MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

C/VM2

Verification Method: Framework for Fire Safety Design

For New Zealand Building Code Clauses
C1-C6 Protection from Fire

C
BUILDING CODE

Using this Verification Method

The Ministry of Business, Innovation and Employment may amend parts of this Verification Method at any time. People using this Verification Method should check on a regular basis whether new versions have been published. The current version can be downloaded from www.building.govt.nz

Users should make themselves familiar with the preface to the New Zealand Building Code Handbook, which describes the status of Verification Methods and explains other ways of achieving compliance.

Defined words (italicised in the text) are explained in the Building Code Clause A2 and in the Definitions section of this Verification Method. Classified uses of buildings are explained in the Building Code Clause A1. Importance levels of building are buildings (italicised in the text) are explained in the Building Code Clause A3.

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Status of C/VM2

This Verification Method C/VM2, Framework for Fire Safety Design, provides a means of compliance with the New Zealand Building Code Clauses C1-C6 Protection from Fire. It is issued under section 22 of the Building Act 2004 as a Verification Method.

This Verification Method is one way that can be used to show compliance with the New Zealand Building Code Clauses C1-C6 Protection from Fire. Other ways of complying with the Building Code are described, in general terms, in the preface of the New Zealand Building Code Handbook.

When can you use C/VM2

This Verification Method is effective from 24 November 2017. It can be used to show compliance with the Building Code Clauses C1-C6 Protection from Fire. It does not apply to building consent applications submitted before 24 November 2017.

The previous version, Amendment 4, of this Verification Method can be used to show compliance with the Building Code Clauses C1-C6 Protection from Fire until 23 November 2017. It can be used for building consent applications submitted before 24 November 2017.

Document History			
	Date	**Alterations**	
New document	Effective from 10 April 2012	C/VM2 is a new publication that can be used to show compliance with the Building Code Clauses C1-C6 Protection from Fire.	
Amendment 1 (Errata 1)	Effective from 30 April 2012	p. 11, 1.2 p. 13, Figure 1.1 a) p. 19, Figure 1.1 g)	p. 32, Table 2.3 p. 39, Table 3.3 p. 59, 4.9
Amendment 2 (Errata 2)	Effective from 15 February 2013 until 18 June 2014	p. 9 Definitions pp. 25–26 2.2.1 p. 33 Table 2.4 p. 40 3.2.4 p. 41 3.2.7	p. 58 4.8 p. 59 4.9 p. 61 4.10 p. 64 Index
Amendment 3	Effective from 19 December 2013 until 28 February 2015	p. 5 Contents p. 7 References p. 10 Definitions p. 15 Figure 1.1 c pp. 25–26 2.2.1 pp. 28–32 Tables 2.1, 2.2, 2.3 p. 35 Table 3.1	pp. 39–42 3.2.4, 3.4, Table 3.3 pp 49–64 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, Tables 4.1 and 4.2 pp. 66–68 A1.1, A1.4, A1.5, Table A1 p. 69 Index
Amendment 4	Effective from 1 July 2014 until 23 November 2017	p. 5–6 Contents pp. 7-8 References p. 10–10A Definitions p. 11–13 1.2, 1.3, Figure 1.1 pp. 14–23 Figure 1.1 p. 24 1.5, Table 1.1 pp. 25–28, 30–31, 33–33A 2.2.1, 2.4, 2.4.4, 2.5, Tables 2.1, 2.2 and 2.4 pp. 34–44 3.1, 3.2.4, 3.2.5, 3.2.6, 3.3, 3.4, 3.4.1, 3.6.1, 3.6.3, 3.6.5, Tables 3.1, 3.2, 3.3	p. 45 Part 4 Contents pp. 46–47 4.1, 4.2 pp. 50–52, 4.5 pp. 53–56, 4.6, Table 4.2 p. 59 4.7 pp. 61–62 4.8 p. 63 4.9 p. 65 4.10 pp. 69–70 A1.6, A1.7, Tables A.1 and A.2 p. 71 Appendix B, Table B1 p. 72 Index
Amendment 5	Effective from 24 November 2017	pp. 11-12 1.2 Scope	

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Amend 4
Jul 2014

References

For the purposes of New Zealand Building Code (NZBC) compliance, the Standards and documents referenced in this Compliance Document (primary reference documents) must be the editions, along with their specific amendments, listed below. Where these primary reference documents refer to other Standards or documents (secondary reference documents), which in turn may also refer to other Standards or documents, and so on (lower-order reference documents), then the version in effect at the date of publication of this Compliance Document must be used.

Standards New Zealand			
NZS 4510: 2008	Fire hydrant systems for buildings *Amend: 1*	4.8	
NZS 4512: 2010	Fire detection and alarm systems in buildings	3.4	
NZS 4515: 2009	Fire sprinkler systems for life safety in sleeping occupancies (up to 2000 m²)	Definitions	
Amend 3 Dec 2013 NZS 4541: 2013	Automatic fire sprinkler systems	Definitions	
AS/NZS 3837: 1998	Method of test for heat and smoke release rates for materials and products using an oxygen consumption calorimeter *Amend: 1* Amend 3 Dec 2013	4.6, Tables 4.1, 4.2	Amend 3 Dec 2013
Standards Australia			
AS 1366:-	Rigid cellular plastics sheets for thermal insulation		
Part 1: 1992	Rigid cellular polyurethane (RC/PUR) *Amend: 1*	4.7, A1.7	
Part 2: 1992	Rigid cellular polyisocyanurate (RC/PIR)	4.7, A1.7	
Part 3: 1992	Rigid cellular polystyrene – moulded (RC/PS-M) *Amend: 1*	4.7, A1.7	
Part 4: 1989	Rigid cellular polystyrene – extruded (RC/PS-E)	4.7, A1.7	Amend 4 Jul 2014
AS 1530:-	Methods for fire tests on building materials, components and structures		
Part 1: 1994	Combustibility test for materials	4.7	
Part 2: 1993	Test for flammability of materials	4.7	
Part 4: 2005	Fire resistance tests for elements of construction	2.4	
AS 4254:-	Ductwork for air-handling systems in buildings	4.7, A1.4	
Part 1: 2012	Flexible duct		
Amend 3 Dec 2013 Part 2: 2012	Rigid duct		
British Standards Institution			
BS 7273:-	Code of practice for the operation of fire protection measures		
Part 4: 2007	Actuation of release mechanisms for doors	4.10	
International Standards Organisation			
ISO 1182: 2010	Reaction to fire tests for products – Non-combustibility test	4.7	
ISO 5660:-	Reaction-to-fire tests		
Part 1: 2002	Heat release, smoke production and mass loss rate	4.6, 4.7, A1.1, A1.2, A1.3, A1.7 Tables 4.1, 4.2	Amends 3 and 4
Part 2: 2002	Smoke production rate (dynamic measurement)	A1.1	

ISO 9239:-	Reaction to fire tests for floorings		
Part 1: 2010	Determination of the burning behaviour using a radiant heat source	4.7, B1.0 Table B1,	
ISO 9705: 1993	Fire tests – Full-scale room test for surface products	4.7, A1.1, A1.2, A1.7	
ISO 13571: 2007	Life-threatening components of fire Guidelines for the estimation of time available for escape using fire data.	2.2.1	Amend 4 Jul 2014
ISO 13784:-	Reaction-to-fire tests for sandwich panel building systems		
Part 1: 2002	Test method for small rooms	A1.1, A1.7	Amend 4 Jul 2014
ISO 13785:-	Reaction-to-fire tests for façades		
Part 1: 2002	Intermediate-scale test	4.6	

European Committee for Standardisation

Eurocode DD ENV 1991:-	Eurocode 1: basis of design and actions on structures,		
Part 2.2: 1996	Actions on structures exposed to fire	2.4 Comment, 2.4.4	

National Fire Protection Association of America

NFPA 285: 1998	Standard method of test for the evaluation of flammability characteristics of exterior non-load-bearing wall assemblies containing components using the intermediate scale, multi-storey test apparatus	4.6	

BRANZ Ltd

BRANZ Study Report No. 137: 2005 Development of the Vertical Channel Test Method for Regulatory Control of Combustible Exterior Cladding Systems, Whiting, P. N.	4.6	

Australian Building Codes Board

International Fire Engineering Guidelines (IFEG): 2005	1.3 Comment	Amend 4 Jul 2014

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.	3.2 Comment 3.2.6 Comment	
SFPE Engineering Guide to Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation, 2000	3.6.1	

General publications

Fire Engineering Design Guide (Centre for Advanced Engineering, 2008)	2.4.4 Comment	

Definitions

The full list of definitions for italicised words may be found in the New Zealand Building Code Handbook.

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 (ie, unable to take effective action to escape to a *place of safety*).

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.

Computational fluid dynamics (CFD) Calculation method that solves equations to represent the movement of fluids in an environment.

Design fire Quantitative description of assumed *fire* characteristics within the *design scenario*.

Design scenario 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 or manual system.

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*.

Fire decay 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 growth Stage of *fire* development during which the *heat release rate* and the temperature of the *fire* are increasing.

Fire load Quantity of heat which 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) *Fire load* per unit area (MJ/M^2).

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*.

Flashover Stage of *fire* transition to a state of total surface involvement in a *fire* of *combustible* materials within an enclosure.

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.

Comment:
The definition for FED has been modified from the ISO definition to be made specific for this Verification Method. The ISO definition is "Ratio of the exposure dose for an insult to that exposure dose of the insult expected to produce a specified effect on an exposed subject of average susceptibility."

Fully developed fire State of total involvement of *combustible* materials in a *fire*.

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).

Importance level As specified in Clause A3 of the *Building Code*.

Incapacitated State of physical inability to accomplish a specific task. Errata 2 Feb 2013

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.

Comment:
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.

Optical density of smoke 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 Ratio of incident light intensity to transmitted light intensity through smoke under specified conditions.

Place of safety means 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 at a design occupant density – depending on the usage this shall not be less than 1.0 m^2 per person; and

Amends 3 and 4

   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 Time period after an alarm or *fire* cue is transmitted and before occupants first travel towards an exit.

Required safe egress time (RSET) 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*.

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.

Comment:
The Fire Safety and Evacuation of Buildings Regulations 2006 use the term *'place of safety'* and allow the *place of safety* to be within the *building* provided that it is protected with a sprinkler system.

Separating element 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 production rate 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. *Smoke separations* shall:

a) Be a smoke barrier complying with BS EN 12101 Part 1, or

b) Consist of rigid *building elements* capable of resisting without collapse:

   i) a pressure of 0.1 kPa applied from either side, and

   ii) self weight plus the intended vertically applied live loads, and

c) Form an imperforate barrier to the spread of smoke, and

d) Be of *non-combustible construction*, or achieve a *FRR* of 10/10/-, except that non-*fire resisting glazing* may be used if it is toughened or laminated *safety glass*.

Amend 4 Jul 2014

Comment:
The pressure requirement is to ensure rigidity and is not a smoke leakage requirement.

Walls and floors, whether *constructed* of sheet linings fixed to studs or joists, or of concrete, glazing, metal or fired clay, need only be inspected by someone experienced in *building construction* to judge whether the *construction* is tight enough to inhibit the passage of smoke.

Item d) is intended to ensure that the *smoke separation* will continue to perform as an effective barrier when exposed to *fire* or smoke for a short period during *fire* development.

There is no requirement for *smoke control doors* or other closures in *smoke separations* to meet the provisions of item d).

Amend 4
Jul 2014

Specific extinction area of smoke
Extinction area of smoke produced by a test specimen in a given time period, divided by the mass lost from the test specimen in the same time period.

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.

Surface spread of flame Flame spread away from the source of ignition across the surface of a liquid or a solid.

Travel distance 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.

Visibility Maximum distance at which an object of defined size, brightness and contrast can be seen and recognised.

Yield Mass of a combustion product generated during combustion divided by the mass loss of the test specimen.

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1 Introduction and scope

CONTENTS

1.1 Purpose

This is a Verification Method for the specific design of *buildings* to demonstrate compliance with NZBC C1 to C6 Protection from Fire. It is suitable for use by professional fire engineers who are proficient in the use of fire engineering modelling methods.

