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Acceptable Solution for New Zealand Building Code Fire Safety Clauses: Analysis of Existing Performance Metrics

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Preface

This report was prepared as a result of a review of the Compliance Document for New Zealand Building Code Fire Safety Clauses.

Acknowledgments

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The authors would like to acknowledge the much appreciated assistance of Nick Saunders and Ngaere MacKinnon of the Department of Building and Housing.

Note

This report is intended primarily for fire engineers, architects, code writers, regulators and researchers.

ACCEPTABLE SOLUTION FOR NEW ZEALAND BUILDING CODE FIRE SAFETY CLAUSES: ANALYSIS OF EXISTING PERFORMANCE METRICS

BRANZ Study Report SR 166 (2007) **APR Edwards and CA Wade**

REFERENCE

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ABSTRACT

A structured query language database was used to collate background information available for the content of C/AS1 (2001). This report summarises the content of this database.

The intention of the research this report is based upon was to produce a tool for assisting in the analysis of the current technical basis for content of C/AS1 and the requirement for further research in specific areas. Of particular interest was to identify where supporting data exists, and thus areas of potential future research where the technical basis of the content of C/AS1 requires further strengthening for New Zealand applications.

This research is not intended as a comprehensive review of the validity of the content of C/AS1. The database is intended as a tool for future use in assisting with documenting background data to assess areas of potential future valuable research.

KEYWORDS

Acceptable Solution, performance, prescriptive, metric, fire safety, building code.

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Abbreviations

ASET	Available Safe Egress Time
BCA	Building Consent Authority
BIA	Building Industry Authority
C/AS1	New Zealand Building Code Fire Safety Clauses Acceptable Solution (2001)
DBH	Department of Building and Housing
FAD	Fractional Asphyxiant concentration Dose
FED	Fractional Effective Dose
FID	Fractional Irritant concentration Dose
FLED	Fire Load Effective Density
FRR	Fire Resistance Rating
FSP	Fire Safety Precaution
N/A	not applicable
NZBC	New Zealand Building Code
NZFS	New Zealand Fire Service
SQL	Structured Query Language
WG	Working Group, as assigned by BIA/DBH

1. INTRODUCTION

1.1 Motivation

At present, the New Zealand Building Code (NZBC) expresses required performance using qualitative statements. This sometimes leads to inconsistency in interpretations and over-reliance on the subjective judgements of both the designer and building consent authorities (BCAs). There is also a trend toward increasing levels of risk aversion by the BCAs toward Alternative Solutions which may serve to stifle innovation in the industry. Increasing the clarity and amount of quantification in the Code will reduce uncertainty in the building consent process and provide a more transparent process for developing both Alternative Solutions and Acceptable Solutions that are technically robust, and provide a more consistent basis for evaluating performance-based fire safety designs (alternative solutions).

Analysis of the technical content of NZBC Fire Safety Acceptable Solution (C/AS1) (2001) and identification of any inherent performance levels included or absent is required. The collation of assumptions and the technical basis for different parts of the Acceptable Solution (where known) would also be useful in aiding the prioritisation of future research.

1.2 Objective

The overall outcome of the project that this report is based on is to achieve New Zealand buildings that contain innovative fire safety solutions that are technically robust, of known performance, cost-effective and that meet the requirements of the NZBC and the societal expectations of New Zealanders.

The objective of this report is to summarise the current requirements of C/AS1 (2001) in order to provide a clearer basis for identifying and prioritising the parts of C/AS1 that lack quantitative measures of performance, or where quantitative measures are inadequate. This will ultimately lead to technical improvements to C/AS1 or any future compliance document that may replace it as well as provide better direction for the assessment of performance-based fire safety designs.

1.3 Scope

As far as practicable, available information on the background to paragraphs of the current NZBC Fire Safety Acceptable Solution (C/AS1) (2001) was incorporated into a structured query language (SQL) database. Background documents held by the Department of Building and Housing (DBH) and associated with the development of C/AS1, dating from approximately 1999 to the present, were the primary source of information. However it is acknowledged that there are many earlier documents associated with the development of the Approved Documents (C1, C2, C3, C4/AS1 1991). Sufficient details are currently included to demonstrate the value of a database as a tool for identifying areas where the technical basis is not strong or is lacking for the major aspects of the current version of C/AS1.

1.4 Summary of topics

First, the database developed for this compilation of C/AS1 (2001) background information is introduced. Summaries of the information gathered are then presented for areas of the document well supported with technical background, including performance metrics, test methods and other background information. Parts of C/AS1 where no, or limited, supporting background information was found are then summarised. Conclusions drawn from this collation of data are then discussed, followed by recommendations for future work.

2. C/AS1 BACKGROUND DATABASE

2.1 Data sources

The database utilises various C/AS1 (2001) background documents. Such documents include proposed C/AS1 text presented for public comment documents (from 1999 to the latest amendments), minutes and associated summary documents for BIA/DBH workgroups (from 1999 onwards), and other documents and associated papers researching areas specifically related to improvement of C/AS1 technical basis. The information summarised in this database is not representative of the totality of information used in the preparation of C/AS1 paragraphs. Information from documents associated with the review leading up to the 2001 version were included. This was deemed to reasonably capture the major aspects of the technical basis for C/AS1 (2001).

2.2 Database information

The SQL database incorporates details of the paragraphs of C/AS1 (2001) including performance metric and limiting values, relevant NZBC (1992) clause, background (where available directly) and details associated with errata and amendments. A major restructuring and renumbering of the compliance document occurred in 2001. Mapping of the paragraphs of C1, C2, C3 and C4/AS1 (1991) to the paragraphs of C/AS1 was performed, linking pre-2001 development work with the current version of the Acceptable Solution (2001). This enabled the inclusion of work produced by BIA/DBH Working Groups and revisions of the paragraphs of the previous version of the document (C1, C2, C3 C4/AS1 1991).

Examples of the information gathered for each of the paragraphs of C/AS1 (2001) are included in Appendix B.

3. SUMMARY OF PERFORMANCE METRICS AND VALUES

The metrics and values used in the development of C/AS1 (2001) are summarised first. Review of the NZBC Clauses C1–C4 leads us to propose six key high-level metrics to which the detailed requirements can be related back to.

Further details of these metrics and the background for these values are included in Appendix A.

3.1 Time to Untenable Conditions

Requirements influencing how quickly or how big the fire develops primarily affect the time available for escape–also known as available safe egress time (ASET). The fire environment is evaluated in terms of tenability or survivability and quantified using parameters such as temperature, smoke and toxic gas concentrations. A summary of the tenability metrics and descriptions of the limiting values is presented in Table 1 (WG6.8, Barnett et al 1998). Key metrics include exposure to radiant and convective heat, and concentration of smoke and combustion narcotic gases.

Table 1: Summary of tenability metrics proposed (WG6.8, Barnett et al 1998).

Description	Tenability metric	Limiting value(s)
Smoke obscuration	Visibility	Floor area < 100 m², 5 m Floor area > 100 m², 10 m
Travel velocity	Nominal travel velocity [a]	normal travel speed is 1.3 m/s emergency travel speed is 1.7 m/s assisted travel speed is 0.75 m/s, and assisted emergency travel speed is 0.85 m/s
Heat	Radiative heat	$t = 0.91(q - 1.7)^{-0.8}$ (3.1) where t is time in minutes to incapacitation due to heat induced injury and q is radiant heat flux in kW/m²
	Convective heat	$t = e^{(5.1849 - 0.0273T)}$ (3.2) where t is time in minutes to incapacitation due to heat induced injury and T is the local gas temperature in degrees Celsius
Asphyxiants	Fractional Effective Dose (FED) [b]	$FED_{incapacitation} = \frac{Dose\ received\ at\ time,\ t}{Dose\ needed\ to\ cause\ incapacitation}$ (3.3) FEDs for various gases can be combined, however FEDs for gases and heat must be considered separately

Notes:
a. Nominal travel velocity is assumed when conditions are better than the tenability limits.
b. Equations for calculating times required for determining the FED are included in Appendix A.

3.2 Time to Escape

Many of the compliance document requirements for means of escape relate to parameters that affect the time required for occupants to escape. Obvious parameters include number of exits, width and length of escape routes, but there are also many requirements that are less quantifiable but are concerned with complexity and arrangement of escape routes, and features that make the escape routes safer and easier to use (e.g. signage, handrails, lighting etc).

The original maximum permitted path lengths (C2/Table 3 1992 and C/AS1 Table 3.3 2001) were developed on an *ad hoc* basis using travel velocities of 18 m/min in open paths and 12 m/min in dead ends. The open path lengths were taken as the distance able to be traversed in 2.5 minutes and the dead end open path lengths as the distance able to be traversed in 1 minute, which is consistent with previous travel distance limits (BRE 1992, NZ 1900:Chapter 5 1988, Scottish Executive 1990). These values were deemed a sound combination of 'non-movement'/'pre-travel' and 'travel' time for firecells with no automatic alarms (WG6.8). The path lengths were determined from travel speed and occupant densities, with safety factors used for different Purpose Groups (WG6.23.1 and WG6.8.5). A summary of the details of the WG6.8 considerations associated with establishing time to escape is included in Appendix A.

3.3 Reasonable Expectations of Fire-fighters

Some compliance document requirements relate to the needs of the Fire Service to undertake search and rescue activities. While time needed to undertake search and rescue, and tenability criteria for fire-fighters, are appropriate metrics, there are also other less quantifiable factors such as the predictability of building performance (e.g. warning of impending collapse),

providing access around buildings, providing sufficient water for fire fighting purposes, providing control panels and hydrants in locations where fire-fighters would expect them to be. We have grouped all these requirements in a metric called 'reasonable expectations of fire-fighters'.

Tenability criteria for fire fighters are expected to be different from the criteria for escaping or stay-in-place occupants. Performance values for the tenability for fire fighter intervention was not found during this literature review. However performance criteria would be useful in future analysis of alternative designs and appropriateness of C/AS1 requirements.

3.4 Fire Spread to Other Property, Household Units & Other Residential Units

Provisions intended to restrict the spread of fire (other than those associated with providing protected escape routes from a building) are for the purpose of protecting other property, household units and other residential units from damage.

For the purpose of assessing separation distance between buildings, a 'Limiting Distance' method (Barnett et al 2002) was used that specified maximum acceptable radiation flux values of 30 kW/m² on the relevant boundary and 16, 17 and 18 kW/m² at 1 m beyond relevant boundary for FHC 3, 2, 1 respectively. Non-fire rated parts of external walls are assumed to act as radiators and the received radiation is calculated on the relevant boundary and at 1 m beyond the relevant boundary. The emitted radiation was assumed to be 87.6 kW/m², 108.4 kW/m² and 151.6 kW/m² for FHC 1, 2 and 3/4 respectively. These values correspond to the radiation from a black body at the temperature in a fire resistance furnace at 30, 60 and 90 minutes respectively with gas emissivity 0.95. It was noted that horizontal flame projection from openings was ignored, and that received radiation values (16–18 kW/m²) may not be low enough to prevent ignition after extended periods of exposure and fire service intervention was indicated as being likely required in many cases to prevent ignition (Barnett et al 2002).

Other key second-level metrics include resistance to internal fire spread using fire resistance ratings, smoke developed and spread of flame indices. Fire spread on external surfaces is limited by extent of vertical fire spread distance or by rate of heat release.

3.5 Safeguard the environment

Objective C3.1 d) of the first schedule of the Building Regulations 1992, specifically addresses safeguarding the environment from the adverse affects of fire. The corresponding functional requirement says 'Significant quantities of hazardous substances are not released into the environment during fire' however this only applies to buildings where significant quantities of hazardous substances are stored and processed.

There are very few requirements in the compliance document that we can attribute to this code objective.

3.6 Outbreak of Fire

The performance requirements of Clause C1 (C1.1) of the first schedule of the Building Regulations 1992 are concerned only with the safe installation of fixed appliances. This metric is primarily addressed in Part 9 of the compliance document.

4. C/AS1 METRICS, CRITERIA AND BUILDING CODE CLAUSES

A summary of the performance metrics and performance criteria, and the NZBC (1992) clauses associated with paragraphs of C/AS1 (2001) and the associated metrics and values that apply, is presented in this section. The order in which topics arise in C/AS1 has been used to maintain consistency with the document and familiarity of users.

A summary of selected C/AS1 paragraphs with performance metrics, criteria and values is included in Appendix C.

4.1 Occupant numbers, Purpose Groups & Fire Hazard Categories

This section contains information on Purpose Group definitions, Fire Hazard Categories and Occupant Densities. This section of C/AS1 is primarily initialising the definitions and values of parameters required for use in the remainder of the document. There is therefore little direct correlation with individual clauses of NZBC (1992), and there are only a few paragraphs with performance metrics or criteria.

For example, paragraphs 2.2.1 and 2.2.10 (C/AS1, 2001) have a metric of Fire Load Energy Density (FLED) MJ/m², where (see Appendix C for more details):

- FHC 1: FLED = 0 – 500 MJ/m²,
- FHC 2: FLED = 501–1000 MJ/m²,
- FHC 3: FLED = 1001–1500 MJ/m², and
- FHC 4: FLED > 1500 MJ/m².

