Consulting Fire Engineers

Project

Masters Store Re-Use Project

72/82 Mulgoa Road, Penrith New South Wales

Principal

Aurrum Holdings Pty Limited

Building Certifier

McKenzie Group Consulting Pty Ltd

Fire Engineering Report

March 2020

Project Number 6222145

Revision E

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Document Authorisation Issue

Project: Masters Store Re-Use Project

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Revision	Date Issued	Status	Prepared By	Reviewed By
A	19th April 2017	**Final**	Teagan MacDonald	Jonathan Shelley
	Comment:	Authorised Final Issue		
B	20th June 2017	**Final**	Teagan MacDonald	Jonathan Shelley
	Comment:	Updated to incorporate new architecturals		
C	10th November 2017	**Final**	Andrew Martin	Jonathan Shelley
	Comment:	Updated to incorporate proposed ceiling over mall area		
D	2nd February 2018	**Final**	Andrew Martin	Jonathan Shelley
	Comment:	Amendments to Smoke Exhaust Rates		
E	30th March 2020	**Final**	David Fox	Graham Timms
	Comment:	Updated to account for new Full Height Walls around Tenancy 5		

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Authorisation of Final Document

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Executive Summary

This document, prepared for Aurrum Holdings Pty Limited (Principal), is the Fire Engineering Report (FER) for the proposed Masters Store Re-Use Project development located at 72/82 Mulgoa Road, Penrith New South Wales.

The proposed redevelopment of the Masters Store in Penrith is part of a nationwide re-development (re-use) of all existing Masters Stores following the closure of the chain. Each store is to be converted into a retail centre containing a number of individual retail tenancies, the majority of which are connected by a mall . The intent of the re-use project is to minimise changes to the existing Masters Store buildings

The existing building is a Class 6 (retail) Large Isolated Building (LIB) and contains a large ground floor retail area which includes the semi-open Garden Centre and Timber Trade Centre. The existing building also contains a mezzanine office level, as shown in Figure A. The total existing floor area is approximately 13,411m^2.

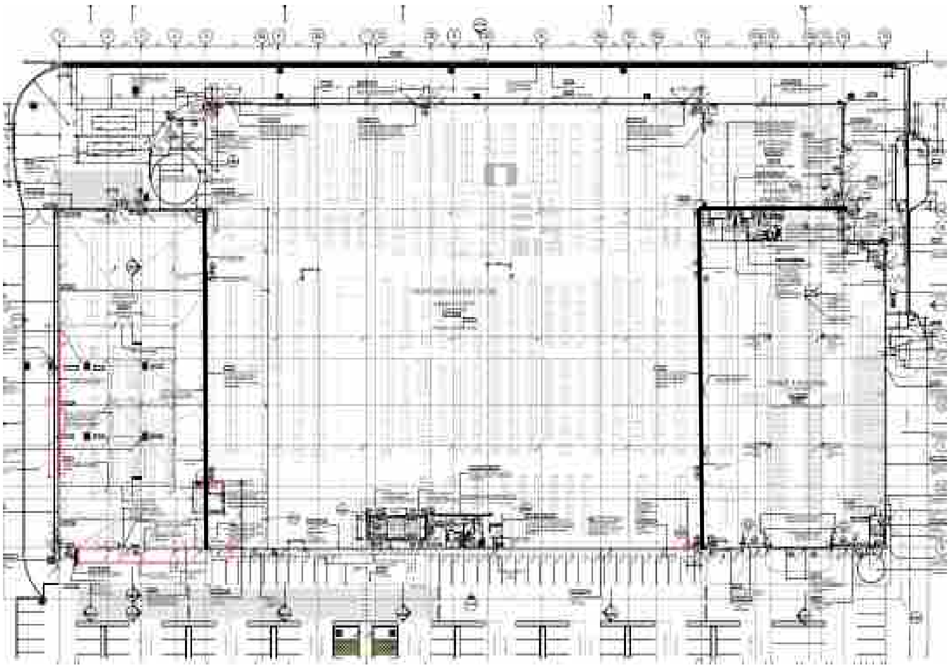

Figure A – Existing Floor Plan

The proposed re-use will fully enclose the existing Garden Centre and Timber Trade Centre areas, creating a total enclosed floor area of approximately 13,425m^2. The proposed re-use will consist primarily of Class 6 retail space, as shown in Figure B. The majority of tenancies will be separated from one another and from the mall by partition walls extending not more than 4.8m above floor level. The upper part of the building (and all services) will generally be open to each tenancy. Full height walls divide the building into two individual Smoke Zones as shown in Figure B.

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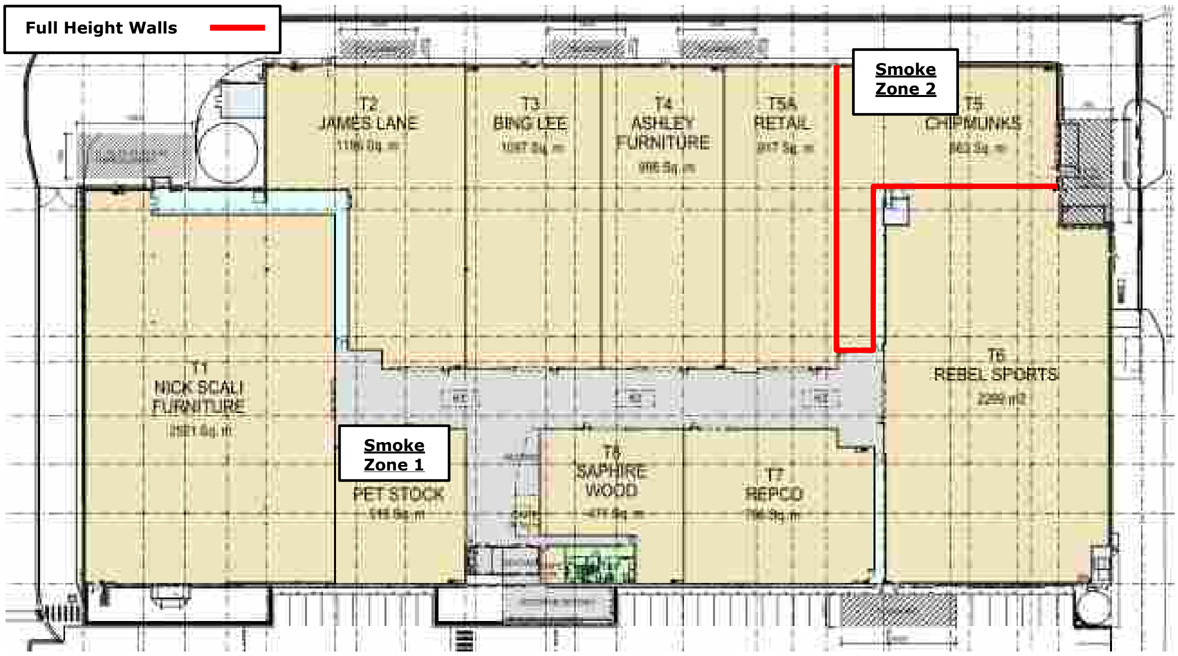

Figure B – Proposed Floor Plan

Utilising the National Construction Code (NCC) 2016 Volume One [1], an acceptable Compliance Solution has been achieved by a combination of compliance with the NCC Deemed-to-Satisfy (DTS) provisions and formulating an acceptable Performance Solution. This approach has allowed the development of an effective alternative building design, whilst maintaining an acceptable level of Fire and Life Safety.

A fire engineering assessment has demonstrated that the Performance Solution achieves compliance with the relevant NCC Performance Requirements. All other Performance Requirements are met by complying with the NCC DTS provisions or remain as required within the existing building permit conditions/design or as accepted by the Authority Having Jurisdiction (AHJ) or other Regulatory Authorities.

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Summary of Performance Solution

Table A summarises the NCC DTS departures and associated NCC DTS Clauses and Performance Requirements. In addition, code compliance, assessment method, proposed analysis method, assessment methodology and acceptance criteria are also summarised. Note that where the proposed redevelopment does not affect the existing compliance issues associated with the original Masters Store, the departure will not be reassessed in this Fire Engineering Report (FER). This is because it has already been addressed in the existing FER. Therefore the Item Reference is stated as Appendix C, i.e. the existing Approved FER. New compliance issues are addressed in Section 7.