1.2 Scope

1.2.1 This Verification Method is for *fire* designs for all *buildings* except those *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 by Part 2 of this Verification Method "The rules and parameters for the Design Scenarios".

Comment:

1. This Verification Method is an analysis tool for *buildings* with simultaneous evacuation schemes that evacuate immediately to the outside, and with typical *fire growth* rates.
2. Additional *fire* safety precautions to those determined by this Verification Method may be necessary to facilitate approval of the intended evacuation procedures to meet the Fire Safety and Evacuation of Buildings Regulations 2006.
3. Examples of *buildings* outside of the scope 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.
4. *Fire* safety design for *buildings* that are outside of the scope can be performed using the Fire Engineering Brief (FEB) process and the appropriate parts of this Verification Method, which can be considered by the *building consent authority* as an *alternative solution*.

Errata 1
Amend 4

Amend 5
Nov 2017

1.2.2 This Verification Method does not provide *fire* design where there is use, storage or processing of *hazardous substances*.

Comment:
Compliance with NZBC F3 and the Hazardous Substances and New Organisms (HSNO) Act 1996 should be considered where applicable in addition to the requirements of this Verification Method.

Amend 5
Nov 2017

1.3 How to use this Verification Method

This Verification Method sets out 10 *design scenarios* that must each be considered and designed for, where appropriate, in order to achieve compliance with NZBC C: Protection from Fire.

The concept *fire* design shall be trialled using *building* specific *fire* design requirements ascertained via the Fire Engineering Brief (FEB) process as described in internationally recognised *fire* engineering process documents.

Comment:
There are a number of internationally recognised process documents including the International Fire Engineering Guidelines and others published by British Standards and the Society for Fire Protection Engineers.

Amend 4
July 2014

Follow the process schematically illustrated in Figure 1.1 as appropriate, analysing or testing the *fire* design against the *design scenarios* as applicable and modelling the *design scenario*: CF Challenging Fire (see Paragraph 4.9) a number of times with the *design fire* positioned in the most challenging locations.

Comment:
ASET/RSET 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 (eg, *fire separations* or smoke detection systems).

In many cases the location that is the most challenging (that which will provide the shortest *ASET/RSET*) will be easily determined.

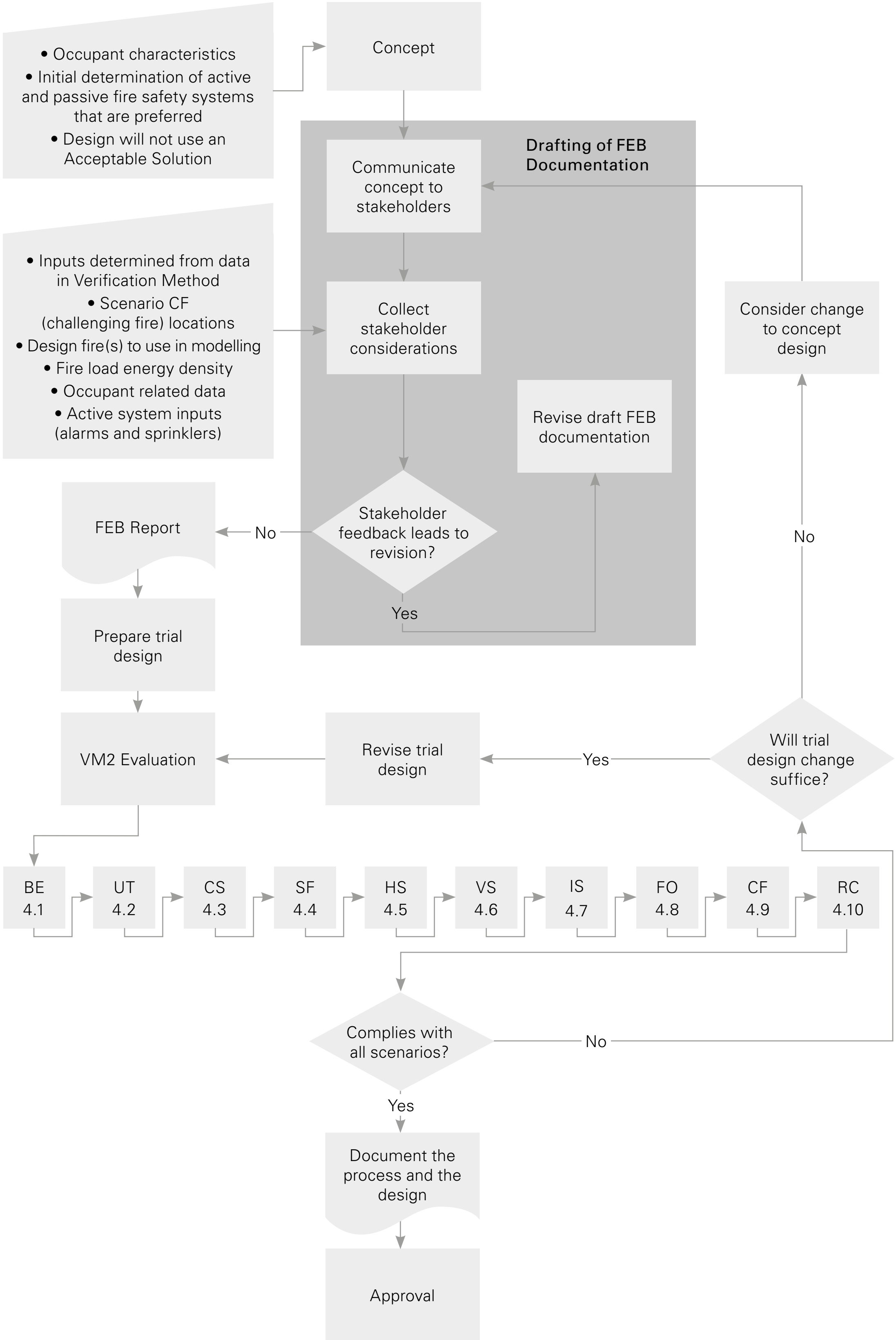
In Figure 1.1, the numbered references are to paragraph numbers in this Verification Method.

Figure 1.1 is guidance information illustrating how the use of this Verification Method – in particular the *design scenarios* – fits into the general iterative *fire* design process. The flowchart assumes design starts at concept design stage. The sequence of assessing each of the *design scenarios* may vary from that idealised in Figure 1.1. The design process outlined in the flowchart will vary when using this Verification Method for assessing Code compliance of existing *buildings*. The overall process described in Figure 1.1 is not itself a normative part of C/VM2.

The communication process relating to FEB development will vary for each project 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 project and the design issues. The key features of both the FEB communication and documentation are that it is unambiguous, complete (i.e. provided with appropriate context) and recorded in some form for later reference.

Amends
3 and 4

Figure 1.1: The design process overview for C/VM2



Amend 4
Jul 2014

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1.4 Design scenarios: Building Code objectives and performance criteria

The *design scenarios* specified in Part 4 are summarised in Table 1.1 (with paragraph numbers given in brackets for ease of reference). Each scenario must be considered separately to achieve the *Building Code* objectives and to satisfy the performance criteria of the *Building Code* clauses shown.

1.5 Construction

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* and smoke separations should be *fire stopped* with appropriate proprietary products for the orientation and be specific for use in that *separating element*.

Amend 4 Jul 2014

Table 1.1 Key features of design scenarios

Design scenario		Building Code objectives	Building Code criteria	Expected method
Keeping people safe				
BE	*Fire* blocks exit (4.1)	C1(a)	C4.5	Solved by inspection
UT	*Fire* in a normally unoccupied room threatening occupants of other rooms (4.2)	C1(a)	C4.3, C4.4	*ASET/RSET* analysis or provide *separating elements*/suppression complying with a recognised Standard
CS	*Fire* starts in a *concealed space* (4.3)	C1(a)	C4.3	Provide *separating elements*/suppression or automatic detection complying with a recognised Standard
SF	Smouldering *fire* (4.4)	C1(a)	C4.3	Provide automatic detection and alarm system complying with a recognised Standard
IS	Rapid *fire* spread involving internal surface linings (4.7)	C1(b)	C3.4	Suitable materials used (proven by testing)
CF	Challenging *fire* (4.9)	C1(a)	C4.3, C4.4	*ASET/RSET* analysis
RC	Robustness check (4.10)	C1(a), C1(b), C1(c)	C3.9, C4.5, C5.8, C6.2(d)	Modified *ASET/RSET* analysis
Protecting other property				
HS	Horizontal *fire* spread (4.5)	C1(b), C1(a)	C3.6, C3.7, C4.2	Calculate radiation from *unprotected areas* as specified
VS	External vertical *fire* spread (4.6)	C1(a), C1(b)	C3.5	Suitable materials used (proven by testing) and *construction* features specified (eg, aprons/spandrels/sprinklers) as required to limit vertical *fire* spread
Firefighting operations				
FO	Firefighting operations (4.8)	C1(b), C1(c)	C3.8, C5.3, C5.4, C5.5, C5.6, C5.7, C5.8, C6.3	Demonstrate firefighter safety

Amend 4 Jul 2014

Part 2: Rules and parameters for the design scenarios

CONTENTS

2.1 Applying the design scenarios

This Verification Method sets out 10 *design scenarios* that must each be considered and designed for, where appropriate, in order to achieve compliance with NZBC C1-C6: Protection from Fire.

This section sets out the *fire* modelling rules, *design fire* characteristics and other parameters to be used in calculations required by the *design scenarios*. Occupancy criteria and calculations for the movement of people are provided in Part 3.

2.2 Fire modelling rules

The *fire* modelling rules in Paragraphs 2.2.1 and 2.2.2 shall be applied to the *design scenarios* as appropriate.

2.2.1 Fire modelling rules for life safety design

The model to be used, and the spaces or volumes to be modelled, shall be established at FEB.

The trial design shall identify the type of separations (eg *fire separation*, smoke separation or unrated *construction*) and closures (eg *fire* or *smoke control doors* etc) proposed, and which of these are relevant for inclusion in the analysis. These modelling rules detail the assumptions to be made regarding the different types of separation or closure. These modelling rules are not intended to imply that it is necessary to include all separations and closures 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. Amend 4 Jul 2014

Fire modelling rules for life safety design shall be as follows:

a) Warning systems in accordance with Paragraph 3.4 shall be installed.

b) *Fire* and *smoke control doors* with self-closers complying with a recognised national or international Standard are assumed closed unless being used by occupants. During egress, when *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.

c) *Smoke control doors* serving bedrooms in sleeping areas where care is provided (these do not have self closers) shall be considered to be closed from the time that evacuation from the bedroom is completed in accordance with Paragraph 3.2 and Table 3.3. Amend 4 Jul 2014

d) External doors and other closures such as roller shutters shall be modelled as closed unless explicitly designed to open in the event of *fire*. Amend 3 Dec 2013

Amend 3 Dec 2013

e) All doors not described in Paragraph 2.2.1 b), c) and d) shall be considered to be open during the analysis unless for substantiated functional reasons as established at FEB the doors can be shown to be closed throughout the time period of analysis (see Commentary).

Amend 4 Jul 2014

Amend 3 Dec 2013

f) Doors being used for egress, when in the open position, are assumed to be half-width for smoke flow calculations.

Amend 3 Dec 2013

Errata 2 Feb 2013

g) Leakage area through non *fire*-rated walls shall be calculated according to Paragraph 2.2.1 i). The leakage may be modelled either as a tall narrow slot from floor to ceiling with the width determined by the calculated area, or as two vents, one at floor level and one at ceiling level, to fit within the computational grid (in the case of *CFD* modelling). Where the leakage is from a room to the outside, it may also be modelled 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.

Errata 2 Feb 2013

Amend 3 Dec 2013

h) Where *CFD* modelling is used, leakage areas shall be calculated according to Paragraph 2.2.1 i) and modelled as described in Paragraph 2.2.1 g). In cases where 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.

Amend 4 Jul 2014

Amend 3 Dec 2013

i) Leakage areas assumed for modelling shall be as follows:

Amend 4 Jul 2014

i) *smoke control doors* that comply with a recognised national or international Standard (including doors that have both *fire* and smoke control capability complying with a recognised national or international Standard) and *smoke separations* are assumed to have zero leakage area, except for a 10 mm gap under doors

Amend 4 Jul 2014

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

iii) *construction* having a *fire resistance rating* (excluding doors) is considered to have no leakage, and

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

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

Amends 3 and 4

k) *Smoke separations* including glazing that comply with recognised national or international Standards 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.

