Unlimited(1)	15.0(2)	7.5
1.0	Unlimited(1)	15.0(2)	8.5
1.1	Unlimited(1)	15.0(2)	9.5
1.2	Unlimited(1)	15.0(2)	10.0
1.3	Unlimited(1)	15.0(2)	11.0
1.4	Unlimited(1)	15.0(2)	12.0
1.5	Unlimited(1)	15.0(2)	13.0
1.6	Unlimited(1)	15.0(2)	14.0
1.7	Unlimited(1)	15.0(2)	15.0(2)

Notes:

(1) For sprinklered *firecells* with a *FLED* ≤ 400 MJ/m^2, there is no limit on the permitted area of *fire resisting glazing*.

(2) For *firecells* with a *FLED* > 400 MJ/m^2, the maximum permitted area of *fire resisting glazing* is 15 m^2.

C.3 Method 2 – Enclosing rectangles for parallel boundary

C.3.1 Application

C.3.1.1 This method shall be applied to *external walls* of *buildings* that are parallel to or angled at no more than 10° to the *relevant boundary* when any part of the *external wall* is 1.0 m or more from the *relevant boundary*.

C.3.1.2 The tables in Appendix C.3.2 can be used to determine:

a) the maximum size of *unprotected areas* in the *external wall* of each space bounded by *separating elements* depending on the dimensions of *unprotected areas*, the *FLED*, and the distance from the *external wall* to the *relevant boundary*; or

b) the minimum required distance from the *relevant boundary* to the closest *unprotected area* where the *unprotected area* has previously been determined.

C.3.1.3 The dimensions of the *unprotected areas* in the *external wall* of each space shall be determined by drawing a rectangle enclosing all *unprotected areas* and the protected areas between them (see Figure C.3.1.3) and measuring the height and width of the enclosing rectangle. The height and width of the enclosing rectangle are used in the tables in Subsection C.3.2.

C.3.2 Maximum percentage of unprotected area for external walls

C.3.2.1 The maximum percentage of *unprotected area* for *external walls* shall comply with:

a) Table C.3.2.1A for *firecells* with a *FLED* ≤ 400 MJ/m^2; and

b) Table C.3.2.1B for *firecells* with a *FLED* > 400 to ≤ 800 MJ/m^2; and

c) Table C.3.2.1C for *firecells* with a *FLED* > 800 MJ/m^2.

C.3.2.2 The maximum enclosing rectangle width shall be:

a) 20 m for *FLED* ≤ 800 MJ/m^2; and

b) 30 m for *FLED* > 800 MJ/m^2.

C.3.2.3 For enclosing rectangle widths greater than given in the tables, an enclosing rectangle width of 20 m for *FLED* ≤ 800 MJ/m^2 and 30 m for *FLED* > 800 MJ/m^2 may be used.

C.3.2.4 Where these tables do not contain the exact measurements for the *firecell* being considered, use the next highest value for rectangle height or rectangle width or next lowest value for *boundary* distance.

C.3.2.5 For enclosing rectangle heights greater than 8.0 m, radiation from *unprotected areas* in the *external wall* shall be determined using calculations in accordance with Paragraph 4.5.2.3.

C.3.2.6 Where the enclosure is sprinklered, increases are permitted in accordance with Paragraph 4.5.2.2(b).

C.3.3 Largest individual unprotected areas

C.3.3.1 For the largest individual *unprotected area* in the *external wall*, determine the minimum permitted distance to the *relevant boundary* using:

a) the height and width of the opening as an enclosing rectangle on its own with 100% *unprotected area*; and

b) Table C.3.2.1A for *firecells* with a *FLED* ≤ 400 MJ/m^2; and

c) Table C.3.2.1B for *firecells* with a *FLED* > 400 to ≤ 800 MJ/m^2; and

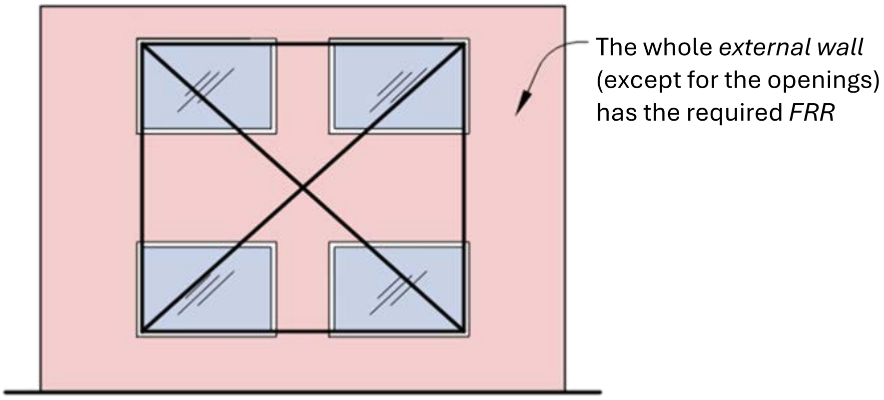
d) Table C.3.2.1C for *firecells* with a *FLED* > 800 MJ/m^2.

C.3.3.2 The minimum permitted distance from the largest single *unprotected area* to the *relevant boundary* must be no greater than the distance between the *external wall* and the *relevant boundary* determined in Subsection C.3.2.

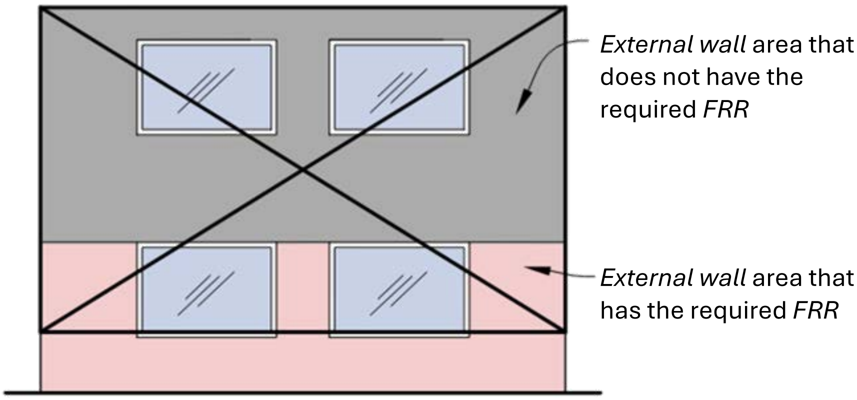
> COMMENT: The enclosing rectangle method assumes that *unprotected areas* are uniformly distributed openings over the total *external wall* of the *firecell*. In most cases, radiant heat flux is more intense from a single large opening than from several small openings with the same total area. This additional check ensures that the radiant heat flux is not exceeded from a single large opening.