Table A – NCC DTS Provision Departures

Item Reference	NCC Clause	NCC Performance Requirements	Performance Solution
Fire Resistance and Stability			
Item 1 Section 7.1	C2.4(b)	CP9	Perimeter Vehicular Access to be; a. Non continuous on the South-east side of the building in lieu of continuous in a forward direction b. Not less than 4.5m in width in localised areas not near corners of the building, in lieu of not less than 6m.
	Code Compliance and Assessment Method:		A0.3(a) and A0.5(b)(ii), as detailed in Section 1.2
	Proposed Analysis Method, Assessment Methodology and Acceptance Criteria:		Qualitative analysis method based on the measures provided to facilitate Fire Brigade intervention Acceptance will be demonstrated where the vehicular perimeter access provisions will not unduly impact upon Fire Brigade intervention
Item 2 Existing Performance Solution, see Appendix C	C2.12	CP6	UPS Battery Area is located in the building without the required fire separation in lieu of 120 minutes fire rating
	Code Compliance and Assessment Method:		A0.3(a) and A0.5(b)(ii), as detailed in Section 1.2
	Proposed Analysis Method, Assessment Methodology and Acceptance Criteria:		Qualitative analysis method based upon the ignition risk, fire load and likelihood of fire spread Acceptance was demonstrated that risk of fire spread from the Communications Room did not unduly impact on the risk of fire spread within the building

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Item Reference	NCC Clause	NCC Performance Requirements	Performance Solution
Access and Egress			
Item 3 Section 7.2	D1.4(c)	DP4, EP2.2	The exit travel distance from any point on a floor: a. to a point at which travel in different directions where two (2) exits are available is not more than: i. 30m within the retail area in lieu of 20m; and b. to the nearest exit, where two (2) exits are available, is not more than: i. 70m within the retail area in lieu of 40m
	Code Compliance and Assessment Method:		A0.3(a) and A0.5(b)(ii), as detailed in Section 1.2
	Proposed Analysis Method, Assessment Methodology and Acceptance Criteria:		Quantitative analysis method based on the occupant life safety assessment methodology detailed in Section 4 and Scenarios detailed in Section 5.3 The assessment methodology is to compare the ratio of the Available Safe Evacuation Time (ASET) to the Required Safe Egress Time (RSET) for the proposed Alternative Solution, ASET/RSET Acceptance will be demonstrated for occupant life safety if ASET/RSET ≥ 1.5 Where a redundancy and/or sensitivity study is undertaken; acceptance will be demonstrated for occupant life safety if ASET/RSET ≥ 1.0

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Item Reference	NCC Clause	NCC Performance Requirements	Performance Solution
Item 4 Section 7.2	D1.5(b)	DP4, EP2.2	The distance between alternative exits to be 100m in lieu of 60m
		Code Compliance and Assessment Method:	A0.3(a) and A0.5(b)(ii), as detailed in Section 1.2
		Proposed Analysis Method, Assessment Methodology and Acceptance Criteria:	Quantitative analysis method based on the occupant life safety assessment methodology detailed in Section 4 and Scenarios detailed in Section 5.3 The assessment methodology is to compare the ratio of the Available Safe Evacuation Time (ASET) to the Required Safe Egress Time (RSET) for the proposed Alternative Solution, ASET/RSET Acceptance will be demonstrated for occupant life safety if ASET/RSET ≥ 1.5 Where a redundancy and/or sensitivity study is undertaken; acceptance will be demonstrated for occupant life safety if ASET/RSET ≥ 1.0
Item 5 Section 7.2	D1.6	DP4, DP6, EP2.2	The aggregate unobstructed egress width to be reduced to 17m in lieu of 29.5m
		Code Compliance and Assessment Method:	A0.3(a) and A0.5(b)(ii), as detailed in Section 1.2
		Proposed Analysis Method, Assessment Methodology and Acceptance Criteria:	Quantitative analysis method based on the occupant life safety assessment methodology detailed in Section 4 and Scenarios detailed in Section 5.3 The assessment methodology is to compare the ratio of the Available Safe Evacuation Time (ASET) to the Required Safe Egress Time (RSET) for the proposed Alternative Solution, ASET/RSET Acceptance will be demonstrated for occupant life safety if ASET/RSET ≥ 1.5 Where a redundancy and/or sensitivity study is undertaken; acceptance will be demonstrated for occupant life safety if ASET/RSET ≥ 1.0

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Item Reference	NCC Clause	NCC Performance Requirements	Performance Solution
Item 6 Existing Performance Solution, see Appendix C	D2.19	DP2	Automatic sliding exit doors are opened via a push button device during after hours, in lieu of failsafe open on fire trip
		Code Compliance and Assessment Method:	A0.3(a) and A0.5(b)(ii), as detailed in Section 1.2
		Proposed Analysis Method, Assessment Methodology and Acceptance Criteria:	Qualitative analysis method based on the safe evacuation of building occupants Acceptance was demonstrated that the provision of the automatic sliding doors does not unduly impact on the ability of the occupants to safely evacuated the building
Fire Fighting Equipment			
Item 7 Section 7.3	E1.5	EP1.4	Early Suppression Fast Response (ESFR)/Storage (i.e. RTI < $50m^{1/2}s^{1/2}$) sprinkler heads to be retained throughout the building for protection of Ordinary Hazard risk in accordance with NFPA13
		Code Compliance and Assessment Method:	A0.3(a) and A0.5(b)(ii), as detailed in Section 1.2
		Proposed Analysis Method, Assessment Methodology and Acceptance Criteria:	Qualitative analysis method based on comparison of ESFR/Storage fire sprinkler requirements under AS 2118.1-1999 with NFPA13 Acceptance will be demonstrated where the retention of the existing early suppression fast response (ESFR)/Storage (i.e. RTI < $50m^{1/2}s^{1/2}$) sprinkler system will not unduly impact on the ability of the occupants to safely evacuate the building, on Fire Brigade intervention and on the likelihood of fire spread

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Item Reference	NCC Clause	NCC Performance Requirements	Performance Solution
Smoke Hazard Management			
Item 8 Section 7.4	E2.2, Table E2.2b, Spec E2.2b	EP2.2	Smoke hazard management to be provided throughout in accordance with NCC DTS Specification E2.2b with the following modifications: a. Rationalised smoke exhaust quantities to the building b. The building part provided with smoke exhaust is to be treated as a single smoke reservoir (i.e. smoke baffles are not provided) c. Smoke exhaust system initiated by fire sprinkler activation d. Omission of smoke exhaust system from Smoke Zone 2 (Tenancy T5)
		Code Compliance and Assessment Method:	A0.3(a) and A0.5(b)(ii), as detailed in Section 1.2

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Item Reference	NCC Clause	NCC Performance Requirements	Performance Solution
	Proposed Analysis Method, Assessment Methodology and Acceptance Criteria:		**Provision of Smoke Exhaust System** Quantitative analysis method based on the occupant and fire fighter life safety assessment methodology detailed in Section 4 and Scenarios detailed in Section 5.3 *Occupant Life Safety* The assessment methodology is to compare the ratio of the Available Safe Evacuation Time (ASET) to the Required Safe Egress Time (RSET) for the proposed Alternative Solution, ASET/RSET Acceptance will be demonstrated for occupant life safety if ASET/RSET ≥ 1.5 Where a redundancy and/or sensitivity study is undertaken; acceptance will be demonstrated for occupant life safety if ASET/RSET ≥ 1.0 *Fire Brigade Intervention* The assessment methodology is to compare the environmental conditions within the building to the Fire Brigade tenability limits Acceptance will be demonstrated if tenability is maintained for the duration of the Primary Analysis **Omission of Smoke Exhaust System to Smoke Zone 2 (Tenancy T5)** Qualitative analysis method based on occupant life safety and Fire Brigade intervention Acceptance will be demonstrated where the omission of smoke exhaust from various building parts will not unduly impact upon occupant life safety or Fire Brigade intervention

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Fire Engineering Outcomes

The Fire Engineering Outcomes (also known as the Trial Concept Design or Performance Solution) are required to address departures from the NCC DTS provisions and are intended to achieve a level of fire and life safety which meets Aurrum Holdings Pty Limited's objectives set out in Section 1.3.

All other items of fire and life safety, where not specifically addressed or reviewed as part of this document are to be in accordance with NCC DTS provisions or as accepted by the Authority Having Jurisdiction (AHJ) and other Regulatory Authorities.

The following Fire Engineering Outcomes detail the required preventative and protective measures based on the fire engineering assessment in order to achieve compliance with the NCC Performance Requirements and shall take precedence over the remainder of the Fire Engineering Report (FER).

Fire and Smoke Resistance

a. Existing Insulated Sandwich Panels (ISPs) may be retained, however new ISPs must be Polyisocyanurate (PIR) Construction.

b. Internal walls must be not more than 4.8m Above Finished Floor Level (AFFL), except as follows:

   i. The following areas must be bound by full height walls (as shown in Figure C)

      – Tenancy 5 (Smoke Zone 2)

   Note: additional full height walls are permitted to be provided, subject to written confirmation from Omnii Pty Ltd.

c. Full height walls are to be provided as follows:

   i. Wall construction must be:

   EITHER:

      – Non-combustible construction lined with not less than 13mm thick layer standard grade plasterboard

   OR:

      – Insulated Sandwich Panel (ISP) construction with steel facers and a Polyisocyanurate (PIR) or non-combustible core.

   ii. From a height of 3.6m AFFL to the underside of the roof:

      – All openings around penetrations and the junctions of the wall and the remainder of the building must be stopped with non-combustible material to prevent the free passage of smoke

      – Any glazed areas within the wall must be safety glass as defined in AS 1288.

   iii. Smoke dampers must be provided where air-handling ducts penetrate the wall, unless the duct forms part of a smoke hazard management system required to continue air movement through the duct during a fire.

   iv. Openings created within the wall by tenancy entry doors and make-up air openings are permitted to be unprotected.

d. As permitted in the existing Fire Engineering Report (FER) for the original Masters Store, refer to Appendix C, Fire Resistance Levels (FRLs) shall be in accordance with NCC DTS provisions, except that the UPS Battery area need not be provided with a FRL.