Errata 1 Amend 3

l) *Smoke separations* that are not tested (eg, non *fire* rated but imperforate *construction*) are assumed to remain in place until the average upper layer temperature reaches 200°C.

Amend 3 Dec 2013

Amend 4 Jul 2014

m) Exterior windows that are not *fire resisting glazing* are assumed to break (ie, glass falls out to become completely open) at the sooner of either average upper layer temperature reaching 500°C or when the *fire* becomes limited by ventilation. Windows that are *fire resisting glazing* may be assumed to remain in place up to the rated time.

Errata 1 Amend 3

n) 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.

Amend 3 Dec 2013

o) *Fractional Effective Dose (FED)* for CO and thermal effects shall be calculated using the procedures described in ISO 13571. FED_{CO} shall include contributions from CO, CO_2 and O_2 gases. $FED_{thermal}$ shall include radiative and convective effects.

Amend 3 Dec 2013

Amend 4 Jul 2014

p) 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.

Amend 3 Dec 2013

Also refer to Paragraph 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.

2.2.2 Fire modelling rules for resistance of fire separations and structural design

a) *Fire* modelling rules shall be as specified in Paragraphs 2.3.2 and 2.3.3 for *fires* reaching full *burnout*, for structural design and for assessing *fire* resistance required of *separating elements*.

b) The *design fire* severity for car parking areas incorporating a vehicle stacking system shall use the *FLED* specified in Table 2.2.

c) 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.

d) 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.

e) For effective openings:

   i) Only those areas of openings in *external walls* and roofs which 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 which are specifically designed to open or to melt rapidly in the event of exposure to *fully developed fire*.

   ii) 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.

   iii) 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 (eg, less than 10 minutes), the ratio of A_h/A_f can be taken as 0.2.

2.3 Design fire characteristics

Analysis for a number of the *design scenarios* is based on the use of '*design fires*'. These are defined by one or more of the following parameters:

a) *Fire* growth rate

b) Peak *heat release rate*

c) *Fire load energy density*

d) Species production (CO, CO_2, water, soot)

e) Heat flux, and

f) Time.

Parameters and modelling instructions are given below for:

a) Pre-*flashover design fires*

b) Post-*flashover design fires*, and

c) Full *burnout design fires*.

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

2.3.1 Pre-flashover design fires

The characteristics of the pre-*flashover design fire* are given in Table 2.1. In most cases (ie, for all *buildings*, including storage *buildings*, that are capable of storage to a height of less than 3.0 m) the *fire* is assumed to grow as a fast t^2 *fire* up to *flashover* or until the *HRR* reaches the peak given in Table 2.1 or becomes ventilation limited.

Table 2.1 Pre-flashover design fire characteristics

Building use	*Fire* growth rate (kW)	Species	Radiative fraction	Peak *HRR*/ *HRR*/m^2
All *buildings* including storage with a stack height of less than 3.0 m	$0.0469\ t^2$	Y_{soot} = 0.07 kg/kg Y_{CO} = 0.04 kg/kg ΔH_C = 20 MJ/kg Y_{CO_2} = 1.5 kg/kg$^{(1)}$ Y_{H_2O} = 0.82 kg/kg$^{(1)}$	0.35	20 MW 500 – 1000 kW/$m^{2(2)}$ 250 kW/$m^{2(3)}$
Carparks (no stacking)	$0.0117\ t^2$		0.35	
Capable of storage to a stack height of between 3.0 m and 5.0 m above the floor	$0.188\ t^2$		0.35	50 MW
Capable of storage to a stack height of more than 5.0 m above the floor and car parks with stacking systems	$0.00068\ t^3\ H$		0.35	1000–2500 kW/$m^{2(2)}$ 250 kW/$m^{2(3)}$

NOTE:
t = time in seconds
H = height to which storage is capable of in metres
Y = *yield* kg/kg
ΔH_C = heat of combustion
(1) As an an alternative to CO_2 + H_2O *yields* use generic fuel as $CH_2O_{0.5}$ and calculate *yields*.
(2) In a CFD model the *fire* is intended to be modelled as a plan area where the size is determined from the peak *HRR*/m^2. A range is provided for *HRR*/m^2 to accommodate different *HRR* and mesh sizes.
(3) Use in a zone model.

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For life safety analysis in sprinklered *buildings*, the *fire* is assumed to be controlled (ie, with a constant *HRR*) after the sprinkler activates based on *RTI*, C-factor and activation temperature as specified in Table 3.2.

2.3.2 Post-flashover design fires

Flashover is assumed to occur when the average upper layer temperature first reaches 500°C.

For uncontrolled *fires*, the burning rate is assumed to be governed by the ventilation limit or the peak *HRR*, whichever is less.

2.3.3 Modelling post-flashover fires

For life safety calculations (ie, *ASET*), modelling the *fire* into the post-*flashover* phase is unlikely to be required for sprinklered *buildings*. The *fire* is expected to be controlled (ie, with a constant *HRR*) after the sprinkler activates based on *RTI*, C-factor and activation temperature, and therefore *flashover* is not expected to occur. Sprinkler response calculations would be expected to confirm that this is the case.

However, note that for the full *burnout design fire* (see Paragraph 2.4), calculations of *fire* resistance shall be based on *burnout* without sprinkler or other intervention, except that the design *FLED* may be modified as described in Paragraph 2.4.1 where sprinklers are installed.

The following parameters shall apply:

a) Post-*flashover* species *yield* for soot is Y_{soot} = 0.14 kg/kg_{fuel}
b) Post-*flashover* species *yield* for CO is Y_{CO} = 0.40 kg/kg_{fuel}, and
c) Design *FLEDs* shall be as specified in Table 2.2 for activities within *buildings*.

The three steps for modelling the *fire* shall be as follows:

Step 1: Determine initial pre-*flashover fire growth* rate from Table 2.1; typically $q = 0.0469t^2$.

Step 2: Run the *fire* model and determine which of the following five cases apply. If necessary adjust the input *HRR* to the model as described below and rerun the model.

Case 1 *Fire growth* reaches the peak *HRR* from Table 2.1 before $T_{UL}=500°C$

Fast *fire growth* to the peak *HRR* from Table 2.1

Species as given for pre-*flashover*

Case 2 Sprinklers activate before *fire growth* reaches the peak *HRR* from Table 2.1

Fast *fire growth* to sprinkler activation

Species as given for pre-*flashover*

Case 3 $T_{UL}=500°C$ before *HRR* reaches the peak from Table 2.1 and *fire* is not ventilation limited

Fast *fire growth* to $T_{UL}=500°C$

Species as given for pre-*flashover*

At $T_{UL}=500°C$ ramp up the *HRR* to the peak *HRR* from Table 2.1 over a period of 15s

Species as given for post-*flashover*

Case 4 $T_{UL}=500°C$ before *HRR* reaches the peak from Table 2.1 and *fire* is ventilation limited

Fire growth to $T_{UL}=500°C$

Species as given for pre-*flashover*

At $T_{UL}=500°C$ (or ventilation limit, whichever occurs first) ramp up the *HRR* to 1.5 times the ventilation limit over a period of 15s

Species as given for post-*flashover*

Case 5 $T_{UL}<500°C$ and *fire* is ventilation limited

Fast *fire growth* to ventilation limit

Species as given for pre-*flashover*

At ventilation limit ramp up the *HRR* to 1.5 times the ventilation limit over a period of 15s

Species as given for post-*flashover*.

For modelling purposes, 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 2.1) due to the lack of sufficient oxygen for complete combustion.

Comment:
Ventilation limit is determined by *fire* modelling. See the commentary document for this Verification Method for a calculation example.

T_{UL} is the average temperature of the upper layer.

Step 3: Allow the *fire* to burn until all the fuel is exhausted, based on the design *FLED*. Use the design *FLEDs* provided in Table 2.2.

Table 2.2 Design FLEDs for use in modelling fires in C/VM2

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

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2.4 Full burnout design fires

Comment:
Design fire characteristics include parameters for *FLED, fire growth* rate and heat of combustion.
This means a post-*flashover* 'full *burnout design fire*' can be defined.

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. However, the maximum *fire resistance rating* for an unsprinklered *firecell* need not exceed 240/240/240 and 180/180/180 for a sprinklered *firecell*, determined using AS 1530.4.

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There are three choices for modelling the full *burnout design fire*:

a) Use a time-equivalent formula to calculate the equivalent *fire* severity and specify *building elements* with a *fire resistance rating* not less than the calculated *fire* severity. In this case, an equivalent *fire* severity of 20 minutes shall be used, if the calculated value is less.

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

c) Construct 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.

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Comment:
1. A common approach to use with this Verification Method is the 'equivalent fire severity' method described in Eurocode 1 Actions on structures, Part 2-2. 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. In c) the designer has to establish and justify at FEB the peak *HRR*.

Amend 4 Jul 2014

2.4.1 Modifications to the design FLED

For assessing the *fire* resistance of structural and non-structural elements, the design *FLED* from Table 2.2 used for the *design fire* shall be modified by multiplying the *FLED* by the applicable F_m factor from Table 2.3.

For assessing *fire* duration for life safety calculations the design *FLED* from Table 2.2 shall be modified by multiplying the *FLED* by the applicable F_m factor from Table 2.3.

Table 2.3 **F_m factors to be applied to FLED**

	Sprinklered *firecell*	Unsprinklered *firecell*
For calcuations of *fire* duration[1] and for *fire* resistance of all non-structural elements[2] Fire resistance of structural elements not covered by the description in the row below	0.50	1.00
Fire resistance of structural elements in a structural system which is unable to develop dependable deformation capacity under post-*flashover fire* conditions [3]	1.00	1.25

Errata 1 Apr 2012

Notes

1. Life safety calculations of the duration of the *fire* (total 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 fire duration. However, where calculation of *fire* resistance of non-structural elements is based on *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.

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2.4.2 Openings for full burnout fires

For the purposes of calculating A_v (the total area (m^2) of vertical windows and doors) in full *burnout design fire* calculations 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.

Comment:
Also refer to the *fire* modelling rules for full *burnout fires* in Paragraph 2.2.2 for effective openings.

2.4.3 Structural fire severity for interconnected floors

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*.

2.4.4 Time equivalence formula

The time equivalence formula shall be taken from Annex E of Eurocode DD ENV 1991-2-2.

Comment:
Further discussion can be found in the Fire Engineering Design Guide.

The required *fire resistance rating* must be greater than the time equivalence (t_e) value calculated using the equations 2.1 and 2.2:

$$t_e = e_f \, k_b \, k_m \, w_f \qquad \text{Equation 2.1}$$

where:

e_f = *FLED* given in Table 2.2 and as modified by Table 2.3.

k_b = conversion factor to account for the thermal properties of the material, as specified in Table 2.4

k_m = modification factor for the structural material.

and

w_f = ventilation factor.

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

Equation 2.2

where

$\alpha_v = A_v / A_f \qquad 0.025 \leq \alpha_v \leq 0.25$

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

$\alpha_h = A_h / A_f$ Amend 4 Jul 2014

A_f = floor area of the *space*

A_v = area of vertical window and door openings (m^2)

A_h = area of horizontal openings in the roof (m^2), and

H = average height of the space (m). Amend 4 Jul 2014

If $A_v < 0.025A_f$ then $A_v = 0.025A_f$ 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.

When $W_f < 0.5$ then use $W_f = 0.5$

When there are multiple vertical openings, the weighted average height (h_{eq}) of all of the openings is used.

For pitched roofs use the average value for H. Amend 4 Jul 2014

k_m = 1.0 for reinforced concrete, protected steel, timber, and a mix of unprotected and protected steel. For unprotected steel:

$$k_m = 13.7\, A_v \sqrt{h_{eq}} / A_t \geq 1.0$$

applicable over the range:

$$0.02 \leq A_v \sqrt{h_{eq}} / A_t \leq 0.20$$

A_t = total internal surface area of the enclosure (walls, floor and ceiling including the openings) (m^2) Amend 4 Jul 2014

2.5 Equivalent time of exposure

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):

1. Specifying a fire resistance rating equal to three times the time period for which the construction is required to perform, or
2. The equivalent time of exposure in a standard *fire* resistance test assuming full *burnout* as described in 2.4.4; or
3. 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*.

