Fire safety engineering assessment

Sydney International Equestrian Centre, Horsley Park

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Amendment schedule

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Executive summary

This report documents the findings of a fire safety engineering assessment undertaken to determine whether the proposed design changes of the indoor arena at Sydney International Equestrian Centre (SIEC), Horsley Park complies with the relevant performance requirements of the National Construction Code Volume One – Building Code of Australia 2011 (BCA). Defire undertook the assessment at the request of Department of Education and Communities.

The SIEC, located at Saxony Road, Horsley Park was designed and constructed specifically for the Sydney 2000 Olympic Games, as a spectator facility for equestrian events within the sand arena. The existing main indoor arena is a steel framed, open sided building (on 3 sides) with a curved, colorbond metal roof. It is approximately 6,000m^2 in floor area with associated judging facilities and basement storage (approximately 500m^2). The SIEC site office administration is located within the northwest corner (approximately 300m^2) with an attached food and beverage kiosk (approximately 150m^2).

The existing design incorporates an AS 1670.1 automatic fire and smoke detection system. The building has been the subject of previous fire engineering assessments by Engineered Fire & Safety Solutions. As part of this project, a review of the original fire engineered design was undertaken to address the following key issues:

1. Replacement or removal of the current AS 1670 type automatic fire and smoke detection system within the arena given the existing system's susceptibility to false alarms due to dust, fumes, insects etc.
2. Allowance of larger population numbers and variety of events – eg functions, concerts, other sports etc – than permitted by the original fire engineered design.
3. Inclusion of the provision of the southern wall, which was constructed post-Olympics and not addressed in the original fire engineering assessment.
4. Allowance for future adjacent building works – covering of warm up arena.

The design of the indoor arena includes areas which do not comply with the deemed-to-satisfy (DTS) provisions of the BCA. Table 1 describes the BCA requirements associated with the fire engineering assessments for the proposed changes.

No	Description of non-compliance	DTS provision	Performance requirements (A0.10)	Method of meeting performance requirements	Assessment method
1.	Increased populations in excess of that allowed under BCA clause D1.6. Omission of smoke detection and alarm system within the indoor arena. Performance based smoke hazard management with permanent openings in the façade in lieu of smoke and heat vents. The smoke hazard management is designed with consideration to the egress provisions, potential occupant numbers and variety of events.	Clauses D1.6 and E2.2 and table E2.2b	DP4 and EP2.2	Complies with performance requirements A0.5(b)(i)	Verification method A0.9(b)(ii)

Table 1 BCA requirements associated with the fire engineering assessments

The indoor arena has been the subject of previous fire safety engineering assessments by Engineered Fire & Safety Solutions. Table 8 describes the BCA requirements associated with the previous fire engineering assessments. With the exception of the evacuation provisions, smoke hazard management and restrictions on populations of the indoor arena which are being revisited, the findings of the previous assessments are not considered to impact upon the assessment documented within this report and vice versa.

The fire safety engineering assessment undertaken found that the design of the indoor arena achieves compliance with the relevant performance requirements of the BCA, subject to the following recommendations:

- This report and the fire safety measures listed in section 5 must be implemented into the design and identified on the fire safety schedule for the building. They must be maintained and certified in accordance with the Environmental Planning and Assessment Regulations 2000 and relevant Australian standards.
- If there are building alterations or additions, a change in use or changes to the fire safety system in the future, a reassessment will be needed to verify consistency with the assessment contained in this report.

Contents

1. Introduction

This report documents the findings of a fire safety engineering assessment undertaken to determine whether the proposed design changes of the indoor arena at Sydney International Equestrian Centre (SIEC), Horsley Park complies with the relevant performance requirements of the National Construction Code Volume One – Building Code of Australia 2011 (BCA) [1]. Defire undertook the assessment in accordance with the International Fire Engineering Guidelines (IFEG) [2] at the request of Department of Education and Communities.

2. Fire engineering brief

The purpose of the fire engineering brief (FEB) is to consult with the relevant stakeholders to define the scope of the project, to agree upon the objectives, fire safety measures, methods of analysis and acceptance criteria for the fire engineering assessment. The IFEG states that the scope of the project and the method by which it will receive regulatory approval dictates the extent of the FEB process required.

An FEB meeting was held in conjunction with the site inspection of the Sydney International Equestrian Centre on 19 December 2011 to review the proposed design changes with the relevant stakeholders. At the end of the meeting / inspection it was agreed that smoke and evacuation modelling will be undertaken to assess the feasibility of the proposed design changes. A second meeting was held on 10 February 2012 to review the results of the smoke modelling undertaken.

As the SIEC is classified as crown building work / development, section 109R of the Environmental Planning and Assessment Act 1979 (EP&A Act) is applicable. Clause 3 of section 109R states that 'a minister, by order in writing, may at any time determine in relation to buildings generally or a specified building or buildings of a specified class that a specified technical provision of the state's building laws:

a) does not apply, or

b) does apply, but with such exceptions and modifications as may be specified.'

This report is intended to form part of the development application (DA) submission to seek approval of the proposed design changes outlined in section 3.1. Comments from Fairfield City Council on Defire report SY110362 R1.1 dated 24 February 2012 are included in Appendix E.

The relevant stakeholders identified for this project are listed in Table 2.

Name	Role	Organisation	Contact details
Matt Brown	Client / project manager	Department of Education and Communities	02 9006 3828
Mark Fulcher	Venue manager	Department of Education and Communities	02 9620 2698
Peter O'Neill	Client representative / BCA consultant	P & D Pty Ltd	0408 221 218
Victor Tung	Accredited fire safety engineer C10 – BPB 417	Defire	02 9211 4333

Table 2 Stakeholders

[1] National Construction Code Volume One – Building Code of Australia 2011, Australian Building Codes Board, Australia, 2011.
[2] International Fire Engineering Guidelines – Edition 2005, Australian Building Codes Board, Australia, 2005.

3. Description of the project

3.1 Project description

The SIEC, located at Saxony Road, Horsley Park was designed and constructed specifically for the Sydney 2000 Olympic Games, as a spectator facility for equestrian events within the sand arena. The existing main indoor arena is a steel framed, open sided building (on 3 sides) with a curved, colorbond metal roof. It is approximately 6,000m^2 in floor area with associated judging facilities and basement storage (approximately 500m^2). The SIEC site office administration is located within the northwest corner (approximately 300m^2) with an attached food and beverage kiosk (approximately 150m^2).

The existing design incorporates an AS 1670.1 automatic fire and smoke detection system. The building has been the subject of previous fire engineering assessments by Engineered Fire & Safety Solutions. As part of this project, a review of the original fire engineered design was undertaken to address the following key issues:

1. Replacement or removal of the current AS 1670 type automatic fire and smoke detection system given the existing system's susceptibility to false alarms due to dust, fumes, insects etc.
2. Allowance of larger population numbers and variety of events – eg functions, concerts, other sports etc – than permitted by the original fire engineered design.
3. Inclusion of the provision of the southern wall, which was constructed post-Olympics and not addressed in the original fire engineering assessment.
4. Allowance for future adjacent building works – covering of warm up arena.

A description of the main characteristics of the indoor arena for the purpose of determining compliance with the BCA is given in Table 3 [3].

Characteristic	BCA clause	Description
Effective height	A1.1	Less than 25m
Type of construction required	C1.1	Type A, due to compartment size
Rise in storeys	C1.2	Two

Table 3 Main building characteristics

Part of building	Use	Classification (A3.2)
Indoor arena	Assembly	9b
Administration	Offices	5

Table 4 Use and classification

[3] Sydney International Equestrian Centre – Building Code of Australia Assessment, Section 70 Report and Section 93 Certification, prepared by Engineered Fire & Safety Solutions, 22 April 1998

3.2 Preventative and protective measures

The existing indoor arena is provided with the major fire safety measures required by the DTS provisions of the BCA listed in Table 5 [4]. Additional fire safety measures required as part of the fire engineering assessment are listed within section 5.

Fire safety measure	Design and installation	Comment
Automatic fire and smoke detection system	BCA96 specification E2.2(a) AS 1670 (except as varied by P&D P/L report dated 10/05/08)	Replacement or removal of the current AS 1670 type automatic fire and smoke detection system is subject of this report.
Emergency lighting	BCA96 clauses E4.2 and E4.4 AS/NZS 2293.1	
Exit signs	BCA96 clauses E4.5, E4.6 and E4.8 AS/NZS 2293.1	
Emergency warning & intercommunication system	BCA96 clause E4.9 AS 2220 (except as varied by EFSS report dated 22/04/98 and P&D P/L report dated 10/05/08)	EWIS system uses only the tone generation component of AS 2220 and does not have WIP phones or visual warning lights.
Fire hydrants	BCA96 clause E1.3 AS 2419.1 (except as varied by EFSS report dated 22/04/98)	Hydrants are located in-ground.
Fire hose reels	BCA96 clause E1.4 AS 2441 (except as varied by EFSS report dated 22/04/98)	Fire hose reels are located within 4m of openings in the vertical plane forming the external wall however they are not defined as 'exits'.
Portable fire extinguishers and fire blankets	BCA96 clause E1.6 AS 2444	

Table 5 Fire safety schedule – indoor arena

3.3 Occupant characteristics

The characteristics of the occupants expected to be in the building are listed in Table 6.

Characteristic	Description
Familiarity	Occupants are expected to be primarily patrons who may not be familiar with the layout of the building and location of fire exits. Staff are also expected to be present who are familiar with the layout of the building.
Awareness	Occupants are expected to be awake and alert to a potential emergency event such as a fire in the building. Some occupants may be focused on a performance and / or under the influence of alcohol.
Mobility	Occupants are assumed to have the same level of mobility as the general population. This may include a limited proportion of mobility impaired occupants. These occupants may require crutches, a wheelchair or similar to evacuate on their own or need assistance from other occupants.
Age	Occupants of all ages may be present within the building.

[4] Review of Installed Fire Safety Systems for Indoor Arena and Stables at Sydney International Equestrian Centre, prepared by P&D Pty Ltd, 10 May 2008

Characteristic	Description
Language	Although occupants may have English as their second language, they are expected to understand signs and verbal instructions in English to the degree necessary to not adversely impact upon evacuation.
Occupant load	The maximum safe occupant load for health and amenity has not been assessed as part of this assessment. The future populations within the facility are expected to be based the population densities in NSW table D1.13 of the BCA which specifies maximum densities of: • 0.5 m²/person for the standing area of the auditorium; • 1.0 m²/person for removable seating within the auditorium; and • seat counts where there is fixed seating. A maximum occupant load assessed as part of the fire engineering assessment within this report is documented in section 5. In particular, the sand arena (~2,500m²) is to be restricted to: • 4,200 persons if all exits from sand arena available – ie 4 × 1m exits and 5.7m exit leading to the warm up arena • 1,300 persons if 5.7m exit leading to the warm up arena is unavailable The seating plan for the indoor arena currently indicates a fixed seats capacity of 1,152 persons. Including the above, the indoor arena is be restricted to no more than 10,000 persons. [5]

Table 6 Occupant characteristics

3.4 Departures from the DTS provisions

The design of the indoor arena includes areas that do not comply with the DTS provisions of the BCA. We intend to use a performance-based fire safety engineering approach to assess the adequacy of the proposed design. Table 7 describes the BCA requirements associated with the fire engineering assessments for the proposed changes.

No	Description of non-compliance	DTS provision	Performance requirements (A0.10)	Method of meeting performance requirements	Assessment method
1.	Increased populations in excess of that allowed under BCA clause D1.6. Omission of smoke detection and alarm system within the indoor arena. Performance based smoke hazard management with permanent openings in the façade in lieu of smoke and heat vents. The smoke hazard management is designed with consideration to the egress provisions, potential occupant numbers and variety of events.	Clauses D1.6 and E2.2 and table E2.2b	DP4 and EP2.2	Complies with performance requirements A0.5(b)(i)	Verification method A0.9(b)(ii)

Table 7 BCA requirements associated with the fire engineering assessments

[5] This is a nominal limit based upon the exit capacities available and restricting occupant movement time to no more than 8 minutes as per Guide to Safety at Sports Grounds. Occupant numbers are likely to be significantly less than this taken into account occupant densities outlined in the BCA and health / amenity.

The indoor arena has been the subject of previous fire safety engineering assessments by Engineered Fire & Safety Solutions. Table 8 describes the BCA requirements associated with the previous fire engineering assessments. With the exception of the evacuation provisions, smoke hazard management and restrictions on populations of the arena which are being revisited, the findings of the previous assessments are not considered to impact upon the assessment documented within this report and vice versa.

No	Description of non-compliance	DTS provision	Performance requirements
Sydney International Equestrian Centre – Building Code of Australia Assessment, Section 70 Report and Section 93 Certification, dated 22 April 1998			
1.	The indoor arena is approximately 51,928m^3 in volume which exceeds the volume limits for a class 9b building of type A construction.	Clause C2.2	CP2
2.	The number of people allowed in the sand arena is 100 persons, which exceeds the calculated 60 persons based upon an occupant density of 10m^2/person.	Clause D1.13	DP4
3.	The gates considered to be exits from the sand arena are not provided with compliant latching mechanisms.	Clause D2.21	DP2
4.	Fire hydrants are installed below ground, rather than as pillar hydrants.	Clause E1.3	EP1.3
5.	Fire hose reels are located within 4m of openings in the vertical plane forming the external wall however they are not defined as ‘exits’.	Clause E1.4	EP1.1
6.	The indoor arena is not provided with smoke and heat vents.	Table E2.2b	EP2.2
7.	The EWIS system uses only the tone generation component of AS 2220 and does not have WIP phones or visual warning lights.	Clause E4.9	EP4.3
8.	The indoor arena is open on 3 sides and technically does not comply regarding the penetration of water.	-	FP1.4
Assessment of Fire Detection at the Indoor Arena and Stables, Sydney International Equestrian Centre, dated March 2000			
1.	Use of rate of rise thermal type A detection in the open sided roof area.	Clause E2.2 and specification E2.2a	EP2.2

Table 8 Previously addressed assessments

4. Scope, objective and assumptions

4.1 Scope and objective

- The scope of this report is limited to the assessments described in section 3.4, for the indoor arena. Although the covering of the warm up arena has been assessed in relation to its impact on occupant life safety within the indoor arena, assessment of occupant life safety within the warm up arena and its potential future usage is outside the scope of this report.
- The objective of this report is to demonstrate compliance with the fire safety aspects of the performance requirements of the BCA. Matters such as property protection (other than protection of adjoining property), business interruption, public perception, environmental impacts and broader community issues – such as loss of a major employer and impact on tourism – have not been considered as they are outside the scope of the BCA.
- This report considers single point arson as a source of ignition. Arson involving accelerants or multiple ignition sources is not considered in this assessment as it is outside the scope of the BCA.
- The scope of our works is limited to considering evacuation and fire safety issues for people with disabilities to the same degree as the DTS provisions of the BCA. Specifically, consideration of evacuation from the building by people with disabilities under the provisions of the Disability Discrimination Act 1992 is excluded.
- If there are building alterations or additions, a change in use or changes to the fire safety systems in the future, a reassessment will be needed to verify consistency with the assessment in this report.
- The data, methodologies, calculations and conclusions documented within this report specifically relate to the building and must not be used for any other purpose.
- The documentation that forms the basis for this report is listed within Appendix A.
- This report has been prepared based upon information provided by others. Defire has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated into this report as a result.

4.2 Assumptions

- The existing building complies with the applicable building standard at the time of construction being BCA 96. All new works comply with the current DTS provisions of the BCA except for the specific assessments described within section 3.4.
- All of the fire safety systems are assumed to be designed, installed and operate in accordance with the appropriate Australian standards, other design codes, legislation and regulations relevant to the project unless specifically stated otherwise.
- For a satisfactory level of fire safety to be achieved, regular testing and maintenance of all fire safety systems and measures, including management-in-use systems, is essential and is assumed in the conclusion of this assessment.