4.2 Means of escape

The C/AS1 (2001) paragraphs associated with means of escape (Part 3) include prescriptive values for such parameters as number, size (width and height), length, and fire protection for occupants (using separation by distance or fire rated construction) of escape routes. The overall performance metric used for determining the C/AS1 requirements for means of escape is time to escape (as discussed in Section 3.2), where the performance value is governed by tenability criteria (as discussed in Section 3.1). Recommended test or evaluation methods and assumptions (including underlying assumptions about fire scenarios and fire sizes) to determine time to escape were not specifically listed in the background documents.

The relevant performance clauses of NZBC (1992) that the means of escape paragraphs (Part 3) of C/AS1 fulfil are primarily:

For descriptions of escape routes:

- C2.3.1 The number of open paths available to each person escaping to an exitway or final exitway or final exit shall be appropriate to: a) the travel distance, b) the number of occupants, c) the fire hazard, and d) the fire safety systems installed in the firecell.
- C2.3.2 The number of exitways or final exits available to each person escaping to an exitway or final exitway or final exit shall be appropriate to: a) the travel distance, b) the number of occupants, c) the fire hazard, and d) the fire safety systems installed in the firecell.

- C2.3.3 Escape routes shall be: a) of adequate size for the number of occupants, b) free of obstruction in the direction of escape, c) of length appropriate to the mobility of the people using them, d) resistant to the spread of fire as required by C3 'Spread of Fire', e) easy to find as required by Clause F8 'Signs', f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and g) easy and safe to use as required by Clause D1.3.3 'Access Routes'.

For protection of occupants from the spread of fire (complying with C2.3.3 d):

- C3.3.1 Interior surface finishes on walls, floors, ceilings and suspended building elements shall resist the spread of fire and limit the generation of toxic gases, smoke and heat, to a degree appropriate to: a) the travel distance, b) the number of occupants, c) the fire hazard, and d) the active fire safety systems installed in the building.

- C3.3.2 Fire separations shall be provided within buildings to avoid the spread of fire and smoke to: a) other firecells, b) spaces intended for sleeping, c) household units within the same building or adjacent buildings, and d) other property.

- C3.3.5 External walls and roofs shall have resistance to the spread of fire, appropriate to the fire load within the building and to the proximity of other household units, other residential units and other property.

- C3.3.6 Automatic fire suppression systems shall be installed where people would otherwise be: a) unlikely to reach a safe place in adequate time because of the number of storeys in the building, b) required to remain within the building without proceeding directly to a final exit, or where the evacuation time is excessive, c) unlikely to reach a safe place due to confinement under institutional care because of mental or physical disability, illness or legal detention, and the evacuation time is excessive, or d) at high risk due to the fire load and fire hazard within the building

- C3.3.9 The fire safety systems installed shall facilitate the specific needs of fire service personnel to: a) carry out rescue operations, and b) control the spread of fire.

Examples of summaries of the associated NZBC (1992) performance clauses and performance metrics are available via the database (BRANZ, 2007).

4.3 Requirements for firecells

The C/AS1 (2001) paragraphs associated with requirements for firecells (Part 4) include prescriptive values for such parameters as number, area of firecells, and fire safety precautions (FSPs) required for firecells and buildings.

The overall performance metric used for determining the C/AS1 (2001) requirements for firecells is time to escape (as discussed in Section 3.2), where the performance value is governed by tenability criteria (as discussed in Section 3.1). Similarly, a recommended guideline (‘test method’) for investigating the performance metric and then determining the appropriate value for the firecell or building to compare to the criteria is not prescribed. Furthermore, the majority of the requirements of Part 4 are qualitative, especially FSPs).

The relevant clauses of NZBC (1992) that Part 4 of C/AS1 fulfil are primarily:

For protection of escaping occupants:

- C2.3.3 Escape routes shall be: a) of adequate size for the number of occupants, b) free of obstruction in the direction of escape, c) of length appropriate to the mobility of the people using them, d) resistant to the spread of fire as required by C3 'Spread of Fire', e) easy to find as required by Clause F8 'Signs', f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and g) easy and safe to use as required by Clause D1.3.3 'Access Routes'.

For protection of occupants (and fire-fighters) from the spread of fire:

- C3.3.2 Fire separations shall be provided within buildings to avoid the spread of fire and smoke to: a) other firecells, b) spaces intended for sleeping, c) household units within the same building or adjacent buildings, and d) other property.

- C3.3.6 Automatic fire suppression systems shall be installed where people would otherwise be: a) unlikely to reach a safe place in adequate time because of the number of storeys in the building, b) required to remain within the building without proceeding directly to a final exit, or where the evacuation time is excessive, c) unlikely to reach a safe place due to confinement under institutional care because of mental or physical disability, illness or legal detention, and the evacuation time is excessive, or d) at high risk due to the fire load and fire hazard within the building.

- C3.3.8 Where an automatic smoke control system is installed, it shall be constructed to: a) avoid the spread of fire and smoke between firecells, and b) protect escape routes from smoke until the occupants have reached a safe place.

- C3.3.9 The fire safety systems installed shall facilitate the specific needs of fire service personnel to: a) carry out rescue operations, and b) control the spread of fire.

For protection of occupants from structural collapse:

- C4.3.1 Structural elements of buildings shall have fire resistance appropriate to the function of the elements, the fire load, the fire intensity and the fire hazard, the height of the buildings and the fire control facilities external to and within them.

- C4.3.2 Structural elements shall have a fire resistance of no less than that of any element to which they provide support within the same firecell.

A summary of all C/AS1 (2001) paragraphs with performance metrics, criteria and values is included in Appendix C. More data is available via the database (BRANZ, 2007).

4.4 Fire resistance ratings

The C/AS1 (2001) paragraphs associated with fire resistance ratings (FRRs) (Part 5) include prescriptive values for such parameters as FRRs of specific building components (e.g. separation of sleeping groups, intermediate floors, glazing etc), and F and S ratings of firecells. The overall performance metrics used for determining the C/AS1 (2001) prescriptive criteria for FRRs are time to escape (as discussed in Section 3.2), where the performance values are governed by tenability criteria (as discussed in Section 3.1), reasonable expectation of fire-fighters (as discussed in Section 3.3) and fire spread to other property and household units (as discussed in Section 3.4).

The relevant performance clauses of NZBC (1992) that Part 5 of C/AS1 (2001) fulfil are primarily:

For protection of occupants, fire fighters and other property from the spread of fire:

- C3.3.2 Fire separations shall be provided within buildings to avoid the spread of fire and smoke to: a) other firecells, b) spaces intended for sleeping, c) household units within the same building or adjacent buildings, and d) other property.

- C3.3.6 Automatic fire suppression systems shall be installed where people would otherwise be: a) unlikely to reach a safe place in adequate time because of the number of storeys in the building, b) required to remain within the building without proceeding directly to a final exit, or where the evacuation time is excessive, c) unlikely to reach a safe place due to confinement under institutional care because of mental or physical disability, illness or legal detention, and the evacuation time is excessive, or d) at high risk due to the fire load and fire hazard within the building.

- C3.3.8 Where an automatic smoke control system is installed, it shall be constructed to: a) avoid the spread of fire and smoke between firecells, and b) protect escape routes from smoke until the occupants have reached a safe place.

- C3.3.9 The fire safety systems installed shall facilitate the specific needs of fire service personnel to: a) carry out rescue operations, and b) control the spread of fire.

For protection of people and household units and other property (due to loss of structural stability):

- C4.3.1 Structural elements of buildings shall have fire resistance appropriate to the function of the elements, the fire load, the fire intensity and the fire hazard, the height of the buildings and the fire control facilities external to and within them.

- C4.3.2 Structural elements shall have a fire resistance of no less than that of any element to which they provide support within the same firecell.

- C4.3.3 Collapse of elements having lesser fire resistance shall not cause the consequential collapse of elements required to have a higher fire resistance.

A summary of all C/AS1 (2001) paragraphs with performance metrics, criteria and values is included in Appendix C. More data is available via the database (BRANZ, 2007).

4.5 Control of internal fire and smoke spread

The C/AS1 (2001) paragraphs associated with control of internal fire and smoke spread (Part 6) include prescriptive values for such parameters as fire and smoke separation of Purpose Groups, firecell construction, closures, surface finishes and smoke control requirements for intermediate floors and atriums.

The overall performance metrics used for determining the C/AS1 (2001) prescriptive criteria for control of internal fire and smoke spread are time to escape (as discussed in Section 3.2), where the performance values are governed by tenability criteria (as discussed in Section 3.1), reasonable expectation of fire-fighters (as discussed in Section 3.3) and spread to other property and household units (as discussed in Section 3.4).

The relevant clauses of NZBC (1992) that Part 6 of C/AS1 (2001) fulfil are primarily:

For protection of occupants, fire fighters and other property from the spread of fire:

- C3.3.2 Fire separations shall be provided within buildings to avoid the spread of fire and smoke to: a) other firecells, b) spaces intended for sleeping, c) household units within the same building or adjacent buildings, and d) other property.

- C3.3.6 Automatic fire suppression systems shall be installed where people would otherwise be: a) unlikely to reach a safe place in adequate time because of the number of storeys in the building, b) required to remain within the building without proceeding directly to a final exit, or where the evacuation time is excessive, c) unlikely to reach a safe place due to confinement under institutional care because of mental or physical disability, illness or legal detention, and the evacuation time is excessive, or d) at high risk due to the fire load and fire hazard within the building.

- C3.3.8 Where an automatic smoke control system is installed, it shall be constructed to: a) avoid the spread of fire and smoke between firecells, and b) protect escape routes from smoke until the occupants have reached a safe place.

- C3.3.9 The fire safety systems installed shall facilitate the specific needs of fire service personnel to: a) carry out rescue operations, and b) control the spread of fire.

For protection of people and household units and other property (due to loss of structural stability):

- C4.3.1 Structural elements of buildings shall have fire resistance appropriate to the function of the elements, the fire load, the fire intensity and the fire hazard, the height of the buildings and the fire control facilities external to and within them.

- C4.3.2 Structural elements shall have a fire resistance of no less than that of any element to which they provide support within the same firecell.

- C4.3.3 Collapse of elements having lesser fire resistance shall not cause the consequential collapse of elements required to have a higher fire resistance.

Examples of summaries of the associated NZBC (1992) clauses and performance metrics are available via the database (BRANZ, 2007).

4.6 Control of external fire spread

The C/AS1 (2001) paragraphs associated with control of external fire spread (Part 7) include requirements for external walls and fire properties of exterior surface finishes.

The overall performance metric used for determining the C/AS1 (2001) requirements for control of external fire spread is fire spread to other property, household units and other residential units (as discussed in Section 3.4), predominantly via received radiation flux.

The relevant performance clauses of NZBC (1992) that Part 7 of C/AS1 (2001) are primarily:

For protection of occupants, fire fighters and other property from the spread of fire:

- C3.3.5 External walls and roofs shall have resistance to the spread of fire, appropriate to the fire load within the building and to the proximity of other household units, other residential units and other property.

- C3.3.6 Automatic fire suppression systems shall be installed where people would otherwise be: a) unlikely to reach a safe place in adequate time because of the number of storeys in the building, b) required to remain within the building without proceeding directly to a final exit, or where the evacuation time is excessive, c) unlikely to reach a safe place due to confinement under institutional care because of mental or physical disability, illness or legal detention, and the evacuation time is excessive, or d) at high risk due to the fire load and fire hazard within the building.

- C4.3.1 Structural elements of buildings shall have fire resistance appropriate to the function of the elements, the fire load, the fire intensity and the fire hazard, the height of the buildings and the fire control facilities external to and within them.

Examples of summaries of the associated NZBC (1992) clauses and performance metrics are available via the database (BRANZ, 2007).

4.7 Fire fighting

The C/AS1 (2001) paragraphs associated with fire fighting (Part 8) include requirements for such parameters as fire service vehicle access and fire fighting facilities.

The overall performance metric used for determining the C/AS1 requirements for fire fighting requirements is reasonable expectation of fire fighters (as discussed in Section 3.3).

The relevant performance clauses of NZBC (1992) that the fire fighting requirement paragraphs of C/AS1 fulfil are primarily:

For protection of occupants, fire fighters and other property from the spread of fire:

- C3.3.9 The fire safety systems installed shall facilitate the specific needs of fire service personnel to: a) carry out rescue operations, and b) control the spread of fire.

Examples of summaries of the associated NZBC (1992) clauses and performance metrics are available via the database (BRANZ 2007).

4.8 Outbreak of fire

The C/AS1 (2001) paragraphs associated with the prevention of the outbreak of fire (Part 9) include requirements for such parameters as installation requirements for fixed appliances.

The overall performance metric used for determining the C/AS1 prescriptive criteria for prevention of the outbreak of fire is received heat transfer (via conduction, convection or radiation) and ventilation (as discussed in Section 3.6).

The relevant clauses of NZBC (1992) that the prevention of the outbreak of fire paragraphs of C/AS1 fulfil are primarily:

For protection of occupants from outbreak of fire:

- C1.3.1 Fixed appliances and services shall be installed so as to avoid the accumulation of gases within the installation and in building spaces, where heat or ignition could cause uncontrolled combustion or explosion.

- C1.3.2 Fixed appliances shall be installed in a manner that does not raise the temperature of any building element by heat transfer or concentration to a level that would adversely affect its physical or mechanical properties or function.

Data is available via the database (BRANZ, 2007).