Figure C.3.1.3: Enclosing rectangles for different unprotected areas

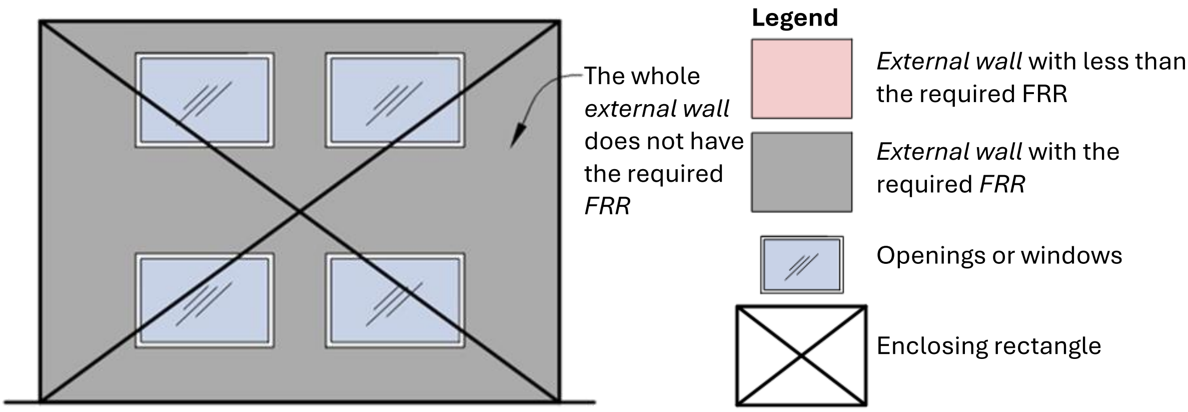
Paragraph C.3.1.3



(a) Enclosing rectangle where the *external wall* is *fire* rated except for the openings



(b) Enclosing rectangle where only a portion of the *external wall* is *fire* rated



(c) Enclosing rectangle where the *external wall* is not *fire* rated

Note:

(1) For the given *external wall* of a single *firecell*, dimensions of the enclosing rectangle vary according to the extent and location of *fire* rated *construction*. The essential requirement is for the rectangle to enclose all *unprotected areas*. This means that such things as an isolated window or door or other non-*fire* rated part of the *external wall* can significantly alter the rectangle dimensions and may include part of the *fire* rated *external wall*.

C.4 Method 3 – Enclosing rectangles for irregular buildings and non-parallel boundaries

C.4.1 Application

C.4.1.1 This method applies where the *building* is of irregular shape or the intersection angle between the *external wall* and *relevant boundary* is between 10° and 80° (see Figure C.4.1.1). The method is a variation of method 2 and evaluates the enclosing rectangle on an assumed reference plane.

> COMMENT: Typically, the most practical placement of this reference plane is parallel to the *relevant boundary* with the largest separation distance at the section of the wall having the largest *unprotected area*.

C.4.1.2 The reference plane shall be vertical, touch at least one point on the *external wall*, and not cross the *relevant boundary* within the length of the enclosure. The plane shall not pass through the enclosure, but may pass through projections such as balconies or copings.

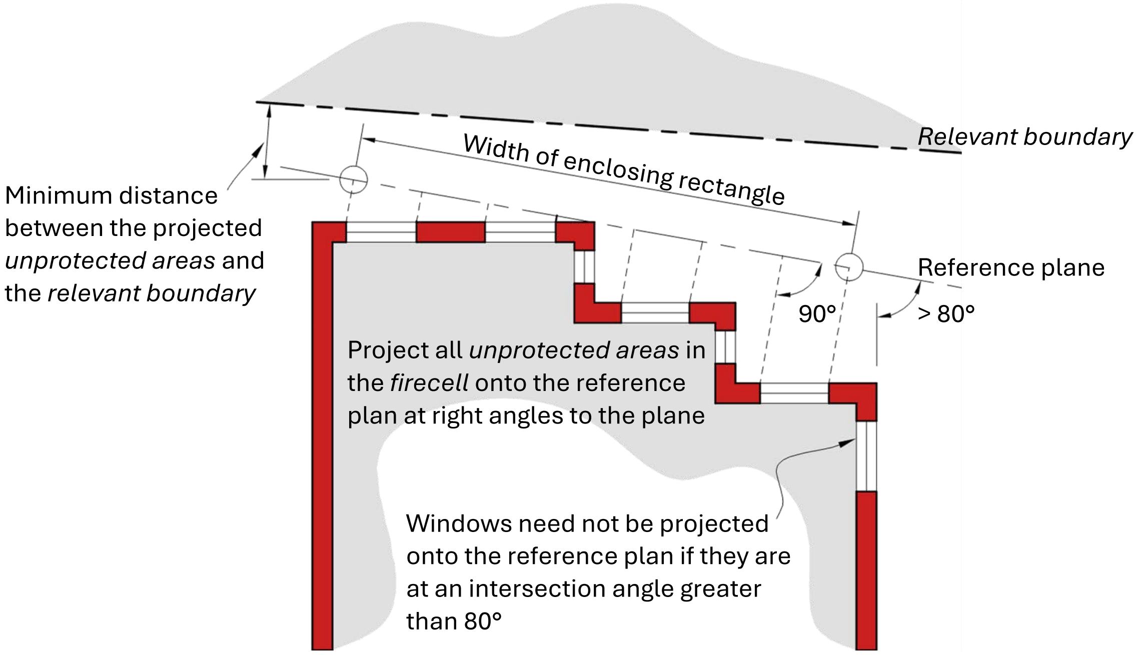
C.4.1.3 The enclosing rectangle is determined by projecting the *unprotected areas* onto the reference plane at right angles to the plane, and the distance to the *relevant boundary* used in the calculations shall be the shortest distance between that *relevant boundary* and the closest projected *unprotected area* on the reference plane. *Unprotected areas* that are more than 80° to the reference plane are not included.

C.4.2 Maximum percentage of unprotected area for external walls

C.4.2.1 Once the enclosing rectangle has been determined, comply with Subsections C.3.2 and C.3.3.

Figure C.4.1.1: Enclosing rectangles for irregular shaped buildings and non-parallel boundaries

Paragraph C.4.1.1



Note:

(1) Use the dimensions of the reference plane to determine the minimum distance to the *relevant boundary*.

Methodology for design scenario HS using horizontal fire spread tables

Table C.3.2.1A: Maximum percentage of unprotected area for external walls for FLED ≤ 400 MJ/m² for increasing heights and widths of the enclosing rectangle (continued on next page)

Paragraphs C.3.2.1(a) and C.3.3.1(b)

Height[1] (m)	Minimum distance[1] (m)	Width[1] 2 m	Width[1] 3 m	Width[1] 4 m	Width[1] 6 m	Width[1] 8 m	Width[1] 10 m	Width[1] 15 m	Width[1] 20 m
1.0	< 1	0	0	0	0	0	0	0	0
	1.0	100	89	85	82	81	81	80	80
	1.1	100	98	92	89	87	85	84	84
	1.2	100	100	100	96	92	90	88	87
	1.3	100	100	100	100	96	94	92	91
	1.4	100	100	100	100	100	98	96	95
	1.5	100	100	100	100	100	100	100	99
	1.6	100	100	100	100	100	100	100	100
2.0	0.0	0	0	0	0	0	0	0	0
	1.0	65	57	53	47	45	44	43	43
	1.1	71	61	57	50	47	46	45	45
	1.2	78	66	60	52	49	48	47	47
	1.3	85	71	64	55	51	50	49	49
	1.4	93	76	67	57	54	52	51	50
	1.5	100	82	71	60	56	54	53	52
	1.6	100	88	75	63	58	56	55	54
	1.7	100	94	79	66	61	59	57	56
	1.8	100	100	83	69	63	61	58	58
	1.9	100	100	88	72	66	63	60	60
	2.0	100	100	92	75	68	65	62	62
	2.1	100	100	97	78	71	68	64	64
	2.2	100	100	100	82	74	70	66	65
	2.3	100	100	100	85	76	72	69	67
	2.4	100	100	100	89	79	75	71	69
	2.5	100	100	100	92	82	77	73	71
	2.6	100	100	100	96	85	80	75	73
	2.7	100	100	100	100	88	82	77	75
	2.8	100	100	100	100	91	85	79	77
	2.9	100	100	100	100	94	88	81	79
	3.0	100	100	100	100	98	90	84	81
	4.0	100	100	100	100	100	100	100	100

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 20 m. The minimum distance is measured to the *relevant boundary*.