Comment:
Further guidance on the applicability of this approach and a suggested procedure is given in the commentary.

Alternatively, other approaches described in Paragraph 2.4 using thermal/structural response calculations may be used when applicable for the particular material or structural element. Amend 4 Jul 2014

Errata 2
Amend 4

Table 2.4	Conversion factor k_b for various lining materials	
Typical values for $\sqrt{kpc}$ J/m²s$^{0.5}$K	*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

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NOTE:

(i) k=thermal conductivity (W/m K)
ρ=density (kg/m^3)
c=specific heat (J/kg K)

(ii) To account for different thermal properties of the walls, ceiling and floor it is permissible to calculate an effective thermal property and determine the k_b factor by interpolation from Table 2.4.

An effective thermal property $\sqrt{kpc} = (\Sigma(b_j A_j))/(A_t - A_v)$ where:

A_j = area of the enclosed surface j, openings not included

b_j = thermal property ($\sqrt{kpc}$) of enclosure surface j

Where a surface comprises multi-layers with different materials, it is only the first few centimetres on the fire exposed side that are relevant for the purposes of this calculation.

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Part 3: Movement of people

CONTENTS

3.1 Occupant numbers

The occupancy of any space in a *building* shall be calculated using the occupant densities provided in Table 3.1.

If, in a particular situation, the *occupant load* derived from Table 3.1 is clearly more than that which will occur, the basis of any proposal for a lesser *occupant load* must be substantiated to the *building consent authority*. However, note that 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.

If the maximum *occupant load* is greater than that calculated from Table 3.1, 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*.

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Table 3.1	Occupant densities
Activity	Occupant density (m²/person)
Aircraft hangars	50
Airports – Baggage handling area – Waiting/check-in – Terminal spaces	2 1.4 10
Area without seating or aisles	1.0
Art galleries, museums	4
Bar sitting areas	1.0
Bar standing areas	0.5
Bleachers, pews or bench type seating	0.45 linear m per person
Bedrooms	As number of bed spaces and staff when appropriate
Bunkrooms	
Dormitories, hostels	
Halls and *wharenui*	
Wards in hospitals, operating theatres and similar	
Detention quarters	
Boiler rooms, plant rooms	30
Bulk storage including racks and shelves (warehouses etc)	100
Call centres	7
Classrooms	2
Commercial kitchens	10
Commercial laboratories, laundries	10
Computer server rooms	25
Consulting rooms (doctors, dentists, beauty therapy)	5
Dance floors	0.6
Day care centres	4
Dining, restaurant and cafeteria spaces	1.25
Early childhood centres	Based on Education (Early Childhood Services) Regulations 2008 plus the number of staff
Exhibition areas, trade fairs	1.4
Fitness centres	5
Gaming and casino areas	1
Heavy industry	30
Indoor games areas, bowling alleys	10
Interview rooms	5
Libraries – stack areas	10
Libraries other areas	7
Lobbies and foyers	1

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Table 3.1	Occupant densities (continued)
Activity	Occupant density (m^2/person)
Mall areas used for assembly uses	1
Manufacturing and process areas	10
Meeting rooms	2.5
Offices	10
Parking *buildings*, garages	50
Personal service facilities	5
Reading or writing rooms and lounges	2
Reception areas	10
Retail and trading (with storage >3.0 m high) (eg trading stores and supermarkets)	5
Retail spaces and pedestrian circulation areas including malls and arcades	3.5
Retail spaces for furniture, floor coverings, large appliances, building supplies and Manchester	10
Showrooms	5
Spaces with fixed seating	As number of seats
Spaces with loose seating	0.8
Spaces with loose seating and tables	1.1
Sports halls	3
Stadiums and grandstands (standing areas)	0.6
Staffrooms and lunch rooms	5
Stages for theatrical performances	0.8
Standing spaces	0.4
Swimming pools: water surface area	5
Swimming pools: surrounds and seating	3
Teaching laboratories	5
Technology class rooms in schools (eg wood work, metal work)	10
Workrooms, workshops	5

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3.2 Required safe egress time (RSET)

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.

The *RSET* in a simple hydraulic model for evacuation (see Comment below) is:

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

Equation 3.1

where:

- t_d = detection time determined from deterministic modelling
- t_n = time from detection to notification of the occupants
- t_{pre} = time from notification until evacuation begins
- t_{trav} = time spent moving toward a *place of safety*, and
- t_{flow} = time spent in congestion controlled by flow characteristics.

The requirements for establishing each of these times are set out in Paragraphs 3.2.1 to 3.2.5.

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 queuing time and the travel time to the exit.

Comment:
This Verification Method defines the minimum analysis required to demonstrate that the *fire* engineer's design 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.

3.2.1 Detection time

The *fire* engineer shall establish the detection time from deterministic modelling or as described in Paragraph 3.4 for a manually activated warning system. It is expected that the model used to calculate the detection time for an automatic warning system will use an appropriate algorithm that includes at least a ceiling jet correlation or a *CFD* model code that solves for the velocity and temperature (and smoke/soot concentration) directly.

Regardless of the actual make/model and installation parameters of the detection device specified to be installed in the *building*, the values given in Table 3.2 for the detector criteria shall be used in this analysis.

Table 3.2	Detector criteria
Heat detectors 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
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	**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
Amend 4 Jul 2014 **Smoke detectors** Optical density at alarm = 0.097 m^{-1} Radial distance = 7 m Distance below ceiling not less than 25 mm	**Projected beam smoke detectors** Optical density at alarm to be determined based on beam path length and the design setting for the total obscuration for alarm[1]

NOTE:

1. The commentary document for this Verification Method provides a method for calculating the optical density for projected beam smoke detectors.
2. When a space is smaller 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.
3. If a higher activation temparature is required by the chosen sprinker standard this shall be used as T_{act}.

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3.2.1.1 Smoke detection optical density criteria for spot detectors

The optical density at alarm criteria in Table 3.2 shall apply to spot detectors (ionisation and photoelectric).

3.2.1.2 Criteria for very high sensitivity air sampling smoke detectors

This type of detector requires specialised design, and 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 shall be used in the analysis.

3.2.2 Notification time

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

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

3.2.3 Pre-travel activity time

Use the values in Table 3.3 for *pre-travel activity times*.

Comment:
The incipient phase of the *fire growth* has not been considered in the *design fire*. This provides an implicit safety factor for the *pre-travel activity time*.

Table 3.3 Pre-travel activity times

Description of *building* use	*Pre-travel activity time(s)*
Buildings where the occupants are considered awake, alert and **familiar** with the *building* (eg, offices, warehouses **not** open to the public)	
Enclosure of origin	30
Remote from the enclosure of origin	60
Buildings where the occupants are considered awake, alert and **unfamiliar** with the *building* (eg, retail shops, exhibition spaces, restaurants)	
Enclosure of origin (standard alarm signal)	60
Remote from the enclosure of origin (standard alarm signal)	120
Enclosure of origin (voice alarm signal)	30
Remote from the enclosure of origin (voice alarm signal)	60
Buildings where the occupants are considered sleeping and **familiar** with the *building* (eg, apartments)	
Enclosure of origin (standard alarm signal)	60
Remote from the enclosure of origin (standard alarm signal)	300
Buildings where the occupants are considered sleeping and **unfamiliar** with the *building* (eg, hotels and motels)	
Enclosure of origin	60
Remote from the enclosure of origin (standard alarm signal)	600
Remote from the enclosure of origin (voice alarm signal)	300
Buildings where the occupants are considered awake and under the care of trained staff (eg, day care, dental office, clinic)	
Enclosure of origin (independent of alarm signal)	60
Remote from the enclosure of origin (independent of alarm signal)	120
Spaces within *buildings* used for early childhood care	
Enclosure of origin (assume staff will respond to room of origin first)	60 s for staff to respond to alarm then 60 s per child per staff to an adjacent *place of safety* (on the same floor)[1]
Remote from the enclosure of origin (independent of alarm signal)	120
Buildings where the occupants are considered sleeping and under the care of trained staff (eg, hospitals and rest homes)	
Enclosure of origin (assume staff will respond to room of origin first)	60 s for staff to respond to alarm then 120 s (per patient per 2 staff)[2]
Remote from the enclosure of origin (independent of alarm signal)	1800
Remote from the enclosure of origin (independent of alarm signal) where occupants are unable to be moved due to the procedure or other factor	1800 or as per specific requirements, whichever is the greater
Buildings where the occupants are considered sleeping and detained under the care of trained staff (eg, prisons etc)	
To be established at FEB, see Commentary to this Verification Method	
Spaces within *buildings* which have only focused activities (eg, cinemas, *theatres* and stadiums)	
Space of origin (occupants assumed to start evacuation travel immediately after detection and notification time or when *fire* in their space reaches 500 kW, whichever occurs first)	0

NOTE:

1. This allows 60 s to move each child from their location to the *place of safety* and then to return to evacuate another child.
2. This 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 (3) 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.

Errata 1 Apr 2012

Amend 3 Dec 2013

Amend 4 Jul 2014

Amends 3 and 4

3.2.4 Travel time

Travel time within a space is governed by:

a) The time taken to travel to the doorway (t_{trav}), or

b) The flow time (ie, the time taken for all the occupants to flow through a restriction, typically a doorway, when queueing is necessary).

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

For **horizontal travel**, the travel time shall be calculated based on the estimated walking speed. Horizontal travel speed shall be calculated using equation 3.2. If the calculated travel speed exceeds 1.2 m/s then the travel speed shall be taken as 1.2 m/s.

Errata 2 Amend 4

Comment:
If the travel speed is calculated as less than 1.2 m/s, then the calculated value is to be used.

Amend 4 Jul 2014

$$S = k - akD \qquad \text{Equation 3.2}$$

where:

S= horizontal travel speed (m/s)

D= occupant density of the space (persons/m²)

k = 1.4 for horizontal travel, and

a =0.266.

Travel time (t_{trav}) is calculated by using equation 3.3:

$$t_{trav} = L_{trav} / S \qquad \text{Equation 3.3}$$

where:

t_{trav} = travel time (s), and

L_{trav} = travel distance (m).

The maximum horizontal travel distance (L_{trav}) shall be determined as follows:

a) Adding together the length of orthogonal travel distance to the nearest exit, or

b) If the actual distance measured around fixed obstructions is known, use this.

Amends 3 and 4

For **vertical travel**, equation 3.2 applies but the values used for k are a function of the stair riser and tread size as given in Table 3.4.

Table 3.4 Maximum flow rates for use in equation 3.2 for horizontal and vertical travel speeds

Exit route elements		k	Speed m/s
Corridor, aisle, ramp, doorway		1.40	1.2
Stair riser (mm)	Stair tread (mm)		
191	254	1.00	0.85
178	279	1.08	0.95
165	305	1.16	1.00
165	330	1.23	1.05

Amend 4 Jul 2014

3.2.5 Time if flow governs

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*.

Amend 4 Jul 2014

Flow rate shall be calculated using equation 3.4:

$$F_c = (1 - aD)kDW_e \qquad \text{Equation 3.4}$$

where:

F_c = calculated flow (persons/sec), and

D = occupant density near flow constriction (ie, for doors, use 1.9 persons/m²)

W_e = effective width of component being traversed in metres.

The effective width is equal to the measured width minus the boundary layer, where the thickness of the boundary layer is given in Table 3.5.

Comment:
Equation 3.4 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.

Table 3.5 Boundary layer width for calculating the effective width of an exit component

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

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 3.4 shall be used with no upper limit on the flow rate.

3.2.6 Direction of opening

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. These requirements need 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 requirement applies to standard, manual, self-closing side-hinged doors and not to automatic sliding doors. In the case of automatic sliding doors, the effective width of the opening may be used in equation 3.4 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.

The maximum flow rate 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.

Amend 4 Jul 2014

3.2.7 Exit doors

Where a primary entrance can be identified the primary entrance shall be designed to egress 50% of the total *occupant load* of the space and the remaining occupants are 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.

Errata 2 Feb 2013

3.3 Requirements for delayed evacuation strategies

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* (eg, 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*'.