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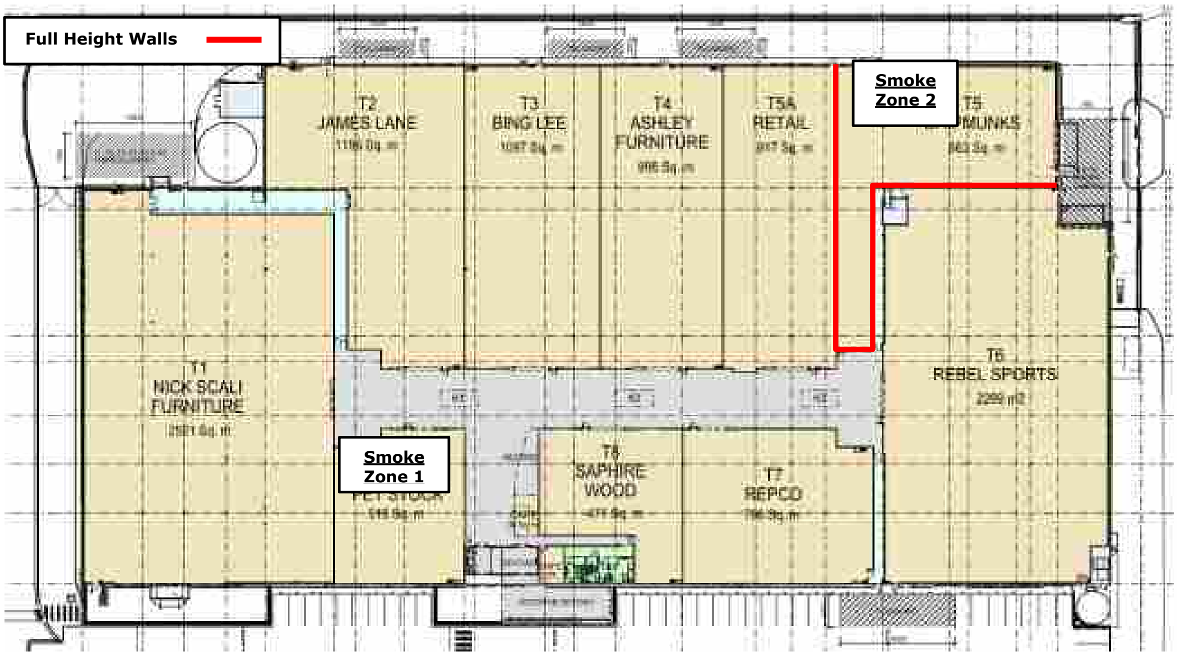

Figure C – Full Height Wall Locations

Ceilings

e. Ceilings must not be installed within the areas of the building provided with smoke exhaust fans, except where permitted in accordance with Table B.

Table B – Ceiling Requirements

Details of Ceiling Provisions	Additional Requirements
Ceilings greater than 25% perforated	No Additional Requirements
Ceilings less than 25% perforated, with a total area of not more than 10% of the total floor area of the tenancy or Mall in which they are located, and not more than a total of 1,000m² in any one smoke zone*	No Additional Requirements
Ceilings less than 25% perforated, with a total area of more than 10% of the total floor area of the tenancy or Mall in which they are located, and not more than a total of 1,000m² in any one smoke zone*	Smoke Detection as per Item 'v'
Ceilings within any tenancy or Mall which exceed a total of 1,000m² in any one smoke zone*	These type of ceilings are not permitted
*a smoke zone is considered to be a building part bound by full height walls	

Perimeter Vehicular Access

f. Perimeter vehicular access must be in accordance with NCC DTS requirements, as shown in Figure D, with the following exceptions:

   i. The perimeter vehicular access is permitted to be non-continuous on the South-west side of the building

   ii. The perimeter vehicular access is permitted to reduce in width to not less than 4.5m, in localised areas on the North-west and South-west side of the building.

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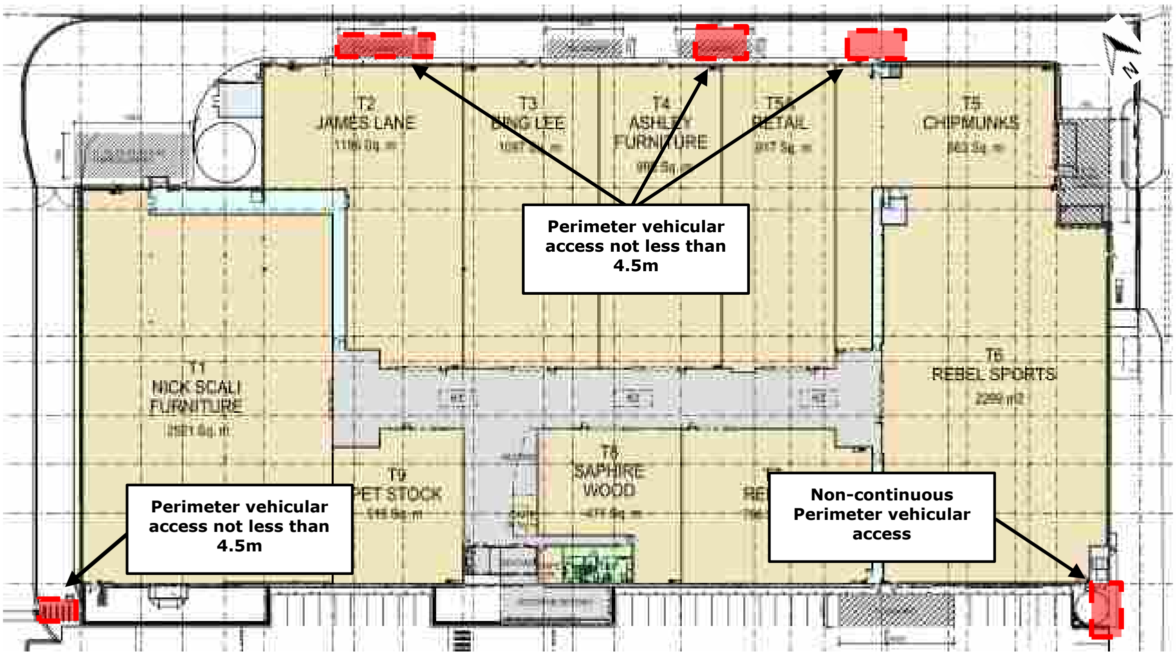

Figure D – Perimeter Vehicular Access

Provisions for Escape

g. The exit travel distances must comply with NCC DTS Clause D1.4, except that the distance of travel:

   i. from any point on a floor to a point from which travel in different directions to two (2) exits is available, is permitted to be not more than 30m, and

   ii. to the nearest exit, when travel in different directions to two (2) exits is available, is permitted to be not more than 70m.

h. The distance between alternative exits must comply with NCC DTS Clause D1.5, except that the distance is permitted to be not more than 100m.

i. The travel distances permitted in Item 'g' and Item 'h' must be achievable from within the Mall, without the need to enter any tenancy (i.e. sufficient exits must be provided from the Mall itself to achieve these outcomes).

j. Where required, additional egress passageways and exit doors must be provided to achieve the travel distances permitted in Item 'g' and Item 'h'.

k. The aggregate unobstructed egress width must be not less than 17m.

l. Automatic sliding doors located in the main entrance of the building will be opened via a push button during after-hours, as permitted in the existing approved Fire Engineering Report for the original Masters Store, refer to Appendix C.

m. Tenancies with roller shutter entry doors must be provided with an additional NCC DTS compliant exit into the mall area.

Fire Hydrants, Hose Reels and Extinguishers

n. The existing fire hydrant system must be retained, and be modified as necessary to maintain compliance with NCC DTS provisions for the original building.

o. The existing fire hose reel system must be retained, and be modified as necessary to maintain compliance with the NCC DTS provisions for the original building.

p. The existing portable fire extinguishers must be retained, and be modified as necessary to maintain compliance with the NCC DTS provisions for the original building.

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Fire Sprinkler Systems

q. The existing Early Suppression Fast Response (ESFR)/Storage (i.e. RTI < $50m^{½}s^{½}$) fire sprinkler systems are permitted to be retained within the building for protection of Ordinary Hazard risk in accordance with NFPA 13 (e.g. limitations on storage heights).

r. Where there is an architectural or building feature that presents an obstruction to ESFR type sprinklers, another appropriate fire sprinkler system type may be permitted to be installed subject to Item 't' and Omnii confirmation, e.g. spray type sprinklers to drop ceilings within tenancies and mall ceilings.

s. Draft curtains must be provided as required to separate different sprinkler types, e.g. ESFR/Storage type sprinkler and High Hazard type sprinklers, in accordance with NFPA 13.

t. Ceilings are not permitted within the building, except as follows:

   i. Small sections of drop ceilings as permitted by the fire sprinkler system design, as detailed in Item 'r',

   ii. Within the café tenancy of the Mall

   iii. Back of House (BoH) office areas less than $100m^2$.