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Table C.3.2.1A: Maximum percentage of unprotected area for external walls for FLED ≤ 400 MJ/m² increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(a) and C.3.3.1(b)

Height[(1)] (m)	Minimum distance[(1)] (m)	Width[(1)] 2 m	Width[(1)] 3 m	Width[(1)] 4 m	Width[(1)] 6 m	Width[(1)] 8 m	Width[(1)] 10 m	Width[(1)] 15 m	Width[(1)] 20 m
3.0	< 1	0	0	0	0	0	0	0	0
	1.0	57	47	40	35	34	33	32	32
	1.1	61	49	43	37	35	34	34	33
	1.2	66	52	45	39	36	35	35	34
	1.3	71	55	47	40	38	37	36	35
	1.4	76	59	49	42	39	38	37	37
	1.5	82	62	52	44	41	39	38	38
	1.6	88	65	55	46	42	41	39	39
	1.7	94	69	57	47	44	42	40	40
	1.8	100	73	60	49	45	43	42	41
	1.9	100	77	63	51	47	45	43	42
	2.0	100	81	66	53	49	46	44	44
	2.1	100	85	69	56	50	48	45	45
	2.2	100	89	72	58	52	49	47	46
	2.3	100	93	76	60	54	51	48	47
	2.4	100	98	79	62	56	52	49	49
	2.5	100	100	82	65	58	54	51	50
	2.6	100	100	86	67	59	56	52	51
	2.7	100	100	90	70	61	57	54	52
	2.8	100	100	94	72	63	59	55	54
	2.9	100	100	97	75	66	61	56	55
	3.0	100	100	100	78	68	63	58	56
	4.0	100	100	100	100	91	82	73	70
	5.0	100	100	100	100	100	100	90	85
	6.0	100	100	100	100	100	100	100	100
4.0	< 1	0	0	0	0	0	0	0	0
	1.0	53	40	35	30	29	28	28	27
	1.1	57	43	36	31	30	29	28	28
	1.2	60	45	38	33	31	30	29	29
	1.3	64	47	40	34	32	31	30	30
	1.4	67	49	42	35	33	32	31	30
	1.5	71	52	43	36	34	32	31	31
	1.6	75	55	45	38	35	33	32	32
	1.7	79	57	47	39	36	34	33	33
	1.8	83	60	49	40	37	35	34	34

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 20 m. The minimum distance is measured to the *relevant boundary*.

Table C.3.2.1A: Maximum percentage of unprotected area for external walls for FLED ≤ 400 MJ/m² increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(a) and C.3.3.1(b)

Height(1) (m)	Minimum distance(1) (m)	Width(1) 2 m	Width(1) 3 m	Width(1) 4 m	Width(1) 6 m	Width(1) 8 m	Width(1) 10 m	Width(1) 15 m	Width(1) 20 m
4.0	1.9	88	63	52	42	38	36	35	34
	2.0	92	66	54	43	39	37	36	35
	2.1	97	69	56	45	41	39	37	36
	2.2	100	72	59	47	42	40	38	37
	2.3	100	76	61	48	43	41	38	38
	2.4	100	79	64	50	45	42	39	39
	2.5	100	82	66	52	46	43	40	40
	2.6	100	86	69	54	47	44	41	40
	2.7	100	90	72	56	49	46	42	41
	2.8	100	94	75	57	50	47	43	42
	2.9	100	97	78	59	52	48	44	43
	3.0	100	100	81	61	53	49	45	44
	4.0	100	100	100	84	71	64	57	54
	5.0	100	100	100	100	92	81	70	65
	6.0	100	100	100	100	100	100	84	77
	7.0	100	100	100	100	100	100	100	90
	8.0	100	100	100	100	100	100	100	100
6.0	< 1	0	0	0	0	0	0	0	0
	1.0	47	35	30	26	25	24	23	23
	1.1	50	37	31	27	25	25	24	24
	1.2	52	39	33	28	26	25	24	24
	1.3	55	40	34	28	26	26	25	24
	1.4	57	42	35	29	27	26	25	25
	1.5	60	44	36	30	28	27	26	25
	1.6	63	46	38	31	28	27	26	26
	1.7	66	47	39	32	29	28	27	26
	1.8	69	49	40	33	30	28	27	27
	1.9	72	51	42	34	31	29	28	27
	2.0	75	53	43	35	31	30	28	28
	2.1	78	56	45	36	32	30	29	28
	2.2	82	58	47	37	33	31	29	29
	2.3	85	60	48	38	34	32	30	29
	2.4	89	62	50	39	35	32	30	30
	2.5	92	65	52	40	36	33	31	30

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 20 m. The minimum distance is measured to the *relevant boundary*.

Table C.3.2.1A: Maximum percentage of unprotected area for external walls for FLED ≤ 400 MJ/m^2 increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(a) and C.3.3.1(b)

Height[1] (m)	Minimum distance[1] (m)	Width[1] 2 m	Width[1] 3 m	Width[1] 4 m	Width[1] 6 m	Width[1] 8 m	Width[1] 10 m	Width[1] 15 m	Width[1] 20 m
6.0	2.7	100	70	56	43	37	35	32	31
	3.0	100	78	61	47	40	37	34	33
	4.0	100	100	84	62	52	47	41	39
	5.0	100	100	100	81	66	58	49	46
	6.0	100	100	100	100	82	71	59	54
	7.0	100	100	100	100	100	87	70	63
	8.0	100	100	100	100	100	100	81	72
	9.0	100	100	100	100	100	100	95	82
	10.0	100	100	100	100	100	100	100	94
	11.0	100	100	100	100	100	100	100	100
8.0	< 1	0	0	0	0	0	0	0	0
	1.0	45	34	29	25	23	23	22	22
	1.1	47	35	30	25	24	23	22	22
	1.2	49	36	31	26	24	23	22	22
	1.3	51	38	32	26	24	24	23	22
	1.4	54	39	33	27	25	24	23	23
	1.5	56	41	34	28	25	24	23	23
	2.0	68	49	39	31	28	26	25	24
	2.5	82	58	46	36	31	29	27	26
	3.0	98	68	53	40	35	32	29	28
	4.0	100	91	71	52	43	39	34	32
	5.0	100	100	92	66	54	47	40	37
	6.0	100	100	100	82	66	57	47	43
	7.0	100	100	100	100	81	69	55	49
	8.0	100	100	100	100	97	82	64	56
	9.0	100	100	100	100	100	96	74	64
	10.0	100	100	100	100	100	100	84	72
	11.0	100	100	100	100	100	100	96	81
	12.0	100	100	100	100	100	100	100	91
	14.0	100	100	100	100	100	100	100	100

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 20 m. The minimum distance is measured to the *relevant boundary*.