Amend 4 Jul 2014

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.

Amend 4 Jul 2014

3.4 Alerting people with alarm systems

There must be automatic detection and alarm systems installed to NZS 4512 or automatic sprinkler systems installed to an appropriate standard to alert the occupants to a *fire*.

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

Amend 3 Dec 2013

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-evacuation time need be included. The time required for the ceiling jet to completely traverse the ceiling can either be determined using *CFD* modelling or by the following relationship if zone modelling is used:

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

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

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

and

For storage height >5 m (rack growth):

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

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

where:

w = width of the space in metres (shortest dimension)

L = length of the space in metres (longest dimension).

3.4.1 Small ancillary spaces

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.

Amend 4 Jul 2014

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 area:

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

Amend 4 Jul 2014

b) Maximum area of the space 500 m²

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

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.

If these criteria are not met, the *RSET* calculations for the adjacent office areas will need to be carried out as per C/VM2 Paragraph 3.2 and include a notification and detection time. C/VM2 requires automatic detection to be installed within the adjacent office.

Amend 4 Jul 2014

The exception to the above requirements is a very small isolated area within the space with a high ceiling such as washrooms or offices each being no larger than 30 m² 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.

Amend 3 Dec 2013

3.5 Fire modelling to determine ASET

For the *design scenario*: CF Challenging fire (see Paragraph 4.9), the designer must demonstrate that the occupants have sufficient time to evacuate the *building* before being overcome by the effects of *fire*.

In *fire* engineering terms, the *available safe egress time* (*ASET*) shall be greater than the *required safe egress time* (*RSET*).

ASET is defined as 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 NZBC C4.3, are:

a) Visibility

b) $FED_{(thermal)}$, and

c) $FED_{(CO)}$.

Exceptions can be applied, as outlined in NZBC C4.4 (a *building* with an automatic sprinkler system and more than 1000 people cannot be exposed to conditions exceeding the *visibility* limits or $FED_{thermal}$ limits).

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

Calculate the *ASET* by choosing a *fire* model and using the *design fire* as specified in Part 2.

In most cases there will be a number of locations for the *fire* that could produce the lowest *ASET* for a given *escape route*. Check a number of rooms to determine the limiting case.

3.6 Exposure to radiation along egress routes

3.6.1 General

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. Therefore, the time to onset of pain (t_p) must be longer than the exposure time (t_{exp}).

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* tested to a recognised national or international Standard is used.

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

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).

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% (see k=0.5 in equation 3.6 below).

f) Analysis is not required where an alternative *escape route* is available.

g) Analysis is not required where insulated glazing with *fire* resistance of not less than -/30/30 is used.

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.

Comment:
Wall wetting sprinkler heads 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. Amend 4 Jul 2014

i) Analysis is not required during the period prior to *ASET* for the room of fire origin.

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.

3.6.2 Time to onset of pain

The time to onset of pain shall be determined using equation 3.5.

$$t_p = \left(\frac{35}{\dot{q}''_r}\right)^{1.33} \quad \text{Equation 3.5}$$

where:

t_p = time required for pain (s), and

$\dot{q}''_r$ = maximum incident thermal radiation (kW/m²)

3.6.3 Radiation from a window to an egressing occupant

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 3.6:

$$\dot{q}''_r = F_W \, \varepsilon k \dot{q}''_w \quad \text{Equation 3.6}$$

where:

$\dot{q}''_w$ = design emitted heat flux from the window. This shall be taken as:

a) 83 kW/m² for *FLED* (from Table 2.3) 400 MJ/m²

b) 103 kW/m² for *FLED* (from Table 2.3) between 400 and 800 MJ/m², and

c) 144 kW/m² for *FLED* (from Table 2.3) greater than 800 MJ/m².

and

ε = emissivity of the *fire* gases (shall be taken as 1.0)

k = glazing factor (=0.5 for *fire resisting glazing*; =1.0 for all other glazing)

F_W = 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*.

For sprinklered *buildings* the maximum incident thermal radiation may instead be determined from Paragraph 3.6.5 and equation 3.8 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.

Amend 4 Jul 2014

The sprinkler controlled *heat release rate* may be used in equation 3.8.

Amend 4 Jul 2014

3.6.4 Exposure time

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/m². The exposure time for the occupant is the *travel distance* required to pass the window, divided by the walking speed as shown in equation 3.7, below:

$$t_{exp} = \frac{D}{V} \quad \text{Equation 3.7}$$

where:

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

V = travel speed (=1 m/s), and

D = the distance the occupant must travel while exposed to incident thermal radiation of at least 2.5 kW/m² from the window or glazing (m).

3.6.5 Radiation from a burning object to an egressing occupant

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Radiation calculations from a burning object can be approximated using the point source model with fixed radiation fraction as given in equation 3.8:

$$\dot{q}''_r = \frac{0.45\,\dot{q}_{Fire}}{4\pi r^2} \quad \text{Equation 3.8}$$

where:

$\dot{q}''_r$ = radiation flux at a distance r from the fire occupant (kW/m²)

$\dot{q}_{Fire}$ = total *heat release rate* from the fire (kw)

and

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

Limitation:

Average upper layer temperature within the *fire* compartment must not have exceeded 150°C.

Part 4: Design scenarios

CONTENTS

Comment:

References in the *design scenarios* to C1(a), C4.5 etc are to clauses within NZBC C1 to C6: Protection from Fire. The relevant *Building Code* clauses are included in full in *italic* at the start of each scenario for ease of reference.

4.1 Design scenario (BE): Fire blocks exit

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.*
What you must satisfy	C4.5 by providing a viable *escape route* or routes for *building* occupants in the event of *fire*. ***C4.5*** *Means of escape to a place of safety in buildings must be designed and constructed with regard to the likelihood and consequence of failure of any fire safety systems.*
Outcome required	Demonstrate that a viable *escape route* (or multiple routes where necessary) has been provided for *building* occupants.

Scenario description

This scenario addresses the concern that an *escape route* may be blocked due to proximity of the *fire source*. In this event, the number of exits and total exit width must be sufficient for occupants to escape before *ASET* is reached.

This scenario applies to *escape routes:*

a) serving more than 50 people, or

b) with a single direction of travel.

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Exception: this scenario does not apply to vertical stair enclosures serving not more than 150 people *fire separated* from all other parts of a *building* or, if the *building* is sprinkler protected, serving not more than 250 people.

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

For each room/space within the *building* (accommodating more than 50 people), 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. *Fire* in *escape routes* can be the result of a deliberately lit *fire* or accidental. *Fire* originating within an *escape route* will be considered to be a severe *fire* applicable to the particular *building* use as described in the *design scenario*: CF Challenging fire (see Paragraph 4.9).

In order to be regarded as alternative *escape routes*, the 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 at least 8.0 m when:

   i) up to 250 occupants are required to use the *escape routes,* or

   ii) more than 250 occupants are requiring escape through more than two *escape routes*

   and 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.*

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

> **Comment:**
> The engineer needs to consider *fire source* locations that prevent the use of exits in *escape routes*.
>
> *Fire* characteristics (eg, *HRR*) and analysis need not be considered in this scenario, as the *fire* is assumed to physically block the exit. It may be assumed that occupant tenability criteria cannot be met where *fire* plumes and flame block an exit.

Method

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

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

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

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4.2 Design scenario (UT): Fire in normally unoccupied room threatening occupants of other rooms

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.*
What you must satisfy	The performance criteria of C4.3 and C4.4 for any *buildings* with rooms or spaces that can hold more than 50 people. This may require analysis. ***C4.3*** *The evacuation time must allow occupants of a building to move to a place of safety in the event of fire so that occupants are not exposed to any of the following:* *a) a fractional effective dose of carbon monoxide greater than 0.3;* *b) a fractional effective dose of thermal effects greater than 0.3;* *c) conditions where, due to smoke obstruction, visibility is less than 10 m except in rooms of less than 100 m^2 where visibility may fall to 5.0 m.* ***C4.4*** *Clause C4.3 (b) and (c) do not apply where it is not possible to expose more than 1,000 occupants in a firecell protected with an automatic fire sprinkler system.*
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.

Scenario description

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

a) 50 occupants with only a manual alarm system, or

b) 150 occupants with automatic detection and alarm

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that 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*.

A *fire* starting in an unoccupied space can grow to a significant size undetected and then spread to other areas where large numbers of people may be present. This scenario is intended to address the concern regarding a *fire* starting in a normally unoccupied room and then migrating into the space(s) that can potentially hold large numbers of occupants in the *building*.

The analysis shall assume that the target space containing the people is filled to capacity under normal use. For analysis, select a *design fire* as described in Part 2 for the applicable occupancy.

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

Method

Either:

a) Carry out *ASET/RSET* analysis to show that the occupants within target spaces are not exposed to untenable conditions, or

b) Include *separating elements* or *fire* suppression to confine the *fire* to the room of origin. If *separating elements* are used the *FRR* shall be based on the following design criteria.

Comment:
Fire suppression includes any automatic system that controls or extinguishes the *fire*. This may include: automatic sprinkler, gas flooding or oxygen depletion systems (that are designed and installed in accordance with internationally recognised standards.

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i) If no automatic *fire* detection is installed in the space of *fire* origin, separating elements shall have *fire* resistance to withstand a full *burnout fire* (see Paragraph 2.4).

ii) If automatic *fire* detection is installed in the space of *fire* origin, *separating elements* shall either:

A) Have a *fire resistance rating* of not less than 60 minutes (-/60/60), or

B) Demonstrate the *separating elements* will be effective for the period from ignition to the time when the *occupied space* (target space) is evacuated.

4.3 Design scenario (CS): Fire starts in a concealed space

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.*
What you must satisfy	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.

Scenario description

This *design scenario* only applies to *buildings* with rooms holding more than 50 occupants and with *concealed spaces*. It does not apply if the *concealed space* has no *combustibles* (other than timber framing) and no more than two dimensions (length, width or depth) greater than 0.8 m.

A *fire* starting in a *concealed space* can develop undetected and spread to endanger a large number of occupants in another room. This scenario addresses a concern regarding a *fire*, originating in a non-separated *concealed space* without either a detection system or suppression system, and spreading into any room within the *building* that can, potentially, hold a large number of occupants.

Assume that active and passive *fire safety systems* in the *building* perform as intended by the design.

Comment:
Fire spreading in *concealed spaces* may also compromise the ability of firefighters to assess the threat to themselves whilst undertaking rescue and firefighting operations.

Method

Due to the difficulty in modelling *fire* spread within *concealed spaces*, it is expected that traditional solutions will apply here (ie, containment, detection or suppression.)

The expected methodology is to either:

a) Use *separating elements* (*cavity barriers*) or suppression to confine *fire* to the *concealed space*, or

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

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 Design scenario (SF): Smouldering fire

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.*
What you must satisfy	For *buildings* with a sleeping use, ensure that there are automatic means of smoke detection and alarm complying with a recognised national or international Standard for occupants who may be sleeping.
Required outcome	Provide an automatic smoke detection and alarm system throughout the *building* that has been designed and installed to a recognised national or international Standard.

Scenario description

This scenario addresses the concern regarding a slow, smouldering *fire* that causes a threat to sleeping occupants. Assume that active and passive *fire safety systems* in the *building* perform as intended by the design.

Method

Amend 3 Dec 2013

Provide an automatic detection and alarm system throughout the *building* including smoke detection in sleeping areas, designed and installed to a recognised national or international Standard. No further analysis is expected.

4.5 Design scenario (HS): Horizontal fire spread

Scenario in brief	A fully developed *fire* in a *building* exposes the *external walls* of a neighbouring *building* or *firecell.*
Code objectives	***C1(b)*** *Protect other property from damage caused by fire.*
What you must satisfy	The performance criteria in C3.6 and C3.7. This will require calculation. C4.2 is to be considered in relation to horizontal *fire* spread across a *notional boundary* to sleeping occupancies and *exitways* in *buildings* under the same *ownership.* ***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/m² and at a distance of 1 m beyond the relevant boundary of the property does not exceed 16 kW/m².* ***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/m², 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/m², do not ignite for 15 minutes.* ***C4.2*** *Buildings must be provided with means of escape to ensure that there is a low probability of occupants of those buildings being unreasonably delayed or impeded from moving to a place of safety and that those occupants will not suffer injury or illness as a result.*
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.*

Amend 4 Jul 2014

Comment:

The performances specified in NZBC C3.6 are deemed to be achieved in *buildings* with an automatic sprinkler system with two independent water supplies, one of which is not dependent on town mains and not used for storage above 3.0 m.