5. SUMMARY OF BACKGROUND INFORMATION AVAILABLE

As far as practicable, available information on the background of the basis for paragraphs of the current C/AS1 (2001) was incorporated into the database. Sources of information included minutes of meetings and work summaries of BIA/DBH Working Groups, explanations of proposed text changes for previous versions of the Acceptable Solution (Approved Documents C1, C2, C3 and C4/AS1 1991), and explanations of amendments to the current version.

This collated background information is useful for providing a commentary of the formulation of the current C/AS1 (2001) requirements. This will be useful when investigating specific aspects or values of C/AS1.

From the data sources used for the population of the database, there were some parts of the document where significant amounts of information were available (such as means of escape and control of external fire spread), other areas where limited information was found (requirements for firecells, FRRs and internal fire and smoke control), and some specific topics where information was not found. This is not to say that this information does not exist, but that it was not available at the time of the compilation of this report or not included in the scope of the literature search (i.e. prior to 1999). Examples of the information available in the database are included in Appendix B.

6. NZBC FIRE SAFETY CLAUSES AND C/AS1 PARAGRAPHS

While mapping individual paragraphs of C/AS1 (2001) to the fire safety performance clauses of the NZBC (1992), as summarised in Section 3.5, it became evident that there are no provisions specifically covering the objective, “C3.1 d) Safeguard the environment from adverse effects of fire” (NZBC 1992) beyond general requirements for the containment of hazardous material stored or processed (e.g. specific FHC 4 requirements). In addition there were no performance metrics or criteria found in the background literature for environmental protection or sustainability.

7. CONCLUSIONS

The conclusions from this work include:

- Background information for the development of C/AS1 (2001) paragraphs and sections is difficult to identify and locate. Therefore a formal compilation of this information is highly useful as an initial resource for the future developments of C/AS1.

- Information collated in the database is not comprehensive. Cross-checking with individuals involved in the development of C/AS1 (2001) may provide additional insight.

- More thorough analysis of specific aspects and individual paragraphs of C/AS1 (2001) is required to identify and prioritise the parts of C/AS1 that lack quantitative measures of performance, or where quantitative measures are inadequate, ultimately leading to technical improvements to C/AS1. However the database produced, as part of this research, is a useful tool that will shorten the lead-in time required to determine useful prior research.

- Methodology for assessing tenability for occupant life safety for a known fire environment is reasonably well developed and internationally accepted (e.g. ISO/TS 13571), subject to the accuracy of the methods used to calculate the expected fire environment. Tenability acceptance criteria should be explicitly stated for both performance-based design and for evaluation of the acceptable solution compliance document.

- Assumptions implicit within the compliance document concerning the size and characteristics of fires for design purposes are unknown (with a few exceptions). These assumptions must be stated before a rigorous assessment of the compliance document against Building Code objectives can be done. Similarly standard design fires are desirable for performance-based design to ensure a consistent approach nationwide to assessing the adequacy of a fire design.

- It is unlikely that all compliance document requirements can be easily related back to a quantitative performance metric. Examples would include features of escape routes that make them easier to use (signage, use of hold-open devices) or some reasonable expectations of fire-fighters (e.g. locations of fire control panels and hydrants).

7.1 Recommendations for future work

7.1.1 Database population

It is recommended that as new amendments and reviews of C/AS1 (2001) are issued, the results are incorporated into this database. This will assist in maintaining a useful tool to help facilitate further analysis of the technical requirements of the compliance document and identification of aspects requiring further research.

Access to this database is currently restricted. However, it may be useful in future to develop a read-only web-interface to the database for public access. Further development of the data-entry interface is also recommended for ease of use by approved users.

7.1.2 Areas suggested for research

Based on this preliminary analysis of the background to C/AS1 (2001), important research topics suggested for future investigation include:

- Metrics and criteria to enable the incorporation of environmental aspects of fire safety in C/AS1 (2001), in accordance with C3.1.d (NZBC 1992), as well as the sustainability provisions supporting the new principles of the Building Act 2004.

- Metrics for assessing the fire hazards of interior surface finishes should be updated. Previous research (Collier et al, 2006) has already suggested an alternative approach for inclusion in the compliance document.

- Development of recommended/standard/guidance ('test methods') to use to challenge firecells and buildings for determining performance metrics values. This will assist in the analysis of performance-based designs and the ensuring the appropriateness of specific prescriptive requirements of C/AS1 (2001). Published performance criteria would also assist in future analyses.

- Performing a comprehensive analysis of C/AS1 (2001) requirements using the agreed upon performance metrics, test methods and criteria for performance-based designs, when these become available. Such an analysis will provide a baseline comparison of the performance criteria and the values achieved using prescriptive requirements of C/AS1 and will assist in determining the appropriateness of the prescriptive values.

- Those parts of the compliance document where solutions are not provided and requiring specific design should be reviewed and suitable requirements developed for inclusion in the compliance document. This will help to more clearly distinguish between the acceptable solutions and alternative solutions.

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8.2 General references

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9. APPENDIX A: DETAILS OF COLLATED INFORMATION RELATED TO THE TECHNICAL BASIS FOR C/AS1 PARAGRAPHS

9.1 Tenability criteria – Summary of WG6.8 recommendations

The following tenability criteria were proposed as a result of WG6.8 and Barnett et al (1998). These criteria were not applied to the development of the content of C/AS1 (2001). This summary is included for comparison with the proposed criteria of ISO/DIS 1371 (2006), which is included in Section A.2.

9.1.1 Smoke obscuration

- For room areas less than or equal to 100 m², minimum visibility required is 5 m.
- For room areas greater than 100 m², minimum visibility required is 10 m.
    - If flashing illuminated exit signs are used, the 10 m limit can be halved.

9.1.2 Travel velocities

- If visibility is greater than the above limits, then effects on travel are zero:
    - normal travel speed is 1.3 m/s
    - emergency travel speed is 1.7 m/s
    - assisted travel speed is 0.75 m/s, and
    - assisted emergency travel speed is 0.85 m/s.

The relationship between visibility less than the above limits and travel velocity in irritant smoke and non-irritant smoke is presented in Table 2.

Table 2: Travel speeds in irritant and non-irritant smoke with decreasing visibility (extracted from Barnett et al 1998).

Visibility (m)	Travel velocity in irritant smoke (m/s)	Travel velocity in non-irritant smoke (m/s)
>= 3.0	1.2	1.2
> 2.5	0.75	0.97
> 2.0	0.3	0.75
> 1.5	0.3	0.52
> 1.0	0.3	0.3

9.1.3 Heat

- Radiative heat:
    - Threshold of radiative heat induced injury (WG6.8)
        - $t = 0.91(q - 1.7)^{-0.8}$ (9.1)
        - where CO, CO_2, HNC and $O_{2,depletion}$ exposure doses are measured in parts per million, where the tenability limit is FID = 1,

          where t is time in minutes to incapacitation due to heat induced injury and q is radiant heat flux in kW/m².

- Convective heat
  - Threshold of convective heat induced injury (WG6.8)
    - $t = e^{(5.1849 - 0.0273T)}$ (9.2)
    - where t is time in minutes to incapacitation due to heat induced injury and T is the local gas temperature in degrees Celsius.

9.1.4 Asphyxiant and irritant gases

- For asphyxiants gases:
  - Fractional Irritant concentration Dose (FID)
    - $FID = \frac{CO}{15000} + \frac{CO_2}{25} + \frac{HCN}{5500} + \frac{O_{2,depletion}}{45}$ (9.3)
    - where CO, CO_2, HNC and $O_{2,depletion}$ exposure doses are measured in parts per million, where the tenability limit is FID = 1,
  - Low oxygen hypoxia
    - Threshold of steady state low oxygen (Purser 1988):
      - $t = e^{(8.13 - 0.54(20.9 - O_2))}$ (9.4)
      - where t is time in minutes to loss of consciousness, and O_2 is oxygen percentage.
  - Carbon dioxide
    - Threshold of steady state carbon dioxide (Purser 1988):
      - $t = e^{(6.1623 - 0.5189CO_2)}$ (9.5)
      - where t is time in minutes to loss of consciousness and CO_2 is carbon dioxide percentage.
    - Carbon dioxide increases the respiratory minute volume, which will increase the rate of uptake of other toxic gases:
      - $k = e^{(0.246CO_2 - 1.9086)}$ (9.6)
      - where k is the multiplication factor on other gases, and CO_2 is the percentage of carbon dioxide.
  - Carbon monoxide
    - Threshold of steady state carbon monoxide:
      - $t = \frac{COHb}{3.32 \times 10^{-5} CO^{1.036} RMV}$ (9.7)
      - where t is time in minutes to loss of consciousness, COHb is carbon monoxide haemoglobin in percent (20% at rest, 30% light work, 40% heavy work), CO is carbon monoxide percentage, and RMV is volume of air breathed in l/min.
      - This is useful for most fire situations, except smouldering fires.

- Hydrogen cyanide
  - Threshold of steady state hydrogen cyanide:
    - $t = e^{(5.396 - 0.023 HCN)}$ (9.8)
    - where t is time in minutes to loss of consciousness and HCN is hydrogen cyanide percentage.

- For irritant gases:
  - Fractional Irritant concentration Dose (FID)
    - $FID = \frac{HCl}{200} + \frac{HBr}{200} + \frac{HF}{120} + \frac{SO_2}{30} + \frac{NO_2}{80} + \frac{acrolien}{2}$ (9.9)
    - where irritant concentrations are measured in ppm and the tenability limit is FID = 1.

9.1.5 Overall

An estimate of the tenability limit for use with design fires that do not include irritant gas concentrations is 0.2 OD/m (Jin 1976). Another approach is an FED method:

$$FED_{incapacitation} = \frac{Dose\ received\ at\ time, t}{Dose\ needed\ to\ cause\ incapacitation} \quad (9.10)$$

FEDs for various gases can be combined and FEDs for different measures of heat exposure can be combined. However, FEDs for gases and heat must be considered separately.

Furthermore, the overall safety factor used in fire safety in New Zealand was 2.0 (Barnett et al 1998).

9.2 Tenability criteria – Summary of ISO/DIS 1371

Table 3 summarises the criteria proposed in the draft standard ISO/DIS 1371 (2006).

Table 3: Summary of tenability criteria proposed in ISO/DIS 1371 (2006).

	Tenability Metric	Limiting Value(s)
Visual obscuration due to smoke	Visual Contrast	$c_v = e^{(-\sigma ML)}$ (9.11) where σ is the mass specific extinction coefficient for smoke aerosol (m^2/g), M is the mass concentration of smoke aerosol (g/m^3), and L is the smoke-filled distance between an object and the viewer (m). Minimum detectable contrast is 0.02.
Exposure to radiant and convected heat	Time to Incapacitation by Radiative Heat	The criteria is approximately 2.5 kW/m^2, below this exposure can be sustained for approximately 30 min. Above this limit: $t_{rad} = 6.9q^{-1.56}$ (9.12) where t is time in minutes to 2nd degree skin burns, and q is radiant heat flux in kW/m^2.
	Time to Incapacitation by Convective Heat	$t_{conv} = e^{\left(4.1\times10^8 T^{-3.61}\right)}$ (9.13) where t is time in minutes to incapacitation due to heat induced injury for a fully clothed subject, and T is the local gas temperature (°C), and $t_{conv} = e^{\left(5\times10^7 T^{-3.4}\right)}$ (9.14) where t is time in minutes to incapacitation due to heat induced injury for a unclothed or lightly clothed subject, and T is the local gas temperature (°C).
	Fractional Effective Dose (FED)	$FED = \begin{cases} \sum_{t_1}^{t_2}\left(\frac{1}{t_{conv}}\right)\Delta t, & if\ q < 2.5\ kW/m^2 \\ \sum_{t_1}^{t_2}\left(\frac{1}{t_{rad}}+\frac{1}{t_{conv}}\right)\Delta t, & if\ q \geq 2.5\ kW/m^2 \end{cases}$ (9.15) Where $\Delta t = t_2 - t_1$ is the time increment of interest (min), and FED = 1 is the limiting criteria.
Inhalation of Asphyxiant gases	Fractional Effective Dose (FED)	$FED = \begin{cases} \sum_{t_1}^{t_2}\frac{\varphi_{CO}}{35000}\Delta t + \sum_{t_1}^{t_2}\frac{\exp(\varphi_{HCN}/43)}{220}\Delta t, & if\ CO_2 \leq 2\%volume \\ \left(\sum_{t_1}^{t_2}\frac{\varphi_{CO}}{35000}\Delta t + \sum_{t_1}^{t_2}\frac{\exp(\varphi_{HCN}/43)}{220}\Delta t\right)\exp\left(\frac{\varphi_{CO_2}}{5}\right), & if\ CO_2 > 2\%volume \end{cases}$ (9.16) Where $\Delta t = t_2 - t_1$ is the time increment of interest (min), φ_{CO} is the average concentration of CO over the time increment (µL/L), φ_{HCN} is the average concentration of HCN over the time increment (µL/L), φ_{CO_2} is the average concentration of CO_2 over the time increment (µL/L), and FED = 1 is the limiting criteria
Exposure to sensory/upper respiratory irritants	Fractional Effective Concentration (FEC)	$FEC = \frac{\varphi_{HCl}}{1000} + \frac{\varphi_{HBr}}{1000} + \frac{\varphi_{HF}}{500} + \frac{\varphi_{SO_2}}{150} + \frac{\varphi_{NO_2}}{250} + \frac{\varphi_{acrolien}}{30} + \frac{\varphi_{formaldehyde}}{250} + \sum\frac{\varphi_i}{F_i}$ (9.17) where φ is average irritant gas concentration (µL/L), and FEC = 1 is the limiting criteria.