5. Fire safety measures

The fire safety measures required as part of the fire engineering assessment are:

5.1 General

1. The existing building is understood to comply with the applicable building standards at the time of construction being BCA 96 or the requirements of the previous fire engineering assessments by Engineered Fire & Safety Solutions. All new works will comply with the current DTS provisions of the BCA unless specifically mentioned.

   This section does not provide a comprehensive list of fire safety measures. The fire safety measures listed within this section relate only to the alternative solutions. The fire safety measures must be read in conjunction with the applicable building standards at the time of construction and/or the DTS provisions of the BCA.

2. Except where specifically superseded by this report, the design must comply with the requirements of the following reports:

   a. Sydney International Equestrian Centre – Building Code of Australia Assessment, Section 70 Report and Section 93 Certification, dated 22 April 1998, prepared by Engineered Fire & Safety Solutions

   b. Assessment of Fire Detection at the Indoor Arena and Stables, Sydney International Equestrian Centre, dated March 2000, prepared by Engineered Fire & Safety Solutions

   c. Review of Installed Fire Safety Systems for Indoor Arena and Stables at Sydney International Equestrian Centre, report 2008/SIEC-1, dated 10 May 2008, prepared P&D Pty Ltd

   Where there is conflict between this report and the reports outlined above, this report takes precedence.

3. The natural ventilation below is relied upon in the assessment of occupant life safety within the indoor arena:

   a. Warm up arena – open on all four sides

   b. Link from the warm up arena to the indoor arena – open on the two opposite sides

4. This report and the requirements listed in this section must be implemented into the design and identified on the fire safety schedule for the building. They must be maintained and certified in accordance with the Environmental Planning and Assessment Regulations 2000 and relevant Australian standards.

5.2 Restrictions on populations and seating configurations

5. The population within the sand arena portion (~2,500m^2) is to be restricted to:

   a. 4,200 persons if all exits from sand arena available – either fixed in the open position or provided with complying operation of doors and latches in accordance with clauses D2.20 and D2.21 of the BCA – ie 4 × 1m exits and 5.7m exit leading to the warm up arena.

   b. 1,300 persons if 5.7m exit leading to the warm up arena is unavailable or provided with non-compliant doors or latches in which case this exit must not be signposted as an emergency exit.

   The main entry point(s) to an event must be available as emergency exit(s).

6. The overall population within the indoor arena is to be restricted to no more than 10,000 persons. This is a nominal limit based upon the exit capacities available and restricting occupant movement time to no more than 8 minutes as per Guide to Safety at Sports Grounds.

   Note: An assessment of the maximum safe occupant load for health and amenity has not been undertaken by Defire. This is understood to be undertaken by the building owner/event manager for each specific event. The seating plan for the indoor arena currently indicates a fixed seats capacity of 1,152 persons.

7. The nominated exits from the sand arena / indoor arena are illustrated in Figure 1.

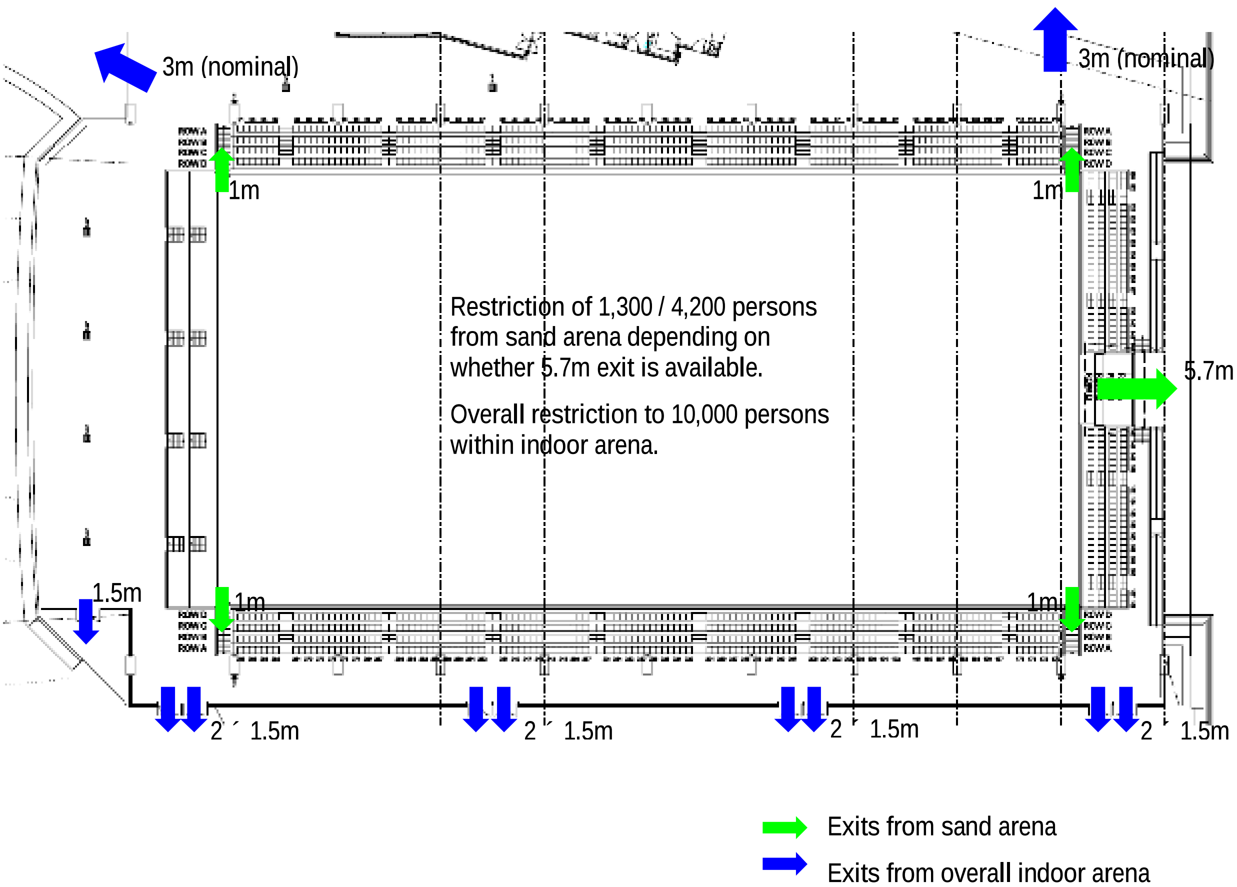

Figure 1 Nominated exits from the sand arena / indoor arena

8. Where additional temporary tiered seating is proposed, seating heights are to be restricted as follows depending upon the proposed usage of the arena:

   a. For typical assembly building use, the finished floor level of the highest row of seating is to be no greater than 5m above the floor level of the sand arena – ie approximately 1.75m above the level of the concourse.

   b. Where higher fuel loads may be present – eg vehicles larger than a van or combustible materials arranged in vertical configurations exceeding 4m, the finished floor level of the highest row of seating is to be no greater than 4.25m above the floor level of the sand arena – ie approximately 1m above the level of the concourse.

9. For fuel loads more severe than a typical lorry with combustible goods, or where quantities of flammable liquids exceeding those allowed under Australian Standard AS 1940-2004 are present, reassessment of the seating height restrictions is required by a suitably qualified fire safety engineer. Explosive material / pyrotechnical displays must not be used within the arena.

5.3 Services and equipment

10. The existing AS 1670 automatic fire and smoke detection system within the unenclosed parts of the indoor arena may be removed, given the existing system's susceptibility to false alarms due to dust, fumes, insects. The detection system within the enclosed parts of the indoor arena – such as the site office administration, food and beverage kiosk, judging facilities and basement storage – is to be retained.

11. Smoke and heat vents in accordance with specification E2.2c of the BCA are not required to be provided on the basis of the provision of permanent openings allowing smoke clearance to the open sky in accordance with the drawings in Appendix A.

5.4 Emergency management

12. An emergency management plan complying with AS 3745-2010 must be developed and implemented for the building. Once the emergency management plan is developed, it is to be implemented with exercises, periodic audits, and suitable procedures to maintain safety. This should include training under simulated fire emergency conditions for all relevant personnel.

6. Assessment 1 – Performance based smoke hazard management and exit provisions

6.1 Introduction

NSW table E2.2b of the BCA states, in relation to smoke hazard management for ‘other assembly buildings’:

(a) ‘Unless otherwise described in (b), in a building or part of a building used as an assembly building (not being a night club, discotheque or the like; or an exhibition hall, museum or art gallery) where the floor area of a fire compartment is more than 2000m^2, the fire compartment must be provided with–

- (i) an automatic smoke exhaust system complying with specification E2.2b; or
- (ii) roof mounted automatic smoke-and-heat vents complying with specification E2.2c, in a single storey building or the top storey of a multi storey building; or
- (iii) if the floor area of the fire compartment is not more than 5000m^2 and the building has a rise in storeys of not more than 2—
  - (A) an automatic smoke detection and alarm system complying with specification E2.2a; or
  - (B) a sprinkler system complying with specification E1.5.’

The indoor arena has been the subject of previous fire engineering assessments by Engineered Fire & Safety Solutions. As part of the previous assessments, an AS 1670 smoke detection system was specified for the indoor arena in conjunction with restrictions on populations / uses for the specific purpose of the SIEC as an Olympic equestrian events venue. As part of this project, a review of the original fire engineered design was undertaken to address the following key issues:

1. Replacement or removal of the current AS 1670 type automatic fire and smoke detection system given the existing system’s susceptibility to false alarms due to dust, fumes, insects etc.
2. Allowance of larger population numbers and variety of events – eg functions, concerts, other sports etc – than permitted by the original fire engineered design.
3. Inclusion of the provision of the southern wall, which was constructed post-Olympics and not addressed in the original fire engineering assessment.
4. Allowance for future adjacent building works – covering of warm up arena.

Given the proposed allowances for increased populations and variety of uses, the assessment also addresses clause D1.6(d) of the BCA which states that if the storey accommodates more than 200 persons, the aggregate unobstructed width, except for doorways, must be increased to–

- (i) 2m plus 500mm for every 60 persons (or part) in excess of 200 persons if egress involves a change in floor level by a stairway or ramp with a gradient steeper than 1 in 12; or
- (ii) in any other case, 2m plus 500mm for every 75 persons (or part) in excess of 200.

This assessment was undertaken to demonstrate that the design complies with performance requirements DP4 and EP2.2 of the BCA.

6.2 Methodology

The assessment undertaken for the building was a quantitative absolute assessment involving the following sub-systems:

- Sub-system A - Fire initiation and development and control
- Sub-system B – Smoke development and spread and control
- Sub-system D – Fire detection, warning and suppression
- Sub-system E – Occupant evacuation and control
- Sub-system F – Fire services intervention

6.3 Intent of the BCA

6.3.1 Dimensions of exits and paths of travel to exits – clause D1.6

The Guide to the BCA [6] says that the intent of clause D1.6 is 'to require exits and paths of travel to an exit to have dimensions to allow all occupants to evacuate within a reasonable time.' The guide expands further that 'the required exit and path of travel widths have been determined on the basis of an estimate of the width required to allow the safe exit of a given number of people expected in particular buildings.'

6.3.2 Smoke hazard management – clause E2.2a

The Guide to the BCA states that the intent of clause E2.2 of the BCA is 'to specify the requirements for minimising the smoke risks'. The guide expands further that the intent of specification E2.2b – in part – is 'to specify the capacity and exhaust rates required of mechanical smoke exhaust systems' and 'to specify the requirements for smoke reservoirs, to enable the containment of smoke in the upper levels of compartments.'

By conservatively estimating the expected peak fire size and subsequent amount of smoke produced based on first principles, the required smoke ventilation can be determined for the various areas of the building taking into account building specific details such as ceiling height.

6.4 Acceptance criteria

6.4.1 ASET/RSET timeline

To demonstrate that the design of the building facilitates safe occupant egress and fire brigade intervention in the event of a fire, the available safe evacuation time (ASET) and the required safe evacuation time (RSET) will be compared to demonstrate that an adequate margin can be achieved for the worst-credible fire scenarios. The ASET / RSET timeline is illustrated in Figure 2.

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[6] National Construction Code Guide to Volume One – Building Code of Australia 2011, Australian Building Codes Board, Australia, 2011.

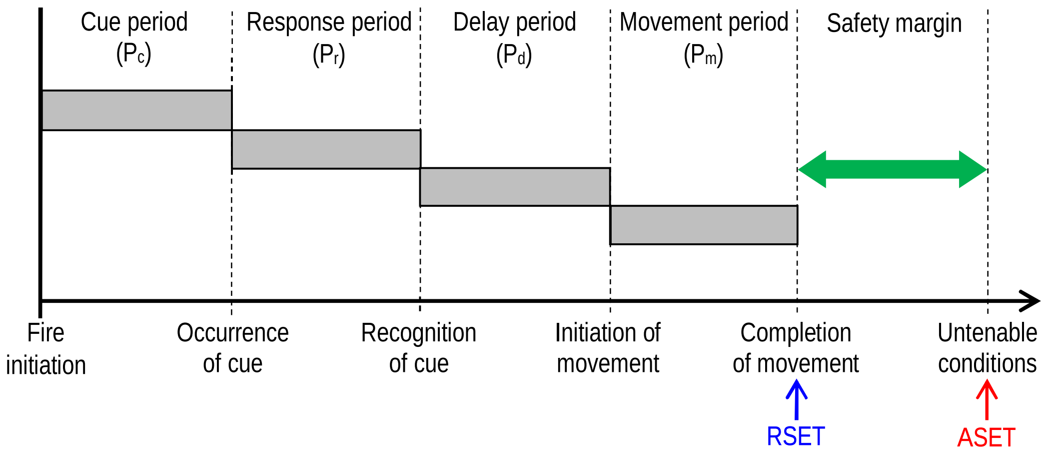

Figure 2 ASET/RSET timeline

6.4.2 Safety margin

All engineering analysis includes a varying degree of uncertainty associated with the assessment methodology and in the estimated input values depending on the amount of relevant statistical data and research available. To account for these potential variations and uncertainties the IFEG recommends that a suitable margin of safety be included in the ASET/RSET assessment to achieve an acceptable level of safety. A commonly accepted level of safety in engineering analysis is that the calculated result will hold true for not less than 95% of all scenarios [7]. That is, acknowledging that the calculation of ASET and RSET are based on distributed variables and hence contains an undetermined level of uncertainty, ensuring that all occupants can safely evacuate for 95% of all fires.

The 95% level of safety can be achieved either by using a conservative assessment methodology and input variables, eg worst-credible fire scenarios, or by applying a safety factor to the calculated results (ASET/RSET) based upon estimated mean values – eg most likely fire scenario and occupant response. The required safety factor will depend on the accuracy and level of conservatism of the assessment methodology and the estimated input variables. The greater level of conservatism, the lower safety factor required to achieve the satisfactory level of safety. For worst-credible fire scenarios and conservatively assumed input values no or very limited safety factor is required [8].

For the purpose of this assessment worst-credible localised fire scenarios will conservatively be used for the ASET/RSET analysis with an additional safety factor of 1.5 – ie a margin of safety equivalent to 50% of each of the components of the RSET will be adopted.

6.5 Tenability criteria

6.5.1 Building occupants

The criteria used to determine the onset of untenable conditions for occupants are consistent with criteria specified in chapter 4 of the Fire Engineering Guidelines [9], which are described in Table 9. The tenability criteria for convected heat, visibility and toxicity only apply if the smoke layer height drops below the limiting value.

[7] A Guide to the Principles of Fire Safety Engineering, Institution of Fire Engineers, UK, November 2002.
[8] CIBSE Guide E - Fire Safety Engineering, CIBSE, UK, 2nd edition. September 2003.
[9] Fire Engineering Guidelines First Edition, Fire Code Reform Centre, Australia, March 1996, p.4-7.