Smoke Detection and Alarm System

u. In the areas of the building provided with rationalised smoke exhaust fans, the existing Smoke Detection and Alarm System must be retained, and be modified as necessary to achieve compliance with the legislation applicable to the original building approval, e.g. at 20m spacing and not more than 10m off walls, excluding the following areas:

   i. Toilets, Canteen/Kitchen areas, Maintenance cupboards or Shower Rooms

v. In areas of the building not provided with smoke exhaust fans, and where detection is needed as a result of the requirements noted in Table B;

   i. Smoke detectors must be provided below ceiling spaced in accordance with Section 5 of AS1670.1-2015 (i.e. 10m x 10m spacing) excluding the following areas;

      – Toilets, Maintenance cupboards or Shower Rooms

   ii. Heat detectors must be provided in accordance with AS1670.1-2015 within Canteen/kitchen areas.

w. Activation of the smoke detection system must shut down the operation of air handling systems in the building and activate the Building Occupant Warning System (BOWS)..

Smoke Exhaust System

x. The building must be divided into two separate smoke zones, with Smoke Zone 1 provided with some exhaust fans, as shown in Figure E, and as follows:

   i. An exhaust rate of not less than $64.8m^3/s$ must be provided to Smoke Zone 1.

   ii. Smoke exhaust need not be provided within Smoke Zone 2 (Tenancy T5), contingent on the following:

      – Full Height Walls must be provided as per Item 'b' and Item 'c'.

      – Smoke detection must be provided as per Item 'v'.

   iii. Each exhaust point/fan must have an exhaust capacity of between $5.8m^3/s$ and $15m^3/s$.

   iv. The total exhaust quantity must be achieved with not less than eight (8) exhaust points/fans, located as shown indicatively in Figure E.

   v. The existing smoke exhaust system may be utilised to achieve part or all of the required exhaust quantity.

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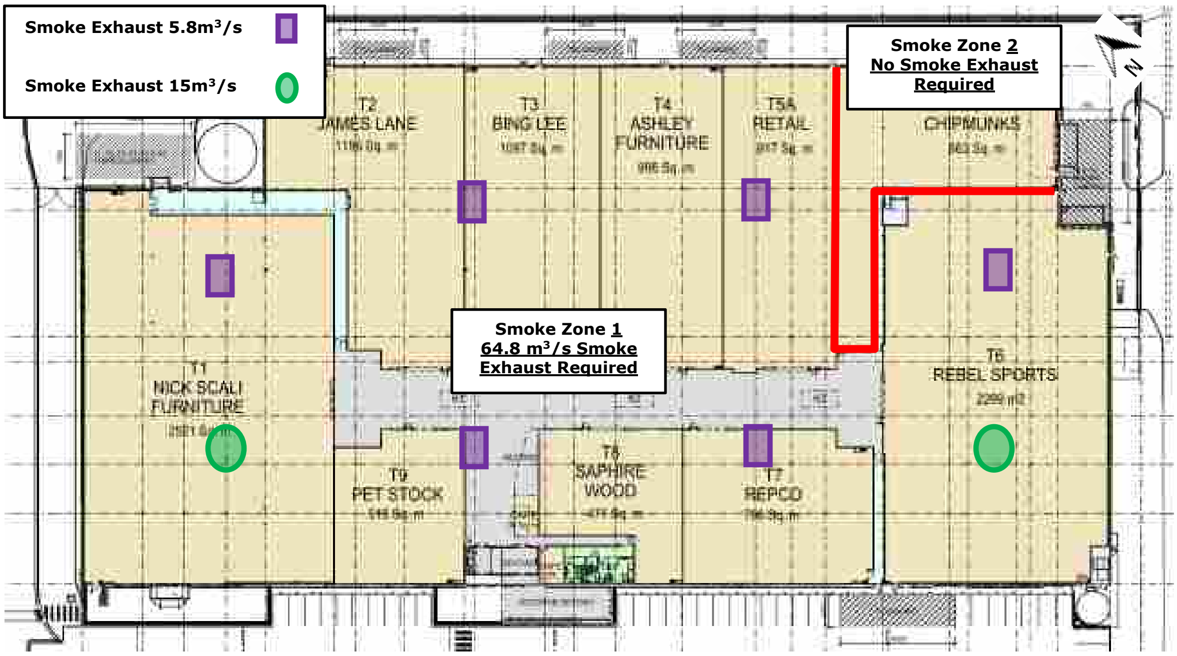

Figure E – Proposed Smoke Exhaust Locations

y. Smoke exhaust fans must be designed to ramp from a stationary position to their maximum exhaust rate in not more than 20 seconds.

Make-Up Air Provisions

z. Operable make-up air louvres must all open simultaneously upon activation of any detector within the building.

aa. Make-up air must be provided for the smoke exhaust system in Smoke Zone 1 in accordance with NCC Specification E2.2b and the following requirements:

   i. Make-up air must be provided by operable louvres located between 2.0m and 3.6m above finished floor level (AFFL) and evenly distributed around side and rear external walls.

   NOTE: The top of the louvre must not exceed 3.6m above finished floor level.

   ii. Not less than 36m² of effective free area for make-up air must be provided as follows:

   – Not less than 8m² of effective free area must be provided to the South-east side of the building; and

   – Not less than 8m² of effective free area must be provided to the North-west side of the building; and

   – Not less than 20m² of effective free area must be provided to the North-east and South-west side of the building combined.

   iii. The air velocity through make-up air openings must not exceed 2.5m/s.

   iv. Operable make-up air louvres must be interlocked with the smoke exhaust fans to open fully on activation of the smoke exhaust fans, and must fail to the fully open position in the event of power failure.

   v. The minimum opening area of tenancy doorways must be not less than 2.0m high and 3.0m wide to allow adequate make-up air through the building during operating hours of the building.

   vi. Tenancy entry doors must be perforated roller shutters with an effective free opening area of not less than 40% to allow adequate make-up air through the building during after-hours of the building.

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Occupant Warning

bb. The existing Building Occupant Warning System (BOWS) must be retained, and be modified as necessary to maintain compliance with the NCC DTS provisions for the original building.

Emergency Lighting and Exit Signs

cc. The existing emergency lighting must be retained, and be modified as necessary to maintain compliance with the NCC DTS provisions for the original building.

dd. The existing exit signs must be retained, and be modified as necessary to maintain compliance with the NCC DTS provisions for the original building.

Commissioning

ee. All fire safety equipment or equipment associated with fire safety must be correctly commissioned including integrated testing.

Maintenance

ff. Equipment and Safety Installations must be maintained in accordance with current and future building maintenance legislation. Failure to do so will render the outcomes of this document invalid, null and void.

gg. Maintenance of Equipment and Safety Installations must be undertaken by an independent, suitably qualified and/or competent representative, i.e. qualified maintenance company or Building Manager's representative – not by the Building Owner.

hh. Up to date logbooks must be provided on site.

Other Provisions

ii. A no-smoking policy must be implemented in accordance with State legislation.

jj. Emergency control organisation and procedures are to be developed and implemented in accordance with AS 3745-2010. The following must also be included as part of the procedures:

   i. Fire wardens must be appointed and trained on a 12 monthly period.

   ii. Staff members must be trained in the emergency evacuation practices, including training of new staff at induction.

   iii. Emergency evacuation practices must be held every 12 months.

kk. The following information must be listed on the Occupancy Classification for the building:

   i. Product stored in the building must meet the design and installation requirements of the fire sprinkler system installed.

ll. Fire orders must be prepared and displayed in accordance with NCC DTS Clause G4.9 for the specific building fire safety systems.

mm. A sign must be provided adjacent to the FIP or in the main entry listing the Performance Solution applicable to the building. The sign must be incised, inlaid or embossed letters on a metal, wood, plastic or similar plate, securely and permanently attached to the wall.

nn. A copy of the approved Fire Engineering Report must be provided at building handover and be located at one of the following:

   i. within the FIP; or

   ii. in the Essential Safety Measures log book cabinet; or

   iii. Management In Use Plan manual; or

   iv. Maintenance manual for the fire protection systems.

oo. No changes to the fire safety strategy without the express written consent of Omnii Pty Ltd.

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1. Introduction

1.1 General

Omnii Pty Ltd has been commissioned by Aurrum Holdings Pty Limited to undertake a performance-based assessment of the Performance design for the Masters Store Re-Use Project located at 72/82 Mulgoa Road, Penrith New South Wales.