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Table C.3.2.1B: Maximum percentage of unprotected area for external walls for FLED > 400 to ≤ 800 MJ/m² for increasing heights and widths of the enclosing rectangle (continued on next page)

Paragraphs C.3.2.1(b) and C.3.3.1(c)

Height[(1)] (m)	Minimum distance[(1)] (m)	Width[(1)] 2 m	Width[(1)] 3 m	Width[(1)] 4 m	Width[(1)] 6 m	Width[(1)] 8 m	Width[(1)] 10 m	Width[(1)] 15 m	Width[(1)] 20 m
1.0	< 1	0	0	0	0	0	0	0	0
	1.0	81	71	68	66	66	65	65	64
	1.1	91	79	75	72	70	69	68	67
	1.2	100	87	81	78	74	72	71	70
	1.3	100	95	88	82	78	76	74	73
	1.4	100	100	96	87	81	79	77	77
	1.5	100	100	100	91	85	83	80	80
	1.6	100	100	100	96	89	86	84	83
	1.7	100	100	100	100	93	90	87	86
	1.8	100	100	100	100	97	93	90	89
	1.9	100	100	100	100	100	97	93	92
	2.0	100	100	100	100	100	100	97	95
	2.1	100	100	100	100	100	100	100	99
	2.2	100	100	100	100	100	100	100	100
2.0	< 1	0	0	0	0	0	0	0	0
	1.0	53	46	43	38	36	36	35	35
	1.1	57	49	46	40	38	37	36	36
	1.2	63	53	48	42	40	39	38	38
	1.3	69	57	51	44	41	40	39	39
	1.4	75	61	54	46	43	42	41	41
	1.5	81	66	57	48	45	44	42	42
	1.6	89	71	60	51	47	45	44	44
	1.7	96	76	64	53	49	47	46	45
	1.8	100	81	67	55	51	49	47	47
	1.9	100	86	71	58	53	51	49	48
	2.0	100	90	74	60	55	53	50	50
	2.1	100	95	78	63	57	54	52	51
	2.2	100	100	82	66	59	56	54	53
	2.3	100	100	86	69	62	58	55	54
	2.4	100	100	90	71	64	60	57	56
	2.5	100	100	94	74	66	62	59	57
	2.6	100	100	99	77	69	64	60	59
	2.7	100	100	100	80	71	66	62	61
	2.8	100	100	100	84	73	69	64	62
	2.9	100	100	100	87	76	71	66	64
	3.0	100	100	100	90	79	73	67	66
	4.0	100	100	100	100	100	97	86	83
	5.0	100	100	100	100	100	100	100	100

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 20 m. The minimum distance is measured to the *relevant boundary*.

Table C.3.2.1B: Maximum percentage of unprotected area for external walls for FLED > 400 to ≤ 800 MJ/m² for increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(b) and C.3.3.1(c)

Height(1) (m)	Minimum distance(1) (m)	Width(1) 2 m	Width(1) 3 m	Width(1) 4 m	Width(1) 6 m	Width(1) 8 m	Width(1) 10 m	Width(1) 15 m	Width(1) 20 m
3.0	< 1	0	0	0	0	0	0	0	0
	1.0	46	38	33	29	27	27	26	26
	1.1	49	40	34	30	28	28	27	27
	1.2	53	42	36	31	29	29	28	28
	1.3	57	45	38	32	30	30	29	29
	1.4	61	47	40	34	32	31	30	29
	1.5	66	50	42	35	33	32	31	30
	1.6	71	53	44	37	34	33	32	31
	1.7	76	56	46	38	35	34	33	32
	1.8	81	59	48	40	36	35	34	33
	1.9	86	62	51	41	38	36	35	34
	2.0	90	65	53	43	39	37	36	35
	2.1	95	68	56	45	41	39	37	36
	2.2	100	72	58	47	42	40	38	37
	2.3	100	75	61	48	43	41	39	38
	2.4	100	79	64	50	45	42	40	39
	2.5	100	83	66	52	46	44	41	40
	2.6	100	86	69	54	48	45	42	41
	2.7	100	90	72	56	50	46	43	42
	2.8	100	94	75	58	51	48	44	43
	2.9	100	99	79	60	53	49	45	44
	3.0	100	100	82	63	55	51	47	45
	4.0	100	100	100	87	74	66	59	56
	5.0	100	100	100	100	96	85	73	68
	6.0	100	100	100	100	100	100	89	82
	7.0	100	100	100	100	100	100	100	96
	8.0	100	100	100	100	100	100	100	100
4.0	< 1	0	0	0	0	0	0	0	0
	1.0	43	33	28	24	23	23	22	22
	1.1	46	34	29	25	24	23	23	23
	1.2	48	36	31	26	25	24	23	23
	1.3	51	38	32	27	25	25	24	24
	1.4	54	40	33	28	26	25	25	24
	1.5	57	42	35	29	27	26	25	25
	1.6	60	44	37	30	28	27	26	26

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 20 m. The minimum distance is measured to the *relevant boundary*.

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Table C.3.2.1B: Maximum percentage of unprotected area for external walls for FLED > 400 to ≤ 800 MJ/m² for increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(b) and C.3.3.1(c)

Height[(1)] (m)	Minimum distance[(1)] (m)	Width[(1)] 2 m	Width[(1)] 3 m	Width[(1)] 4 m	Width[(1)] 6 m	Width[(1)] 8 m	Width[(1)] 10 m	Width[(1)] 15 m	Width[(1)] 20 m
4.0	1.7	64	46	38	31	29	28	27	26
	1.8	67	48	40	33	30	29	27	27
	1.9	71	51	42	34	31	29	28	28
	2.0	74	53	43	35	32	30	29	28
	2.1	78	56	45	36	33	31	30	29
	2.2	82	58	47	38	34	32	30	30
	2.3	86	61	49	39	35	33	31	30
	2.4	90	64	51	40	36	34	32	31
	2.5	94	66	53	42	37	35	33	32
	2.6	99	69	56	43	38	36	33	33
	2.7	100	72	58	45	39	37	34	33
	2.8	100	75	60	46	41	38	35	34
	2.9	100	79	62	48	42	39	36	35
	3.0	100	82	65	50	43	40	37	36
	4.0	100	100	92	68	57	52	46	44
	5.0	100	100	100	90	74	66	56	53
	6.0	100	100	100	100	94	82	68	62
	7.0	100	100	100	100	100	100	81	73
	8.0	100	100	100	100	100	100	95	84
	9.0	100	100	100	100	100	100	100	97
	10.0	100	100	100	100	100	100	100	100
6.0	< 1	0	0	0	0	0	0	0	0
	1.0	38	29	24	21	20	19	19	19
	1.1	40	30	25	22	20	20	19	19
	1.2	42	31	26	22	21	20	20	19
	1.3	44	32	27	23	21	21	20	20
	1.4	46	34	28	24	22	21	20	20
	1.5	48	35	29	24	22	21	21	20
	1.6	51	37	30	25	23	22	21	21
	1.7	53	38	31	26	23	22	21	21
	1.8	55	40	33	26	24	23	22	22
	1.9	58	41	34	27	25	23	22	22
	2.0	60	43	35	28	25	24	23	22
	2.1	63	45	36	29	26	24	23	23
	2.2	66	47	38	30	27	25	24	23

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 20 m. The minimum distance is measured to the *relevant boundary*.