No.	Tenability criteria	Limiting value	Comment
1	Smoke layer height	2m	If the hot layer below 2m tenability criteria 3, 4 and 5 become the controlling factors.
2	Heat radiation	$2.5kW/m^2$ @ 2m above floor level	A hot layer temperature of 200°C, which equates to a heat radiation of $2.5kW/m^2$, is adopted as the limiting value for heat radiation for this assessment.
3	Convected heat	60°C	60°C as recommended by the Fire Engineering Guidelines for humid air/smoke.
4	Visibility	10m @ 2m above floor level	Visibility on the general floor away from exits is determined on the basis of way-finding through non-illuminated objects using a visibility factor of 2.3. Near exits with illuminated signage, an increased visibility factor of 8 is used. [10, 11]
5	Toxicity	N/A	Not critical for visibility in excess of 10m Limiting conditions for all toxic products are unlikely to be exceeded during evacuation if the visibility remains greater than 10m.

Table 9 Occupant tenability acceptance criteria

6.5.2 Fire-fighters

The tenability acceptance criteria proposed for fire-fighters in full turnout gear are identified in Table 10. [12]

No.	Tenability criteria	Limiting value	Comment
1	Heat radiation	$3kW/m^2$ @ 1.5m above floor level	For areas outside the direct vicinity of the fire.
2	Convected heat	120°C @ 1.5m above floor level	For areas outside the direct vicinity of the fire.

Table 10 Fire-fighters tenability acceptance criteria

6.6 Fire scenarios

6.6.1 Design fire selection

The selection of appropriate fire scenarios is a critical element of any fire safety engineering assessment. The number of scenarios selected is dependent on the scope of the project and the method of assessment. The following factors must be taken into consideration when selecting credible design fire scenarios:

- likelihood of occurrence
- potential consequences
- impact on the non-compliances being assessed

[10] CIBSE Guide E - Fire Safety Engineering, CIBSE, UK, 2nd edition. September 2003.
[11] NIST Special Publication 1019-5, Fire Dynamics Simulator (Version 5) – User's Guide, October 2007
[12] Australian Fire Authorities Council, Fire Brigade Intervention Model V2.2, October 2004.

Considering the criteria described above, the following credible design fire scenarios have been selected to be quantitatively analysed:

1. A fire involving combustibles associated with typical assembly buildings
2. A truck fire

Due to the natural ventilation available, a fire within the covered warm up arena was not explicitly analysed as it is not considered to impact upon occupant life safety within the indoor arena.

6.6.2 Design fires

The performance space is proposed to be used in a variety of layouts including seated, partially seated and non-seated. The worst case scenarios in terms of the risk to occupant safety are considered to be fully seated layouts which will contain maximum populations and seating heights. The high level seating must be demonstrated to provide safe evacuation prior to being affected by the smoke layer. For the purposes of the assessment and conservativeness, an ultra-fast t^2 fire growing to a maximum heat release rate of 10MW was adopted. This corresponds to the maximum fire size detailed for unsprinklered class 9 buildings in figure 2.1 of specification E2.2b of the BCA.

For the truck fire scenario, PIARC suggests a heat release rate of 20-30MW for a lorry with burning goods. The fire is assumed have an ultra-fast t^2 growth rate up to 30MW to account for wide range of combustibles which could potentially be stored in the truck. [13]

6.6.3 External wind

The efficiency of natural smoke ventilation may be affected by wind. According to Project 6 [14] the provision of symmetrical venting and vents that are not exposed to wind will overcome this potential problem. Within the proposed design, vents are provided to three sides of the building.

As an additional sensitivity analysis, a parametric study of the effect of wind on the smoke-layering inside the building has been modelled, for a 10MW fire involving combustibles associated with typical assembly buildings. A westerly wind direction was conservatively selected due to the large ventilation openings on the eastern elevation – in order to assess the impact of reducing their efficiency.

Annual wind data from Bureau of Meteorology are attached in Appendix D. On the basis of the data provided, a 3m/s was adopted in the analysis.

6.7 Smoke modelling

The smoke modelling conducted for the building utilises computational fluid dynamics (CFD) modelling.

6.7.1 Fire Dynamics Simulator version 5 (FDS5)

The ASET is determined by modelling the development of untenable conditions within the indoor arena. This involves modelling smoke production and spread with respect to fire size and time. The ASET values are determined for the building based on the output of the modelling conducted to predict smoke generation and movement.

CFD was used to model smoke generation and movement. The CFD program used for this modelling was Fire Dynamics Simulator – version 5 (FDS5). This program has been developed by National Institute of Science and Technology (NIST) in the United States, for the purposes of modelling smoke

[13] Systems and equipment for fire and smoke control in road tunnels, PIARC 05.16.B – 2006
[14] Fire Code Reform Centre, Fire safety in shopping centres, Final research report, Project 6, July 1998

and fire in buildings and outdoors. A full description of the CFD modelling conducted is included in Appendix B.

6.7.2 Smoke modelling results

The results of the smoke modelling for the building are summarised in Table 11 with the output data attached in Appendix B.

Fire scenario	Area considered	ASET (minutes)	Criteria	Comment
Fire involving typical assembly building combustibles	Indoor arena	> 30 > 30 > 30	Heat flux 2.5kW/m^2 Smoke temp 60°C Visibility 10m	Results indicate hot layer drops quickly initially but reaches steady state conditions after approximately 4.5 minutes. Thereafter, visibility of 10m and above is maintained at a height of 7m above the floor level of the sand arena. If seating is to be configured such that the finished floor level of the highest row of seating is to be no greater than 5m above the floor level of the sand arena – ie approximately 1.75m above the level of the concourse, the occupants are afforded tenable conditions in excess of 30 minutes.
Truck fire	Indoor arena	> 30 > 30 > 30	Heat flux 2.5kW/m^2 Smoke temp 60°C Visibility 10m	The increased fire size results in a greater depth of smoke layer. Upon reaching steady state conditions, visibility of 10m and above is maintained at a height of 6.25m above the floor level of the sand arena. If seating is to be configured such that the finished floor level of the highest row of seating is to be no greater than 4.25m above the floor level of the sand arena – ie approximately 1m above the level of the concourse, the occupants are afforded tenable conditions in excess of 30 minutes.

Table 11 Summary of smoke modelling results

6.8 Evacuation assessment

The results of the evacuation assessment for the building are summarised in Table 12. A full description of the evacuation assessment and calculations are attached in Appendix C.

Fire scenario	Area considered	Cue type	Cue period (minutes)	Pre-movement phase (minutes)	Movement period (minutes)	RSET (minutes)
Fire involving typical assembly building combustibles	Indoor arena	Visual and olfactory cues	1.5	3	< 8	< 12.5
Truck fire	Indoor arena	Visual and olfactory cues	1.5	3	< 8	< 12.5

Table 12 Evacuation times

6.9 Comparison of ASET/RSET margin

A comparison of the ASET/RSET margin for the scenarios assessed are summarised in Table 13. The ASET/RSET margin for the assessed areas exceeds the acceptance criteria specified in section 6.4.

Fire scenario	Area considered	ASET (minutes)	RSET (minutes)	ASET/RSET
Fire involving typical assembly building combustibles	Indoor arena	> 30	< 12.5	> 2.4 (> 1.5)
Truck fire	Indoor arena	> 30	< 12.5	> 2.4 (> 1.5)

Table 13 Comparison of ASET/RSET margin

6.10 Fire brigade intervention

Fire brigades are expected to initiate fire fighting activities within approximately 30 minutes [15] – based on an arrival within 10 minutes and set-up within 20 minutes – for a building in Sydney. The nearest to fire stations to SIEC are Bonnyrigg Heights (6km away) and Smithfield (8.8km away).

The smoke modelling performed demonstrated that temperatures within the building remain below 60°C for the duration of the modelling with the exception of the region immediately surrounding the fire. These temperatures are below the tenability limits for attending fire-fighters except in the localised area of the fire.

6.11 Impact of wind

As expected, the presence of an external wind reduces the efficiency of the smoke ventilation available. For strong winds the smoke layering is de-stratified by the air movement inside the building. Although there are localised areas downwind of the fire where the visibility is less than 10m, occupants will not be subjected to convected or radiant heat exceeding the tenability limits.

6.12 Conclusion

The assessment undertaken for the proposed design demonstrates that occupants are expected to be able to evacuate safely in the event of a fire. The proposed design of the indoor arena is therefore considered to achieve compliance with performance requirements DP4 and EP2.2 of the BCA, subject to compliance with the fire safety measures given in section 5.

[15] This is considered a conservative estimate based upon Table 13.1 of Fire Engineering Guidelines 1996 - Fire Code Reform Centre Ltd - 1st Edition - March 1996.

Appendix A Drawings and information

Drawing title	Dwg no	Date	Drawn
Indoor arena plans	EQA/101	20/10/99	Equus 2000 Pty Ltd
Indoor arena roof & reflected ceiling plans	EQA/102	20/10/99	Equus 2000 Pty Ltd
Indoor arena elevations	EQA/103	20/10/99	Equus 2000 Pty Ltd
Indoor arena sections	EQA/104	20/10/99	Equus 2000 Pty Ltd
Indoor arena stair & section details	EQA/110	20/10/99	Equus 2000 Pty Ltd
Indoor arena section details	EQA/111	20/10/99	Equus 2000 Pty Ltd
Seating plan – Sydney International Equestrian Centre	-	Sept 2003	Timothy Court & Company Architects
Fire alarm & EWS systems equipment layout – Indoor arena	EC4708-3D	28/06/99	Wormald Fire Systems

Other information	Ref no	Date	Prepared by
Sydney International Equestrian Centre – Fire Safety and Alarm Systems Certification of Design	B6054	05/01/98	Engineered Fire & Safety Solutions
Building Code of Australia Certification – Sydney International Equestrian Centre	-	10/03/98	Engineered Fire & Safety Solutions
Sydney International Equestrian Centre – Building Code of Australia Assessment, Section 70 Report and Section 93 Certification	-	22/04/98	Engineered Fire & Safety Solutions
Assessment of Fire Detection at the Indoor Arena and Stables, Sydney International Equestrian Centre	-	March 2000	Engineered Fire & Safety Solutions
Review of Installed Fire Safety Systems for Indoor Arena and Stables at Sydney International Equestrian Centre	2008/SIEC-1	10/05/08	P&D Pty Ltd
Notice of Determination Building Approval – Sydney International Equestrian Centre	132/97	05/05/98	Olympic Coordination Authority
Notice of Determination Building Approval – Sydney International Equestrian Centre	18/01	29/10/01	Olympic Coordination Authority
Comments on modification of development consent for Sydney International Equestrian Centre, Horsley Park	CRM 122974/2012	12/07/12	Fairfield City Council

Appendix B FDS smoke modelling assessment

B.1 Introduction

This section provides a brief overview of FDS5 [16,17] for the purposes of familiarisation. The theoretical basis of FDS5 is described in detail within the FDS5 Technical Reference Guide. The FDS User's Guide provides a thorough explanation of how to setup and perform simulations.

The FDS model was developed specifically for modelling building fires. FDS is a computational fluid dynamics (CFD) model generally applied to fire-driven fluid flow. In FDS, the computational domain is discretised into three dimensional rectilinear volumes referred to as the grid or mesh. The partial derivatives of the conservation equations of mass, momentum and energy are approximated as finite differences, and the solution is updated in time on the rectilinear grid.

The geometry specified by the user in FDS conforms to the rectilinear grid and hence is limited by the resolution of the grid. Similarly, boundary conditions such as vents are applied as patches on the exterior of the domain which will also conform to the rectilinear grid.

Output from the simulation is included in this appendix at various times so the ability of occupants to safely evacuate from the fire and smoke affected areas can be assessed.

B.2 FDS input parameters

B.2.1 General

The following general parameters were applied in the FDS models described in this section:

- Turbulence was modelled using Large Eddy Simulation (LES). In a LES, the larger geometry dependant eddies are solved explicitly and the smaller eddies are filtered using a sub-grid scale model.
- The combustion model which FDS utilises for LES application is based on a mixture fraction. The mixture fraction is 'a conserved scalar quantity that is defined as the fraction of gas at a given point in the flow field that originates as fuel' – ie at the surface of a burning fuel the mixture fraction is 1 and in fresh air the mixture fraction is 0.
- All walls, columns, ceilings and floors are assumed to be inert, ie no heat gain of bounding construction is modelled. This is considered an acceptable approximation as the heat transfer from the smoke to surrounding structures for areas remote from the fire is relatively low for localised fires.
- Openings were modelled as passive openings to an infinite reservoir, ie no significant over- or under-pressure can be created, with outside temperature the same as the initial internal temperature.
- Air is the only fluid simulated with the computational domain at the commencement of the simulation.
- The temperature for the ambient environment has been specified as 20°C.

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[16] http://www.fire.nist.gov/fds/
[17] McGrattan K.B. et Al., Fire Dynamics Simulator (Version 5) – User's Guide, NIST Special Publication 1019-5, NIST, US, January 2008.

B.2.2 Fire properties

The design fuel for the scenarios modelled was based on a mixture of combustibles:

Material	Mass percentage	Volume percentage
Wood	40%	29%
Nylon	15%	11%
PVC	15%	17%
Polyurethane	15%	18%
Polystyrene	15%	26%

The mixture of combustible was chosen to represent generic building materials and contents such as cellulosic materials, textile fabrics, rigid plastics, expanded plastics and upholstery foam found in typical building occupancies. The properties of the combined fuel in comparison to the individual components are shown in Table 14 [18,19].

	Wood	Nylon	PVC	Polyurethane	Polystyrene	Average mixture
Common use	Shelving and building partitions	Clothing	Rigid plastics	Upholstery/ furniture	Packing materials	-
Heat of combustion (kJ/g)	17.7	30.8	16.4	27.2	39.2	22.5
Soot yield (g/g)	0.015	0.075	0.14	0.23	0.16	0.1
CO yield (g/g)	0.006	0.028	0.053	0.086	0.060	0.037
Mass optical density (m^2/g)	0.037	0.23	0.40	0.33	0.34	0.21
Heat of combustion, CO yield and mass optical density data for components taken from Enclosure Fire Dynamics. Property for mixture and CO yield for all materials derived using method outlined in FDS Users guide.						

Table 14 Combustion product yields for design fire

The resulting material reaction that was used within FDS is as follows:

```
&REAC ID='MIXED_COMBUSTIBLES'
FYI=' 40% Wood, 15% PVC, 15% Polyurethane, 15% Nylon, 15% Polystyrene'
C= 1
H=1.764
O= 0.385
CO_YIELD= 0.037
VISIBILITY_FACTOR= 2.303
SOOT_YIELD= 0.1
MASS_EXTINCTION_COEFFICIENT= 4994 /
IDEAL = .FALSE. /
```

[18] Karlsson, B and Quintiere, J.G., Enclosure Fire Dynamics, CRC Press, 2000
[19] McGratton, K and Forney, G, Fire Dynamics Simulator (Version 5) Users Guide, NIST Special Publication 1019-5, January 2008

B.2.3 Visibility factor

The visibility calculation in FDS, which by default is based on a reflective exit sign, has conservatively been adjusted by reducing the 'VISIBILITY FACTOR' from 3.0 to 2.3 – ie by increasing the light attenuation in the smoke by a factor of 1.3. This adjustment is required to ensure that FDS calculates the visibility to non-illuminated walls and obstructions such that a predicted visibility of 10m correlates to a smoke optical density of $0.1m^{-1}$ or 1.0dB/m in accordance with the Fire Engineering Guidelines.

Where queuing locally in front of an exit occurs a higher visibility factor of 8 should be applied, representing the visibility to an illuminated exit sign. As only one visibility factor can be modelled this will be accounted for by assessing when a visibility of 2.9m is reached at the exits, being equivalent to a visibility of 10m to an illuminated exit sign.

B.3 Grid resolution

B.3.1 Available research on grid resolution

Validation tests of FDS have been undertaken by NIST. Three experiments were completed where a pool of heptane was burned and gas temperatures were collected. The room measured 27m long, 14m wide and 19m high with a sloped ceiling, an exhaust duct and several doors opening at the base of the room. The analysis region surrounding the fire measured 4m by 4m by 10m high with computational cells that measured 0.13m. Further away from the fire larger grids were used. The modelling resulted in calculations that agreed reasonably well with the measurements where the upper thermocouples were within 10°C of the measured temperatures that varied between 100°C and 150°C above ambient. The lower layer measurements were also within 10°C with these temperatures between 20°C and 100°C but the measurement near the floor under predicted the temperature by approximately 10°C [20].