9.3 Time to escape (WG6.8)

This information was collated from the minutes of WG6.8. Summarised considerations of WG6.8 follow.

NZ 1900:Chapter 5 used exitway widths based on a flow capacity of 40 persons/minute/unit of (human) width (WG 6.8).

For smaller firecells:

- tenability time reduces
- chances of seeing, hearing or smelling fire increases, so pre-movement time decreases
- smaller firecells tend to be controlled by dead end lengths and evacuation time reduces to 1.0 min.

For larger firecells:

- tenability time increases
- chances of seeing, hearing or smelling fire or smoke decreases, awareness of hazard decreases, and travel starts later
- larger firecells tend to be controlled by open path lengths and evacuation times increase to 2.5 min.

9.3.1 Travel velocities for different densities

Travel velocities associated with different densities:

- low density occupancies can have travel speeds up to 73 m/min
- high density occupancies (4–5 people/m²) creates a crowd standstill.

The time to escape was considered for several situations. Points of consideration for total travel time were 1) detection time, 2) pre-travel time, 3) travel time, and 4) time remaining between nominal time and reaching tenability limit. The FIRECALC ASETBX program was used. A simplistic closed room was assumed with a small vent around the bottom of the walls.

9.3.2 Comparison of detection times

Assumptions for the modelling were:

- Tenability limit was based on either:
    - smoke visibility (10 m) with a smoke layer threshold (eye-level) at 1.5 m, or
    - smoke temperature (80ºC).
- A moderate fire growth curve.
- For human detection: detection occurs when smoke layer is 10% of the stud height and an alert human being is in the room of fire origin.

- Time for 'human detection' plus 1.0 min and plus 2.5 min was used for comparison with the automatic detection scenarios. Time for human detection formed the baseline for alert occupants and no automatic alarms.

- 150 m² is associated with 24 m of dead end travel (2 sides of a 12 m square room, 24 m DEOP for WL).

- Smoke detectors: spacing of 9 m between detectors; detection should happen sooner than compared to the layer over the whole firecell; 200 mm smoke layer in 81 m² (worst radial distance of 6.4 m).

- Heat detectors: rated at 57ºC, worst radial distance of 4.3 m (36 m²).

- Rapid response sprinkler: rated at 57ºC, RTI 50, worst radial distance of 2.1 m (9 m²).

- Standard sprinkler: rated at 57ºC, RTI 250, worst radial distance of 2.1 m (9 m²).

Table 4: Model results for threshold floor areas for various methods of detection in unsprinklered firecells (WG6.8).

Stud height for unsprinklered firecell (m)	Threshold floor areas for first method of detection
3.0	<430 m² for smoke detection compared to heat detection >430 m² for heat detection compared to smoke detection <500 m² human detection was faster than automatic detection <800 m² human detection was faster than heat detection <600 m² human detection was faster than rapid response sprinkler <1200 m² human detection was faster than standard sprinkler
6.0	smoke detection always faster than heat detection <500 m² human detection was faster than automatic detection <800 m² human detection was faster than heat detection <600 m² human detection was faster than rapid response sprinkler <1200 m² human detection was faster than standard sprinkler

Table 5: Comparative times to detection, using alert human detection as the baseline (WG6.8).

Detection method	Time to detection (s)	Acceptable increase compared to 'alert human detection'
Human	Used as baseline	N/A
Smoke	~53	+100%
Heat	~175	+20% for >500 m²
Rapid response sprinkler	~160	+100% for >300 m²
Standard sprinkler	~250	+100% for >500 m²
Standard sprinklers and smoke detectors combined	Increase in time remaining until tenability limits are reached is increased dramatically. This combination gives the best results.	100% + 100% = 200% would be acceptable
Standard sprinklers and heat detectors combined	The increase in time remaining until tenability limits are reached is only slightly increased, but still better than either system individually.	20% + 100 % = 120% was deemed reasonable for >400 m²

For sleeping occupancies compared to alert occupancies, the allowable increases for installed automatic alarms should only be half of the allowable increases for alert occupants and only apply for added sprinklers.

Other tenability studies have been carried out with similar results for three room sizes (12, 108, 1024 m²), using conservative tenability limits considered (10 m visibility, 80ºC).

NFPA Life Safety Code only allows concessions for sprinklers (not heat or smoke detectors). Furthermore, acceptable increases are from 25 to 52% for sprinklers (compared to 50 to 100%).

9.3.3 Overall WG6.8 conclusions

A summary of the overall conclusions presented by WG6.8 includes:

- For low density and alert occupancies (e.g. WL):
    - No need to limit concessions based on firecell areas, because if the human detection baseline case is acceptable without automatic detection then it should also be acceptable with automatic detection.
    - 20% for heat detectors and 100% for smoke detectors seems reasonable.

- For WL, WM and WH:
    - Combination increases of 100% + 100% = 200% for smoke detectors and sprinklers seem reasonable.
    - Combination increases of 20% + 100% = 120% for heat detectors and sprinklers.
- For sleeping Purpose Groups:
    - Half that of low density and alert occupancies:
        - 10% for heat detectors
        - 50% for smoke detectors
        - 50% for sprinklers.
    - Combinations are allowed.
    - Maximum combinations:
        - no greater than 2x for assembly and sleeping Purpose Groups
        - no greater than 3x for low occupant density Purpose Groups.
- No further increases for occupant densities less than 0.05 persons/m², as design travel speeds will not increase from 73 m/min.

10. APPENDIX B: EXAMPLES OF SUMMARIES OF SELECT DATABASE ENTRIES

Following are examples of summaries of the database entries (as at 30 March 2007) for select paragraphs of C/AS1 (2001).

paragraph P2.2.1

content Table 2.1 shall be used to determine the purpose group appropriate to the activity, and the fire hazard category (FHC). When a specific activity is not shown in Table 2.1, the nearest suitable purpose group and fire hazard category must be chosen.

COMMENT:
1. The purpose group is used as an entry point to several parts of this acceptable solution, e.g. when determining the number and size of exitways and other fire safety precautions.

2. The fire hazard category is used to determine the S rating requirements of Part 4. While there is a relationship between the fire hazard category and the Fire Load Energy Density (FLED), it is recognised that FLED is only one factor affecting the fire severity and thus the impact of the fire on the building structure. Other important factors may include ventilation, surface area to mass ratio of the fuel, and its rate of burning. The fire hazard category was chosen in preference to FLED because it is better able to categorise certain spaces containing mainly low heat release rate fuels (e.g. frozen meat carcasses).

3. The S ratings in Table 5.1 are classified in terms of fire hazard category. While FHC covers more than just the energy density of fire load, there is a direct link between these two parameters, as tabulated below:

NOTES:
1. The fire hazard category for a given purpose group is given in Table 2.1.

2. FLED is expressed as MJ fire load per m2 floor area and is the sum of the fire loads from all of the combustible materials divided by the floor area of the space. Fire load is calculated for each combustible material as Fire Load (MJ) = Combustible Mass (kg) x Heat of Combustion (MJ/kg).

3. Each fire hazard category covers a number of purpose groups with design (80 percentile) fire load energy densities of these groups lying in the range stated in column 2 of the above table. The design value of FLED for fire determination of S rating associated with each fire hazard category is also taken as the 80 percentile value of this range, in accordance with accepted practice. This design value adopted also directly covers the specific FLED associated with almost all purpose group uses which come within each fire hazard category.

image path background P_2_2_1.jpg

BC clause C2.3.1, C2.3.2, C3.3.6

metric level 1 Time to escape,
Fire spread to other property, household units, and other residential units

performance test method

metric value FHC 1 = 0 - 500 MJ/m²
FHC 2 = 501 - 1000 MJ/m²
FHC 3 = 1001 - 1500 MJ/m²
FHC 4 >1500 MJ/m²

purpose group all

FHC all

occupant load all

building height all

boundary	all
distance	
sprinklers	
other FSP's	
reference	
pre-2001 ref	A P2.1.0
comment	
	WORKGROUPS
associated workgroup	WG 6.28.2
description	New Purpose Group WF
note	comment
comment	
information	WG Recommendations: (additional note for the FHC table) Note: 4. Fire hazard Category 4 may also include fires which grow at a very fast rate. Fire growth rates may be assessed from NFPA-92B. Specific fire design is required for buildings with such fires. 2001 CHANGES
old text	
new text	
explanation	
image path	http://www.branzfire.com/cas1/images/ ERRATA & AMENDMENTS
detail	
amendment	
previous text	
proposed text	
explanation	

paragraph	P2.2.10
content	Fire hazard category 4: Fire hazard category 4 includes materials with a fire load energy density (FLED) of greater than 1500 MJ/m2, and materials which have a fire growth rate of 1 MW or more in less than 75 seconds. Any firecell with a fire hazard category of 4 (FHC 4) shall have the S rating determined by fire engineering design (see Paragraph 5.6.11). Table 2.1 provides an indication of where fire hazard category 4 is likely to apply, but the examples given are not exhaustive. Paragraph 5.6.12 describes the circumstances in which the fire hazard category may be reduced if the FHC 4 purpose group comprises only a small proportion of the firecell.
image path	http://www.branzfire.com/cas1/images/
background	
BC clause	
metric level 1	Time to escape, Fire spread to other property, household units, and other residential units
performance test method	
metric value	FLED > 1500 MJ/m² or fire growth rate of 1 MW or more in less than 75 s
purpose group	
FHC	4
occupant load	all
building height	all
boundary distance	all
sprinklers	
other FSP's	
reference	NFPA 92B
pre-2001 ref	A P2.10.0
comment	
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	
	2001 CHANGES
old text	A2.10 Fire hazard category 4 Fire hazard category 4 includes materials with a fire load energy density (FLED) of greater than 1500 MJ/m², and materials which have a heat release rate (hrr) of 1 MW or more in less than 75 seconds. Any firecell with a fire hazard category of 4 shall have the S rating determined by fire engineering design (sec C3/AS 1 Paragraph 3.2.5). Table A1 provides an indication of where/in: hazard category 4 is likely to apply but the examples given are not exhaustive. Paragraph B2.10 describes the circumstances in which the fire hazard category may be reduced if the purpose group comprises only a small proportion of the firecell.
new text	A2.10 Fire hazard category 4 Fire hazard category 4 includes materials with a fire load energy density (FLED) of greater than 1500 MJ/m², and materials which have a fire growth rate of 1 MW or more in less than 75 seconds. Any firecell with a fire hazard category of 4 shall have the S rating determined by fire engineering design (see C3/AS1 Paragraph 3.2.5). Table A1 provides an indication of where fire hazard category 4 is likely to apply but the examples given are not exhaustive. Paragraph B4.9.1 describes the circumstances in which the fire hazard category may be reduced if the FHC 4 purpose group comprises only a small proportion of the firecell.

explanation	Editorial and reference change only.
image path	http://www.branzfire.com/cas1/images/
	ERRATA & AMENDMENTS
detail	
amendment	Amd 5: 1 Oct 2005
previous text	
proposed text	
explanation	

paragraph F3.4.0

content Increase in Width for Horizontal Escape Routes Having a Single Direction of Escape Paragraph 3.3.2 d)

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background

BC clause C2.3.3 Escape routes shall be:
a) of adequate size for the number of occupants,
b) free of obstruction in the direction of escape,
c) of length appropriate to the mobility of the people using them,
d) resistant to the spread of fire as required by C3 'Spread of Fire',
e) easy to find as required by Clause F8 'Signs',
f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and
g) Easy and safe to use as required by Clause D1.3.3 'Access Routes'.

metric level 1 time to escape

performance test method

metric value 5 effective mm/person or 7 nominal mm/person

purpose group all

FHC all

occupant load all

building height all

boundary distance all

sprinklers either

other FSP's concessions for FSPs

reference

pre-2001 ref C2 O4.0.0

comment

WORKGROUPS

associated workgroup WG ..

description

note

comment

information

2001 CHANGES

old text

new text

explanation

image path 1999_C2_F_4_0_0.jpg

detail	
amendment	
previous text	
proposed text	
explanation	

paragraph P3.5.2

content Sprinklers:

Where the firecell is protected by a sprinkler system, (fire safety precaution Type 6 or 7), open path lengths given in Table 3.3 may be increased by:

a) 100% for purpose groups WL, WM, WH, WF, CS, CL, CM, IA and ID, and

b) 50% for purpose groups SA, SR and SH.

COMMENT:
This applies whatever the reason for use of a sprinkler system. For the purposes of means of escape, sprinklers are not regarded as providing absolute protection, as they operate only after the fire has reached a certain intensity, by which time the fire can have produced significant quantities of smoke. They are therefore regarded as providing only a fire development delay factor, which enables more time for escape.

image path http://www.branzfire.com/cas1/images/

background

BC clause C2.3.3 Escape routes shall be:
a) of adequate size for the number of occupants,
b) free of obstruction in the direction of escape,
c) of length appropriate to the mobility of the people using them,
d) resistant to the spread of fire as required by C3 'Spread of Fire',
e) easy to find as required by Clause F8 'Signs',
f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and
g) Easy and safe to use as required by Clause D1.3.3 'Access Routes'.