The performance requirements of C3.6 are also to be applied to limit the radiation at the *notional boundary* to sleeping occupancies and *exitways* in *buildings* under the same *ownership*. This partially contributes to the achievement of the functional requirement C4.2.

Scenario description

A fully developed *fire* in a building exposes the *external walls* of a neighbouring *building* (*other property*) or *firecell* (sleeping occupancy, *exitway* or *other property*).

Amend 4 Jul 2014

This scenario addresses a *fire* in a *building* that leads to high levels of radiation heat exposure across a *relevant boundary*, potentially:

1) Igniting the *external walls* of a neighbouring *building*, or
2) Leading to *fire* spread to *other property*, sleeping occupancies and *exitways*.

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An exception to 2) above is 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 for separation of *escape routes*, to separate sleeping occupancies, or by the FO scenario.

Amend 4 Jul 2014

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 supplied by two independent water supplies, one of which is not dependent on town mains, there are no restrictions on the amount of *unprotected area* and the fire engineer does not need to assess the external fire spread to the boundary.

Unprotected area shall include both unrated *external wall construction* as well as any unrated 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 Paragraph 2.4 and with *insulation* sufficient to meet NZBC C3.7.

Furthermore, 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*.

Unprotected area is not permitted within 1.0 m of a *relevant boundary*, except for a combination of small *unprotected area* and/or *fire resisting glazing* as described in Acceptable Solutions C/AS2 to C/AS6 Paragraph 5.4 or in the commentary document for this Verification Method.

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Design fire

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 taken as:

a) 83 kW/m² for *FLED* ≤400 MJ/m²

b) 103 kW/m² for *FLED* between 400 and 800 MJ/m², and

c) 144 kW/m² for *FLED* greater than 800 MJ/m², and

d) 58 kW/m² for *FLED* for sprinklered *firecells* not containing a storage occupancy or a storage occupancy with a capability to store to more than 3.0 m

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Emissivity of *fire* gases shall be taken as 1.0.

Method 1 Calculation

Calculate 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. The calculations must take into account:

a) The distance to the boundary, and

b) The size/shape of the *unprotected area* in the *external walls*, assuming the emitted radiant heat flux specified above for the applicable *FLED* range.

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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:

a) the emitted radiation flux for sprinklered *firecells* Amend 4 Jul 2014

b) 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

c) 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 metres.

The *unprotected area calculated* using the emitted radiation flux for sprinklered *firecells* is not permitted to be doubled.

The fire engineer only needs to consider one *fire separated* space at a time as a potential source of thermal radiation.

For unsprinklered *buildings*, the width of the enclosing rectangle need be no greater than 20 m for *FLED* up to and including 800 MJ/m², or no greater than 30 m for *FLED* greater than 800 MJ/m². The actual width of the enclosing rectangle shall be used if it is less than 20 m.

Method 2 Tabulated values

Use the tabulated values of the maximum percentage of permitted *unprotected area* directly from the Acceptable Solutions C/AS2 to C/AS6 as appropriate for the *firecell*, or the tables as provided in the commentary for this Verification Method. Amend 4 Jul 2014

The tables in the commentary document along with additional tables for *fire resisting glazing* and return and/or wing walls have been produced in accordance with this Verification Method. These tables can be used directly for unsprinklered *firecells* as long as *external walls* are parallel to, or angled at no more than, 10° to the *relevant boundary* and are no closer than 1.0 m to the *relevant boundary*.

For *external walls* at greater angles 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 the commentary document.

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In all *firecells* protected with an automatic sprinkler system, the maximum permitted *unprotected area* obtained from tabulated values (in an Acceptable Solution or commentary) for an unsprinklered space can be doubled.

Horizontal fire spread from roofs

In addition for unsprinklered *buildings* where the average *fire load* exceeds 1200 MJ/m² and the *building* is located within 1.0 m of a *relevant boundary,* horizontal *fire* spread via a non-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 Paragraph 2.4. 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-rated roof does not exceed 16 kW/m². Amend 4 Jul 2014

Canopies

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The potential for any space to expose *other property* shall be evaluated. However, 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/ m², and

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

Cladding

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To demonstrate that NZBC C3.7 is achieved, it is expected that relevant *fire* test results for the selected cladding system will be provided. Engineers may also choose to comply with Paragraph 5.8 of the relevant Acceptable Solutions C/AS2 to C/AS6 or with Table 4.1 to satisfy the performance criteria of this clause. Amend 3 Dec 2013

Table 4.1 Acceptable heat release rates for external wall cladding systems for control of horizontal fire spread (Note 1)

Building height	Distance to relevant boundary (all buildings)	
	< 1.0 m (note 2)	1.0 m or more (note 3)
< 7.0 m	A	–
≥ 7.0 m and < 25 m	A	B (note 5)
≥ 25 m	A	B

Key:

The *external wall* cladding system shall have a peak *heat release rate* and a total heat released not greater than given below for the applicable performance level

	Peak *heat release rate* (kW/m^2) (Note 4)	Total heat released (MJ/m^2) (Note 4)	
A B –	100 150 No requirement	25 50 No requirement	(The smaller the *heat release* value the more stringent the requirement)

Notes:

1. Check *design scenario* VS for possible greater requirements.
2. The maximum permitted radiation flux criteria specified in the NZBC assume claddings within 1.0 m of the *relevant boundary* will not ignite.
3. As an alternative to specifying a cladding meeting the 'B' performance level, engineers may calculate the contribution of a *combustible* cladding to the radiation received at and beyond the *relevant boundary* to demonstrate the maximum permitted radiation flux criteria specified in the NZBC are not exceeded.
4. Determined by testing to ISO 5660.1 or AS/NZS 3837 at an irradiance of 50 kW/ m^2 for a duration of 15 minutes.
5. Where the *building* is fully sprinklered in accordance with a recognised Standard, there is no requirement.

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4.6 Design scenario (VS): External vertical fire spread

Scenario in brief	A *fire source* exposes the *external wall* and leads to significant vertical *fire* spread.
Code objectives	*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.*
What you must satisfy	The performance criteria of C3.5 (ie, 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: • tenable conditions are maintained on *escape routes* until the occupants have evacuated, and • vertical *fire* spread does not compromise the safety of firefighters working in or around the *building.* *C3.5 Buildings must be designed and constructed so that fire does not spread more than 3.5 m vertically from the fire source over the external cladding of multi-level buildings.*
Required outcome	Demonstrate that the *building's* external claddings do not contribute to excessive vertical *fire* spread using one of the methods described.

Scenario description

This *design scenario* applies to:

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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

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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:

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1. `This scenario is not concerned with horizontal *building*-to-*building fire* spread across a *relevant boundary*, as this is addressed in the *design scenario*: HS (see Paragraph 4.5).

2. Multi-level *buildings* include:

a) *Buildings* with more than one full floor

b) *Buildings* that have more than one *intermediate floor* and the *escape height* of the uppermost *intermediate floor* is greater than 10 m, e.g. a multi-storey office with an atrium.

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There are three considerations in this scenario:

Part A: External vertical *fire* spread over the façade materials, and

Part B: *Fire* plumes spreading *fire* vertically up the *external wall* via openings and *unprotected areas*, and

Part C: *Fire* plumes spreading *fire* from a lower *firecell* through an unprotected lower roof to an adjacent higher *external wall* via *unprotected areas*.

Comment:

Part A addresses concerns regarding the contribution of *combustible* claddings to vertical *fire* spread.

Parts B and C 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.* In the case of Part C, vertical *fire* spread via an unprotected lower roof to an adjacent *building* also needs to be considered.

Part A: External vertical fire spread over facade materials

This part applies to all multi-level *buildings* with a *building height* of more than 10 m where upper floors contain sleeping uses or *other property*. Amend 4 Jul 2014

The *design fire* for this scenario shall be a *fire source* that is either:

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

b) Adjacent to an *external wall*, such as a *fire* plume emerging from a window opening or from an *unprotected area* of the wall burning.

The *design fire* exposure is: Amend 4 Jul 2014

a) Radiant flux of 50 kW/m² impinging on the façade for 15 minutes for *buildings* in *importance levels* 2 and 3, or

b) Radiant flux of 90 kW/m² impinging on the façade for 15 minutes for *buildings* in *importance level* 4.

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.

This can be achieved by:

a) Limiting the maximum *HRR* from a cladding material when exposed to the design event to no more than 100 kW/m², or

b) Limiting the extent of the vertical flame spread distance (on the façade) to no more than 3.5 m above the *fire source*. This accepts that *fire* spread via the façade materials may occur to the floor immediately above, but not two floors above.

Method

For Part A, either:

a) Comply with Table 4.2 in C/VM2, or

b) Use *non-combustible* materials, or

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c) Use large or medium scale façade type tests to determine the extent of vertical flame test is not more than 3.5 m above the *fire* source.

Comment:
Validated flame spread models could be used for some materials.

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The requirements given in the relevant Acceptable Solution Paragraph 5.8 for *fire* properties of external claddings are acceptable means of demonstrating compliance with Part A above for *buildings* with an *importance level* not higher than 3.

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Part B: External vertical fire spread via openings and unprotected areas

This part applies to other 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.*

The *design fire* exposure is a *fire* plume projecting from openings or *unprotected areas* in the *external wall*, with characteristics determined from the *design fire* as described in Part 2 for the applicable occupancy.

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*.

This can be achieved by either:

a) Limiting external vertical *fire* spread with the introduction of *fire* rated construction on certain areas of the *external wall* to prevent a *fire* plume extending from a lower opening or *unprotected area*, and then re-entering the *building* via an opening or *unprotected area* at a higher level, or

b) Installing an automatic sprinkler system in accordance with an approved standard.

Method

For Part B, either:

a) Follow the requirements of Acceptable Solutions C/AS2 to C/AS6 and provide *construction* features such as aprons and/or spandrels, or

b) Install an automatic sprinkler system in accordance with an approved standard, or

c) Calculate the effect of the radiation from *fire* plumes projected from openings. *Fire* plume characteristics and geometry shall be derived from the design fires as described in Part 2 for the applicable geometry.

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Part C: Lower Roof Exposure

This part 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*.

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*.

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 area located in a higher *external wall*.

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.

This can be achieved by:

a) *Fire* rating the underside of the lower roof where it represents an exposure risk to the higher *external wall* in order to prevent a *fire* plume extending through the lower roof, or

b) *Fire* rating parts of the higher *external wall* to prevent the *fire* plume that has passed through the unrated lower roof spreading into the higher levels , or

c) Installing sprinklers in the compartment below the unprotected lower roof.

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Method

For Part C follow the requirements of Part 5: Control of external fire spread of the relevant Acceptable Solutions (C/AS2 to C/AS6) and use:

a) Construction features that will provide a *fire* rating to the underside of any part of the lower roof that is within 5.0 metres of the higher *external wall*. The *fire resistance rating* to be applied over the rated area of the lower roof shall be based on the *burnout fire* determined in Paragraph 2.4 for the space below the roof or,

b) Construction features that will enable a fire rating to be provided to all parts of the *external wall* that are within 9.0 metres vertically, of any area of unprotected lower roof that is within 5 metres horizontally of the higher *external wall*. The *fire resistance rating* to be provided over the required area of the *external wall* shall be based on the *burnout fire* determined in Paragraph 2.4 for the space below the roof,

c) The installation of sprinklers to an approved standard throughout the space below the roof.

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Table 4.2	Acceptable heat release rates for external wall cladding systems for control of vertical fire spread (Note 1)		
Building height		Sleeping uses or *other property* on an upper floor	No sleeping uses nor *other property* on an upper floor
≤ 10 m		–	–
> 10 m and < 25 m		A (sleeping care or detention) B (other sleeping) B (*other property*) – Note 2	–
≥ 25 m		A	–
Key: The *external wall* cladding system shall have a peak *heat release rate* and a total heat released not greater than given below for the applicable performance level			
	Peak *heat release rate* (kW/m²) (Note 3)	Total heat released (MJ/m²) (Note 3)	
A B –	100 150 No requirement	25 50 No requirement	(The smaller the *heat release* value the more stringent the requirement)

Notes:

1. Check *design scenario* HS for possible greater requirements.
2. Where the *building* is fully sprinklered in accordance with a recognised Standard, there is no requirement.
3. Determined by testing to ISO 5660.1 or AS/NZS 3837 at an irradiance of 50 kW/ m² for a duration of 15 minutes.