Research undertaken by the University of Canterbury concluded that the grid size could have a significant impact on the results and was dependent on the geometry of the enclosure. It was concluded that the temperature predictions in the fire and plume were unreliable unless a fine grid was used but a finer grid outside the fire region did not necessarily mean more accurate predictions. Comparisons to US Navy hangar tests concluded that a 600 mm grid over-predicted the temperatures by as much as 200°C in the region of the fire plume while away from the fire the predictions were more accurate near the ceiling [21]. Therefore in modelling smoke in the region away from the fire, the results are not as sensitive to grid size. For the smoke modelling conducted in this assessment the exact characteristics of the plume are not the main concern, rather the conditions in the smoke layer far from the plume are of interest.

A comparison of FDS model predictions with experiments conducted in a hangar with a 15m ceiling concluded that a reasonable agreement with empirical plume correlations were achieved when the spatial grid in the vicinity of the fire is about one tenth of the characteristic fire diameter [22].

[20] McGrattan K.B. et Al., Fire Dynamics Simulator (Version 5) Technical Reference Guide, Volume 3, NIST Special Publication 1018-5, January 2008
[21] Petterson N., 'Assessing the Feasibility of Reducing the Grid Resolution in FDS Field Modelling', University of Canterbury, NZ 2002
[22] Davis W. et Al.. 'Comparison of Fire Model Predictions with Experiments Conducted in Hangar with a 15 meter Ceiling', NISTIR 5927. US 1996

B.3.2 Calculation of characteristic fire diameter

The research presented in B.3.1 concluded that the cell size within the fire region should be approximately one-tenth the characteristic fire diameter which is approximately 0.25-0.4m for a 10-30MW fire. Equation 1 shows the formula for the characteristic fire diameter.

$$D^* = \left(\frac{Q}{r_\infty T_\infty c_p \sqrt{g}} \right)^{2/5}$$

where:

D* = Characteristic fire diameter (m)

Q = Heat release rate (kW)

ρ_∞ = Density of ambient air (kg/m^3)

T_∞ = Ambient air temperature (K)

c_p = Heat capacity of ambient air (kJ/(kg K))

g = Gravity (9.81 m/s^2)

Equation 1 Characteristic fire diameter

B.3.3 Modelled grid resolution

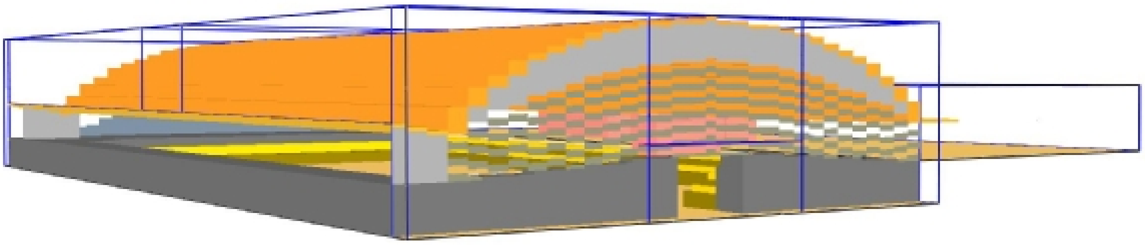
Based on the information provided in sections B.3.1 and B.3.2 the grid resolution summarised in Table 15 is considered acceptable for the purpose this assessment and provides an appropriate estimation of the overall smoke movement and temperatures.

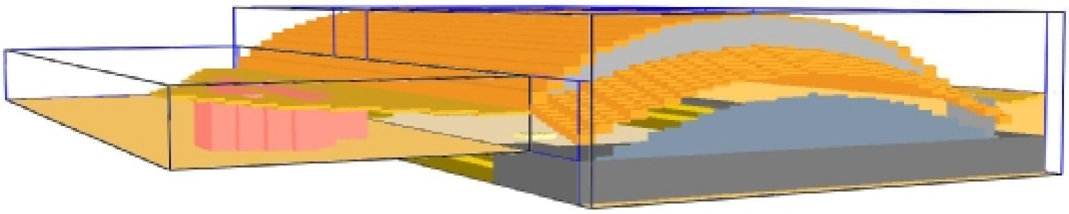
The aspect ratio of the cells in the models is maintained within the recommended limit of 1:3 in the FDS manual.

Area	Direction	Cell size (m)
Fire region	X-direction	0.25
	Y-direction	0.25
	Z-direction	0.25
Away from fire region	X-direction	0.5
	Y-direction	0.5
	Z-direction	0.25

Table 15 Grid resolution

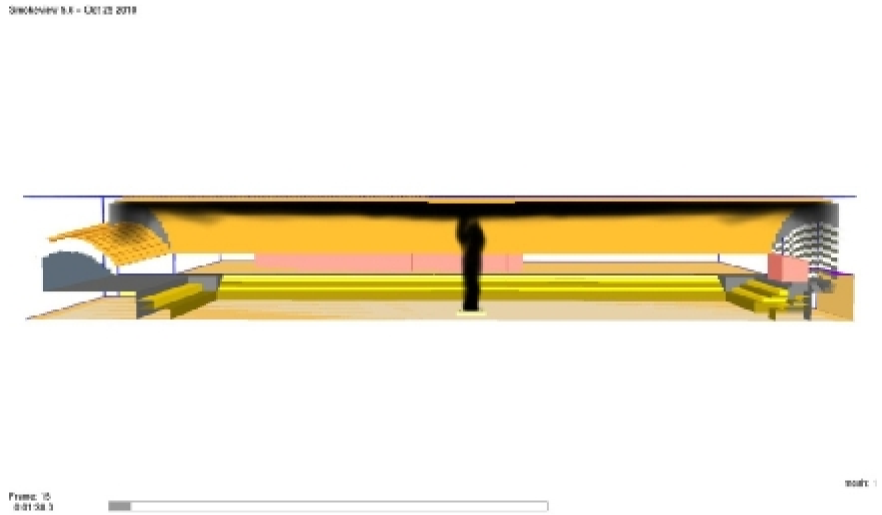
B.4 Model geometry



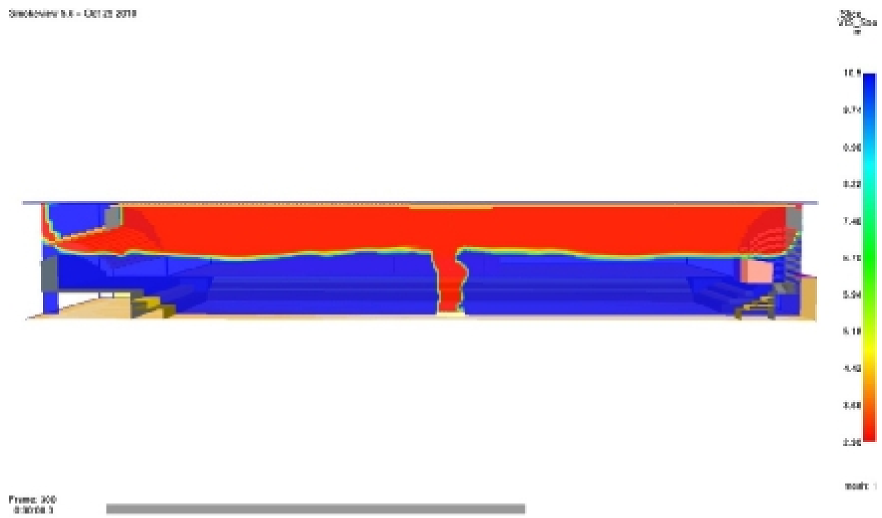


B.5 Scenario 1 results – 10MW fire involving typical assembly building combustibles [23]

B.5.1 Smoke spread

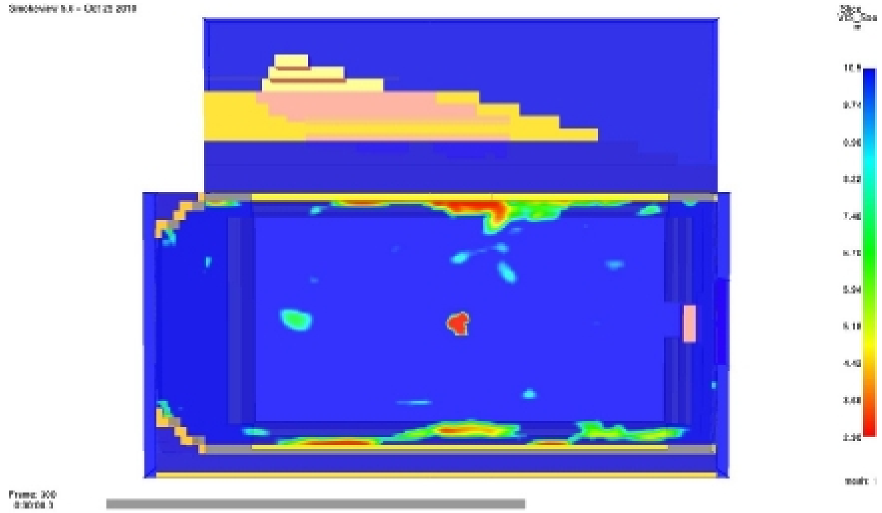
Timeline	
1.5 minutes After 1.5 minutes, a significant portion of the ceiling (approximately 10%) is covered with a smoke layer. This is taken to be the cue period when occupants receive visual and olfactory cues.	

B.5.2 Visibility – section

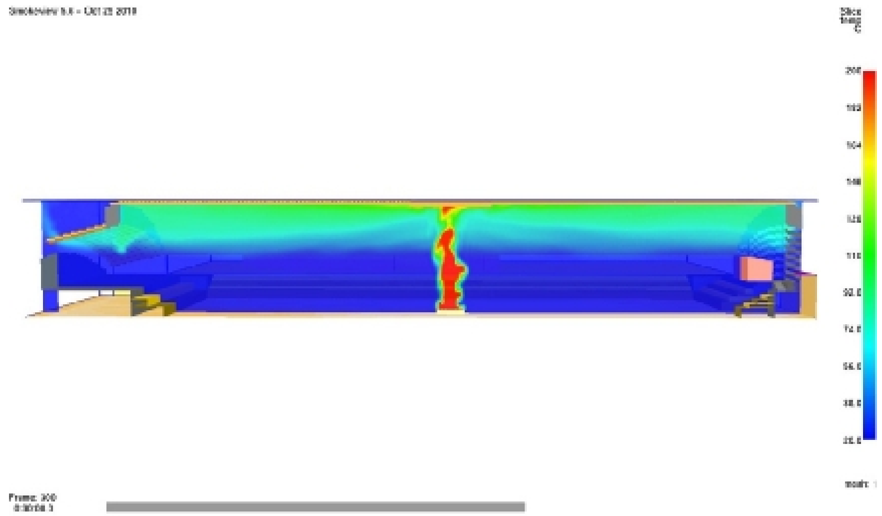
Timeline	The colour blue indicates visibility exceeding 10m to non-illuminated walls and obstructions which is the limit for tenability. Other colours indicate a visibility of less than 10m.
30 minutes After 30 minutes, visibility of 10m and above is maintained at a height of 7m above the floor level of the sand arena.	

[23] FDS data file – SY110362-SIEC4.data

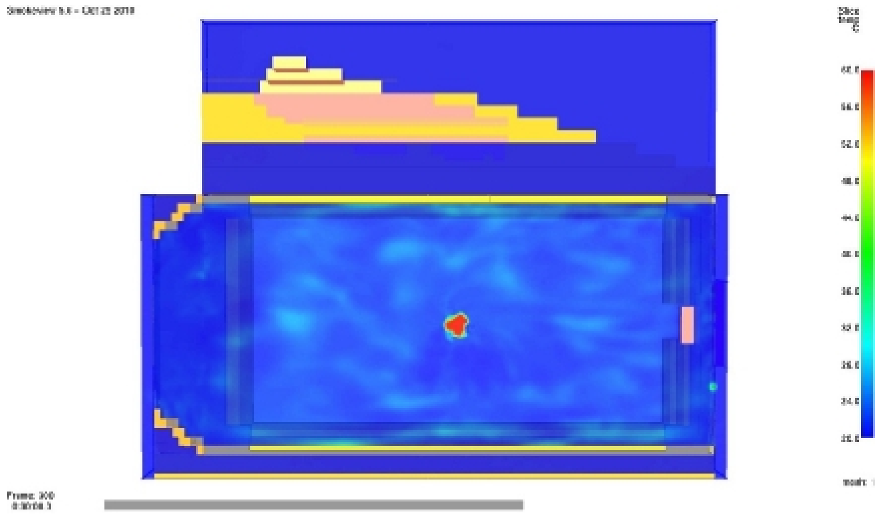
B.5.3 Visibility at 7m above floor level

Timeline	The colour blue indicates visibility exceeding 10m to non-illuminated walls and obstructions which is the limit for tenability. Other colours indicate a visibility of less than 10m.
30 minutes After 30 minutes, visibility of 10m and above is generally maintained at a height of 7m above the floor level of the sand arena.	

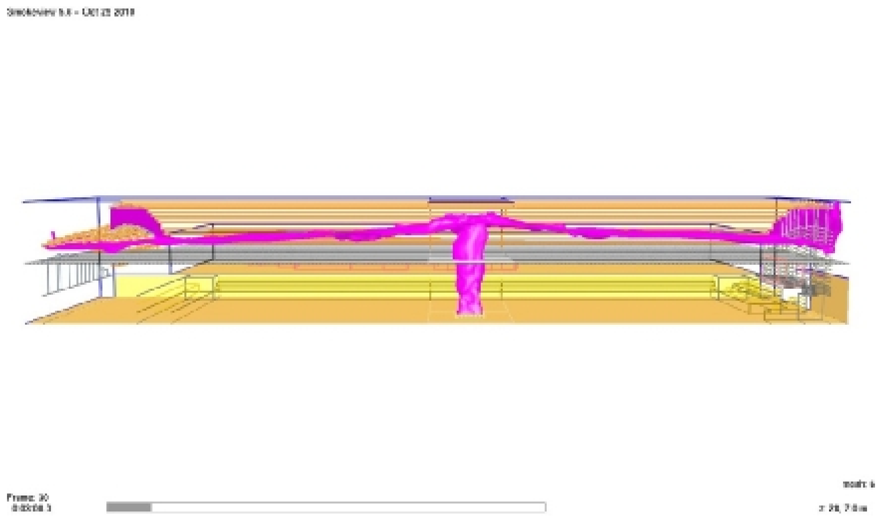
B.5.4 Temperatures – section

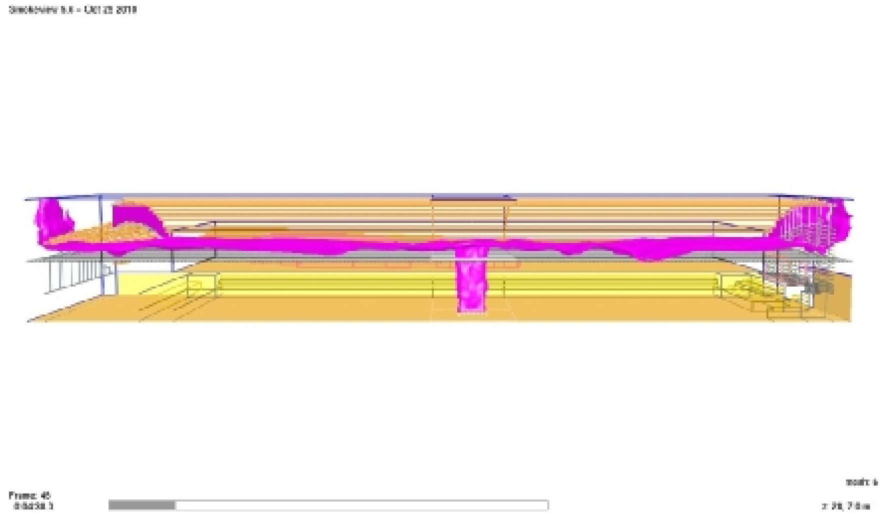
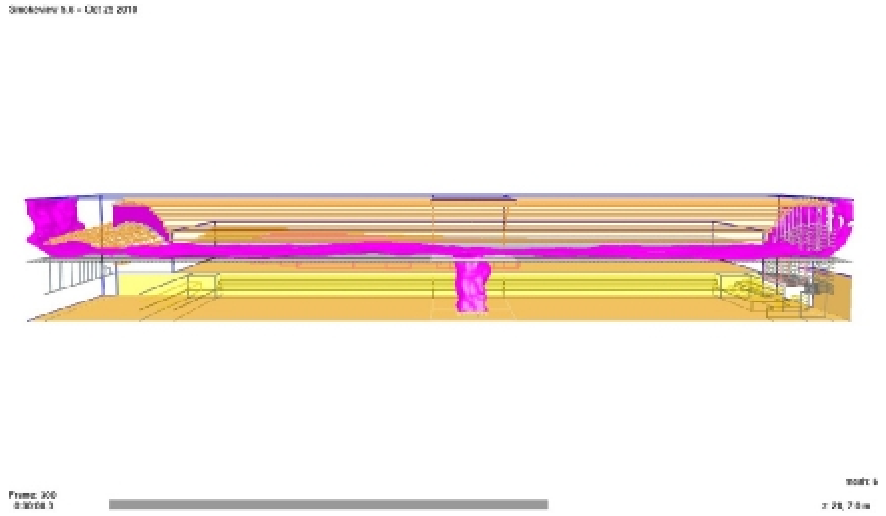
Timeline	The colour blue indicates temperatures of approximately 20°C. The colour red indicates temperatures of approximately 200°C which corresponds to the limit for tenability for radiation.
30 minutes After 30 minutes, the upper layer temperatures throughout the building are less than 200°C, with the exception of the immediate vicinity of the fire.	