C3.3.6 Automatic fire suppression systems shall be installed where people would otherwise be:
a) unlikely to reach a safe place in adequate time because of the number of storeys in the building.
b) Required to remain within the building without proceeding directly to a final exit, or where the evacuation time is excessive,
c) unlikely to reach a safe place due to confinement under institutional care because of mental or physical disability, illness or legal detention, and the evacuation time is excessive, or d) at high risk due to the fire load and fire hazard within the building.

metric level 1 time to escape

performance test method

metric value nominal 2.5 minutes with concessions: a) +100% b) +50%

purpose group a) WL, WM, WH, WF, CS, CL, CM, IA and ID, b) SA, SR and SH

FHC all

occupant load all

building height all

boundary distance all

sprinklers sprinklered - this applies regardless of the reason for the use of the sprinkler system

other FSP's

reference

pre-2001 ref B M1.0.0

comment

WORKGROUPS

associated workgroup WG 10.0.0

description Significant Risk in Fire

note

comment

information WG10 conclusions:
1. 'acceptable level of high risk' be used instead of 'significant risk'
2. individual risk can be considered when Individual Risk, IR >= 1.0 x 10^(-5)/year. New buildings should aim for a higher standard, using a value of IR >= 1.0 x 10^(-6)/year.
3. IR values could not be established for individual sleeping PGs, as no published data was available. However a pilot risk assessment of rest homes for the aged - indicated 'significant risk' for IR and Societal Risk (SR).
4. Good regulation depends on good statistics.
5. Continued application of generic risk assessment recommended, and investigation of analytic Quantitative Risk Assessment methods for maximum benefit of safety in NZ.

The following recommendations were submitted by WG10, based on a generic risk assessment:
a) For rates of death by fire are to be reduced, early warning devices will need to be installed in all sleeping PGs including private dwellings.
b) Smoke detectors:
* should be fitted to all existing and new private dwellings - subject to a detailed study on cost benefits,
* should be fitted to all existing SC that are rest homes for aged, regardless of the number of beds,
* should be fitted in all new sleeping PGs, regardless of the number of beds.
c) Sprinklers:
* should be installed in all existing and new SC that are rest homes for aged, with 6 or more beds.
d) Disabled people safety:
* a special work group should be set up to study and make recommendations on the safety of disabled people in fire situations.
e) Working/ business /storage activities:
* For life safety - fire safety precautions installed in could be scaled down & resourses redirected to .
* For property loss reduction - existing standards may need to be increased.

Reference: Barnett, C.R., Fardenier, J., Narayanan, P., 1997, "Siginificant Risk in Fire", Report for the Building Insudtry Authority, Wellington.

2001 CHANGES

old text

new text

explanation

image path 1999_B_T_1_A_0.jpg

ERRATA & AMENDMENTS

detail

amendment

previous text

proposed text

explanation

paragraph	F3.12.0
content	Alternative Open Path Separation Paragraph 3.8.3
image path	F_3_12_0.jpg
background	
BC clause	C2.3.1 The number of open paths available to each person escaping to an exitway or final exitway or final exit shall be appropriate to: a) The travel distance, b) the number of occupants, c) the fire hazard, and d) the fire safety systems installed in the firecell. C2.3.3 Escape routes shall be: a) of adequate size for the number of occupants, b) free of obstruction in the direction of escape, c) of length appropriate to the mobility of the people using them, d) resistant to the spread of fire as required by C3 'Spread of Fire', e) easy to find as required by Clause F8 'Signs', f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and g) Easy and safe to use as required by Clause D1.3.3 'Access Routes'.
metric level 1	time to escape
performance test method	
metric value	90° and 8 m
purpose group	all
FHC	all
occupant load	all
building height	all
boundary distance	all
sprinklers	either
other FSP's	all
reference	
pre-2001 ref	C2 F14.0.0
comment	
	WORKGROUPS
associated workgroup	WG 6.4.5
description	Minimum Distance Between Exitways
note	
comment	
information	
	2001 CHANGES

old text	Figure 14
new text	Amend Figure 14 to meet new 3.2.1.
explanation	
image path	1999_C2_F_14_0_0.jpg
	ERRATA & AMENDMENTS
detail	
amendment	
previous text	
proposed text	
explanation	

paragraph	F3.25.0
content	Degree and Width of Openings Paragraphs 3.3.6 e) and 3.17.5
image path	F_3_25_0.jpg
background	
BC clause	C2.3.3 Escape routes shall be: a) of adequate size for the number of occupants, b) free of obstruction in the direction of escape, c) of length appropriate to the mobility of the people using them, d) resistant to the spread of fire as required by C3 'Spread of Fire', e) easy to find as required by Clause F8 'Signs', f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and g) Easy and safe to use as required by Clause D1.3.3 'Access Routes'.
metric level 1	time to escape
performance test method	
metric value	2.5 minutes
purpose group	all
FHC	all
occupant load	all
building height	all
boundary distance	all
sprinklers	either
other FSP's	concessions
reference	
pre-2001 ref	C2 O27.0.0
comment	
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	
	2001 CHANGES
old text	
new text	
explanation	
image path	1999_C2_F_27_0_0.jpg
	ERRATA & AMENDMENTS

detail

amendment

previous text

proposed text

explanation

paragraph	F3.25.0
content	Degree and Width of Openings Paragraphs 3.3.6 e) and 3.17.5
image path	F_3_25_0.jpg
background	
BC clause	C2.3.3 Escape routes shall be: a) of adequate size for the number of occupants, b) free of obstruction in the direction of escape, c) of length appropriate to the mobility of the people using them, d) resistant to the spread of fire as required by C3 'Spread of Fire', e) easy to find as required by Clause F8 'Signs', f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and g) Easy and safe to use as required by Clause D1.3.3 'Access Routes'.
metric level 1	time to escape
performance test method	
metric value	2.5 minutes
purpose group	all
FHC	all
occupant load	all
building height	all
boundary distance	all
sprinklers	either
other FSP's	concessions
reference	
pre-2001 ref	C2 F27.0.0
comment	
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	
	2001 CHANGES
old text	
new text	
explanation	
image path	http://www.branzfire.com/cas1/images/
	ERRATA & AMENDMENTS

detail

amendment

previous text

proposed text

explanation

paragraph	P5.9.2
content	Primary element loadings: During a fire primary elements shall, resist collapse under: a) The design dead and live loads required by NZBC B1, and b) Any additional loads caused by the fire. COMMENT: 1. NZBC B1 Clause B1.3.3 (c) and (i) requires that structural stability take account of temperature and fire effects. 2. Additional loadings can arise from changes in length or other deformations in building elements as a result of high temperatures. 3. Except with timber members, yield strength generally reduces with temperature increase, so that strength reduction is related to the time for which the primary element is exposed to fire. Factors which need to be taken into account include the maximum temperature attained, the capacity of the element to absorb heat, potential loss of section, the degree of exposure, whether any applied coating is used to protect the element from the effects of fire, and the degree of restraint provided by the surrounding structure.
image path	http://www.branzfire.com/cas1/images/
background	
BC clause	C3.3.2 Fire separations shall be provided within buildings to avoid the spread of fire and smoke to: a) other firecells, b) spaces intended for sleeping, and c) household units within the same building or adjacent buildings. d) Other property
metric level 1	Reasonable expectations of firefighters, Time to untenable conditions, Fire spread to other property, household units, and other residential units
performance test method	
metric value	complying with NZBC B1, and loads caused by fire
purpose group	
FHC	
occupant load	
building height	
boundary distance	
sprinklers	
other FSP's	
reference	
pre-2001 ref	C4 P1.1.2

comment

WORKGROUPS

associated workgroup WG ..

description

note

comment

information

2001 CHANGES

old text

new text

explanation

image path http://www.branzfire.com/cas1/images/

ERRATA & AMENDMENTS

detail

amendment

previous text

proposed text

explanation

paragraph	P6.8.2
content	An individual SH or SR household unit may contain one or more upper floors provided that the open path length provisions of Table 3.3 are satisfied. COMMENT: 1. For purpose groups SR and SH, Table 3.3 permits maximum lengths of 24 m for the dead end, and 60 m for the total open path where no FSPs are installed. 2. See Paragraphs 1.3.3 and 1.3.4 for other purpose group SH requirements.
image path	http://www.branzfire.com/cas1/images/
background	
BC clause	C2.3.3 Escape routes shall be: a) of adequate size for the number of occupants, b) free of obstruction in the direction of escape, c) of length appropriate to the mobility of the people using them, d) resistant to the spread of fire as required by C3 'Spread of Fire', e) easy to find as required by Clause F8 'Signs', f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and g) Easy and safe to use as required by Clause D1.3.3 'Access Routes'.
metric level 1	time to escape
performance test method	60 m open path, 24 m dead end open path
metric value	
purpose group	SH, SR
FHC	
occupant load	
building height	
boundary distance	
sprinklers	
other FSP's	
reference	
pre-2001 ref	C3 P2.10.2
comment	
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	

2001 CHANGES

old text 2.10.2 Where an individual SR household unit contains two floor levels, the unit shall be regarded as a single firecell and the upper floor shall not be treated as an intermediate floor length when assessing the fire safety precautions in Table B1/7 (Appendix B).

new text 2.10.2 An individual SH or SR household unit may contain one or more upper floors provided that the open path length provisions of C2/AS1 Table 3 are satisfied. Comment: For purpose groups SR and SH, C2IAS1 Table 3 permits maximum lengths of 24 m for the dead end, and 60 m for the total open path.

explanation Existing text now not needed with the altered definition of intermediate floor. New text takes account of modern trends to 3 level household units.

image path http://www.branzfire.com/cas1/images/

ERRATA & AMENDMENTS

detail

amendment

previous text

proposed text

explanation

paragraph	P6.9.5
content	Air ducts passing through exitways shall not include combustible materials.
image path	http://www.branzfire.com/cas1/images/
background	
BC clause	C2.3.3 Escape routes shall be: a) of adequate size for the number of occupants, b) free of obstruction in the direction of escape, c) of length appropriate to the mobility of the people using them, d) resistant to the spread of fire as required by C3 'Spread of Fire', e) easy to find as required by Clause F8 'Signs', f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and g) Easy and safe to use as required by Clause D1.3.3 'Access Routes'. C3.3.2 Fire separations shall be provided within buildings to avoid the spread of fire and smoke to: a) other firecells, b) spaces intended for sleeping, and c) household units within the same building or adjacent buildings. d) Other property.
metric level 1	Time to escape, Time to untenable conditions
performance test method	AS 1530.1
metric value	pass AS 1530.1
purpose group	IE
FHC	
occupant load	
building height	
boundary distance	
sprinklers	
other FSP's	
reference	
pre-2001 ref	C3 P2.11.4
comment	
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	
	2001 CHANGES

old text	
new text	
explanation	
image path	http://www.branzfire.com/cas1/images/
	ERRATA & AMENDMENTS
detail	
amendment	
previous text	
proposed text	
explanation	

paragraph	P6.9.7
content	Ventilation in enclosed exitways for purpose groups SC, SD, SR and SA: In vertical safe paths natural ventilation shall be achieved using roof-mounted ventilators with a nominal exhaust capacity of no less than 0.7 m3/sec, or vents at the top of the safe path providing a total free vent area of no less than 1.5 m2. Make-up air shall be provided using vents or grilles providing a total free vent area of no less than 0.7 m2, and located no higher than 1.0 m above the lowest floor level. Where vents are not permanently open, they shall be opened automatically when activated by a smoke detection system (complying with F7/AS1) in the safe paths.
image path	http://www.branzfire.com/cas1/images/
background	
BC clause	C2.3.3 Escape routes shall be: a) of adequate size for the number of occupants, b) free of obstruction in the direction of escape, c) of length appropriate to the mobility of the people using them, d) resistant to the spread of fire as required by C3 'Spread of Fire', e) easy to find as required by Clause F8 'Signs', f) provided with adequate illumination as required by Clause F6 'Lighting for Emergency', and g) Easy and safe to use as required by Clause D1.3.3 'Access Routes'. C3.3.2 Fire separations shall be provided within buildings to avoid the spread of fire and smoke to: a) other firecells, b) spaces intended for sleeping, and c) household units within the same building or adjacent buildings. d) Other property.
metric level 1	time to untenable conditions
performance test method	
metric value	0.7 m3/sec exhaust
purpose group	IE, SC, SD, SR, SA
FHC	
occupant load	
building height	
boundary distance	
sprinklers	
other FSP's	smoke extract
reference	
pre-2001 ref	C2 P8.2.3
comment	
	WORKGROUPS