The fire engineering assessment is to address the relevant Performance Requirements of the National Construction Code (NCC) 2016 Volume One [1], where a Performance Solution is proposed, via various analysis methods, as defined in the International Fire Engineering Guidelines (IFEG) [2].

Utilising the NCC, an acceptable Compliance Solution is to be achieved by a combination of compliance with the NCC Deemed-to-Satisfy (DTS) provisions and formulating an acceptable Performance Solution. This approach is intended to allow the development of an effective a Performance based building design, whilst maintaining an acceptable level of Fire and Occupant Life Safety.

1.2 Legislative Requirements

This project is to be designed under The Environmental Planning and Assessment Act 1979 (as amended) and the Environmental Planning and Assessment Regulations 2000, which in turn adopt the NCC and referred Standards.

The fire engineering assessment will need to demonstrate that the Performance Solution achieves compliance with the relevant NCC Performance Requirements. All other Performance Requirements are to be met by complying with the NCC DTS provisions or remain as required within the existing building permit conditions/design or as accepted by the Authority Having Jurisdiction (AHJ) and other Regulatory Authorities. It is also to be commensurate with the Objectives outlined in Section 1.3.

1.2.1 NCC Compliance

Compliance with the NCC as stated in Clause A0.1 is achieved by satisfying the Performance Requirements. Note the Performance Requirements are the only part of the NCC with which a building design must satisfy.

1.2.2 Meeting the Performance Requirements

NCC Clause A0.2 states that compliance with the NCC Performance Requirements can only be satisfied by a—

a. Performance Solution; or

b. Deemed-to-Satisfy Solution; or

c. combination of (a) and (b).

1.2.3 Performance Solutions

NCC Clause A0.3 states:

a. a Performance Solution must:

   i. comply with the Performance Requirements; or

   ii. be at least equivalent to the Deemed-to-Satisfy-Provisions.

   and be assessed according to one or more of the Assessment Methods.

b. A Performance Solution will only comply with the NCC when the Assessment Methods used satisfactorily demonstrate compliance with the Performance Requirements.

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1.2.4 Assessment Methods

NCC Clause A0.5 details the following assessment methods or any combination of them can be used to determine that the Performance Solution complies with the Performance Requirement, as appropriate:

a. Evidence to support that the use of a material or product, form of construction or design meets a Performance Requirement or a Deemed-to-Satisfy Provision as described in NCC Clause A2.2.

b. Verification Methods such as—

   i. the Verification Methods in the NCC; or

   ii. such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements.

c. Expert Judgement.

d. Comparison with the Deemed-to-Satisfy Provisions.

1.2.5 Relevant Performance Requirements

The Performance Requirements relevant to a Performance Solution will be determined in accordance with NCC Clause A0.7.

1.3 Client Objectives

It is understood that Aurrum Holdings Pty Limited's objectives are to achieve compliance with the NCC.

At a community level, fire safety objectives are met if the relevant legislation and regulations are complied with. As stated in Clause A0.1 of the NCC, "A Building Solution will comply with the NCC if it satisfies the Performance Requirements".

The NCC's goal in the area of fire safety is to protect the lives of the building occupants, facilitate Fire Brigade intervention in the event of an emergency, and protect adjacent property from the spread of fire and physical damage caused by structural failure [3].

1.4 Fire Brigade Objectives

The overall philosophy of the Fire Brigade objectives throughout Australia is to protect life, property and the environment from fire [4].

Fire and Rescue New South Wales (FRNSW) corporate objectives [5] include attendance to 90% of all fires within 10 minutes from the time of notification.

In 2012/13 the percentage of all calls responded to within 10 minutes in the greater Sydney area was in the 90th percentile, whilst 95% of building fires were responded to within 10 minutes. Outside the greater Sydney area, the average response time to these calls was 9 minutes. Over 80% of structural fires were contained to the room of fire origin.

Over and above the requirements of the NCC, the Fire Brigade has functions with regard to property protection and considerations regarding occupational health and safety for its employees, which we understand are commensurate with the Fire Safety Strategy to be incorporated.

1.5 Fire Engineering Brief

A Fire Engineering Brief Questionnaire (FEBQ) dated 16th December 2016, Revision 01 was prepared by Omnii Pty Ltd for Masters Store Re-Use Project which defined the scope for the fire engineering assessment as agreed by the fire engineering team and stakeholders listed in Section 1.6. An overall project FEBQ was also prepared and submitted to FRNSW on 9th December 2016.

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The FEBQ and the overall project FEBQ outlined the scope of the work for the fire engineering assessment, set down the basis on which the fire engineering assessment was to be undertaken and served as an agreement of the objectives, proposed trial designs, analysis methods and acceptance criteria prior to the start of the analysis.

An FEB meeting held with Omnii, McKenzie Group and FRNSW on 14th February 2017. At this FEB meeting it was agreed that Omnii would proceed with the preparation of Fire Engineering Reports (FERs) for each individual NSW site.

It should be noted that based on architectural changes during the design and development of the project, NCC DTS variations may have changed since the issuance of the aforementioned FEB. These have been removed or included within the document as appropriate and discussed and agreed with the Building Certifier.

1.6 Relevant Stakeholders

The relevant stakeholders for this project are listed in Table 1.1 and Table 1.2.

Table 1.1 – Design Stakeholders

Role	Company	Representative
Client/Principal	Aurrum Holdings Pty Limited	David Gutwenger
Architect	The Buchan Group	Clinton Jasmin
Fire Safety Engineer	Omnii Pty Ltd	Graham Timms
Fire Consultant		David Fox
Mechanical Engineer	Fusion HVAC	Mike Palmer

Table 1.2 – Review and Authority Stakeholders

Role	Company	Representative
Building Certifier	McKenzie Group Consulting Pty Ltd	Geoffrey Pearce
Fire Brigade	Fire and Rescue New South Wales	Jamie Vistnes

1.7 Sources of Information

This document is based on the following sources of information:

a. Verbal direction from David Gutwenger regarding proceeding with base case ESFR/Storage fire sprinkler system retention

b. BCA report, prepared by McKenzie Group Consulting Pty Ltd dated December 2016, refer Appendix B

c. Approved Fire Engineering Report (FER), prepared by AECOM Australia Pty Ltd dated April 2013, refer Appendix C

d. The Buchan Group architectural plans received 14th February 2020 for the Masters Repurposing Project, refer to Table 1.3

e. Leffler Simes Architects existing architectural plans received 17th November 2016, refer to Table 1.3.

f. Design Review Report, prepared by Fusion HVAC Revision B, refer Appendix D

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Table 1.3 – Architectural Plans

Discipline	Company	Drawing No	Revision
Existing Architectural	Leffler Simes Architects	GA 200	N
Proposed Architectural	The Buchan Group	ACD-20001	C04
Proposed Architectural	The Buchan Group	ACD-01001	C03

1.8 Glossary

A glossary of items is provided in Appendix A.

1.9 Limitations

Limitations relate to design boundaries applied to the analyses undertaken and the relevance of empirical results for formulation of recommended outcomes. The following limitations apply to this document.

a. The relevant design criteria for the Performance Solution to meet the Performance Requirements of the NCC are set out herein. Where not specifically mentioned, the design is expected to meet the NCC DTS requirements of all relevant codes and legislation at the time of construction and/or at the time of production of this document.

b. No liability is accepted for the application or use of the Fire Engineering Outcomes listed herein and/or the parameters on which Omnii have based this analysis, including the set design criteria and specific project scope/works and parameters, by any third party outside the stakeholders and design team noted herein for this specific project works.

c. No liability is accepted for the accuracy of the documents provided by others which form the basis of the analysis.

d. Drawings referred to or incorporated in this document may change resulting from design variations. Readers of all fire engineering documentation must ensure that they observe the latest project related drawings and relate these to this document. Changes to the sources of information will require further fire engineering assessment to determine compliance with the intent of the design objectives.

e. Fire Resistance Level (FRL) grading periods, where not specifically indicated as a three component unit for building works, must be applied at the given FRL rating in accordance with the structural adequacy/integrity/insulation criteria specified in the relevant NCC DTS provision for the Class occupancy applicable.

f. The analysis of deliberate fires through acts of malicious intent or arson is limited to the assessment as addressed in the DTS provisions of the NCC. That is to say:

   i. the likelihood of a fire through acts of malicious intent or arson is no greater than for a design fully compliant with the DTS provisions of the NCC. The proposed design is equivalent to the DTS provisions of the NCC in this regard.

   ii. multiple fire ignitions are not considered in either the DTS provisions of the NCC or the proposed design. While possible through malicious intent or arson, this event is unlikely.

   iii. ignition of a single item of fuel contained on the premises is within the limitation of this analysis in so far as it is considered to result in design fires similar to those resulting by accidental cause.

g. Only one fire will occur at any time. It is in our opinion the NCC DTS provisions only consider a single fire. This is evident by prescribing alternative exits and fire sprinkler systems being designed for only one area of operation.