B.5.5 Temperatures at 7m above floor level

Timeline	The colour blue indicates temperatures of approximately 20°C. The colour red indicates temperatures of approximately 60°C which is the limit for tenability.
30 minutes After 30 minutes, the temperatures at a height of 7m above the floor level of the sand arena are less than 60°C, with the exception of the immediate vicinity of the fire.	

B.5.6 10m visibility isosurface

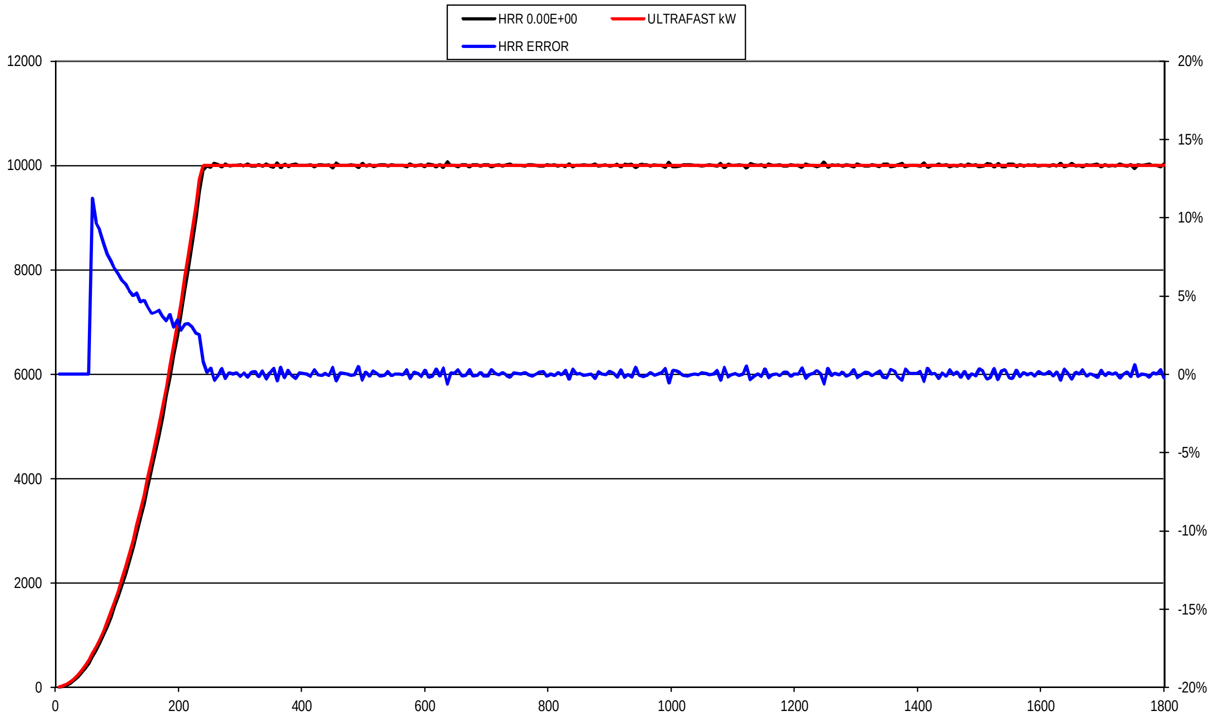
Timeline	
3 minutes	

Timeline	
4.5 minutes	
30 minutes	

B.5.7 Error checking

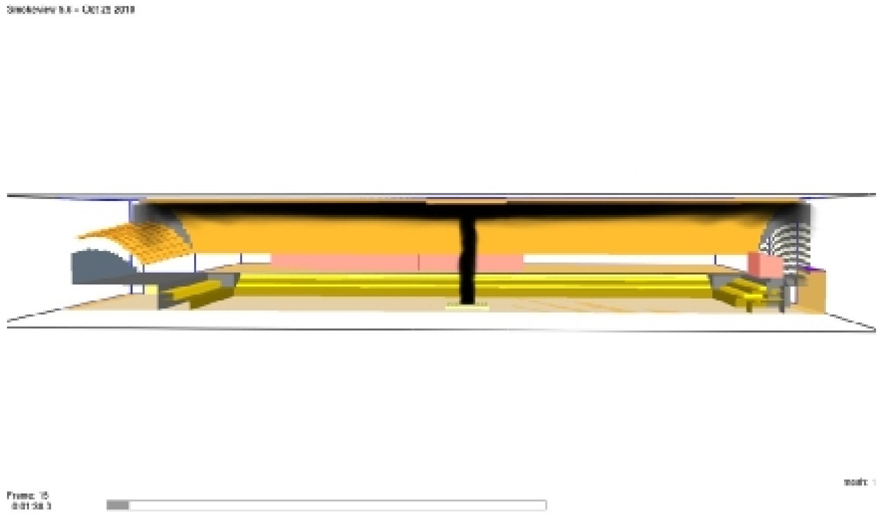
Heat release rate

The following graph compares the heat release rate specified in the FDS input file with the actual heat release rate measured in the output to confirm consistency. The graph shows consistency between input and output data with errors of less than 12.5% during the early growth phase when the fire size is small and less than 2% error once the peak fire size is reached.

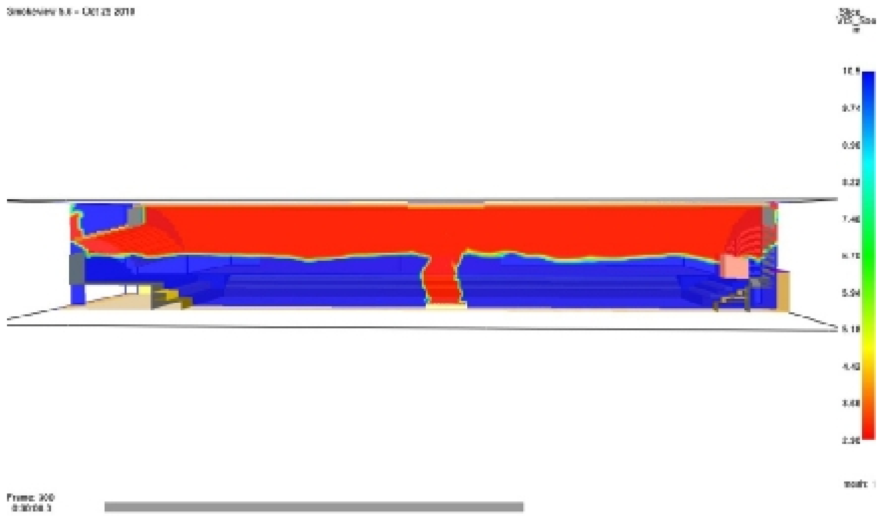


B.6 Scenario 2 results – 30MW truck fire [24]

B.6.1 Smoke spread

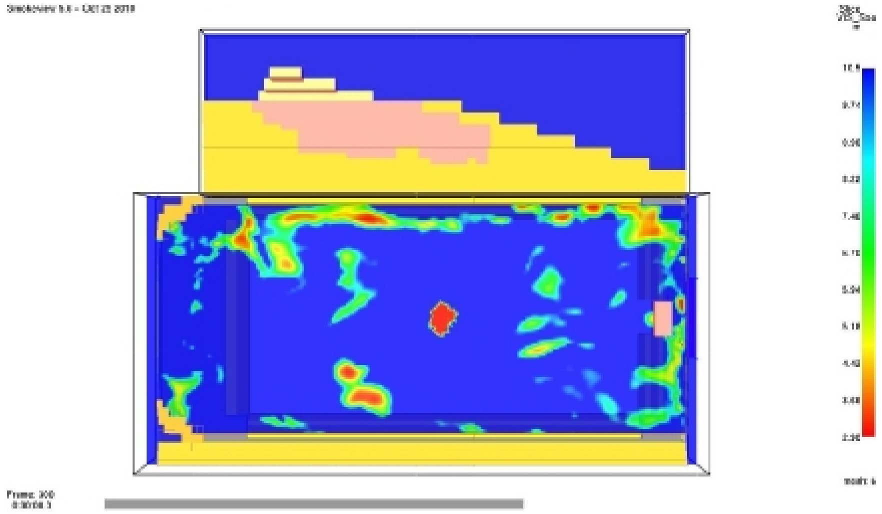
Timeline	
1.5 minutes After 1.5 minutes, a significant portion of the ceiling (approximately 10%) is covered with a smoke layer. This is taken to be the cue period when occupants receive visual and olfactory cues.	

B.6.2 Visibility – section

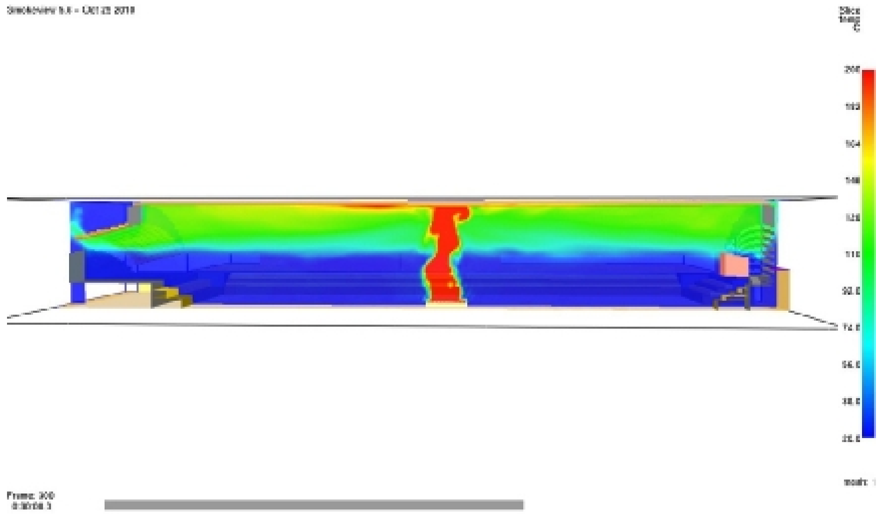
Timeline	The colour blue indicates visibility exceeding 10m to non-illuminated walls and obstructions which is the limit for tenability. Other colours indicate a visibility of less than 10m.
30 minutes After 30 minutes, visibility of 10m and above is maintained at a height of 6.25m above the floor level of the sand arena.	

[24] FDS data file – SY110362-SIEC3.data

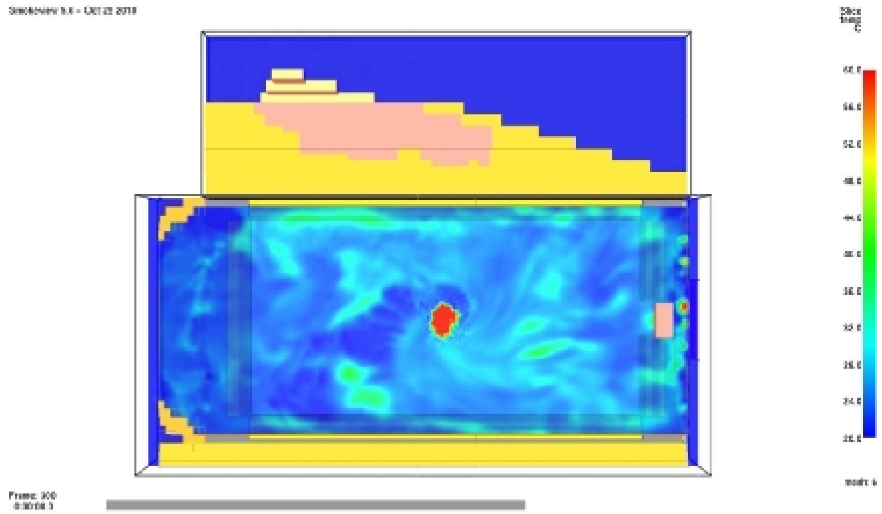
B.6.3 Visibility at 6.25m above floor level

Timeline	The colour blue indicates visibility exceeding 10m to non-illuminated walls and obstructions which is the limit for tenability. Other colours indicate a visibility of less than 10m.
30 minutes After 30 minutes, visibility of 10m and above is generally maintained at a height of 6.25m above the floor level of the sand arena.	