associated workgroup	WG ..
description	
note	
comment	
information	
	2001 CHANGES
old text	8.2.3 In enclosed stairways the vent area shall be no less than either: 1.5 m² at both top and bottom of the stairs, or 2.5% of the plan floor area of the stairway and be provided at each floor level. Where closures are fitted to the vents, they shall be opened automatically when activated by a smoke detection system in the safe paths.
new text	8.2.2 In vertical safe paths natural ventilation shall be achieved using roof-mounted ventilators with a nominal exhaust capacity of no less than 0.7 m³lsec, or vents at the top of the safe path providing a total free vent area of no less than 1.5 m'. Make up air shall be provided using vents or grilles providing a total free vent area of no less than 0.7 m², and located no higher than 1.0 m above the lowest floor level. Where vents are not permanently open, they shall be opened automatically when activated by a smoke detection system (complying with F7/AS1) in the safe paths. Comment: 1. Permanent ventilation in external walls should be by specific design taking into account adverse wind effects and tenability in the exitway. 2. Exhaust capacities for ventilators are normally given by the manufacturer and are dependent on wind speed. A capacity based on a design wind speed that is exceeded 95% of the time is considered acceptable. 3. The ventilation system should not develop a negative pressure more than 0.5 Pa above atmospheric otherwise the ratings of the fire doors will be compromised. If mechanical ventilation is used the preferred position for the fan is at the bottom of the shaft to generate positive pressure.
explanation	Experience has shown that permanently open vents in external walls are not effective unless carefully designed and unless the effects of wind direction and pressure are accounted for. It is recommended that if external wall vents are to be provided they should be subject to specific design. Floor area of stair not relevant therefore option removed.
image path	http://www.branzfire.com/cas1/images/
	ERRATA & AMENDMENTS
detail	
amendment	
previous text	
proposed text	
explanation	

paragraph	P6.9.11
content	Vertical safe path smoke control: Vertical safe paths which exceed a height of 25 m, shall be divided by smoke separations and smoke control doors at the landing nearest mid-height (see Figure 6.1). This requirement does not apply to pressurised exitways, or where the building is sprinklered.
image path	http://www.branzfire.com/cas1/images/
background	
BC clause	C2.3.3 Escape routes shall be: (a) Of adequate size for the number of occupants, (b) Free of obstruction in the direction of escape, (c) Of length appropriate to the mobility of the people using them, (d) Resistant to the spread of fire as required by Clause C3 “Spread of Fire”, (e) Easy to find as required by Clause F8 “Signs”, (f) Provided with adequate illumination as required by Clause F6 “Lighting for Emergency”, and (g) Easy and safe to use as required by Clause D1.3.3 “Access Routes”.
metric level 1	time to untenable conditions
performance test method	
metric value	
purpose group	IE
FHC	
occupant load	
building height	
boundary distance	
sprinklers	
other FSP's	
reference	
pre-2001 ref	C2 P8.3.1
comment	
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	
	2001 CHANGES
old text	8.3.1 Where internal stairways exceed a height of 25 m, safe paths shall be divided by

smoke separations and smoke control doors at the landing nearest mid-height. (See Figure 29). This requirement does not apply to pressurised exitways, or where the building is sprinklered.

new text 8.3.1 Vertical safe paths Where internal stairways exceed a height of 25 m, safe paths shall be divided by smoke separations and smoke control doors at the landing nearest mid-height. (See Figure 29). This requirement does not apply to pressurised exitways, or where the building is sprinklered.

explanation New title, text unchanged.

image path http://www.branzfire.com/cas1/images/

ERRATA & AMENDMENTS

detail

amendment

previous text

proposed text

explanation

paragraph P7.8.10

content Open sided buildings:

For an open sided building located closer to a relevant boundary than the distances allowed in Paragraphs 7.8.9 c) and d), the following additional requirements shall be met:

a) The roof cladding shall satisfy the rate of heat release requirements of Table 7.5 except that no less than 15% of the roof area shall be constructed to be self venting (by opening or melting rapidly) in the event of a fire occurring below. No self venting area shall be located closer than 1.0 m to any attached building, sleeping purpose group, other property or relevant boundary, and

b) If the open sided building is detached, the primary elements supporting the roof adjacent to the relevant boundary shall have a FRR of no less than 15/-/-, or

c) If the open sided building is attached to another building, a wall shall be provided adjacent to the relevant boundary. The wall shall have no unprotected areas and shall be rated from both sides with a FRR of no less than 15/15/15.

COMMENT:
Examples of open sided buildings having a roof area exceeding 40 m2 are canopies over forecourt areas at service stations, while those with roof areas of less than 40 m2 would be structures such as carports associated with detached dwellings.

image path http://www.branzfire.com/cas1/images/

background Non-fire rated parts of external walls are assumed to act as radiators and the received radiation is calculated on the relevant boundary and at 1 m beyond the relevant boundary. The emitted radiation 87.6 kW/m², 108.4 kW/m² and 151.6 kW/m² for FHC 1, 2, 3/4 respectively. These correspond to the radiation from a black body at the temperature in a fire resistance furnace at 30, 60 and 90 minutes respectively with gas emissivity 0.95. Received radiation values (16-18) may not be low enough to prevent ignition for extended periods. Fire Service intervention is assumed as historical risk of fire spread between properties is relatively low.

BC clause C3.3.5 External walls and roofs shall have resistance to the spread of fire, appropriate to the fire load within the building and to the proximity of other household units, other residential units and other property.

C4.3.2 Structural elements shall have a fire resistance of no less than that of any element to which they provide support within the same firecell.

C4.3.3 Collapse of elements having lesser fire resistance shall not cause the consequential collapse of elements required to have a higher fire resistance.

metric level 1 Fire spread to other property, household units or other residential units

performance test method theoretical - 'Limiting Distance' method

metric value 30 kW/m² on the relevant boundary 16, 17, 18 kW/m² at 1 m beyond relevant boundary for FHC 3, 2, 1 respectively.

purpose group all

FHC all

occupant load all

building height all

boundary all

distance	
sprinklers	either
other FSP's	all
reference	Barnett, CR and Wade, CA. 2002. A Regulatory Approach to Determining Fire Separation between Buildings based on the Limiting Distance Method. Paper presented at the 4th International Conference on Performance Based Codes and Fire Safety Design Methods.
pre-2001 ref	C3 N4.7.4
comment	NEW
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	
	2001 CHANGES
old text	
new text	4.7.4 For an open sided building located closer to a relevant boundary than the distances allowed in Paragraphs 4.7.3 (c) and (d), the following additional requirements shall be met: a) The roof cladding shall satisfy the rate of heat release requirements of Table 3 except that no less than 15% of the roof area shall be constructed to be self venting (by opening or melting rapidly) in the event of a fire occurring below. No self venting area shall be located closer than 1.0 m to any attached building, sleeping purpose group, other property or relevant boundary, and b) If the open sided building is detached, the primary elements supporting the roof adjacent to the relevant boundary shall have a FRR of no less than 15/-/-, or c) If the open sided building is attached to another building, a wall shall be provided adjacent to the relevant boundary. The wall shall have no unprotected areas and shall be rated from both sides with a FRR of no less than 15/15/15. Comment: Examples of open sided buildings having a roof area exceeding 40 m² are canopies over forecourt areas at service stations, While those with roof areas of less than 40m² would be structures such as carports associated with detached dwellings.
explanation	
image path	http://www.branzfire.com/cas1/images/
	ERRATA & AMENDMENTS
detail	
amendment	
previous text	
proposed text	
explanation	

paragraph	F7.9.0
content	Method 4 - Return Walls on External Walls having an Intersection Angle of Between 80° and 135° with the Relevant Boundary or Notional Boundary Paragraphs 7.7.2, 7.7.3 and 7.7.5
image path	F_7_9_0.jpg
background	Non-fire rated parts of external walls are assumed to act as radiators and the received radiation is calculated on the relevant boundary and at 1 m beyond the relevant boundary. The emitted radiation 87.6 kW/m², 108.4 kW/m² and 151.6 kW/m² for FHC 1, 2, 3/4 respectively. These correspond to the radiation from a black body at the temperature in a fire resistance furnace at 30, 60 and 90 minutes respectively with gas emissivity 0.95. Received radiation values (16-18) may not be low enough to prevent ignition for extended periods. Fire Service intervention is assumed as historical risk of fire spread between properties is relatively low.
BC clause	C3.3.5 External walls and roofs shall have resistance to the spread of fire, appropriate to the fire load within the building and to the proximity of other household units, other residential units and other property.
metric level 1	Fire spread to other property, household units or other residential units
performance test method	theoretical - 'Limiting Distance' method
metric value	30 kW/m² on the relevant boundary 16, 17, 18 kW/m² at 1 m beyond relevant boundary for FHC 3, 2, 1 respectively.
purpose group	all
FHC	all
occupant load	all
building height	all
boundary distance	all
sprinklers	either
other FSP's	all
reference	Barnett, CR and Wade, CA. 2002. A Regulatory Approach to Determining Fire Separation between Buildings based on the Limiting Distance Method. Paper presented at the 4th International Conference on Performance Based Codes and Fire Safety Design Methods. Me
pre-2001 ref	C3 F10.0.0
comment	
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	

2001 CHANGES

old text Figure 10A Worked examples. Unprotected areas in external walls

new text Figure 10A Worked examples. Unprotected areas in external walls

explanation New figures given in Appendix C.

image path 1999_C_F_4_0_0.jpg

ERRATA & AMENDMENTS

detail

amendment

previous text

proposed text

explanation

paragraph	F7.10.0
content	Open Sided Buildings - Separation Distances and FRR Requirements Paragraph 7.8.8
image path	F_7_10_0.jpg
background	Non-fire rated parts of external walls are assumed to act as radiators and the received radiation is calculated on the relevant boundary and at 1 m beyond the relevant boundary. The emitted radiation 87.6 kW/m², 108.4 kW/m² and 151.6 kW/m² for FHC 1, 2, 3/4 respectively. These correspond to the radiation from a black body at the temperature in a fire resistance furnace at 30, 60 and 90 minutes respectively with gas emissivity 0.95. Received radiation values (16-18) may not be low enough to prevent ignition for extended periods. Fire Service intervention is assumed as historical risk of fire spread between properties is relatively low.
BC clause	C3.3.5 External walls and roofs shall have resistance to the spread of fire, appropriate to the fire load within the building and to the proximity of other household units, other residential units and other property.
metric level 1	Fire spread to other property, household units or other residential units
performance test method	theoretical - 'Limiting Distance' method
metric value	30 kW/m² on the relevant boundary 16, 17, 18 kW/m² at 1 m beyond relevant boundary for FHC 3, 2, 1 respectively.
purpose group	all
FHC	all
occupant load	all
building height	all
boundary distance	> 1.0 m for Area > 40 m², or > 0.3 m for Area < 40 m²
sprinklers	either
other FSP's	all
reference	Barnett, CR and Wade, CA. 2002. A Regulatory Approach to Determining Fire Separation between Buildings based on the Limiting Distance Method. Paper presented at the 4th International Conference on Performance Based Codes and Fire Safety Design Methods. Me
pre-2001 ref	C3 O10.0.0
comment	NEW
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	
	2001 CHANGES

old text Figure 10 Separation of unprotected areas

new text Figure 10 Open sided buildings - separation distances and FRR requirements

explanation Existing Figure 10 moved to Appendix C and revised. New Figure 10 gives examples of different types of open sided buildings described in the text.

image path 1999_C3_F_10_0_0.jpg

ERRATA & AMENDMENTS

detail

amendment

previous text

proposed text

explanation

paragraph	P7.11.2
content	External walls: The peak rate of heat release and the total heat released from the external wall cladding system, as determined in accordance with Paragraph C9.1, shall not exceed the limits given in Table 7.5. These requirements do not apply where: a) Surface finishes are no more than 1.0 mm in thickness and applied directly to a noncombustible substrate, or b) The entire wall assembly has been tested at full scale in accordance with NFPA 285 and passed the test criteria. COMMENT: Other full scale facade test
image path	http://www.branzfire.com/cas1/images/
background	Gives exceptions for meeting fire properties specified in Table 7.2 if a full-scale facade test has been successfully undertaken, or where the amount of combustible material is low (<1mm thick)
BC clause	C3.3.5 External walls and roofs shall have resistance to the spread of fire, appropriate to the fire load within the building and to the proximity of other household units, other residential units and other property.
metric level 1	extent of vertical fire spread
performance test method	NFPA 285
metric value	NFPA 285 has criteria relating to fire spread to an upper floor in the test facility.
purpose group	
FHC	
occupant load	
building height	
boundary distance	
sprinklers	
other FSP's	
reference	
pre-2001 ref	C3 P4.9.2
comment	
	WORKGROUPS
associated workgroup	WG ..
description	
note	

comment

information

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old text 4.9.2 External walls For external walls the acceptable properties of exterior surface finishes depend on the purpose groups exposed to the fire hazard, the building height, and distance from the relevant boundary. The requirements are given in Table 2, but do not apply where surface finishes are not more than 1.0 mm in thickness and applied directly to a non-combustible substrate.

new text 4.9.2 External walls The peak rate of heat release and the total heat release from the external wall cladding system, as determined in accordance with Paragraph E9.0 of Appendix E, shall not exceed the limits given in Table 3. These requirements do not apply where a) where surface finishes are not more than 1.0 mm in thickness and applied directly to a non-combustible substrate, or b) the entire wall assembly has been tested at full-scale in accordance with NFPA 285 and passed the test criteria. Comment: Other full-scale test methods may also be acceptable to the Territorial Authority. Comment: 1. For external walls the acceptable. properties of external wall e/adding systems depend on the purpose group, the building height, presence of sprinklers and the distance from the relevant boundary. 2. An external wall cladding system includes any applied surface finish such as a paint or other coating combined with the substrate material. Fire tests should be carried out on samples representative of the finished product as used on the building, in order to determine compliance with Table 3.

explanation Exemptions for thin combustible finishes on non-combustible substrates are no longer needed as the proposed test/evaluation procedure will also fairly treat these finishes.

image path http://www.branzfire.com/cas1/images/

ERRATA & AMENDMENTS

detail

amendment

previous text

proposed text

explanation

paragraph P7.11.3

content External walls:

Where a building has firecells containing different purpose groups, the acceptable peak rate of heat release and total heat released (as specified in Table 7.5) of an external wall cladding system may have different values provided that:

a) For each purpose group the value is no greater than required by Table 7.5 for the building height (not just the height of the firecell), and

b) The value applied to a firecell is no greater than required by any firecells at a higher level on that wall.