Table C.3.2.1B: Maximum percentage of unprotected area for external walls for FLED > 400 to ≤ 800 MJ/m² for increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(b) and C.3.3.1(c)

Height(1) (m)	Minimum distance(1) (m)	Width(1) 2 m	Width(1) 3 m	Width(1) 4 m	Width(1) 6 m	Width(1) 8 m	Width(1) 10 m	Width(1) 15 m	Width(1) 20 m
6.0	2.3	69	48	39	31	27	26	24	24
	2.4	71	50	40	32	28	26	24	24
	2.5	74	52	42	32	29	27	25	24
	2.7	80	56	45	34	30	28	26	25
	3.0	90	63	50	38	33	30	27	27
	4.0	100	87	68	50	42	38	33	32
	5.0	100	100	90	65	53	47	40	37
	6.0	100	100	100	83	66	58	47	44
	7.0	100	100	100	100	82	70	56	51
	8.0	100	100	100	100	99	84	66	58
	9.0	100	100	100	100	100	99	76	66
	10.0	100	100	100	100	100	100	88	75
	11.0	100	100	100	100	100	100	100	85
	12.0	100	100	100	100	100	100	100	96
	13.0	100	100	100	100	100	100	100	100
8.0	< 1	0	0	0	0	0	0	0	0
	1.0	36	27	23	20	19	18	18	17
	1.1	38	28	24	20	19	18	18	18
	1.2	40	29	25	21	19	19	18	18
	1.3	41	30	25	21	20	19	18	18
	1.4	43	32	26	22	20	19	19	19
	1.5	45	33	27	22	20	20	19	19
	2.0	55	39	32	25	23	21	20	20
	2.5	66	46	37	29	25	23	22	21
	3.0	79	55	43	33	28	26	23	23
	4.0	100	74	57	42	35	31	27	26
	5.0	100	96	74	53	43	38	32	30
	6.0	100	100	94	66	53	46	38	35
	7.0	100	100	100	82	65	55	44	40
	8.0	100	100	100	99	78	66	51	45
	9.0	100	100	100	100	92	77	59	52
	10.0	100	100	100	100	100	90	68	58
	11.0	100	100	100	100	100	100	77	66
	12.0	100	100	100	100	100	100	88	73
	14.0	100	100	100	100	100	100	100	91
	17.0	100	100	100	100	100	100	100	100

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 20 m. The minimum distance is measured to the *relevant boundary*.

Table C.3.2.1C: Maximum percentage of unprotected area for external walls for FLED > 800 MJ/m² for increasing heights and widths of the enclosing rectangle (continued on next page)

Paragraphs C.3.2.1(c) and C.3.3.1(d)

Height[1] (m)	Minimum distance[1] (m)	Width[1] 2 m	Width[1] 3 m	Width[1] 4 m	Width[1] 6 m	Width[1] 8 m	Width[1] 10 m	Width[1] 15 m	Width[1] 20 m	Width[1] 30 m
1.0	< 1	0	0	0	0	0	0	0	0	0
	1.0	58	51	49	47	47	47	46	46	46
	1.1	65	56	53	51	50	49	48	48	48
	1.2	73	62	58	56	53	52	51	50	50
	1.3	81	68	63	59	56	54	53	53	52
	1.4	90	74	68	62	58	57	55	55	55
	1.5	100	81	74	65	61	59	57	57	57
	1.6	100	88	80	69	64	62	60	59	59
	1.7	100	96	86	72	67	64	62	61	61
	1.8	100	100	91	75	70	67	64	64	63
	1.9	100	100	96	79	72	69	67	66	66
	2.0	100	100	100	83	76	72	69	68	68
	2.1	100	100	100	87	79	75	72	71	70
	2.2	100	100	100	90	82	78	74	73	72
	2.3	100	100	100	94	85	81	76	75	74
	2.4	100	100	100	99	88	83	79	78	77
	2.5	100	100	100	100	92	86	81	80	79
	2.6	100	100	100	100	95	89	84	82	81
	2.7	100	100	100	100	99	92	86	85	83
	2.8	100	100	100	100	100	95	89	87	86
	2.9	100	100	100	100	100	99	91	89	88
	3.0	100	100	100	100	100	100	94	92	90
	3.1	100	100	100	100	100	100	97	94	93
	3.3	100	100	100	100	100	100	100	99	97
	3.5	100	100	100	100	100	100	100	100	100
2.0	< 1	0	0	0	0	0	0	0	0	0
	1.0	38	33	31	27	26	25	25	25	25
	1.1	41	35	33	29	27	27	26	26	26
	1.2	45	38	35	30	28	28	27	27	27
	1.3	49	41	37	32	30	29	28	28	28
	1.4	53	44	39	33	31	30	29	29	29
	1.5	58	47	41	35	32	31	30	30	30
	1.6	63	50	43	36	34	32	31	31	31
	1.7	69	54	46	38	35	34	33	32	32
	1.8	75	58	48	40	36	35	34	33	33

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 30 m. The minimum distance is measured to the *relevant boundary*.

Table C.3.2.1C: Maximum percentage of unprotected area for external walls for FLED > 800 MJ/m² for increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(c) and C.3.3.1(d)

Height(1) (m)	Minimum distance(1) (m)	Width(1) 2 m	Width(1) 3 m	Width(1) 4 m	Width(1) 6 m	Width(1) 8 m	Width(1) 10 m	Width(1) 15 m	Width(1) 20 m	Width(1) 30 m
2.0	1.9	81	61	51	41	38	36	35	34	34
	2.0	87	65	53	43	39	38	36	36	35
	2.1	94	68	56	45	41	39	37	37	36
	2.2	100	72	59	47	42	40	38	38	37
	2.3	100	76	61	49	44	42	40	39	38
	2.4	100	80	64	51	46	43	41	40	40
	2.5	100	84	67	53	47	45	42	41	41
	2.6	100	88	71	55	49	46	43	42	42
	2.7	100	92	74	57	51	48	44	43	43
	2.8	100	96	77	60	53	49	46	45	44
	2.9	100	100	80	62	54	51	47	46	45
	3.0	100	100	84	64	56	52	48	47	46
	4.0	100	100	100	91	77	69	62	59	57
	5.0	100	100	100	100	100	90	77	72	69
	6.0	100	100	100	100	100	100	94	86	81
	7.0	100	100	100	100	100	100	100	100	94
	7.5	100	100	100	100	100	100	100	100	100
3.0	< 1	0	0	0	0	0	0	0	0	0
	1.0	33	27	23	20	19	19	19	19	19
	1.1	35	29	24	21	20	20	19	19	19
	1.2	38	30	26	22	21	20	20	20	20
	1.3	41	32	27	23	22	21	21	20	20
	1.4	44	34	28	24	23	22	21	21	21
	1.5	47	36	30	25	23	23	22	22	22
	1.6	50	38	31	26	24	23	23	22	22
	1.7	54	40	33	27	25	24	23	23	23
	1.8	58	42	35	28	26	25	24	24	24
	1.9	61	44	36	30	27	26	25	24	24
	2.0	65	46	38	31	28	27	25	25	25
	2.1	68	49	40	32	29	28	26	26	26
	2.2	72	51	42	33	30	28	27	27	26
	2.3	76	54	44	35	31	29	28	27	27
	2.4	80	56	46	36	32	30	28	28	28
	2.5	84	59	48	37	33	31	29	29	28

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 30 m. The minimum distance is measured to the *relevant boundary*.