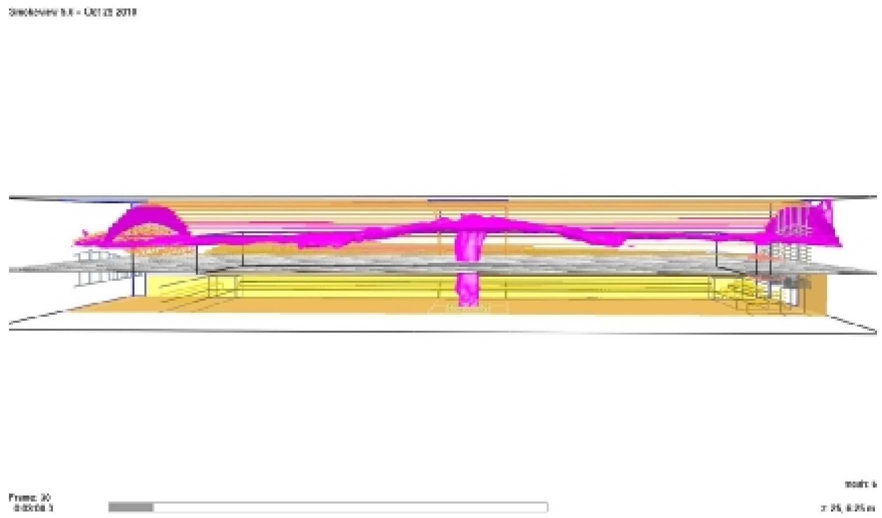
B.6.4 Temperatures – section

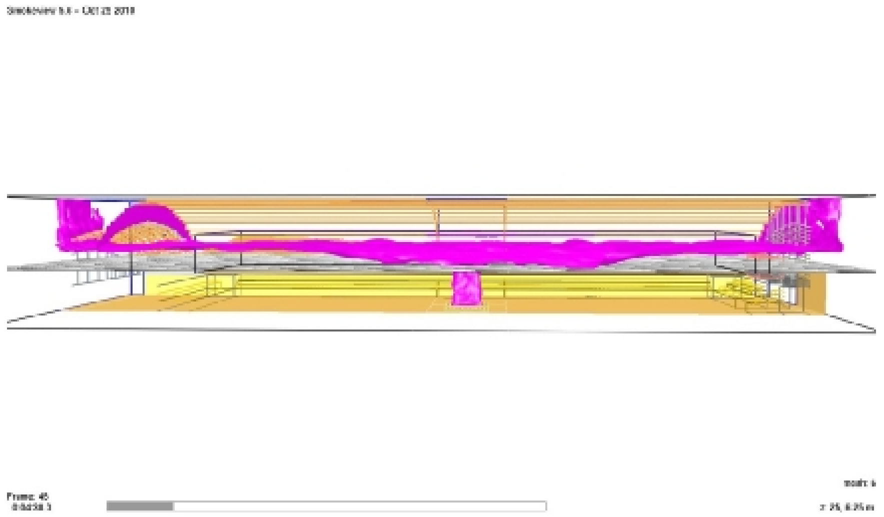
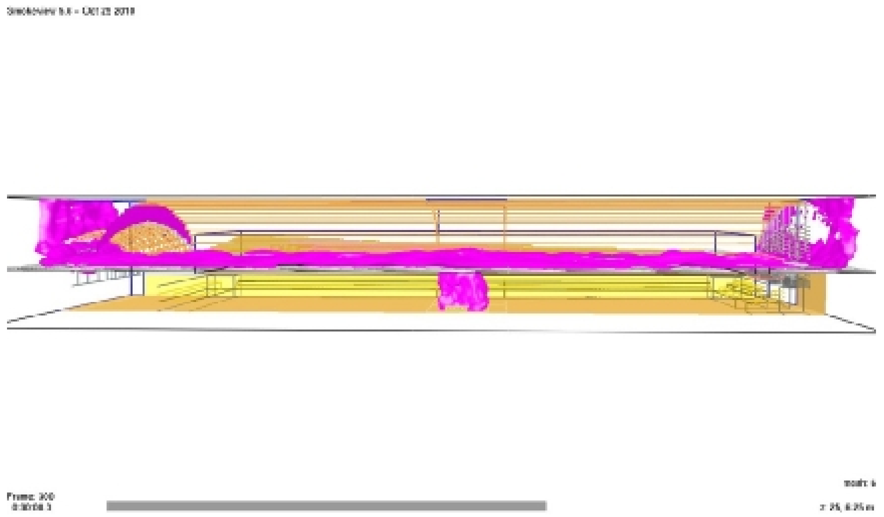
Timeline	The colour blue indicates temperatures of approximately 20°C. The colour red indicates temperatures of approximately 200°C which corresponds to the limit for tenability for radiation.
30 minutes After 30 minutes, the upper layer temperatures throughout the building are less than 200°C, with the exception of the immediate vicinity of the fire.	

B.6.5 Temperatures at 6.25m above floor level

Timeline	The colour blue indicates temperatures of approximately 20°C. The colour red indicates temperatures of approximately 60°C which is the limit for tenability.
30 minutes After 30 minutes, the temperatures at a height of 6.25m above the floor level of the sand arena are less than 60°C, with the exception of the immediate vicinity of the fire.	

B.6.6 10m visibility isosurface

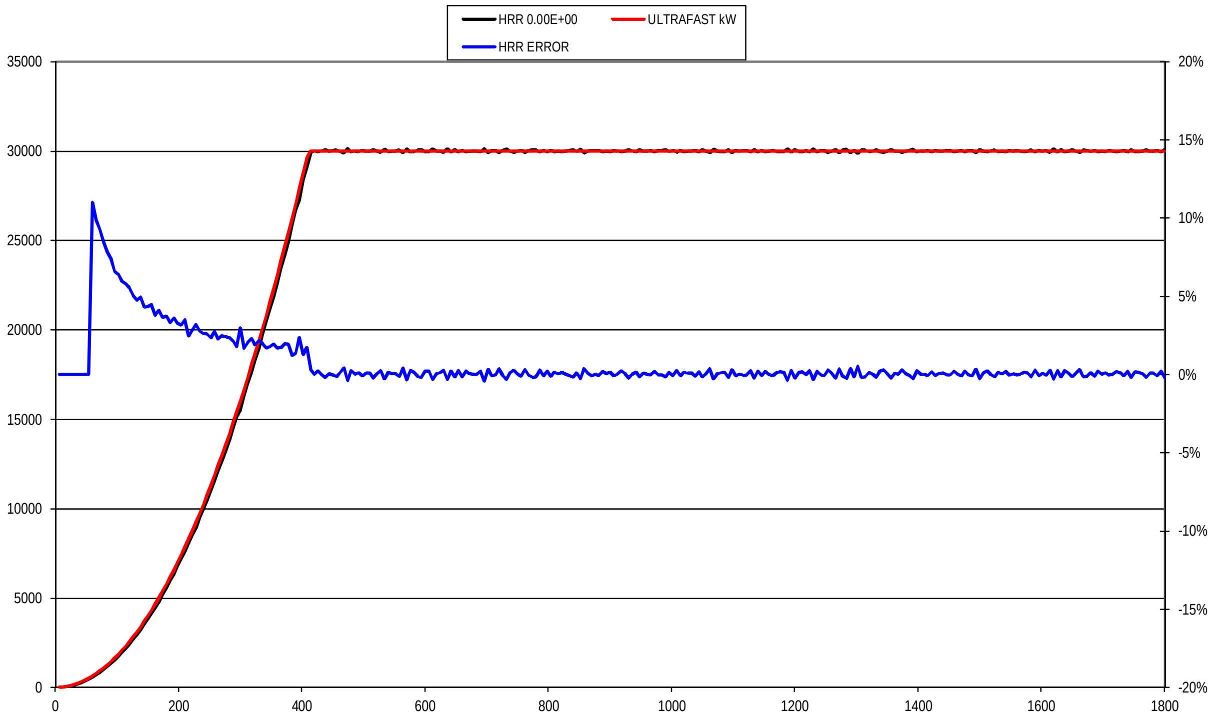
Timeline	
3 minutes	

Timeline	
4.5 minutes	
30 minutes	

B.6.7 Error checking

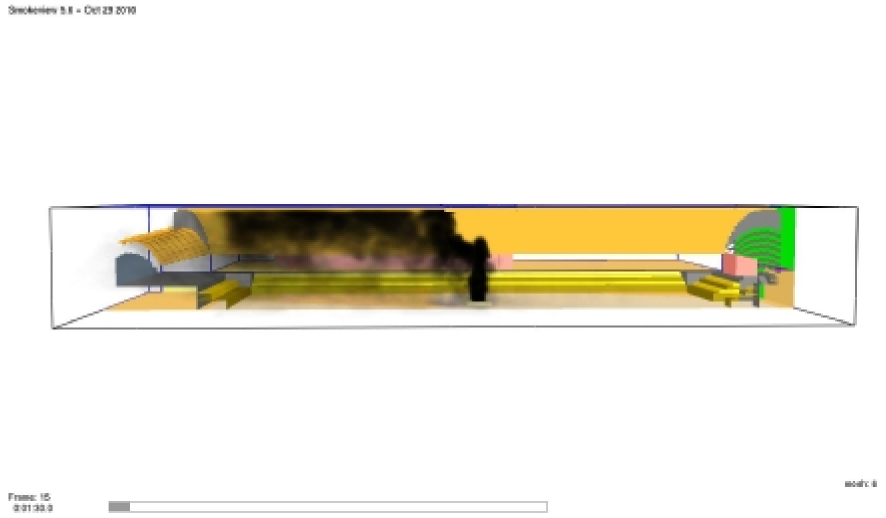
Heat release rate

The following graph compares the heat release rate specified in the FDS input file with the actual heat release rate measured in the output to confirm consistency. The graph shows consistency between input and output data with errors of less than 12.5% during the early growth phase when the fire size is small and less than 2% error once the peak fire size is reached.

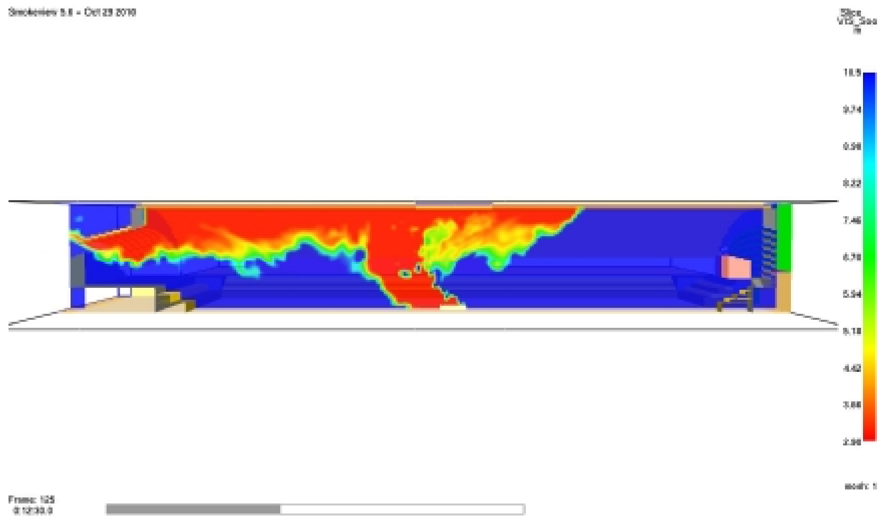


B.7 Scenario 3 results – 10MW fire involving typical assembly building combustibles, with 3m/s westerly wind [25]

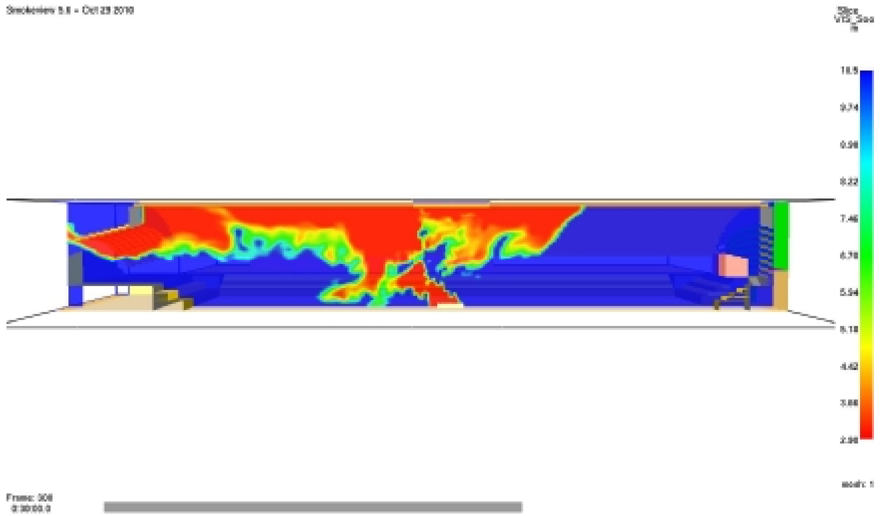
B.7.1 Smoke spread

Timeline	
1.5 minutes After 1.5 minutes, a significant portion of the ceiling downstream of the fire is covered with a smoke layer. This is taken to be the cue period when occupants receive visual and olfactory cues.	

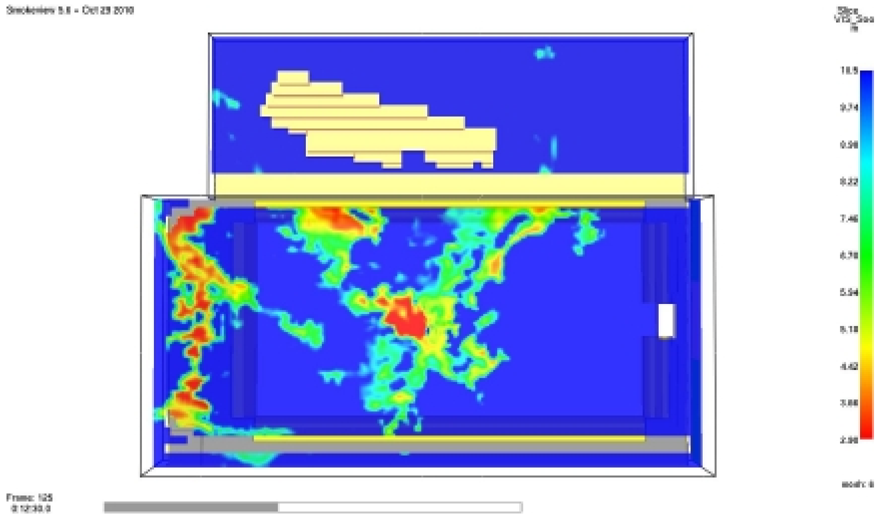
B.7.2 Visibility – section

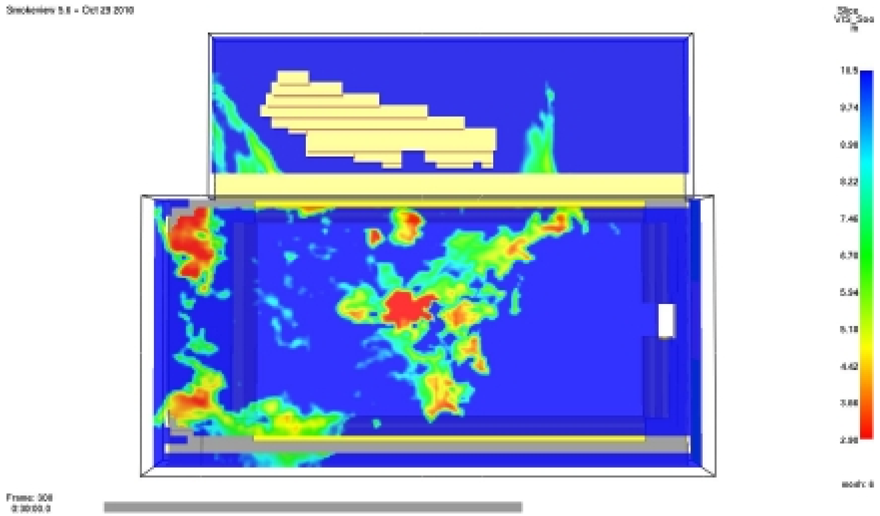
Timeline	The colour blue indicates visibility exceeding 10m to non-illuminated walls and obstructions which is the limit for tenability. Other colours indicate a visibility of less than 10m.
12.5 minutes Smoke layering is de-stratified by the air movement inside the building.	

[25] FDS data file – SY110362-SIEC3.data

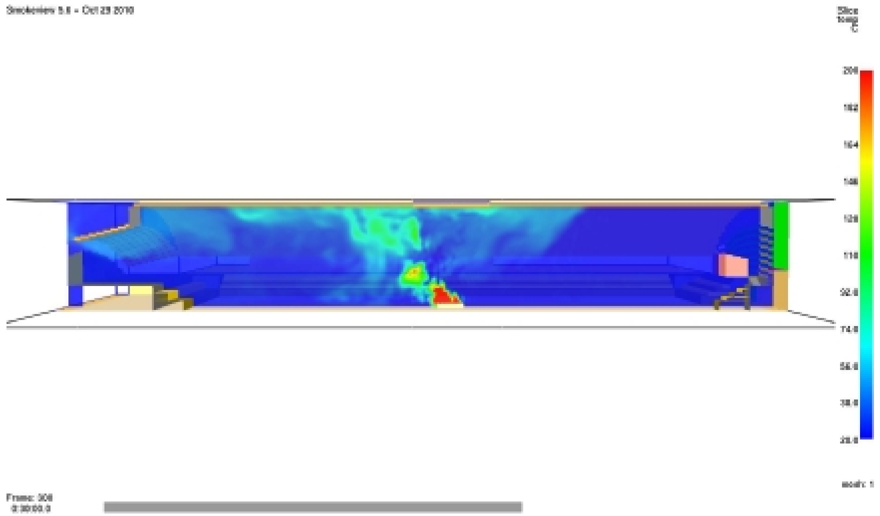
Timeline	The colour blue indicates visibility exceeding 10m to non-illuminated walls and obstructions which is the limit for tenability. Other colours indicate a visibility of less than 10m.
30 minutes Smoke layering is de-stratified by the air movement inside the building.	