COMMENT:
1. This means that where any purpose group requires a Type B performance, all lower floors shall have either a Type B or Type A performance in terms of Table 7.5. Should any purpose group require a Type A performance, all floors below shall have a Type A performance.

2. For external walls the acceptable properties of external wall cladding systems depend on the purpose group, the building height, presence of sprinklers and the distance from the relevant boundary.

3. An external wall cladding system includes any applied surface finish such as a paint or other coating combined with the substrate material. Fire tests should be carried out on samples representative of the finished product as used on the building, in order to determine compliance with Table 7.5.

4. While the specific heat release rate of a cladding system must be verified by standard test results, the following is an indication of the performance of some types of construction.

* Non-combustible materials such as concrete, brick, glass and steel meet the Type A and Type B requirements.

* Cellulose fibre-cement products with applied finishes/coatings less than 1.0 mm thick would 'typically' meet Type A and Type B requirements.

* Ordinary timber products would 'typically' not meet the requirements of Type A or Type B.

image path http://www.branzfire.com/cas1/images/

background explains how to apply Table 7.2 where the building has different purpose groups.

BC clause C3.3.5 External walls and roofs shall have resistance to the spread of fire, appropriate to the fire load within the building and to the proximity of other household units, other residential units and other property.

C3.3.6 Automatic fire suppression systems shall be installed where people would otherwise be:
a) unlikely to reach a safe place in adequate time because of the number of storeys in the building.
b) Required to remain within the building without proceeding directly to a final exit, or where the evacuation time is excessive,
c) unlikely to reach a safe place due to confinement under institutional care because of mental or physical disability, illness or legal detention, and the evacuation time is excessive, or
d) at high risk due to the fire load and fire hazard within the building.

metric level 1	extent of vertical fire spread
performance test method	AS/NZS 3837 (cone calorimeter) or NFPA 285 (full scale facade test)
metric value	AS/NZS 3837 - Heat Release Rate < 100 kW/m2 and Total Heat Release < 25 MJ/m2 (Performance Level A). Heat Release Rate < 150 kW/m2 and Total Heat Release < 50 MJ/m2 (Performance Level B).
purpose group	
FHC	
occupant load	
building height	
boundary distance	
sprinklers	
other FSP's	
reference	
pre-2001 ref	C3 P4.9.3
comment	
	WORKGROUPS
associated workgroup	WG ..
description	
note	
comment	
information	
	2001 CHANGES
old text	4.9.3 Where a combustible surface finish of thickness greater than 1.0 mm is fixed or applied to an external wall, the area to be regarded as unprotected area shall be: a) Half the surface finish area for walls requiring a FRR. b) The total surface finish area for walls not requiring a FRR. Comment: Combustible surface finishes increase the risk of vertical fire spread up the exterior of a building.
new text	Deleted.
explanation	Existing 4.9.3 deleted and replaced with new paragraph. The adjustment to unprotected area is not considered necessary with the revised approach to assessing surface finishes. Proposed text was: 4.9.3 External wall cladding systems in buildings with a building height not greater than 7.0 m, and which do not contain SC, SD, SA, or SR purpose groups need not comply with Table 3 provided the external wall is permitted to have 100% unprotected area. This was paragraph was deleted after public review
image path	http://www.branzfire.com/cas1/images/
	ERRATA & AMENDMENTS
detail	

amendment

previous text

proposed text

explanation

11. APPENDIX C: SUMMARY OF DATABASE ENTRIES FOR PARAGRAPHS AND METRICS

The following is a summary of the database entries (as at 30 March 2007) for paragraphs of C/AS1 (2001) and the associated high-level and secondary-level metrics.

Reference	Level 1 Metric	Level 2 Metric
P2.2.1	Time to escape, Fire spread to other property, household units, and other residential units	Fire Load Energy Density (MJ/m²)
P2.2.10	Time to escape, Fire spread to other property, household units, and other residential units	Fire Load Energy Density
T3.2.0	time to escape	effective width per person (+boundary layer) or nominal width per person
P3.2.1	time to escape	number of escape routes
P3.2.2	time to escape	number of escape routes
F3.3.0	time to escape	effective width per person (+boundary layer) or nominal width per person
P3.3.1	Time to escape	height of escape route
P3.3.2	time to escape	effective width per person (+boundary layer) or nominal width person
P3.3.3	time to escape	provision of handrails
P3.3.4	time to escape	maximum stairway width credited
P3.3.5	time to escape	stair width
P3.3.6	time to escape	width of escape route
P3.3.7	time to escape	width of escape route
F3.4.0	time to escape	effective width per person (+boundary layer) or nominal width per person
P3.4.1	time to escape	length of escape route
P3.4.2	time to escape	length of escape route
P3.4.3	time to escape	holding capacity of exitway
P3.4.4	time to escape	length of escape route
P3.4.5	time to escape	holding capacity of exitway
P3.4.6	time to escape	length of the escape route
P3.4.7	time to escape	length of the escape route
P3.4.8	time to escape	length of the escape route
P3.5.1	time to escape	length of the escape route
P3.5.2	time to escape	length of the escape route
P3.5.3	time to escape	length of the escape route
P3.5.4	time to escape	length of the escape route
P3.5.5	time to escape	length of the escape route
P3.5.6	time to escape	length of escape route
P3.6.1	time to escape	escape route configuration
P3.7.1	time to untenable condition	smoke control by separation and pressurisation
P3.8.1	time to escape	number, width, height, length of escape routes
P3.8.3	time to escape	open path separation

P3.8.4	time to escape	escape route configuration
P3.9.1	time to escape	escape route configuration
P3.9.2	time to escape	escape route configuration
P3.9.3	time to escape	requirements for fixed seating
P3.9.4	time to escape	aisle width
P3.9.5	time to escape	aisle width
P3.9.6	time to escape	aisle width
P3.9.7	time to escape	length of escape route
P3.9.8	time to escape	1. barriers 2. handrails
P3.9.9	time to escape	ease of use - step dimensions
P3.9.10	time to escape	requirements for loose seating
P3.9.11	time to escape	requirements for loose seating
P3.9.12	time to escape	escape route configuration
P3.9.13	time to escape	escape route configuration
P3.9.14	time to escape	escape route configuration
P3.10.1	time to escape	escape route configuration
P3.10.2	time to escape	requirements for ladders
P3.11.1	time to untenable condiitions	smoke separations
P3.11.2	time to escape	escape route configuration
P3.11.4	time to escape	escape route configuration
P3.11.6	time to escape	escape route configuration
P3.11.7	time to escape	length of escape route
P3.11.8	time to escape	escape route configuration
F3.12.0	time to escape	open path separation
P3.12.1	time to untenable conditions	permitted uses of exitways
P3.12.2	time to untenable conditions	permitted uses of exitways
P3.12.3	Time to escape Time to untenable condition	provisions for passenger lifts
P3.13.1	Time to escape	provision of refuge areas
P3.13.2	Time to escape	provision of refuge areas
P3.14.1	Time to escape	provisions for external escape routes, separation by distance or fire rated construction
P3.14.2	Time to escape	separation distance
P3.14.3	Time to escape, Time to untenable conditions	separation distance
P3.14.4	Time to escape, Time to untenable conditions	fire resistance rating
P3.14.5	Time to escape, Time to untenable conditions	escape angle
P3.14.6	Time to escape, Time to untenable conditions	fire resistance ratings
P3.14.7	Time to escape, Time to untenable conditions	minimum ventilation area, and location
P3.14.8	Time to escape	provision of barriers
P3.15.0	time to escape	number of escape routes
P3.15.1	time to escape	number of escape routes
P3.15.2	time to escape	number of escape routes
P3.15.3	time to escape	number of escape routes
P3.15.4	time to escape	number of escape routes
P3.15.5	time to escape	number of escape routes

P3.15.6	time to escape	number of escape routes
P3.15.7	time to escape	number of escape routes
P3.15.8	time to escape	number of escape routes
P3.15.9	time to escape	number of escape routes
P3.16.1	Time to escape	provision of safe paths & final exits
P3.16.2	Time to escape	provisions for aisles and walkways
P3.16.3	Time to escape	provisions for upper floors and intermediate floors
P3.16.4	Time to escape	final exit separation
P3.16.5	Time to escape	provisions for tiered seating, c) exitway spacing
P3.16.6	Time to escape	separtion by fire resistant construction
P3.16.7	Time to escape, Time to untenable conditions	ventilation of hot smoke & gases
P3.16.8	Time to escape	provisions for safe paths for multiple PGs
P3.16.9	Time to escape	provisions for safe paths for multiple PGs
P3.17.0	time to escape	
P3.17.1	time to escape	provision of door closers and latching
P3.17.2	time to escape	provisions for locking devices
P3.17.3	time to escape	direction of door opening
P3.17.4	time to escape	direction of door opening
P3.17.5	time to escape	width of escape route
P3.17.6	time to escape	provision of door vision panels
P3.17.7	time to escape	provisions for revolving doors, automatic doors and access control systems
P3.17.8	time to escape	provisions for revolving doors, automatic doors and access control systems
P3.17.9	time to escape	provision of hold-open devices
P3.17.10	time to escape	provision of hold-open devices
P3.17.11	time to escape	provisions for delayed unlocking devices
P3.17.12	time to escape	provision of smoke control doors
P3.17.13	time to escape	provision of fire doors
P3.17.14	time to escape	provision of panic bolts
P3.18.0	time to escape	windows used for escape
P3.18.1	time to escape	windows used for escape
P3.18.2	time to escape	windows used for escape
P3.18.3	time to escape	windows used for escape
P3.18.4	time to escape	windows used for escape
P3.18.5	time to escape	windows used for escape
P3.18.6	time to escape	windows used for escape
P3.18.7	time to escape	windows used for escape
P3.19.1	Time to escape	provison of lighting
P3.19.2	Time to escape	provision of lighting
P3.20.1	Time to escape	provision of signs
F3.25.0	time to escape	
P4.2.1	Time to escape	division of building using firecells

	Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	
P4.2.2	Time to escape	smokecell floor area
P4.2.3	reasonable expectations of firefighters	firecell floor area
P4.2.4	Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	effective roof venting area
P4.2.5	Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units Time to untenable conditions	firecell floor area
P4.2.6	Time to untenable conditions Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P4.2.7	Time to untenable conditions Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P4.5.1	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P4.5.2	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P4.5.3	Time to escape	fire safety precautions
P4.5.4	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P4.5.5	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P4.5.6	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	provision of alarm systems
P4.5.7	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	F ratings of common areas
P4.5.8	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	a) fire safety precautions, b) minimum firecell rating
P4.5.9	Time to escape	fire safety precautions
P4.5.10	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P4.5.11	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units,	fire safety precautions

	and other residential units	
P4.5.12	Time to escape	provision of alarm system
P4.5.13	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P4.5.14		F rating
P4.5.15	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P4.5.16	Time to escape	fire safety precautions
P4.5.17	Time to escape	smoke control system
P4.5.18	Time to escape	smoke control
P4.5.19	Time to escape Reasonable expectations of fire fighters	fire safety precaution
P4.5.20	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	Fire safety precautions
P4.5.21	Time to escape Reasonable expectations of fire fighters	fire safety precautions
P4.5.22	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire safety precautions
P5.3.1	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	F rating
P5.3.2	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	S rating
P5.5.1	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	F rating
P5.5.2	Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	S rating
P5.5.3	Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	S rating
P5.6.3	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire resistance rating - insulation
P5.6.4	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	provision of insulation component of fire resistance ratings
P5.6.5	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	insulation component of fire resistance ratings
P5.6.6	Time to escape Reasonable expectations of fire fighters	fire resistance ratings

	Fire spread to other property, household units, and other residential units	
P5.6.7	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire resistance rating
P5.6.8	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	floor fire resistance rating
P5.6.9	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	fire resistance rating, fire safety precautions
P5.6.10	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units	continued services to building, tenability of means of escape
P5.6.11	Time to escape Reasonable expectations of fire fighters Fire spread to other property, household units, and other residential units, Safeguard the environment	S rating
P5.6.12	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units, Safeguard the environment	fire hazard category
P5.6.13	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units, Safeguard the environment	sprinklers
P5.7.1	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units,	provision of FRR
P5.7.2	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units, Safeguard the environment	fire resistance rating
P5.7.3	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units	provision of floor fire resistance rating
P5.7.4	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units	provision of fire resistance ratings
P5.7.5	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units	provision of fire resistance ratings
P5.7.6	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units	provision of protected external walls
P5.7.7	Time to escape, Reasonable expectations of fire fighters,	provisions for stability