Table C.3.2.1C: Maximum percentage of unprotected area for external walls for FLED > 800 MJ/m² for increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(c) and C.3.3.1(d)

Height(1) (m)	Minimum distance(1) (m)	Width(1) 2 m	Width(1) 3 m	Width(1) 4 m	Width(1) 6 m	Width(1) 8 m	Width(1) 10 m	Width(1) 15 m	Width(1) 20 m	Width(1) 30 m
3.0	2.6	88	62	50	39	34	32	30	29	29
	2.7	92	65	52	40	35	33	31	30	30
	2.8	96	68	54	42	37	34	32	31	30
	2.9	100	71	56	43	38	35	32	32	31
	3.0	100	74	58	45	39	36	33	32	32
	4.0	100	100	85	62	53	48	42	40	39
	5.0	100	100	100	84	69	61	52	49	47
	6.0	100	100	100	100	88	77	63	58	55
	7.0	100	100	100	100	100	94	76	69	63
	8.0	100	100	100	100	100	100	90	80	72
	9.0	100	100	100	100	100	100	100	92	82
	10.0	100	100	100	100	100	100	100	100	91
	10.8	100	100	100	100	100	100	100	100	100
4.0	< 1	0	0	0	0	0	0	0	0	0
	1.0	31	23	20	17	17	16	16	16	16
	1.1	33	24	21	18	17	17	16	16	16
	1.2	35	26	22	19	18	17	17	17	17
	1.3	37	27	23	19	18	18	17	17	17
	1.4	39	28	24	20	19	18	18	17	17
	1.5	41	30	25	21	19	19	18	18	18
	1.6	43	31	26	22	20	19	19	18	18
	1.7	46	33	27	22	21	20	19	19	19
	1.8	48	35	29	23	21	20	20	19	19
	1.9	51	36	30	24	22	21	20	20	20
	2.0	53	38	31	25	23	22	21	20	20
	2.1	56	40	32	26	23	22	21	21	21
	2.2	59	42	34	27	24	23	22	21	21
	2.3	61	44	35	28	25	24	22	22	22
	2.4	64	46	37	29	26	24	23	22	22
	2.5	67	48	38	30	27	25	23	23	23
	2.6	71	50	40	31	27	26	24	23	23
	2.7	74	52	41	32	28	26	24	24	24
	2.8	77	54	43	33	29	27	25	24	24
	2.9	80	56	45	34	30	28	26	25	25
	3.0	84	58	46	35	31	28	26	25	25

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 30 m. The minimum distance is measured to the *relevant boundary*.

Table C.3.2.1C: Maximum percentage of unprotected area for external walls for FLED > 800 MJ/m² for increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(c) and C.3.3.1(d)

Height[(1)] (m)	Minimum distance[(1)] (m)	Width[(1)] 2 m	Width[(1)] 3 m	Width[(1)] 4 m	Width[(1)] 6 m	Width[(1)] 8 m	Width[(1)] 10 m	Width[(1)] 15 m	Width[(1)] 20 m	Width[(1)] 30 m
4.0	4.0	100	85	66	49	41	37	33	31	30
	5.0	100	100	90	65	53	47	40	38	36
	6.0	100	100	100	84	67	59	48	45	42
	7.0	100	100	100	100	84	72	58	52	48
	8.0	100	100	100	100	100	87	68	60	55
	9.0	100	100	100	100	100	100	79	69	62
	10.0	100	100	100	100	100	100	92	79	69
	11.0	100	100	100	100	100	100	100	90	77
	12.0	100	100	100	100	100	100	100	100	85
	13.0	100	100	100	100	100	100	100	100	94
	13.7	100	100	100	100	100	100	100	100	100
6.0	< 1	0	0	0	0	0	0	0	0	0
	1.0	27	20	17	15	14	14	14	13	13
	1.1	29	21	18	16	15	14	14	14	14
	1.2	30	22	19	16	15	14	14	14	14
	1.3	32	23	19	16	15	15	14	14	14
	1.4	33	24	20	17	16	15	15	14	14
	1.5	35	25	21	17	16	15	15	15	15
	1.6	36	26	22	18	16	16	15	15	15
	1.7	38	27	22	18	17	16	15	15	15
	1.8	40	28	23	19	17	16	16	15	15
	1.9	41	30	24	19	18	17	16	16	16
	2.0	43	31	25	20	18	17	16	16	16
	2.1	45	32	26	21	19	17	17	16	16
	2.2	47	33	27	21	19	18	17	17	16
	2.3	49	35	28	22	19	18	17	17	17
	2.4	51	36	29	23	20	19	17	17	17
	2.5	53	37	30	23	20	19	18	17	17
	2.7	57	40	32	25	22	20	19	18	18
	3.0	64	45	35	27	23	21	20	19	19
	4.0	91	62	49	36	30	27	24	23	22
	5.0	100	84	65	46	38	33	28	27	25
	6.0	100	100	84	59	48	41	34	31	29
	7.0	100	100	100	74	58	50	40	36	33
	8.0	100	100	100	90	71	60	47	42	38

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 30 m. The minimum distance is measured to the *relevant boundary*.

Table C.3.2.1C: Maximum percentage of unprotected area for external walls for FLED > 800 MJ/m² for increasing heights and widths of the enclosing rectangle (continued from previous page)

Paragraphs C.3.2.1(c) and C.3.3.1(d)

Height(1) (m)	Minimum distance(1) (m)	Width(1) 2 m	Width(1) 3 m	Width(1) 4 m	Width(1) 6 m	Width(1) 8 m	Width(1) 10 m	Width(1) 15 m	Width(1) 20 m	Width(1) 30 m
6.0	9.0	100	100	100	100	85	71	54	48	42
	10.0	100	100	100	100	100	83	63	54	47
	11.0	100	100	100	100	100	97	72	61	52
	12.0	100	100	100	100	100	100	82	68	58
	13.0	100	100	100	100	100	100	92	77	63
	14.0	100	100	100	100	100	100	100	85	69
	16.0	100	100	100	100	100	100	100	100	83
	18.4	100	100	100	100	100	100	100	100	100
8.0	< 1	0	0	0	0	0	0	0	0	0
	1.0	26	19	17	14	13	13	13	13	12
	1.1	27	20	17	15	14	13	13	13	13
	1.2	28	21	18	15	14	13	13	13	13
	1.3	30	22	18	15	14	14	13	13	13
	1.4	31	23	19	16	14	14	13	13	13
	1.5	32	23	19	16	15	14	13	13	13
	2.0	39	28	23	18	16	15	14	14	14
	2.5	47	33	27	20	18	17	15	15	15
	3.0	56	39	31	23	20	18	17	16	16
	4.0	77	53	41	30	25	22	20	19	18
	5.0	100	69	53	38	31	27	23	22	21
	6.0	100	88	67	48	38	33	27	25	23
	7.0	100	100	84	58	46	40	32	28	26
	8.0	100	100	100	71	56	47	37	33	29
	9.0	100	100	100	85	66	55	42	37	33
	10.0	100	100	100	100	78	65	49	42	36
	11.0	100	100	100	100	90	75	55	47	40
	12.0	100	100	100	100	100	86	63	53	44
	14.0	100	100	100	100	100	100	79	65	53
	17.0	100	100	100	100	100	100	100	87	68
	20.0	100	100	100	100	100	100	100	100	86
	22.2	100	100	100	100	100	100	100	100	100

Note: (1) The height and width of the enclosing rectangle is shown in Figure C.3.1.3 and Figure C.4.1.1. For enclosing rectangle widths greater than given in the table, use an enclosing rectangle width of 30 m. The minimum distance is measured to the *relevant boundary*.