B.7.3 Visibility at 6.25m above floor level

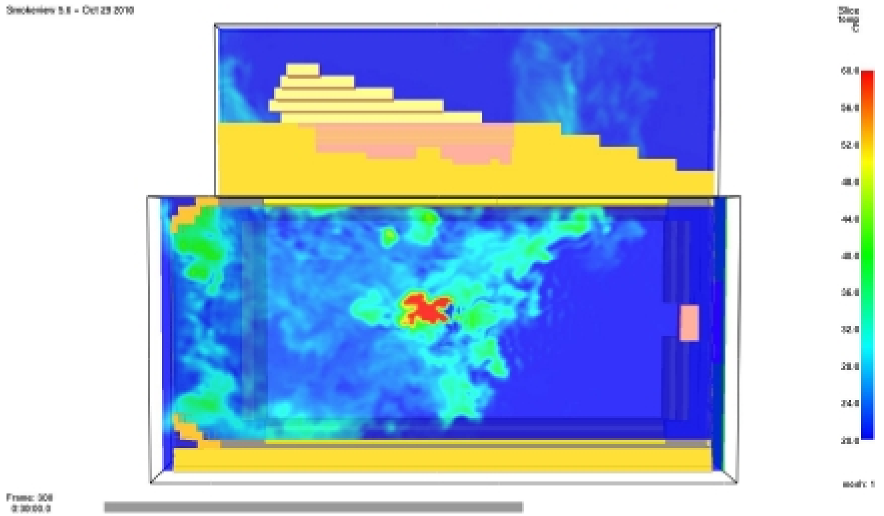
Timeline	The colour blue indicates visibility exceeding 10m to non-illuminated walls and obstructions which is the limit for tenability. Other colours indicate a visibility of less than 10m.
12.5 minutes After 12.5 minutes, visibility of 10m and above is maintained for the majority of the arena at a height of 6.25m above the floor level of the sand arena. There are localised areas where visibility is less than 10m due to the de-stratification of the smoke layer.	

Timeline	The colour blue indicates visibility exceeding 10m to non-illuminated walls and obstructions which is the limit for tenability. Other colours indicate a visibility of less than 10m.
30 minutes After 30 minutes, visibility of 10m and above is maintained for the majority of the arena at a height of 6.25m above the floor level of the sand arena. There are localised areas where visibility is less than 10m due to the de-stratification of the smoke layer.	

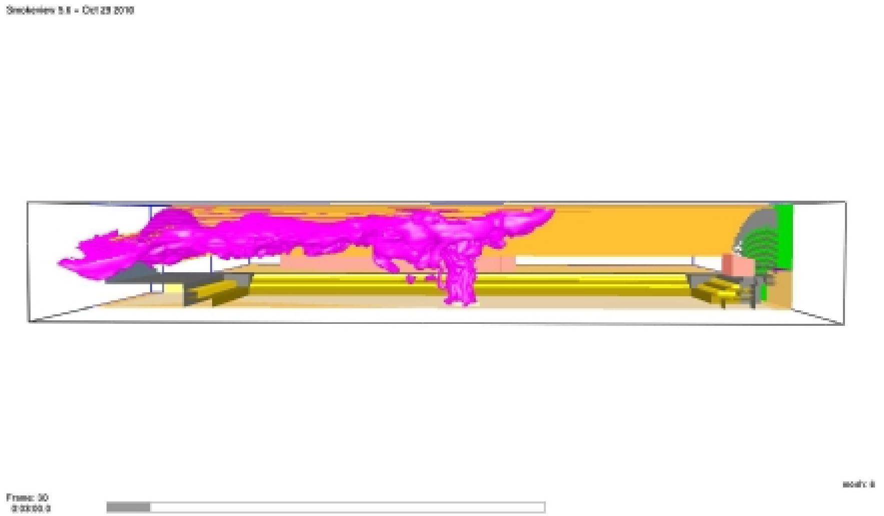
B.7.4 Temperatures – section

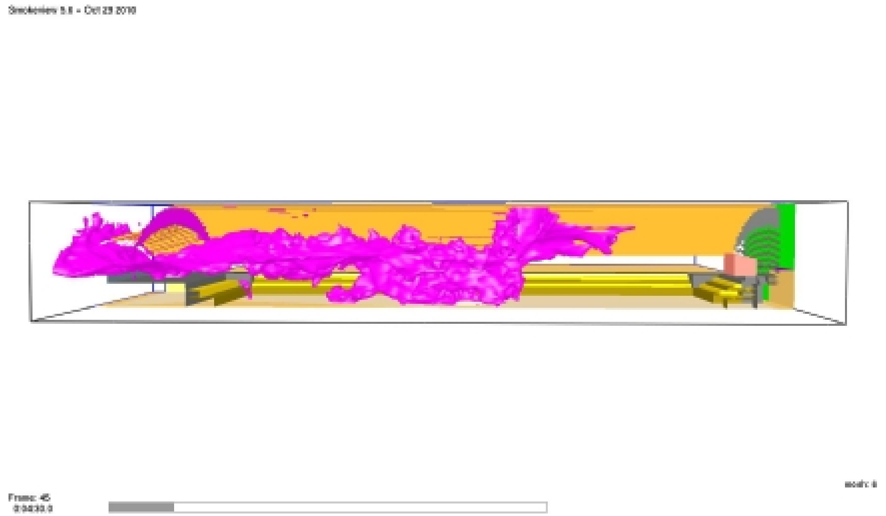
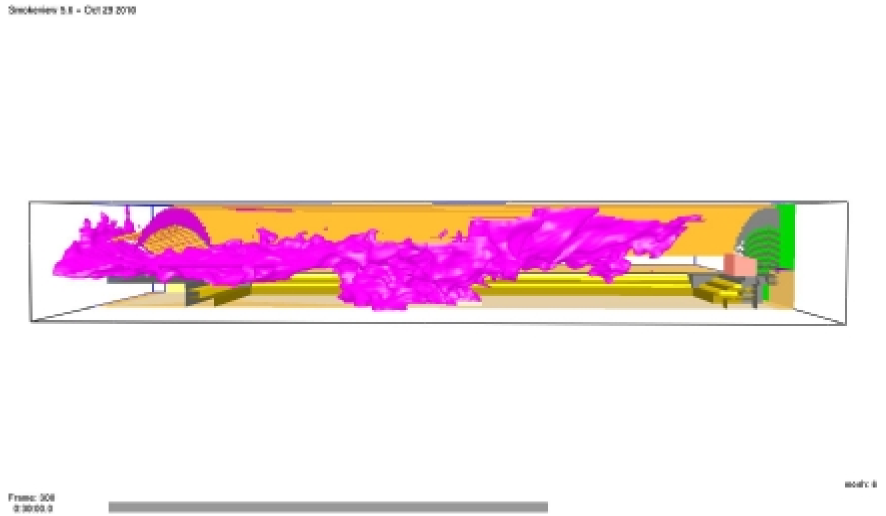
Timeline	The colour blue indicates temperatures of approximately 20°C. The colour red indicates temperatures of approximately 200°C which corresponds to the limit for tenability for radiation.
30 minutes After 30 minutes, the upper layer temperatures throughout the building are less than 200°C, with the exception of the immediate vicinity of the fire.	

B.7.5 Temperatures at 6.25m above floor level

Timeline	The colour blue indicates temperatures of approximately 20°C. The colour red indicates temperatures of approximately 60°C which is the limit for tenability.
30 minutes After 30 minutes, the temperatures at a height of 6.25m above the floor level of the sand arena are less than 60°C, with the exception of the immediate vicinity of the fire.	

B.7.6 10m visibility isosurface

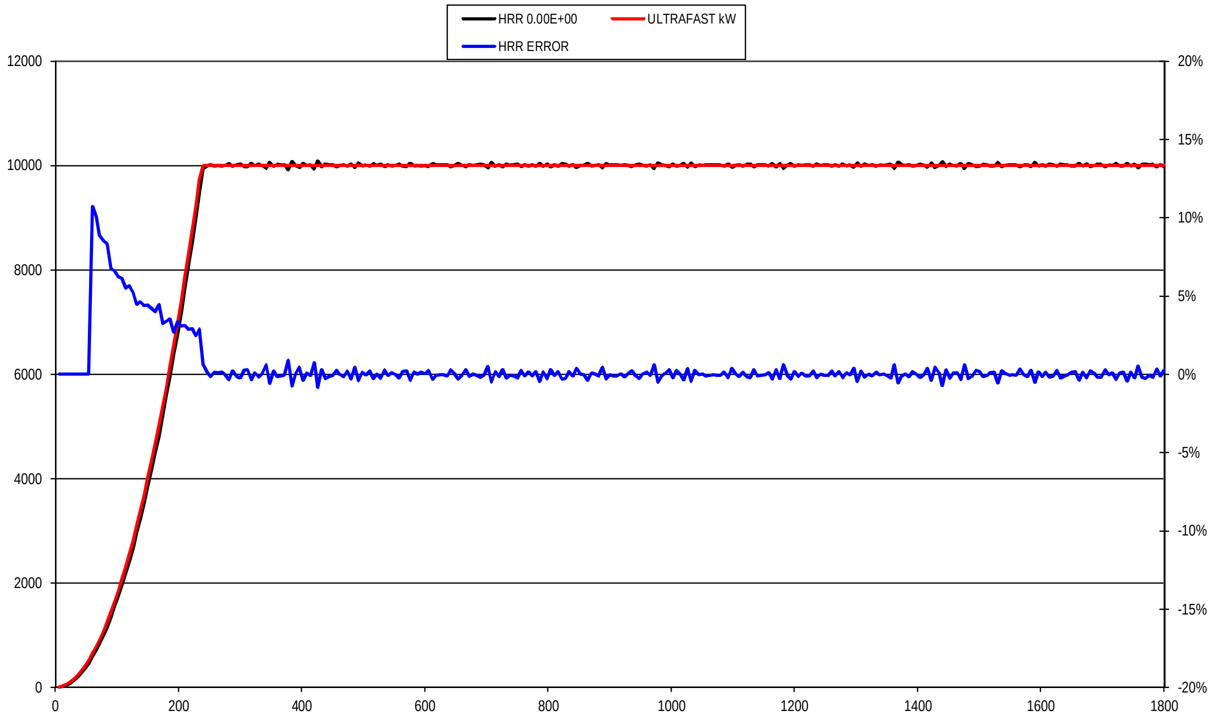
Timeline	
3 minutes	

Timeline	
4.5 minutes	
30 minutes	

B.7.7 Error checking

Heat release rate

The following graph compares the heat release rate specified in the FDS input file with the actual heat release rate measured in the output to confirm consistency. The graph shows consistency between input and output data with errors of less than 12.5% during the early growth phase when the fire size is small and less than 2% error once the peak fire size is reached.



Appendix C Evacuation assessment

C.1 Evacuation assessment framework

The International Fire Engineering Guidelines state that the RSET is the time from when a fire initiates to the time when occupants reach a place of safety. The framework used to calculate the RSET is based upon Equation 2. The RSET is measured from the same point of origin as the fire at the time of initiation. The calculation of the RSET using Equation 2 is the addition of four periods, which are briefly described by the following:

- Cue period (P_c) – taken from the time of fire initiation to the time a cue indicates the occurrence of a fire.
- Response period (P_r) – taken from the time a cue indicates the occurrence of a fire to the time occupants recognise the cue as an indication of a fire.
- Delay period (P_d) – taken from the time occupants recognise the cue as an indication of fire to the time occupants commence evacuation.
- Movement period (P_m) – taken from the time occupants commence evacuation to the time when occupants reach a place of safety. This period is calculated on the basis of human walking speeds and queuing at exits affected by crowding.

$$RSET = P_c + P_r + P_d + P_m$$

where :

P_c is the cue period,

P_r is the response period,

P_d is the delay period, and

P_m is the movement period.

Equation 2 Calculation of RSET

C.2 Populations nominated

The populations within the indoor arena are detailed in Table 6.

C.3 Cue period (P_c)

The cue period is primarily dependent on the fire location, the fire growth rate and the active detection systems provided within the fire zone. As the smoke detection system within the indoor arena is to be removed, the cue period will be dependent on intrinsic cues. From the smoke modelling results as indicated in Appendix B, a significant portion of the ceiling – approximately 10% – is covered with a smoke layer for the fire scenarios assessed after approximately 1.5 minutes. It is therefore considered that the majority of occupants are expected to receive intrinsic cues after this time.

C.4 Pre-movement phase ($P_r + P_d$)

The pre-movement phase is the time taken between when the cue was first received and the movement phase to a place of safety. Pre-movement time can be broken down into two components, response period (P_r) and delay period (P_d).

C.4.1 Response period (P_r)

The occupant response period involves the process of interpreting the automatic or intrinsic cue and identifying it as a cause for evacuation. The response period is dependent upon the type of cue.

C.4.2 Delay period (P_d)

Following the time for the occupants to interpret the cue and identify it as a cause for evacuation, occupants undertake actions such as collecting belongings, looking for other occupants and investigating to obtain further information prior to beginning to move towards the exits.

C.4.3 Pre-movement phase ($P_r + P_d$)

The pre-movement phase for occupants within the indoor arena is assumed to be 3 minutes, based upon: [26]

- occupants awake but may be familiar with the building, alarm system and evacuation procedure; and
- occupants in a large room / space of fire origin who can clearly see smoke and flames at a distance.

C.5 Movement period (P_m)

This section describes the evaluation of the times necessary for movement of occupants to the exits.

Observations and experiments have shown that evacuation flow speed of a group is a function of the population density [27,28,29]. If the population density is less than about 0.54 persons/m^2 in the exit route individuals will move at their own pace, independent of the speed of others. If the population density exceeds approximately 3.8 persons/m^2, no movement will take place until enough of the crowd has passed from the crowded area to reduce the density. Between the density limits of 0.54 and 3.8 persons/m^2 the relationship can be considered as a linear function. This linear function is given by Equation 3 with Figure 3 showing the relationship between speed and density. The maximum speed occurs when the density is less than 0.54 persons/m^2.

[26] Proulx, G., Movement of People: The Evacuation Timing, Chapter 3-13 of the SFPE Handbook of Fire Protection Engineering, 3rd Edition, SFPE, Bethesda, Maryland, 2002, pp 3-351.
[27] Predtechenskii, V.M., and Milinskii, A.I., Planning for Traffic in Buildings (translated from the Russian), Stroizdat Publishers, Moscow, 1978. English translation published for the National Bureau of Standards and the National Science Foundation, Amerind Publishing Co., New Delhi, India, 1978.
[28] Fruin, J.J., Pedestrian Planning Design, Metropolitan Association of Urban Designers and Environmental Planners Inc., New York, 1971.
[29] Pauls, J.L., Effective Width Model for Evacuation Flow in Buildings, in Proceedings, Engineering Applications Workshop, Society of Fire Protection Engineers, Boston, 1980.

$$S = k - 0.266kD$$

where :

S = speed along the line of travel (m/s).

D = density in persons/m ^{2}.

k = constant.