	Fire spread to other property, household units, and other residential units	
P5.7.8	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units	provisions for stability
P5.7.9	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units	minimum fire resistance ratings
P5.8.1	Time to escape, Time to untenable conditions, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units	glazing integrity & insulation ratings
P5.8.2	Time to escape, Time to untenable conditions, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units	provisions for uninsulated fire resisting glazing
P5.8.3	Time to escape	provisions for uninsulated fire resisting glazing
P5.8.4	Time to escape	glazing dimensions
P5.8.5	Time to escape	provisions for uninsulated fire resisting glazing
P5.8.6	Time to escape	minimum separation of uninsulated fire resisting glazing
P5.8.7	Time to escape	maximum permitted area of uninsulated fire resisting glazing
P5.8.8	Time to escape, Reasonable expectations of fire fighters, Fire spread to other property, household units, and other residential units	maximum area of uninsulated fire resisting glazing
P5.8.9	Time to escape	maximum area non-fire resisting glazing
P5.8.10	Time to escape, Time to untenable conditions	provisions for uninsulated glazing in fire doors and smoke doors
P5.8.11	Time to escape, Time to untenable conditions	provisions for glazing in smoke doors
P5.9.1	Reasonable expectations of firefighters, Time to untenable conditions, Fire spread to other property, household units, and other residential units	structural stability
P5.9.2	Reasonable expectations of firefighters, Time to untenable conditions, Fire spread to other property, household units, and other residential units	structural stability
P5.9.4	Reasonable expectations of firefighters, Time to untenable conditions, Fire spread to other property, household units, and other residential units	provisions for structrual stability - unrated primary elements
P5.9.5	Reasonable expectations of firefighters,	provisions for structural stability

	Time to untenable conditions, Fire spread to other property, household units, and other residential units	
P5.9.6	Reasonable expectations of firefighters, Time to untenable conditions, Fire spread to other property, household units, and other residential units	fire resistance ratings
P6.1.1	Time to escape, Fire spread to other property, household units, and other residential units	internal fire and smoke spread
P6.1.2	Time to escape, Fire spread to other property, household units, and other residential units	control of internal fire and smoke spread: a) subdividing firecell floor area, b) separation, c) integrity, d) fire stopping concealed spaces & ducts, e) surface finishes, f)automatic fire and smoke suppression systems
P6.2.1	Time to escape, Fire spread to other property, household units, and other residential units	minimum FRR between F0 (by Table 4.1) firecells
P6.3.1	Time to escape	minimum FRR of proscenium wall
P6.3.2	Time to escape	a) provision of sprinklers, b),c),d),e) provision of roof vents, f) heat sensing device system
P6.4.1	Time to escape, Time to untenable conditions	smoke leakage
P6.5.1	Time to escape	provisions for fire resistance ratings for below tiered seating
P6.5.2	Time to escape	provisions for fire resistance ratings below tiered seating
P6.6.1	Fire spread to other property, household units, and other residential units	minimum fire resistance ratings
P6.6.2	Fire spread to other property, household units, and other residential units	minmum fire resistance ratings
P6.6.3	Time to escape, Time to untenable conditions	provisions for immobile occupants
P6.6.4	Time to escape, Time to untenable conditions	provisions for subdivision of firecells
P6.6.5	Fire spread to other property, household units, and other residential units	fire resistance ratings, provisions for beds
P6.7.3	Time to escape	a) number of beds b) smoke control - limiting gaps
P6.8.1	Fire spread to other property, household units, and other residential units	fire resistance rating
P6.8.2	time to escape	length of escape route
P6.9.4	time to untenable conditions	smoke separation
P6.9.5	Time to escape, Time to untenable conditions	material combustibility
P6.9.7	time to untenable conditions	ventilation rate
P6.9.10	time to untenable conditions	ventilation rate
P6.9.11	time to untenable conditions	smoke leakage (into exitway)
P6.10.4	Time to escape, Time to untenable conditions	ventilation rate
P6.10.6	Time to escape,	ventilation rate

	Time to untenable conditions	
P6.12.9	Time to escape, Time to untenable conditions	smoke leakage
P6.20.0	Time to escape, Time to untenable conditions	material flammability
P6.20.1	Time to escape, Time to untenable conditions	material flammability
P6.20.2	Time to escape, Time to untenable conditions	material flammability
P6.20.3	Time to escape, Time to untenable conditions	material flammability - SFI, SDI
P6.20.4	Time to escape, Time to untenable conditions	material flammability
P6.20.5	Time to escape, Time to untenable conditions	material flammability
P6.20.6	Time to escape, Time to untenable conditions	material flammability
P6.20.7	Time to escape, Time to untenable conditions	material flammability
P6.20.8	Time to escape, Time to untenable conditions	material flammability - low radius of effects of ignition
P6.20.9	Time to escape, Time to untenable conditions	material flammability
P6.20.10	Time to escape, Time to untenable conditions	material flammability
P6.20.11	Time to escape, Time to untenable conditions	material flammability
P6.20.12	Time to escape, Time to untenable conditions	material flammability
P6.20.13	Time to escape, Time to untenable conditions	material flammability
P6.20.14	Time to escape, Time to untenable conditions	material flammability
P6.20.15	Time to escape, Time to untenable conditions	material flammability
P6.20.16	Time to escape, Time to untenable conditions	material flammability - Flammability Index
P6.20.17	Time to escape, Time to untenable conditions	material flammability
P6.20.18	Time to escape, Time to untenable conditions	material flammability
P6.20.19	Time to escape, Time to untenable conditions	material flammability
P6.20.20	Time to escape, Time to untenable conditions	material flammability
P6.20.21	Time to escape, Time to untenable conditions	material flammability
P6.22.9	time to untenable conditions	area of smoke reservoir
P6.23.3	Time to escape, Reasonable expectations of firefighters	emergency power supply
P6.23.4	Time to escape, Reasonable expectations of firefighters	emergency power supply
T7.1.0	maximum received radiation flux	
F7.1.0	maximum received radiation flux	
P7.1.1	Fire spread to other property, household units, and other residential units	
P7.1.3	Fire spread to other property, household units, and other residential units	provision of external fire control

P7.2.1	Fire spread to other property, household units, and other residential units	provision of fire separations
T7.2.1	maximum received radiation flux	
P7.2.2	Fire spread to other property, household units, and other residential units	provision of fire separation
T7.2.2	maximum received radiation flux	
T7.2.3	maximum received radiation flux	
T7.2.4	maximum received radiation flux	
T7.2.5	maximum received radiation flux	
T7.2.6	maximum received radiation flux	
T7.3.0	maximum received radiation flux	
F7.3.0	maximum received radiation flux	
P7.3.1	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.2	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.3	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.4	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.5	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.6	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.7	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.8	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.9	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.10	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.11	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.12	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.13	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.3.14	Fire spread to other property, household units, and other residential units	
P7.3.15	Fire spread to other property, household units, and other residential units	maximum received radiation flux
T7.4.0	maximum received radiation flux	
F7.4.0	maximum received radiation flux	
P7.4.1	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.4.2	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.4.3	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.4.4	Fire spread to other property, household units, and other residential units	maximum received radiation flux
T7.5.0	vertical fire spread	rate of heat release (from cladding material)
F7.5.0	maximum received radiation flux	
P7.5.1	Fire spread to other property, household units, and other residential units	maximum received radiation flux

P7.5.2	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.5.3	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.5.4	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.5.5	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.5.6	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.5.7	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.5.8	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.5.9	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.5.10	Fire spread to other property, household units, and other residential units	maximum received radiation flux
F7.6.0	maximum received radiation flux	
P7.6.1	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.6.2	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.6.3	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.6.4	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.6.5	Fire spread to other property, household units, and other residential units	maximum received radiation flux
F7.7.0	maximum received radiation flux	
P7.7.1	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.7.2	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.7.3	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.7.4	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.7.5	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.7.6	Fire spread to other property, household units, and other residential units	maximum received radiation flux
P7.7.7	Fire spread to other property, household units or other residential units	maximum received radiation flux
F7.8.0	Fire spread to other property, household units or other residential units	
P7.8.1	Fire spread to other property, household units or other residential units	separation distance, fire rating
P7.8.2	Fire spread to other property, household units or other residential units	parapet dimensions
P7.8.3	Fire spread to other property, household units or other residential units	fire rating
P7.8.4	Fire spread to other property, household units or other residential units	separation distance
P7.8.5	Fire spread to other property, household units or other residential units	separation distance, fire rating
P7.8.6	Fire spread to other property, household units or other residential units	maximum received radiation flux, material flammability

P7.8.7	Fire spread to other property, household units or other residential units	separation distance, fire rating
P7.8.8	Fire spread to other property, household units or other residential units	separation distance
P7.8.9	Fire spread to other property, household units or other residential units	distance to boundary, ventilation
P7.8.10	Fire spread to other property, household units or other residential units	rate of heat release roof venting area
F7.9.0	Fire spread to other property, household units or other residential units	maximum received radiation flux
P7.9.1	Fire spread to other property, household units, and other residential units	provisions for fire spread from roofs
P7.9.2	Fire spread to other property, household units, and other residential units	provisions for fire protection from spread of fire from roofs
P7.9.3	Time to escape	separation distance, fire resistance ratings
P7.9.4	Fire spread to other property, household units, and other residential units	provision of fire resistance ratings of primary elements supporting an area of roof required to be protected
P7.9.5	Fire spread to other property, household units, and other residential units	provision of fire rating of primary elements supporting an unrated roof
P7.9.6	Fire spread to other property, household units, and other residential units	provision of fire protection from fire spread from a lower roof
P7.9.7	Fire spread to other property, household units, and other residential units	separation by distance
P7.9.8	Fire spread to other property, household units, and other residential units	provisions for protection from a lower roof
P7.9.9	Fire spread to other property, household units, and other residential units	separation distance from a lower roof
P7.9.10	Fire spread to other property, household units, and other residential units	provision of vertical fire spread protection
P7.9.11	Fire spread to other property, household units, and other residential units	minimum separtion of unprotected areas
P7.9.12	Fire spread to other property, household units, and other residential units	aprons & spandrels sizes
P7.9.13	Fire spread to other property, household units, and other residential units	provisions for fire resistance ratings of aprons & spandrels
P7.9.14	Fire spread to other property, household units, and other residential units	separation between an external wall and a fire separation
P7.9.15	Fire spread to other property, household units, and other residential units	provisions for eaves & floors overhanging an external wall
P7.9.16	Fire spread to other property, household units, and other residential units	separation distances
P7.9.17	Fire spread to other property, household units, and other residential units	provisions for measuring vertical distance
P7.9.18	Fire spread to other property, household units, and other residential units	provisions for external thermal insulation
P7.9.19	Fire spread to other property, household units, and other residential units	provisions for external thermal insulation
F7.10.0	Fire spread to other property, household units or other residential units	distance to boundary, fire rating
P7.10.1	Fire spread to other property, household units, and other residential units	provisions for fire rated external walls
P7.10.2	Fire spread to other property, household units, and other residential units	provisions for protected areas
P7.10.3	Fire spread to other property, household units, and other residential units	provisions for primary elements in 100% unprotected area walls
P7.10.4	Fire spread to other property, household units, and other residential units	provisions for wing walls & return walls

P7.10.5	Fire spread to other property, household units, and other residential units	S rating
P7.10.6	Fire spread to other property, household units or other residential units	fire resistance rating
P7.10.7	Fire spread to other property, household units or other residential units	fire resistance rating
P7.10.8	Fire spread to other property, household units or other residential units	fire resistance rating
P7.11.1	Fire spread to other property, household Units or other residential units	material flammability
P7.11.2	extent of vertical fire spread	rate of heat release
P7.11.3	extent of vertical fire spread	rate of heat release
P7.11.4	Fire spread to other property, household units, and other residential units	rate of heat release
P8.1.1	reasonable expectations of firefighters	fire service vehicle access
P8.1.2	reasonable expectations of firefighters	loading on roadway pavement, road widths and hardstands
P8.2.1	reasonable expectations of firefighters	fire hydrant systems
P8.2.2	reasonable expectations of firefighters	maximum fire hose length
P8.2.3	reasonable expectations of firefighters	Fire systems centre
P8.2.4	reasonable expectations of firefighters	Fire systems centre
P8.2.5	reasonable expectations of firefighters	Fire Service lift control
P8.2.6	reasonable expectations of firefighters	Voice communication system
P9.1.1	Outbreak of fire	provisions for installed solid fuel appliances
P9.1.2	Outbreak of fire	provisions for installed solid fuel appliances
P9.2.1	Outbreak of fire	provisions for installed gas burning appliances
P9.2.2	Outbreak of fire	provisions for installed gas burning appliances
P9.3.1	Outbreak of fire	provisions for installed domestic oil-fired appliances
P9.3.2	Outbreak of fire	provisions for installed domestic oil-fired appliances
P9.3.3	Outbreak of fire	provisions for installed domestic oil-fired appliances
P9.4.1	Outbreak of fire	provisions for downlights, clearance from building elements
P9.5.2	Outbreak of fire	provisions for open fires & chimneys
P9.5.3	Outbreak of fire	provisions for open fires & chimneys, flue cross-sectional area
P9.5.4	Outbreak of fire	provisions for open fires & chimneys, flue lining materials
P9.5.5	Outbreak of fire	provisions for open fires & chimneys, provision of flue liners
P9.5.6	Outbreak of fire	clearance of chimney above roof
P9.5.9	Outbreak of fire	provisions for hearths
P9.5.10	Outbreak of fire	provisions for open fires & chimneys
P9.5.12	Outbreak of fire	ventilation space around chimney or flue