C.5 Method 4 – Return walls and wing walls

C.5.1 Application

C.5.1.1 This method shall be applied to *external walls* of *buildings* where the intersection angle is 80° or greater and less than 135°. It may be used for all values of *FLED*.

C.5.1.2 This method is used to achieve protection by providing either return walls or wing walls. Where the *firecell* is sprinklered, wing walls and return walls are not required.

> COMMENT: It is more economical to use a return wall in the *firecell* of fire origin than to use a wing wall as a shield between that *firecell* and the property being protected.

C.5.1.3 The lengths of return walls and wing walls are determined using:

a) the equations in Subsection C.5.2 and C.5.3 depending on the intersection angle; and

b) for the protection of *other property*:

   i) Table C.5.1.3A for return walls, and

   ii) Table C.5.1.3B for wing walls; or

c) for the protection of sleeping occupancies or *safe paths* on the same property:

   i) Table C.5.1.3C for return walls, and

   ii) Table C.5.1.3D for wing walls; or

C.5.1.4 Separation distances are measured between *unprotected areas* in the *firecells* being considered and the *relevant boundary* or the *notional boundary* coinciding with the *external wall* of the other *firecell* (see Figure C.5.1.4).

C.5.1.5 The dimensions of the *unprotected areas* in the *external wall* of each space shall be determined by drawing a rectangle enclosing all *unprotected areas* and the protected areas between them within a maximum distance of 20 m measured at right angles to the *relevant boundary*. The dimensions of the rectangle are:

a) A_o (the equivalent opening area) found by summing all individual *unprotected areas* within the enclosing rectangle; and

b) h_{eq} (the equivalent opening height of the enclosing rectangle); and

c) W_{eq} (equivalent opening width) found by dividing A_o by h_{eq}.

> COMMENT:
>
> 1. It is assumed that *unprotected areas* more than 20 m from the *relevant boundary* do not pose a radiation threat.
> 2. The tables in this section are based on the assumption that the equivalent opening area is located at the end of the wall nearest the *relevant boundary*. This is a conservative, but safe, simplification for determining the most severe thermal radiation likely to be emitted from a *fire* within the space bounded by *separating elements*.

C.5.2 Return wall and wing wall lengths for intersection angles ≥ 80° to < 90°

C.5.2.1 The length of return walls shall be determined from Equation C.1.

C.5.2.2 The length of wing walls shall be determined from Equation C.2.

Equation C.1: $L_r = D_B - D_S$

Equation C.2: $L_w = \frac{L_B \times L_r}{D_B}$

where:

L_r is the return wall length (m) measured at right angles to the *relevant boundary* (see Figure C.5.1.4); and

L_w is the wing wall length (m); and

D_B is the minimum permitted distance between *unprotected areas* in the *external wall* being considered and the *relevant boundary* (metres). D_B is determined from Table C.5.1.3A and Table C.5.1.3C based on h_{eq} and W_{eq} from Paragraph C.5.1.5 and is measured at right angles to the *relevant boundary* (see Figure C.5.1.4); and

D_S is the shortest distance between the *external wall* of the space bounded by *separating elements* being considered and the *relevant boundary* (m) and is measured at right angles to the *relevant boundary* (see Figure C.5.1.4); and

L_B is the wing wall length if that wall is located on the *relevant boundary* (m). L_B is determined from Table C.5.1.3B and Table C.5.1.3D based on h_{eq} and W_{eq} from Paragraph C.5.1.5.

C.5.2.3 On the *relevant boundary*, $D_S = 0$ and therefore:

a) the return wall length (L_r) is equal to D_B; and

b) the wing wall length (L_w) is equal to L_B.

C.5.3 Return wall and wing wall lengths for intersection angles ≥ 90° to < 135°

C.5.3.1 For angles of 90° or greater, the return wall length and wing wall length can be reduced linearly to give shorter return walls or wing walls by applying Equation C.3 and Equation C.4.

Equation C.3: $L_f = \left(\frac{135 - \theta}{45}\right) \times \left(D_B - D_S\right)$

Equation C.4: $L_w = \left(\frac{135 - \theta}{45}\right) \times \frac{L_B \times L_r}{D_B}$

Where:

L_r is the return wall length (m); and

L_w is the wing wall length (m); and

θ is the intersection angle (°); and

D_B is the minimum permitted distance between *unprotected areas* in the *external wall* being considered and the *relevant boundary* (m). D_B is determined from Table C.5.1.3A and Table C.5.1.3C based on h_{eq} and W_{eq} from Paragraph C.5.1.5; and

D_S is the shortest distance between the *external wall* of the space bounded by *separating elements* being considered and the *relevant boundary* and is measured at right angles to the *relevant boundary* (m) (see Figure C.5.1.4); and

L_B is the wing wall length if that wall is located on the *relevant boundary* (m). L_B is determined from Table C.5.1.3B and Table C.5.1.3D based on h_{eq} and W_{eq} from Paragraph C.5.1.5.

Table C.5.1.3A: Minimum separation distance between unprotected areas and the relevant boundary for return walls for the protection of other property

Paragraph C.5.1.3, Equation C.1, and Equation C.3

h_{eq}(1) (m)	D_B (m)(2) for W_{eq}(1) = 1 m	D_B (m)(2) for W_{eq}(1) = 2 m	D_B (m)(2) for W_{eq}(1) = 3 m	D_B (m)(2) for W_{eq}(1) = 4 m	D_B (m)(2) for W_{eq}(1) = 6 m	D_B (m)(2) for W_{eq}(1) = 8 m	D_B (m)(2) for W_{eq}(1) = 10 m	D_B (m)(2) for W_{eq}(1) = 20 m
1	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
6	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5
8	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.7
10	0.4	0.4	0.4	0.4	0.5	0.6	0.7	0.9

Notes:

(1) The equivalent opening height h_{eq} and equivalent opening width W_{eq} are determined in accordance with Paragraph C.5.1.5.

(2) The minimum distance between *unprotected areas* and the *relevant boundary* (D_B) is shown in Figure C.5.1.4.

Table C.5.1.3B: Minimum length of wing wall if located on the relevant boundary for the protection of other property

Paragraph C.5.1.3, Equation C.1, Equation C.2, Equation C.3, and Equation C.4

h_{eq}(1) (m)	L_B (m)(2) for W_{eq}(1) = 1 m	L_B (m)(2) for W_{eq}(1) = 2 m	L_B (m)(2) for W_{eq}(1) = 3 m	L_B (m)(2) for W_{eq}(1) = 4 m	L_B (m)(2) for W_{eq}(1) = 6 m	L_B (m)(2) for W_{eq}(1) = 8 m	L_B (m)(2) for W_{eq}(1) = 10 m	L_B (m)(2) for W_{eq}(1) = 20 m
1	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7
2	0.6	0.9	1.1	1.2	1.2	1.3	1.3	1.3
3	0.7	1.1	1.4	1.6	1.7	1.8	1.9	1.9
4	0.7	1.2	1.6	1.8	2.1	2.3	2.4	2.5
6	0.7	1.3	1.9	2.2	2.7	3.1	3.3	4.4
8	0.7	1.4	2.0	2.5	3.2	3.6	5.2	6.3
10	0.7	1.4	2.1	2.6	3.4	4.1	6.1	7.9

Notes:

(1) The equivalent opening height h_{eq} and equivalent opening width W_{eq} are determined in accordance with Paragraph C.5.1.5.