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4.7 Design scenario (IS): Rapid fire spread involving internal surface linings

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.*
What you must satisfy	The performance criteria of C3.4 for materials used as internal surface linings in the relevant *building* areas, as also specified in C3.4. Where *foamed plastics* or combustible insulating materials form part of an element requiring a *Group Number* in accordance with NZBC Clause C3.4(a), the completed assembly shall achieve a *Group Number* as specified in C3.4(a) and the *foamed plastics* shall comply with the flame propagation criteria as specified in AS 1366 for the type of material being used. (Amend 3 Dec 2013) **Comment:** The completed system may or may not include a surface lining product enclosing any insulation material from any adjacent *occupied space*. If a surface lining is not included then the *foamed plastics* or combustible *insulating materials* when tested alone shall achieve a *Group Number* of 3. Otherwise a surface lining is also required such that the completed system achieves a *Group Number* of 3.

Walls and ceiling linings and ducts	*Limits on application*	
C3.4(a) *Materials used as internal surface linings in the following areas of buildings must meet the performance criteria specified below:*	*Clause C3.4 does not apply to detached dwellings, within household units in multi-unit dwellings, or outbuildings and ancillary buildings.*	
Area of building	***Performance determined under the conditions described in ISO 9705: 1993***	
	Buildings not protected with an automatic fire sprinkler system	***Buildings 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*	*Material Group Number 1-S*	*Material Group Number 1 or 2*
Ceiling materials in crowd and sleeping uses but not household units or where care or detention is provided	*Material Group Number 1-S or 2-S.*	*Material Group Number 1 or 2*
Wall materials in crowd and sleeping uses except household units or where care or detention is provided	*Material Group Number 1-S or 2-S*	*Material Group Number 1, 2 or 3*
Wall/ceiling materials in occupied spaces in all other locations in buildings, including household units *External surfaces of ducts for HVAC systems* *Acoustic treatment and pipe insulation within air-handling plenums in sleeping uses*	*Material Group Number 1, 2 or 3*	*Material Group Number 1, 2 or 3*

	Floor surfaces suspended flexible fabrics and membrane structures		
	C3.4(b) *Floor surface materials in the following areas of buildings must meet the performance criteria specified below:*		
	Area of building	*Minimum critical radiant flux when tested to ISO 9239-1: 2010*	
		Buildings not protected with an automatic fire sprinkler system	*Buildings protected with an automatic fire sprinkler system*
	Sleeping areas and exitways in buildings where care or detention is provided	*4.5 kW/m²*	*2.2 kW/m²*
	Exitways in all other buildings	*2.2 kW/m²*	*2.2 kW/m²*
	Firecells accommodating more than 50 persons	*2.2 kW/m²*	*1.2 kW/m²*
	All other occupied spaces except household units	*1.2 kW/m²*	*1.2 kW/m²*
	C3.4(c) is to be satisfied by ensuring that: a) 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 when tested to AS 1530 Part 2 b) Suspended flexible fabrics and membrane structures shall have a *flammability index* of no greater than 12 when tested to AS 1530 Part 2 in the following locations: i) *exitways* from spaces where people sleep, and ii) all *occupied spaces* within crowd uses.		
Required outcome	Demonstrate that *surface finishes* comply with these performance requirements.		

Scenario description

The performance criteria required for lining materials will depend on their location within a *building*, the use of the *building* and its *importance level*.

The criteria in NZBC C3.4 shall be applied to lining materials, except in the following cases:

a) Small areas of non-conforming product within a space with a total aggregate surface area not more than 5.0 m²

b) Electrical switches, outlets, cover plates and similar small discontinuous areas

c) Pipes and cables used to distribute power or services

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

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

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

g) 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

h) Individual *doorsets*, and

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i) 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 m², whichever is less.

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

Material *Group Numbers* apply to the exposed surface of the interior wall or ceiling lining. They are determined by the *fire* testing laboratory using the procedure described in Appendix A. This is either to:

a) ISO 9705, which is a full-scale room corner test, or

b) ISO 5660, which is a bench-scale fire test on a small sample of the material.

A correlation is used that allows the ISO 9705 result to be predicted using data obtained in the ISO 5660 test.

If an 'S' is appended to the material *Group Number*, the material also is required to meet smoke production criteria. The limit for maximum smoke production is:

a) 5.0 m^2/s if the ISO 9705 test is used, or

b) 250 m^2/kg if the ISO 5660 test is used.

Materials that are classified *non-combustible* when tested to AS 1530.1 or ISO 1182 can be assigned a material *Group Number* of 1 or 1–S without further evaluation using Appendix A.

When testing to ISO 1182 the following criteria are required to be classified as non-combustible:

$\Delta T \leq 30°C$

$\Delta m \leq 50\%$

$t_f = 0s$

Where:

ΔT= The rise in temperature of the furnace

Δm = The mass loss of the specimen

t_f = The time of sustained flaming

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Rigid or flexible ductwork meeting the *fire* hazard properties set out in AS 4524 can be assigned a material *Group Number* of 1 or 1-s without further evaluation using Appendix A.

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The minimum critical flux for a floor surface material or covering is determined by *fire* testing to ISO 9239 Part 1 (radiant panel test).

A critical radiant heat flux may be assigned to some flooring materials, without further evaluation, using Appendix B.

Method

The following tests shall be applied to lining materials to achieve compliance with NZBC C3.4, unless otherwise permitted in this Verification Method.

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For wall/ceiling lining materials, external surface of ducts and pipe insulation:

a) Small scale testing to ISO 5660 (cone calorimeter test) provided it is appropriate for the type of material, or

b) Full scale testing to ISO 9705 (room corner test), or

c) Small scale testing to meet *fire* hazard properties set out in AS 4254 for rigid and flexible ductwork.

For floor surface materials:

a) *Fire* testing to ISO 9239 Part 1 (radiant panel test).

For suspended flexible fabrics and membrane structures:

a) *Fire* testing to AS 1530 Part 2 (flammability test).

4.8 Design scenario (FO): Firefighting operations

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

Scenario description

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

For the purposes of NZBC Clause C3.8, 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:

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

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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.

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For the purposes of NZBC C3.8, take the time that the Fire Service first applies water to the *fire* as either:

a) 1200 seconds, or

b) 1000 seconds if there is an automatic alarm and direct connection to the Fire Service, or

c) Some other time as determined and supported by the application of a *fire* brigade intervention model.

Use the *design fire* as described in Paragraph 2.3 for the applicable occupancy. This can be modified to account for ventilation conditions.

Where *fire separations* are specified to create *firecells* of area not more than 5000 m^2, the full *burnout design fire* defined in Paragraph 2.4 shall be used to determine the required *fire* resistance of the *fire separation*.

For the purposes of NZBC 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 (~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 the New Zealand Fire Service.

In relation to NZBC 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 Pararaph 2.4 and by meeting the requirements below.

A. For buildings with an escape height >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

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Comment:
In the case of *intermediate floors*, 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 ~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 NZBC C5.5 to provide water to all points of the *building*.

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* ≤100 people and an *escape height* ≤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 a) or b) above.

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B. For buildings with an escape height ≤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

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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

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Comment:
In the case of *intermediate floors*, 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 ~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 NZBC C5.5 to provide water to all points of the *building*.

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

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Comment:
These requirements permit search and rescue operations, and attempt to avoid unexpected or sudden collapse that would endanger Fire Service personnel within the *building*. See commentary C2.5 for guidance on design to resist collapse and prevent *fire* spread for a given period of time. An *FRR* of 30/30/- may be used to comply with b) and c) above.

Intermediate floors – additional requirements:

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 a), b), or c).

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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 Design scenario (CF): Challenging fire

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.*
What you must satisfy	The performance criteria of C4.3 and C4.4. This will require analysis. ***C4.3*** *The evacuation time must allow occupants of a building to move to a place of safety in the event of a fire so that occupants are not exposed to any of the following:* *(a) a fractional effective dose of carbon monoxide greater than 0.3;* *(b) a fractional effective dose of thermal effects greater than 0.3;* *(c) conditions where, due to smoke obscuration, visibility is less than 10 m except in rooms of less than 100 m^2 where the visibility may fall to 5 m.* ***C4.4*** *Clause C4.3 (b) and (c) do not apply where it is not possible to expose more than 1000 people in a firecell protected with an automatic fire sprinkler system.*
Required outcome	Demonstrate *ASET>RSET* for *design fires* in various locations within the *building.*

Scenario description

The challenging *fires* are intended to represent credible worst case scenarios in normally occupied spaces that will challenge the *fire* protection features of the *building*.

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

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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, which has all of the following:

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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, and

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 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.

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For c), the *fire* engineer does not have to demonstrate that tenability is maintained for occupants within the enclosure of *fire* origin; however, they must demonstrate that the challenging *fire* in this space does not threaten occupants in the rest of the *building*. This includes demonstrating that the *structural adequacy, integrity* and *insulation* of floors, stairs and walkways forming *escape routes* and the smoke and *fire separations* protecting these *escape routes* is maintained sufficiently to protect the occupants in the rest of the *building* for the duration of their *RSET*. 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*. The *design fires* shall be characterised with a power law *HRR*, peak *HRR* and *FLED* as specified in Part 2. Design values for *yields* are specified for CO, CO_2 and soot/smoke. Hydrogen cyanide production need not be considered.

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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*. The *design scenario*: RC (see Paragraph 4.10) will require the overall robustness of the design to be examined separately.

Comment:
Refer to Commentary to Paragraph 3.2.7 when there is an identifiable primary exit via a reception or lobby area and determining *RSET* in such a situation

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The *fire* engineer shall:

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

b) Consider the impact on occupants who may be using *escape routes* external to the *building* as well as internal routes (see Paragraph 3.6.1), and

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c) Assume that active and passive *fire safety systems* in the *building* will perform as intended by the design.

Method

This scenario requires the *ASET/RSET* analysis of the impact on all *building* occupants of *design fires* located in various locations within the *building*, except for those rooms or spaces excluded in the scenario description above.

The *fire* engineer is expected to calculate the *fire* environment in the *escape routes* over the period of time the occupants require to escape. Assess the *fire* environment based on the *fractional effective dose* and *visibility* at the location of the occupants.

The *fire* engineer will typically select a *fire* calculation model appropriate to the complexity and size of the *building*/space that allows the *fractional effective dose* and *visibility* to be determined.

4.10 Design scenario (RC): Robustness check

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 objectives	***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.*
What you must satisfy	This scenario contributes to testing the performance criteria of C3.9, C4.5, C5.8 and C6.2d). Where tenability criteria are evaluated, these criteria only need to be assessed based on *FED* (CO). ***C3.9*** *Buildings must be designed and constructed with regard to the likelihood and consequence of failure of any fire safety system intended to control fire spread.* ***C4.5*** *Means of escape to a place of safety in buildings must be designed and constructed with regard to the likelihood and consequence of failure of any fire safety systems.* ***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.* ***C6.2*** *Structural systems in buildings that are necessary for structural stability in fire must be designed and constructed so that they remain stable during fire and after fire when required to protect other property taking into account:* *(a) …* *(b) …* *(c) …* *(d) the likelihood and consequence of failure of any fire safety systems that affect the fire severity and its impact on structural stability.*
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.

Scenario description

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

a) More than 150 people, or

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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.

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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)

b) *Fire* 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* 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.

This particular scenario focuses on the *ASET/RSET* life safety calculations performed as part of the *design scenario*: CF Challenging fire (see Paragraph 4.9). The robustness of the design shall be tested by considering the *design fire* with each key *fire safety system* rendered ineffective in turn.

For this scenario, where tenability criteria are evaluated, the engineer needs to assess these based on *FED* (CO).