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h. Occupants will become aware of the fire through fire cues, respond to the cue, cope with the cue and attempt to avoid the fire, as intended by the NCC for safe evacuation.

i. Responsibility for re-installation and costs of any damages caused by fire is considered to be beyond the scope of the fire engineering assessment.

j. This fire engineering solution is derived making all reasonable assumptions regarding Disability Discrimination Act (DDA) issues. That is, all physically and intellectually handicapped occupants within the building are capable of evacuating to the fire exit of their own accord, or are assisted by colleagues/others.

k. The fire engineering assessment, in this case, will not include for building and contents damage, stock loss, goodwill impact, environmental impact (in a fire situation) or any loss of trade or business interruption associated directly or indirectly with a fire in these premises.

l. Except where specifically noted herein, the fire engineering assessment will not address nor analyse explosive materials, multiple ignition sources and locations, processing of flammable liquids, arson, sabotage of existing fire safety systems, bulk storage or the like.

m. Omnii Pty Ltd incorporates all reasonable and practical efforts into producing a Fire Safety Strategy commensurate with the client's objectives, expectations and operations. Omnii Pty Ltd cannot guarantee, in producing a Fire Safety Strategy, by way of the FEB, FER and fire engineering assessment, that ignition or fire will not occur. Moreover, no amount of advice can guarantee that ignition or fire will not occur.

n. Unless explicitly noted herein, this fire engineering assessment does not address protection of the building during construction, renovation or demolition.

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2. Project Description

2.1 Principal Building Characteristics

2.1.1 General

The proposed redevelopment of the Masters Store in Penrith is part of a nationwide re-development (re-use) of all existing Masters Stores following the closure of the chain. Each store is to be converted into a retail centre containing a number of individual retail tenancies, connected by a mall. The intent of the re-use project is to minimise changes to the existing Masters Store buildings. The existing Garden and Timber Trade Centre areas will be fully enclosed and made part of the overall internal space, however existing structure and services will be retained wherever possible. The majority of individual tenancies will be separated from one another and from the mall by partition walls.

The existing building is a Class 6 (retail) Large Isolated Building (LIB) and as shown in Figure 2.1, contains a large ground floor retail area which includes the semi-open Garden Centre and Timber Trade Centre, as well as a mezzanine office level. The total existing floor area is approximately 13,411m^2.

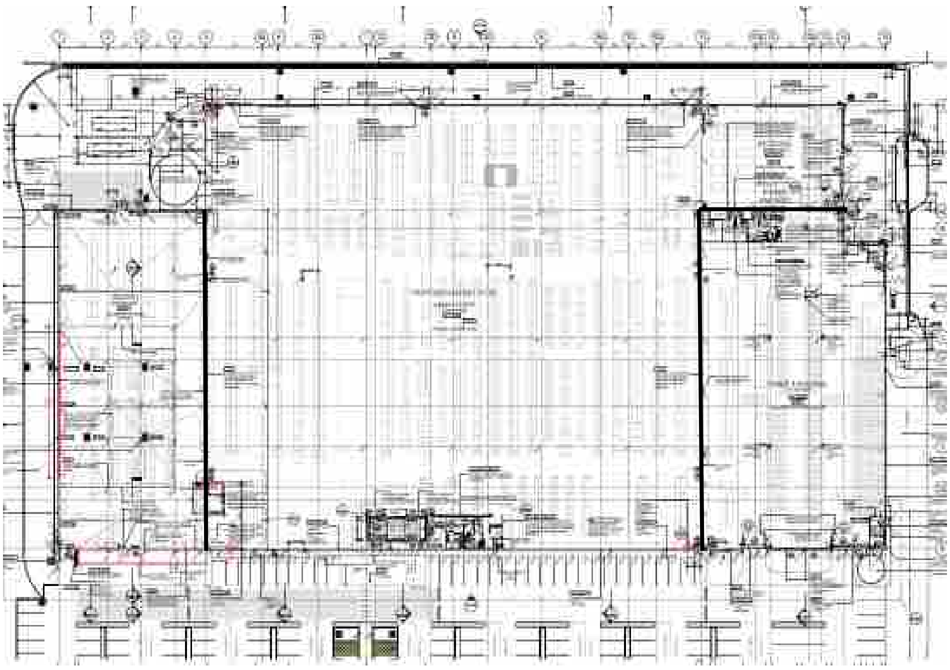

Figure 2.1 – Existing Floor Plan

The proposed re-use will fully enclose the existing Garden Centre and Timber Trade Centre areas, creating a total enclosed floor area of approximately 13,425m^2. The proposed re-use will consist primarily of Class 6 retail space, as shown in Figure 2.2. The majority of tenancies will be separated from one another and from the mall by partition walls extending not more than 4.8m above floor level. The upper part of the building (and all services) will generally be open to each tenancy. Full height walls divide the building into two individual Smoke Zones as shown in Figure 2.2.

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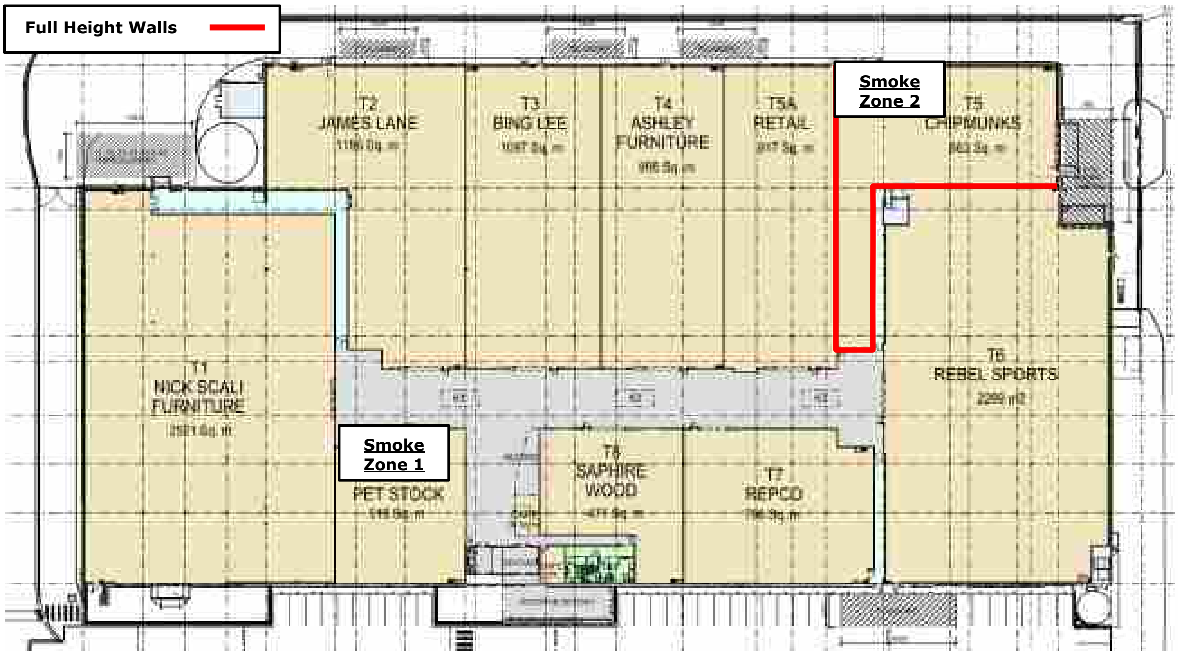

Figure 2.2 – Proposed Floor Plan

2.1.2 Building Characterisation

Table 2.1 details the general subject building characteristics that are relevant to the NCC.

Table 2.1 – General Building Characteristics

Characteristic	Description
Effective height	0m
Rise in storeys	1
Storeys contained	1
Classifications	Class 6, Class 9b
Type of construction	C
Relevant Code	NCC 2016 Volume One

Table 2.2 details the function or uses of the building or building part associated with the subject building classification.

Table 2.2 – Building Classification and Function or Use

Building Classification	Description
Class 6 (Retail)	The building is primarily for the display of retail goods for sale. The goods will be stored in shelves and racks or block stacked on the floor. Pallet jacks may be used to move goods within the store and used to load and unload racks.
Class 9b (Play Centre)	The Class 9b part of the building is primarily for the early care of children aged between 0 and 5 years old. It should be noted that due to the age of the children, the staff to child ratio is understood to be at least 1:10 throughout the facility. Staff will be available to assist with evacuation. This is considered the 'norm' for this type of facility.

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2.1.3 Building Layout, Size and Shape

Table 2.3 sets out the floor areas of the various parts of the building. The floor areas are approximate based on information as referenced in Section 1.7.

Table 2.3 – Building Floor Areas

Level	Occupancy Type	NCC Classification	Floor Area (Gross) (m^2)
Ground Floor	Retail	Class 6	13,425
Ground Floor	Play Area	Class 9b	863

2.1.4 Property Location

The existing Penrith Masters Store is located at 72/82 Mulgoa Road, Penrith New South Wales and occupies the site, as shown in Figure 2.3.

Figure 2.3 – Site Location [6]

2.1.5 Proximity to Other Buildings and Boundaries

The site is bound to the North-west and South-west by Mulgoa Road and Regentville Road respectively. General compliance to boundaries and Fire Source Features (FSFs) is understood to be in accordance with the DTS provisions of the NCC.