(2) L_B is the wing wall length if that wall is located on the *relevant boundary*.

Methodology for design scenario HS using horizontal fire spread tables

Table C.5.1.3C: Minimum separation distance between unprotected areas and the notional boundary for return walls for the protection of sleeping occupancies or safe paths on the same property

Paragraph C.5.1.3, Equation C.1, and Equation C.3

h_{eq}(1) (m)	D_B (m)(2) for W_{eq}(1) = 1 m	D_B (m)(2) for W_{eq}(1) = 2 m	D_B (m)(2) for W_{eq}(1) = 3 m	D_B (m)(2) for W_{eq}(1) = 4 m	D_B (m)(2) for W_{eq}(1) = 6 m	D_B (m)(2) for W_{eq}(1) = 8 m	D_B (m)(2) for W_{eq}(1) = 10 m	D_B (m)(2) for W_{eq}(1) = 20 m
1	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6
4	0.4	0.4	0.5	0.6	0.7	0.8	0.8	0.9
6	0.4	0.5	0.7	0.8	1.0	1.1	1.1	1.2
8	0.4	0.5	0.7	0.9	1.1	1.3	1.4	1.5
10	0.4	0.5	0.8	1.0	1.3	1.4	1.5	1.9

Notes:

(1) The equivalent opening height h_{eq} and equivalent opening width W_{eq} are determined in accordance with Paragraph C.5.1.5.

(2) The minimum distance between *unprotected areas* and the *notional boundary* (D_B) is shown in Figure C.5.1.4.

Table C.5.1.3D: Minimum length of wing wall if located on the notional boundary for the protection of sleeping occupancies or safe paths on the same property

Paragraph C.5.1.3, Equation C.1, Equation C.2, Equation C.3, and Equation C.4

h_{eq}(1) (m)	L_B (m)(2) for W_{eq}(1) = 1 m	L_B (m)(2) for W_{eq}(1) = 2 m	L_B (m)(2) for W_{eq}(1) = 3 m	L_B (m)(2) for W_{eq}(1) = 4 m	L_B (m)(2) for W_{eq}(1) = 6 m	L_B (m)(2) for W_{eq}(1) = 8 m	L_B (m)(2) for W_{eq}(1) = 10 m	L_B (m)(2) for W_{eq}(1) = 20 m
1	0.8	1.1	1.2	1.3	1.3	1.4	1.4	1.4
2	1.0	1.5	1.9	2.1	2.3	2.5	2.6	2.7
3	1.1	1.8	2.3	2.6	3.1	3.4	3.6	3.9
4	1.2	2.0	2.6	3.1	3.7	4.2	4.4	5.1
6	1.2	2.2	3.0	3.6	4.6	5.2	5.8	7.2
8	1.2	2.3	3.2	4.0	5.2	6.2	6.8	8.8
10	1.2	2.4	3.4	4.2	5.6	6.7	7.6	10.5

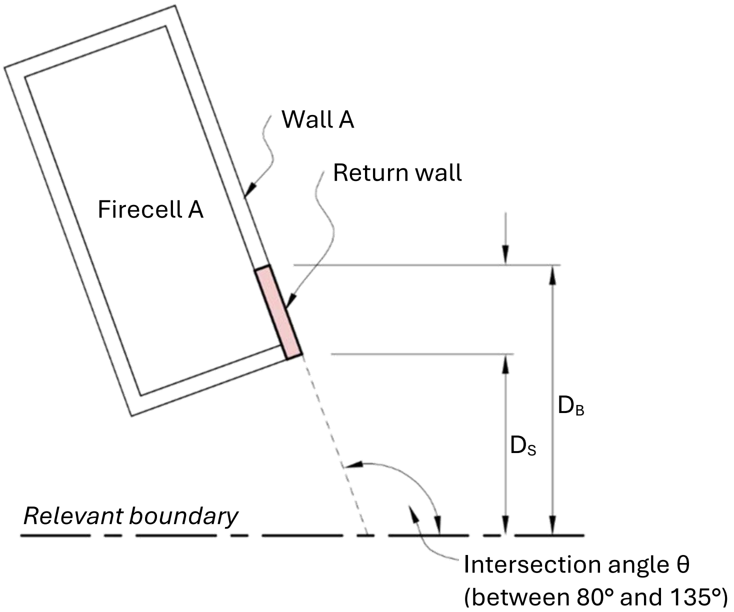
Notes:

(1) The equivalent opening height h_{eq} and equivalent opening width W_{eq} are determined in accordance with Paragraph C.5.1.5.

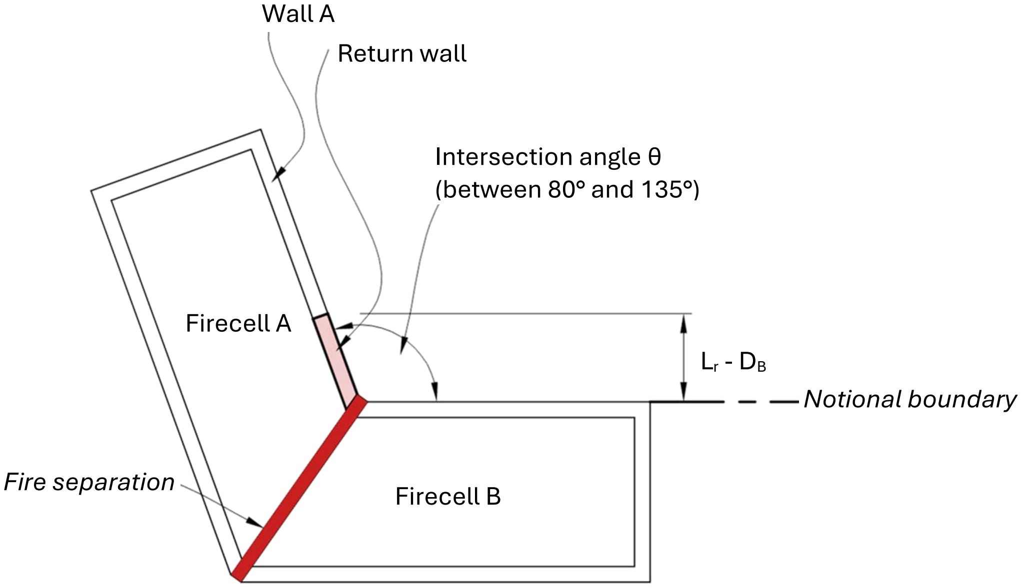
(2) L_B is the wing wall length if that wall is located on the *relevant boundary*.

Figure C.5.1.4: Return walls on external walls having an intersection angle of between 80° and 135° with the relevant boundary or notional boundary

Paragraphs C.5.1.4, C.5.2.1, and C.5.3.1, Table C.5.1.3A, and Table C.5.1.3C



(a) Plan view of the return wall length for preventing *fire* spread from wall A to the *relevant boundary*



(b) Plan view of the return wall for preventing *fire* spread from the *external wall* of Firecell 1 to Firecell 2 in the same or adjoining *building*

Notes:

(1) D_S is the shortest distance between the *external wall* being considered and the *relevant boundary*.

(2) D_B is the minimum permitted distance between *unprotected areas* in wall A and

(a) the *relevant boundary* as determined from Table C.5.1.3A for plan (a); or

(b) the notional boundary as determined from Table C.5.1.3C for plan (b).

(3) L_r is the required return wall length measured at right angles to the *relevant boundary* or *notional boundary* as applicable.

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