Comment:
Ideally, a comprehensive quantitative probabilistic risk assessment would be used to assess the safety of a design. However, the risk assessment tools and supporting data are currently not suitable for inclusion within this Verification Method. Therefore, the framework currently requires a deterministic *ASET/RSET* approach with additional checks and balances to meet *Building Code* objectives.

As a general rule, when calculating *ASET* times, *fire safety systems* may be assumed to operate as designed, provided they are manufactured and installed in accordance with recognised national or international Standards. However, in the situations defined above, additional *fire safety systems* are required to provide redundancy and robustness to the *fire* safety design.

Method

In the circumstances described in the scenario, assume the failure of each key *fire safety system* in turn. If *ASET* cannot be shown to be greater than *RSET* when each key system fails, then the design must be altered until the requirements of this scenario can be satisfied.

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

Robustness check of vertical escape routes

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

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*.

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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*.

This check assumes that all *fire safety systems* are operating as designed.

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Appendix A (normative): Establishing Group Numbers for lining materials

A1.1 Tests for material Group Numbers

Materials shall be assigned a material *Group Number* when tested to either:

a) ISO 9705 Fire tests – full scale room test for surface products, or

b) ISO 5660 Reaction to fire tests (Heat release, smoke production and mass loss rate) Part 1: Heat release rate (cone calorimeter method); and ISO 5660 Reaction to fire tests (Heat release, smoke production and mass loss rate) Part 2: Smoke production rate (dynamic measurement).

This is except in the following cases:

a) Metal-skin panel assemblies with *combustible* core materials, which shall only be assessed using either the ISO 9705 or ISO 13784 Part 1 test method, or

b) Foil-faced *combustible* materials, which shall only be assessed using the ISO 9705 test method, but if forming part of rigid and flexible ductwork may instead satisfy the requirements of A1.4 a), or

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c) Other products that an accredited test laboratory believes are not appropriate to be evaluated using the ISO 5660 test method due to the configuration or other characteristics of the product. Such products shall be assessed using either the ISO 9705 test or another large scale test if deemed to be appropriate.

Comment:
ISO 5660 is unsuitable in cases where the *fire* performance of the assembly is dominated by the *construction* details rather than the flammability characteristics of the surface material or in cases where, due to the configuration of the material in the test, significant mechanical damage occurs at full scale which does not occur with small, horizontal samples.

A1. 2 Determining a material's Group Number when tested to ISO 9705

For a material tested to ISO 9705, the material's *Group Number* shall be determined as follows:

Group Number 1 material has total heat release not greater than 1 MW following exposure to 100 kW for 10 minutes then 300 kW for 10 minutes

Group Number 1–S material has total heat release not greater than 1 MW following exposure to 100 kW for 10 minutes then 300 kW for 10 minutes and the average smoke production rate over the period 0–20 min is not greater than 5.0 m^2/s

Group Number 2 material has total heat release not greater than 1 MW following exposure to 100 kW for 10 minutes

Group Number 2–S material has total heat release not greater than 1 MW following exposure to 100 kW for 10 minutes and the average smoke production rate over the period 0–10 min is not greater than 5.0 m^2/s

Group Number 3 material has total heat release not greater than 1 MW following exposure to 100 kW for 2 minutes, and

Group Number 4 material has total heat release greater than 1 MW following exposure to 100 kW for 2 minutes.

The rate of total heat release determined in ISO 9705 includes contribution from both the internal lining and the exposure source (100 kW or 300 kW).

The *Group Number* of a material predicted in accordance with Paragraph A1.3 using data obtained by testing the material at 50 kW/m^2 irradiance in the horizontal orientation with edge frame in accordance with ISO 5660 is given by:

Group Number 1 material: as predicted in accordance with Paragraph A1.3

Group Number 1-S material: as predicted in accordance with Paragraph A1.3 and an average *specific extinction area* less than 250 m^2/kg

Group Number 2 material: as predicted in accordance with Paragraph A1.3

Group Number 2-S material: as predicted in accordance with Paragraph A1.3 and an average *specific extinction area* less than 250 m^2/kg

Group Number 3 material: as predicted in accordance with Paragraph A1.3, and

Group Number 4 material: as predicted in accordance with Paragraph A1.3.

A1. 3 Determining a material's Group Number when tested to ISO 5660

For a material tested to ISO 5660, the material's *Group Number* must be determined in accordance with the following:

a) Data must be in the form of time and *HRR* pairs for the duration of the test. The time interval between pairs should not be more than 5 seconds. The end of the test (t_f) is determined as defined in ISO 5660, and

b) At least three replicate specimens must be tested.

The following five steps must be applied separately to each specimen:

Step 1: Determine time to ignition (t_{ig}). This is defined as the time (in seconds) when the *HRR* reaches or first exceeds a value of 50 kW/m^2.

Step 2: Calculate the Ignitability Index (I_{ig}) expressed in reciprocal minutes.

$$I_{ig} = \frac{60}{t_{ig}}$$

Step 3: Calculate the following two *HRR* indices:

$$IQ_1 = \int_{t_{ig}}^{t_f} \left[\frac{q''(t)}{(t - t_{ig})^{0.34}} \right] dt$$

$$IQ_2 = \int_{t_{ig}}^{t_f} \left[\frac{q''(t)}{(t - t_{ig})^{0.93}} \right] dt$$

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> **Comment:**
> These definite integral expressions represent the area under a curve from the ignition time until the end of the test, where the parameter is plotted on the vertical axis and time (t) is plotted on the horizontal axis.

Step 4: Calculate the following three integral limits:

$$IQ_{,10\text{min}} = 6800 - 540 I_{ig}$$

$$IQ_{,2\text{min}} = 2475 - 165 I_{ig}$$

$$IQ_{,12\text{min}} = 1650 - 165 I_{ig}$$

Step 5: Classify the material in accordance with the following:

i) If $IQ_1 > IQ_{10}$ min and $IQ_2 > IQ_2$ min, the material is a *Group Number* 4 material

ii) If $IQ_1 > IQ_{10}$ min and $IQ_2 \le IQ_2$ min, the material is a *Group Number* 3 material

iii) If $IQ_1 \le IQ_{10}$ min and $IQ_2 > IQ_{12}$ min, the material is a *Group Number* 2 material

iv) If $IQ_1 \le IQ_{10}$ min and $IQ_2 \le IQ_{12}$ min, the material is a *Group Number* 1 material, or

v) If the ignition criterion in Step 1 above is not reached, the material is a *Group Number* 1 material.

Repeat steps 1 to 5 above for each replicate specimen tested. If a different classification group is obtained for different specimens tested, then the highest (worst) classification for any specimen must be taken as the final classification for that material.

> **Comment:**
> It is expected that the *fire* testing laboratory will determine the material *Group Number* as described in this section when reporting the *fire* test results.

A1.4 Determining a Group Number for surfaces of ducts for HVAC systems

Surfaces of rigid and flexible ductwork for *HVAC* systems shall be assigned either:

a) A material *Group Number* of 1-s when the ductwork complies with the fire hazard properties set out in AS 4254, or

b) A material *Group Number* as determined by A1.2 or A1.3.

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A1.5 Determining a Group Number for some surface finishes

For the purposes of compliance with the *surface finish* requirements, the specified combinations of substrate and coating in Table A1 can be taken as having the performance indicated without the need for further evaluation using A1.2 or A1.3.

Table A1 Specified performances for some substrate and coating combinations

Coating (coating in good condition and well adhered to substrate)	Substrate	Performance (with or without coating)
Waterborne or solvent borne paint coatings ≤ 0.4 mm thick Polymeric films ≤ 0.2 mm thick	Concrete and masonry ≥ 15 mm thick Sheet metal ≥ 0.4 mm thick, or Fibre-cement board ≥ 6.0 mm thick Glass	G1-S
Waterborne or solvent borne paint coatings ≤ 0.4 mm thick	Gypsum plasterboard with or without paper facing ≥ 9.5 mm thick ≥ 400 kg/m^3 core density < 5% wt organic contribution to board	G2-S
Waterborne or solvent borne paint coatings, varnish or stain ≤ 0.4 mm thick ≤ 100 g/m^2	Solid wood or wood product ≥ 9.0 mm thick ≥ 600 kg/m^3 for particle boards, or ≥ 400 kg/m^3 for all other wood and wood products	G3
Note: The requirements of this table do not apply to metal faced panels with polymeric substrate.		

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A1.6 Selecting a substrate for testing materials or coatings usually applied to a substrate

Materials or coatings that are usually applied to a particular substrate shall be applied to the appropriate substrate. Where the material may be applied to a variety of substrates, the substrate selected for testing shall be one which most closely represents the end use condition. The choice shall be based on Table A2. A test result for a material or coating tested on any one of the specified substrates may be also be used when the material or coating is applied to any other substrate of the same type or a less reactive type and of equal or greater density.

However, Table A2 only applies where the substrate is not modified by the application of a surface coating or treatment.

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Where the substrate is modified by a surface coating or treatment, through significant absorption of material into it, the coating and substrate should be specifically tested. Notwithstanding the above, a surface coating on any nominated substrate may be tested and a *Group Number* assigned as described in A1.2 or A1.3.

Table A2: Selection of substrate

Substrate type	Substrate material
1 (most reactive)	Timber, Standard grade plywood, hardboard, fibre/particleboard (where the substrate is less than 12 mm thick)
2	Timber, Standard grade plywood, hardboard, fibre/particleboard (where the substrate is 12 mm thick or greater)
3	Paper faced gypsum board products
4 (least reactive)	Concrete/masonry, fibre-reinforced cement board, non-paper faced gypsum boards

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A1.7 Wall and ceiling elements that include foamed plastics or combustible insulating materials

Elements are parts of the *buildings* such as ceilings and walls. An assembly is a collection of materials and components that make up the element to form a system.

Samples submitted for testing to ISO 5660 are limited to a maximum thickness of 50 mm, and therefore only those parts within 50 mm of the exposed surface of an assembly which comprises composite layers need be included in the test specimen. When conducting a test to ISO 5660 or ISO 9705, the test laboratory may decide if a lesser thickness is appropriate or if the *foamed plastics* or *combustible* insulation may be omitted from the test specimen entirely (ie. when the surface lining is sufficiently robust and well-fixed such that substrate materials are unlikely to influence the outcome of the *Group Number* classification).

Foamed plastics or combustible insulating materials that form part of an element requiring a group number can be assumed not to influence the group number classification and need not be included in the test specimen in the following examples.

a) The surface lining material is a rigid sheet product of gypsum plasterboard, plywood, solid wood, wood composite, fibre-reinforced cement, concrete or masonry and is not less than 9 mm thick, and

b) It is securely fastened with steel fasteners to a conventional lightweight timber or steel frame or a concrete/masonry wall, according to manufacturers' literature, and

c) All sheet joins are supported and sealed and/or stopped with a non-flaming material.

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In all other situations, or when there is doubt whether the examples above apply to a particular assembly, an accredited testing laboratory shall be consulted.

Notwithstanding the above, foamed plastics must still meet the flame propagation criteria of AS 1366 and metal-skin panel assemblies with combustible core materials and foil-faced combustible insulating materials require ISO 9705 or ISO 13874.1 testing as described in Paragraph A1.1.

Appendix B (normative): Critical Radiant Flux values for some flooring materials

B1.0 For the purposes of compliance with Clause C3.4(b) of the Building Code the following critical radiant flux values may be assigned as shown in Table B1 for the given flooring material without further evidence of testing to ISO 9239-1:2010.

Table B1 Specified performances for some flooring materials

Flooring material	Critical Radiant Flux (CRF)
Concrete[2], brick, ceramic or porcelain tile	4.5 kW/M^2
Wood Products, Plywood or Solid Timber [1,2] ≥ 12 mm thick; and ≥ 400 kg/m^3	2.2 kW/M^2

Note

1. Some timber species and thicknesses and with/without applied coatings when tested may achieve a higher CRF. When a greater CRF is required to meet Clause C3.4 (b) than given in this table, supporting test data to ISO 9239-1:2010 for the product is required.
2. May include waterborne or solvent borne applied surface coatings not more than 0.4 mm thick and not more than 100 g/m^2.

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References are to the relevent paragraphs, figures or tables in **C/VM2** unless otherwise stated. References to Appendices are prefixed by the Appendix letter.