2.1.6 General Egress Provisions

Egress from the building is via multiple exits located around the perimeter of the building including the main entrance of the building, as shown in Figure 2.4. Egress will be direct to open space.

The egress provisions are subject to a performance solution due to increased travel distances, increased distances between exits and reduced aggregate unobstructed egress width, refer to Section 7.2.

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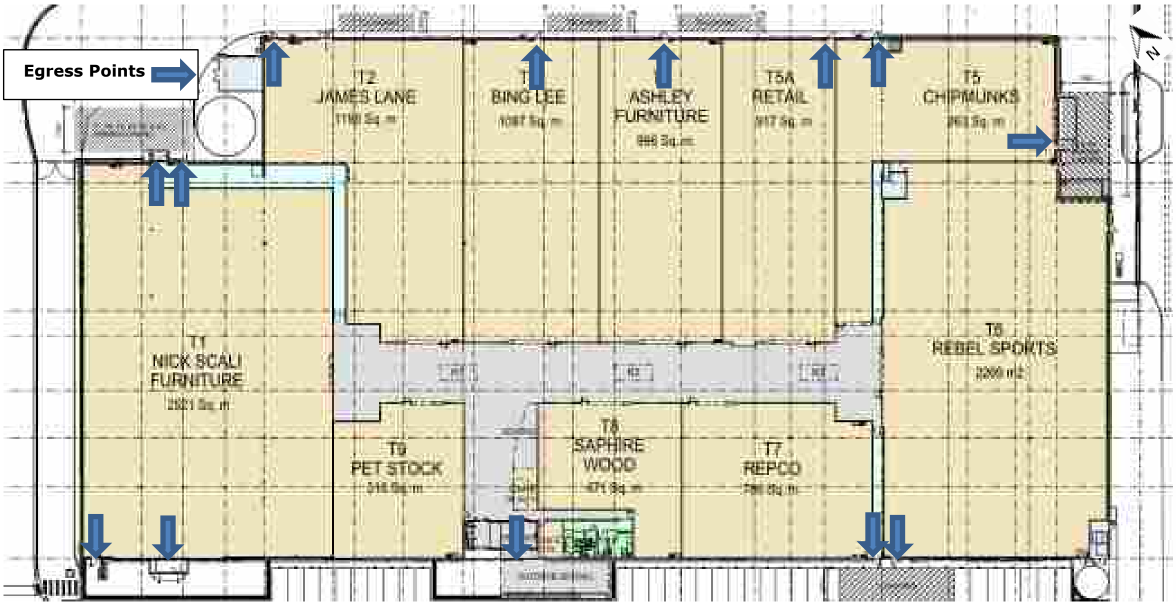

Figure 2.4 – Egress from the Building

2.2 Dominant Occupant Characteristics

2.2.1 Distribution

Representative populations will be utilised for floor evacuation modelling where considered necessary to verify the design performance, such as when assessing increased distance of travel. The population to be used for the purposes of this fire engineering assessment will be based on FCRC Project 6 [7] for Class 6 areas.

Given the building is classified as a Retail building (Class 6) and will consist of a number of individual retail tenancies with associated BoH storage, occupancy loads are unlikely to exceed the Occupancy Load distributions prescribed within the Project 6 [7] Report. Therefore, the use of Project 6 [7] occupancy loads is considered appropriate.

Sensitivity studies shall be undertaken for the Retail area with the NCC DTS population in accordance with NCC Table D1.13.

Table 2.4 sets out the overall number of persons to be accommodated in the various parts of the building according to their Class and floor areas.

Table 2.4 – Number of Persons to be Accommodated in Building

Building Parts		Floor Areas	Occupant Nos. (Project 6)		Occupant Nos. (DTS)*	
Level	Occupancy Type	(m²)	m²/P	No.	m²/P	No.
Ground Floor	Retail (Shop)	11,618	6	1,936	3	2,711
Ground Floor	Play Area	863	N/A	N/A	4	216*
Ground Floor	Retail (Mall)	1,807	10	181	5	253

*Note: 30% has been discounted from the total retail floor area to allow for racking and back of house areas for NCC DTS Table D1.13 occupant loads only

Play Area tenancy capacity will be limited by maximum admission

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2.2.2 Attributes

Based on the function and use of the building, occupants can be classified into the dominant groups detailed in Table 2.5.

Table 2.5 – Dominant Occupant Attributes

Attributes	Description
Staff	
State of Awareness	Generally alert, awake and aware of their surroundings. It is considered that, due to employee requirements, staff are not likely to be under the influence of drugs or alcohol while on the premises.
Physical and Mental aspects	It is expected that the majority of staff will not have any relevant physical or mental impairments. However, there may be a minority of staff who are physically and/or mentally impaired.
Familiarity with the Building	Generally familiar with the building configuration, including the location of the main entry and exit points as well as available egress paths.
Emergency Training	Staff are expected to be trained in emergency evacuation procedures. This may include training using fire hose reels and/or fire extinguishers for an initial attack on a fire, if safe to do so. Staff are also expected to understand the standard 'Evacuation' tone, have the ability to follow directions from voice over commands received via an Intercom System and be able to follow exit signage.
Patrons	
State of Awareness	Generally alert, awake and aware of their surroundings. It is considered that patrons are not likely to be under the influence of drugs or alcohol while on the premises.
Physical and Mental State	It is expected that the majority of patrons will not have any relevant physical or mental impairments, as representative of the general population. However, there may be a minority of patrons who are physically and/or mentally impaired. A number of the occupants may also be unaccompanied children or family groups.
Familiarity with the Building	Generally familiar with the building configuration, including the location of the main entry and exit points as well as available egress paths.
Emergency Training	There is no expectation for patrons to be trained in emergency procedures or on the use of fire hose reels or fire extinguishers. However, patrons are expected to understand the standard 'Evacuation' tone, have the ability to follow directions from voice over commands received via an Intercom System and be able to follow exit signage.
Children	
State of Awareness	May be awake or asleep. Therefore, children may not be alert or aware of their surroundings. However, it is considered that they will not be under the influence of drugs or alcohol.
Physical and Mental State	It is expected that the majority of children will not have any relevant physical or mental impairments. However, there may be a minority of children who are physically and/or mentally impaired. Furthermore, there may be a number of children that are not of walking age and therefore will require assistance.
Familiarity with the Building	Based on the age of the children, it is expected that they may not be familiar with the building layout or the location of exits.

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Attributes	Description
Emergency Training	There is no expectation for children to be trained in emergency procedures or on the use of fire hose reels or fire extinguishers. Children are also not expected to understand the standard 'Evacuation' tone nor have the ability to follow directions from voice over commands received via an Intercom System nor be able to follow exit signage.

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2.3 Fire Brigade Characteristics

2.3.1 Proximity to Fire Station

Table 2.6 details the fire stations in the local area around the proposed project. This information was obtained from www.fire.nsw.gov.au.

Table 2.6 – Local Area Fire Stations

Fire Station	Fire Station Address	Approx. Distance from Site (km)	Staffing Type
Regentville	2-6 Jeanette Street, Regentville	3.1km	Permanent
Penrith	290-294 High Street, Penrith	3.5km	Permanent

2.3.2 Fire Brigade Equipment and Access

It is anticipated that the responding Fire Brigade (i.e. trained personnel) will arrive to this building on receipt of a public initiated call (i.e. occupant or passerby) or an automated call from the installed fire sprinkler system.

Consistent with Standard Operational Procedures, it is expected that responding Fire Brigade personnel will be wearing appropriate turnout uniform in accordance with occupational health and safety requirements.

The site is bound to the North-west and South-west by Mulgoa Road and Regentville Road respectively. Vehicular access is via Mulgoa Road and Regentville Road with the fire hydrant booster located on the boundary facing Mulgoa Road as shown indicatively in Figure 2.5. Perimeter vehicular access is subject to a performance solution as the width of the access road is permitted to reduce in width to 4.5m in localised areas not near corners of the building, refer to Section 7.1.

Fire fighter access to the building is via multiple points located around the perimeter of the building. The fire pump room is accessible from the outside on the North-west side of the building.