Equation 3 Evacuation speed as a function of density

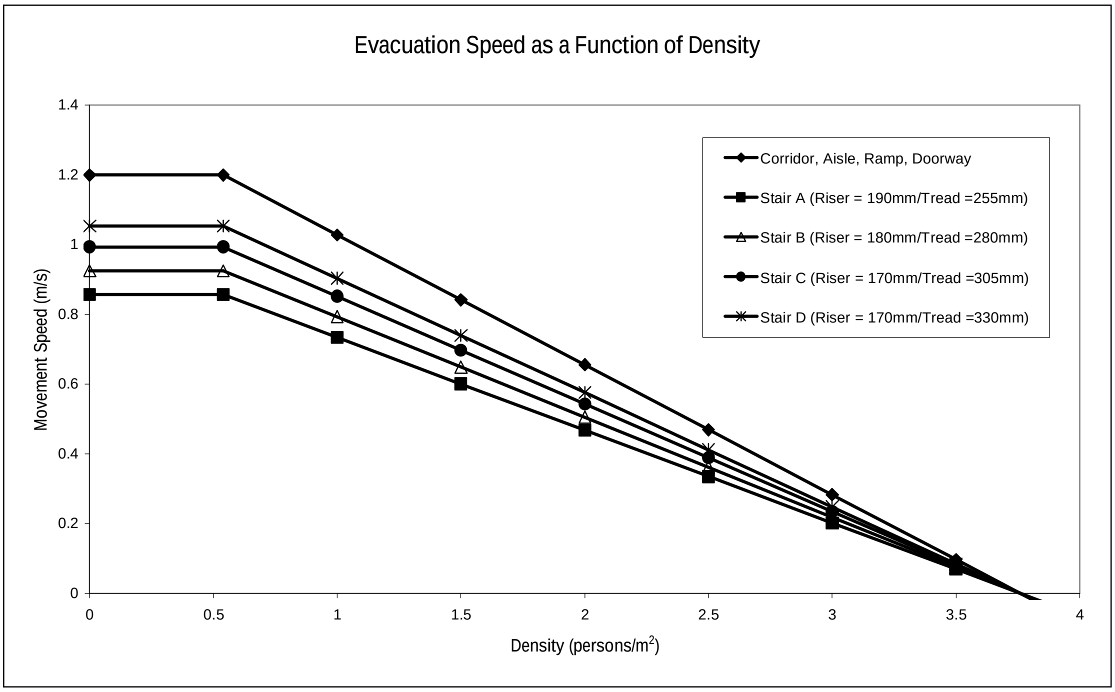


Figure 3 Evacuation speed as a function of density

It is recognised that there has been recent debate about the validity of data and recommendations previously relied upon for egress design [30], due to 'demographic changes, especially reduced fitness levels brought on by increasing sedentary lifestyles, increased body size and increased body weight' and 'reduced individual and societal motivation plus physiological condition.' In the absence of updated research data however, it is considered that the previously adopted data to be applicable especially given the level of conservatism inbuilt into the other aspects of the quantitative assessment combined with the safety margin of 1.5 adopted.

The travel time calculations are included in Table 16 to Table 18. Restrictions in section 5.2 for the number of occupants within the indoor arena have been specified on the basis of the exit capacities available and limiting occupant movement time to no more than 8 minutes as per Guide to Safety at Sports Grounds. The calculated occupant evacuation times were determined on the flow rates, travel speeds and boundary layers outlined in the SFPE Handbook of Fire Safety Engineering.

[30] Pauls, J.L., Performance of Means of Egress – Conducting the Research Needed to Establish Realistic Expectations, in Proceedings, 7th International Conference on Performance-Based Codes and Fire Safety Design Methods, April 2008.

Variable	Value	Comment
Population	4,200	
Aggregate unobstructed width (m)	9.7	4 × 1m exits + 5.7m exit from the sand arena
Total effective width (m)	8.34	Boundary layers in accordance with Table 3-13.1 of SFPE Handbook, 4th edition.
Flow rate per metre effective width (persons/m/s)	1.194	From SFPE Handbook
Effective flow rate (persons/s)	9.96	Effective width × flow rate per metre
Resultant queuing time (min)	7.03	Population / flow rate
Travel distance (m)	60	
Travel speed (m/s)	1.00	From SFPE Handbook
Travel time (min)	1.00	Travel distance / travel speed
Total evacuation time (min)	7.03	Queuing time exceeds travel time. Less than 8 minutes.

Table 16 Evacuation from the sand arena – 5.7m exit available

Variable	Value	Comment
Population	1,300	
Aggregate unobstructed width (m)	4	4 × 1m exits from the sand arena. 5.7m exit unavailable
Total effective width (m)	3.04	Boundary layers in accordance with Table 3-13.1 of SFPE Handbook, 4th edition.
Flow rate per metre effective width (persons/m/s)	1.01	From SFPE Handbook
Effective flow rate (persons/s)	3.07	Effective width × flow rate per metre
Resultant queuing time (min)	7.06	Population / flow rate
Travel distance (m)	60	
Travel speed (m/s)	1.00	From SFPE Handbook
Travel time (min)	1.00	Travel distance / travel speed
Total evacuation time (min)	7.06	Queuing time exceeds travel time. Less than 8 minutes.

Table 17 Evacuation from the sand arena – 5.7m exit not available

Variable	Value	Comment
Population	10,000	
Aggregate unobstructed width (m)	21.5	9 double doors from southern wall + direct egress to outside from northern side.
Total effective width (m)	18	Boundary layers in accordance with Table 3-13.1 of SFPE Handbook, 4th edition.
Flow rate per metre effective width (persons/m/s)	1.300	From SFPE Handbook
Effective flow rate (persons/s)	23.40	Effective width × flow rate per metre
Resultant queuing time (min)	7.13	Population / flow rate
Travel distance (m)	60	
Travel speed (m/s)	1.00	From SFPE Handbook
Travel time (min)	1.00	Travel distance / travel speed
Total evacuation time (min)	7.13	Queuing time exceeds travel time. Less than 8 minutes.

Table 18 Overall evacuation from the indoor arena

C.6 RSET

The results of the evacuation assessment are summarised in Table 19.

Fire scenario	Area considered	Cue type	Cue period (minutes)	Pre-movement phase (minutes)	Movement period (minutes)	RSET (minutes)
Fire involving typical assembly building combustibles	Indoor arena	Visual and olfactory cues	1.5	3	< 8	< 12.5
Truck fire	Indoor arena	Visual and olfactory cues	1.5	3	< 8	< 12.5

Table 19 RSET

Appendix D Annual wind data – Horsley Park

D.1 9am

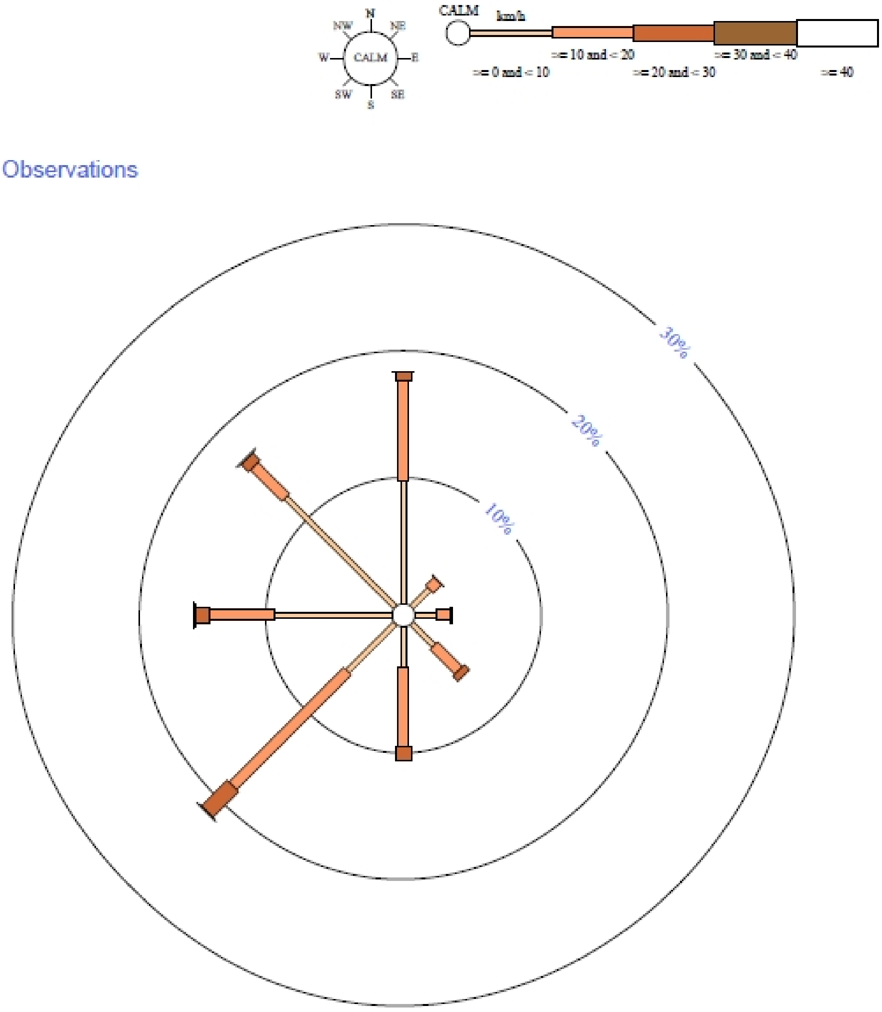
Rose of Wind direction versus Wind speed in km/h (04 Sep 1997 to 30 Sep 2010)
Custom times selected, refer to attached note for details

HORSLEY PARK EQUESTRIAN CENTRE AWS
Site No: 067119 • Opened Sep 1997 • Still Open • Latitude: -33.8511° • Longitude: 150.8567° • Elevation 100m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.

9 am
4623 Total Observations

Calm 5%



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D.2 3pm

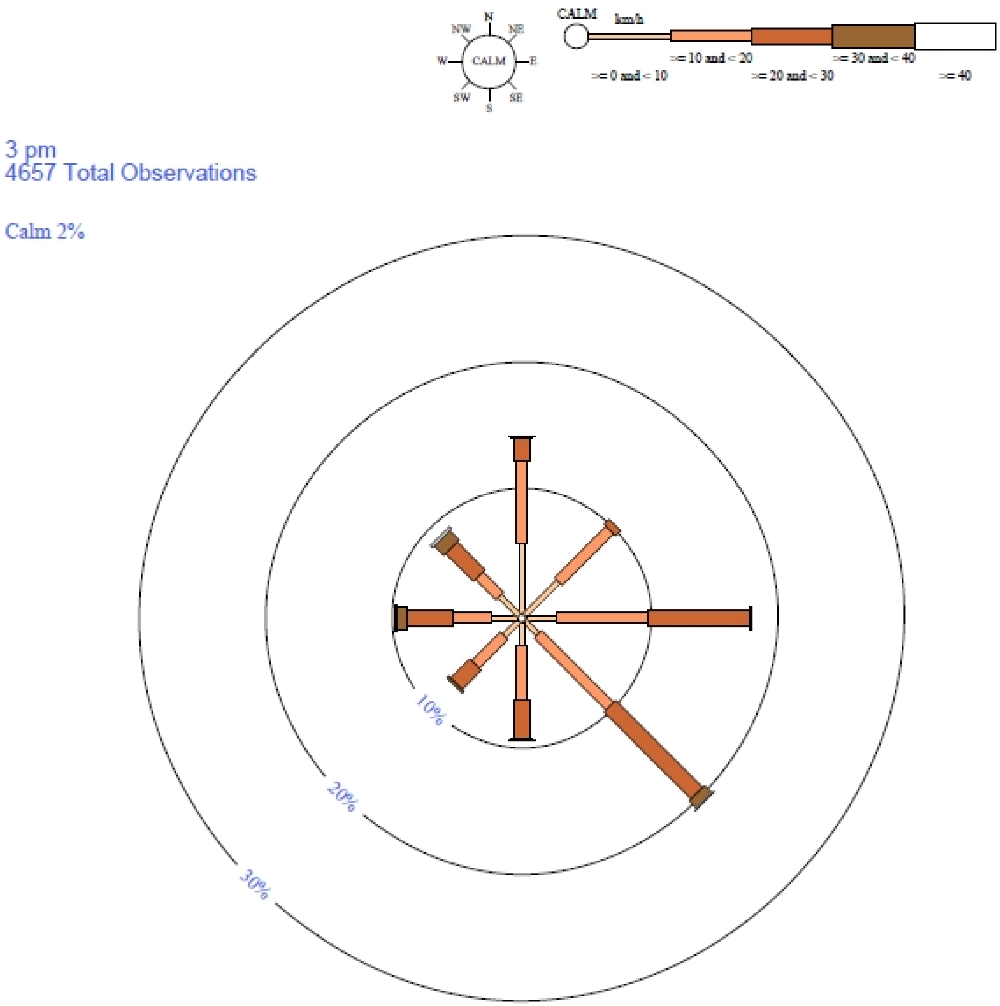
Rose of Wind direction versus Wind speed in km/h (04 Sep 1997 to 30 Sep 2010)

Custom times selected, refer to attached note for details

HORSLEY PARK EQUESTRIAN CENTRE AWS

Site No: 067119 • Opened Sep 1997 • Still Open • Latitude: -33.8511° • Longitude: 150.8567° • Elevation 100m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



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Appendix E Comments from Fairfield City

The following table includes comments taken from Fairfield City Council's comments on modification of development consent for Sydney International Equestrian Centre, Horsley Park. The associated responses from Defire are also included.

Fairfield City comment	Defire response
Council does not raise objections to the proposed modifications.	Noted.
Council has perused the fire engineering report and would like the fire engineer to be informed of the following before referencing the fire engineering report in the modified consent:	Noted. Refer to comments below.
(i) The report should require that the fire engineering report be listed within the fire safety schedule applicable for the property. The existing fire safety schedule would need to be modified to include both the fire engineered solution and to exclude the automatic fire detection and alarm system, which this alternative solution covers.	Noted. The referencing of our fire engineering report in the fire safety schedule is required - as nominated in our executive summary and fire safety measures section.
(ii) No maintenance assessment frequencies are noted in the report for the fire engineered solution such as an annual assessment.	Maintenance assessment frequencies as per the Environmental Planning and Assessment Regulations 2000 and relevant Australian standards are assumed. This is also stated in the executive summary and fire safety measures section. In any case, there has not been any additional active fire safety measures specified as part of the Defire report.
(iii) No commissioning procedures are noted in the report which would confirm that the fire engineered solution has been correctly implemented on site.	As per our response to item (ii) above, there has not been any additional active fire safety measures specified as part of the Defire report. The fire safety measures focuses on the exit provisions and the population restrictions. Naturally, each configuration will require confirmation that the parameters in the fire engineering report are complied with however there is no "commissioning procedures" as such.
(iv) Table 6 on page 9 details the population density as per Table D1.13 as 0.5 square metres per person. Due to the use of the venue, it is considered that the population density specified in the NSW varied Table D1.13 to be more relevant.	Noted. This has been amended in this report version. It is however noted that there is no material difference to the analysis documented as the populations that can be accommodated have been derived on a performance basis (rather than rely upon the occupant density).
(v) Table 6 also links a restricted population of 10,000 people citing the British 'Guide to Safety at Sports Grounds' movement / egress time of 8 minutes. It is suggested that this movement time be commented on during the RSET/ASET analysis to show some correlation between the referenced egress time (specified in the guide) and the RSET/ASET analysed times.	The RSET analysis shows that the movement time is less than 8 minutes, as a result of the reference to the Guide to Safety at Sports Ground. The egress appendix states "Restrictions in section 5.2 for the number of occupants within the indoor arena have been specified on the basis of the exit capacities available and limiting occupant movement time to no more than 8 minutes as per Guide to Safety at Sports Grounds. The calculated occupant evacuation times were determined on the flow rates, travel speeds and boundary layers outlined in the SFPE Handbook of Fire Safety Engineering." The calculation worked backwards to determine the populations allowed.
(vi) It is noted that Section 5.2(9) of the report prohibits the use of explosive material within the arena. It is assumed that this would restrict the use of pyrotechnical displays within the arena.	Noted – correct. The restriction in pyrotechnical displays has been reviewed by Department of Education and Communities.

Fairfield City comment	Defire response
(vii) Tables 16-18 references Table 3-14.1 of the SFPE Handbook as the location of boundary layers. Perusal of this particular table finds that it references transition descriptors for a typical room in a residential occupancy, not boundary layers. Council found this reference in the fourth and current edition of the SFPE handbook.	Noted. This has been amended in this report version. The version of the SFPE handbook used in our report was the 3rd edition (referenced elsewhere in the report). Table 3-14.1 in the 3rd edition is the same as Table 3-13.1 in the 4th (and current edition).