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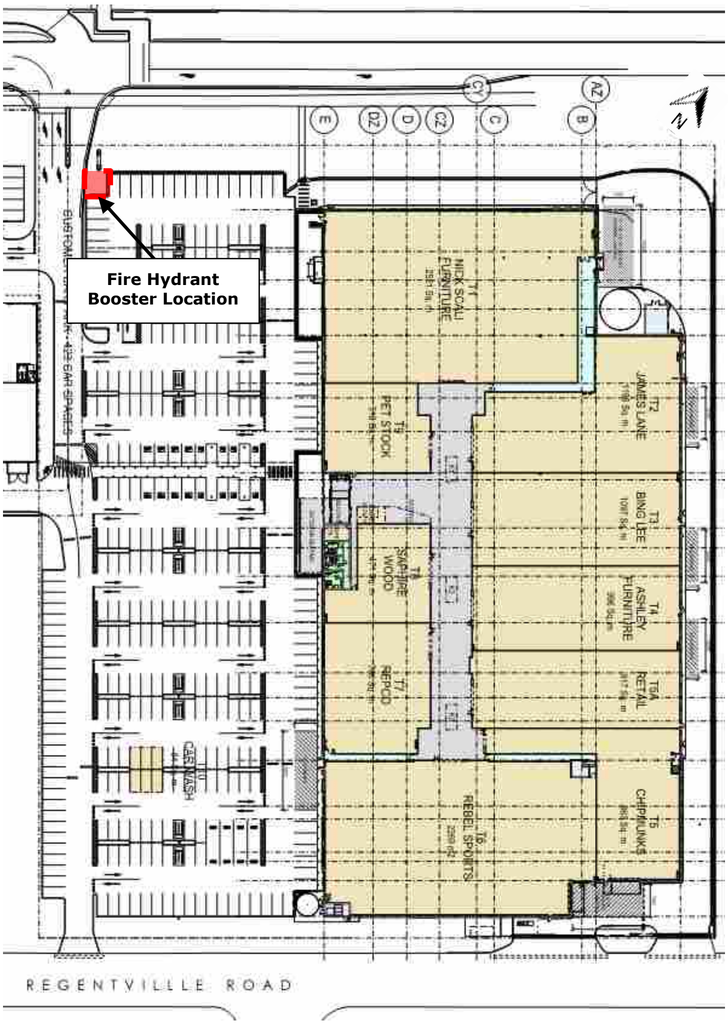

Figure 2.5 – Fire Brigade Installation Location and Access

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3. Hazards and Safety Measures

3.1 Hazards and Safety Measures

Design fires and Fire Scenarios are selected with consideration to the features of the building not complying with the DTS provisions of the NCC. Fires generally occur based on the available ignition sources and fuel load present within the various areas of the building.

Table 3.1 identifies the possible ignition sources, packages of fuel (fire sources) and the average fuel load densities for the different occupancies (obtained from IFEG [2] and FEDG [8]) within the building, which are considered to cause the worst credible hazard with respect to the proposed NCC DTS non-compliances.

Table 3.1 – Possible Ignition Sources and Fuel Loads

Ignition Sources	Fuel Sources	Fuel Load (MJ/m^2)
Retail (Class 6)		
• Display lighting • Faulty electrical equipment • Faulty electrical power distribution • Heating and cooling equipment • Cooking • Smoking • Suspicious / Arson	• Fuel load varies based on type of retail	• Clothing Store 600 • Electrical Store 500 • Toy Store 500 • Book Store 1,000 • Bedding Store 500 • Liquor Store 700 • Furniture Store 400 • Food Store 700 • Bakery 200 • Hardware Store 300 • Shoe Store 500 • Restaurant 300
Play Centre (Class 9b)		
• Short circuiting of wiring in electrical lighting/equipment • Electrical faults in distribution system and/or fittings • Heating equipment	• Chairs, desks and furnishings • Books and paper material • Electrical equipment such as computers, projectors and other audio/visual equipment • Rubbish bins • Linings and coverings	• Play Area 400

The Building Solution also incorporates preventative and protective measures, as detailed in Table 3.2, which assists in reducing the risks associated with the ignition and fuel sources identified in Table 3.1.

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Table 3.2 – Safety Measures

Preventative Measures	Protective Measures
Retail (Class 6)	
• No smoking policy • Electrical safety devices • House keeping • Presence of staff • Staff training	• Smoke exhaust system • Smoke detection system • Fire sprinkler system • Fire hydrant coverage • Fire hose reel coverage • Fire extinguisher coverage • Building Occupant Warning System • Emergency Lighting and Exit Signs • Multiple egress paths and exits • Emergency procedures (e.g. automatic shutdown of air handling units) • System monitoring by Fire Brigade or Fire Brigade Monitoring Station
Play Centre (Class 9b)	
• No smoking policy • Electrical safety devices • House keeping • Safety procedures • Presence of staff • Staff training • Security procedures	• Fire compartmentation or bounding construction • Fire hydrant coverage • Fire hose reel coverage • Fire extinguisher coverage • Multiple egress paths and exits • Emergency Lighting and Exit Signs

Arson/Suspicious fires are discounted in this instance (relative to the proposed Building Solution reviewed) and are outside the scope of this document. No amount of professional advice (in both DTS and performance based building solutions) can obviate from arson. Management procedures/security are considered to address this issue as for any building.

It is noted that all new electrical works are understood to be installed in accordance with AS 3000 and light fittings and electrical equipment would be expected to be in accordance with appropriate Australian Standards, thus the risks associated with electrical works are considered to be no greater than those in a NCC DTS building.

In any case, the assessments contained within this document assume that a fire will start.

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4. Assessment Methodologies

4.1 General

These assessment methods have been formulated to show that the proposed Performance Solution achieves compliance with the Performance Requirements as per NCC Clause A0.2 and where applicable qualitative or comparative assessments are proposed (i.e. for assessing fire safety systems) as per NCC Clause A0.5 (as noted in Section 1.2) via analysis methods as outlined in the IFEG.

4.2 Occupant Life Safety

The objective for occupant life safety is to safe guard occupants from illness or injury while evacuating from the building. A fire in the subject building should not cause conditions, such that paths of egress become unusable for the duration of the evacuation.

Acceptance for occupant life safety, based on a Performance Solution, can be demonstrated via the following:

Absolute ASET/RSET Analysis

This assessment of the occupant life safety is carried out using an absolute quantitative analysis with deterministic data.

An absolute approach where the Available Safe Evacuation Time (ASET), which is determined when the tenability within a space can no longer be maintained (refer Section 4.2.1) is compared to the Required Safe Evacuation Time (RSET) determined as per Section 4.2.2.

The safety margin for occupant life safety is determined by the ratio of ASET to RSET (i.e. ASET/RSET) or the time elapsed between ASET and RSET, where ASET is greater than RSET as depicted in Figure 4.1.

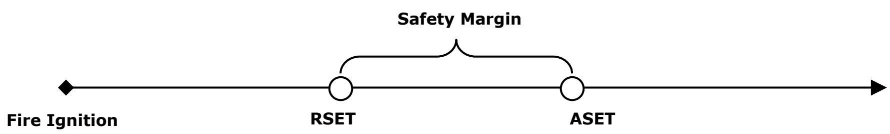

Figure 4.1 – ASET – RSET Timeline for an Absolute Analysis

4.2.1 Available Safe Evacuation Time

The parameters for tenability criteria, based on the Fire Engineering Design Guide (FEDG) [8] and CIBSE Guide E: Fire Engineering [9] for occupant life safety, require that conditions be maintained so that the temperature, level of visibility and level of toxicity do not endanger human life. The time at which untenable conditions occur will be determined via appropriate design Fire Scenarios, as detailed in Section 5.3.

The tenability criteria for occupant life safety can be simplified into the following criteria:

a. The radiant heat from the smoke layer does not exceed 2.5kW/m².

   Note: This equates to a temperature of approximately 180°C from a smoke layer height of 2.0m Above Finished Floor Level (AFFL) or greater.

b. The temperature of air where people are exposed within the smoke layer (i.e. smoke layer height less than or equal to 2.0m AFFL) is less than 60°C.

c. Visibility shall be assessed for way finding at 2.0m AFFL, and is not less than 10m for large rooms;

   Note: Toxicity is generally considered to be acceptable if visibility is not less than 10m and exposure to occupants is not likely to exceed 30 minutes.

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4.2.2 Required Safe Evacuation Time

The Required Safe Evacuation Time (RSET) is the time required for the last occupant to evacuate the occupied space to a place of safety. RSET is determined via the following equation:

$RSET = t_a + t_p + t_t$

where: t_a is the alarm time

t_p is the pre–movement time

t_t is the travel time

These parameters are discussed further in Section 5.4.

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4.3 Fire Brigade Intervention

The objective for Fire Brigade intervention is to facilitate the Fire Brigade to undertake fire-fighting operations. A fire within the subject building should not cause conditions within the building or at fire-fighting installations, such that extreme conditions are encountered. Refer Table 4.1.

Acceptance for Fire Brigade intervention can be demonstrated based on the following extract from the FBIM Manual [4].

The following criteria have been established from a paper written in the Fire Journal, January 1995. The project was carried out by the UK Home Office Fire Experimental Unit.

These results are based on firefighters dressed in standard A26 tunics with overtrousers to an equivalent specification, firehoods, gloves, helmets, rubber boots and breathing apparatus. It is important that the personal protective equipment utilised by the relevant fire authority, and its performance in comparison to the above specifications, is taken into consideration when establishing the limits for firefighter safety.

The results summarised in Table 4.1 are relative to a height of 1.5m Above Finished Floor Level (AFFL).

Table 4.1 – Fire Brigade Conditions

Condition	Time (minutes)	Air Temperature °C		Radiation kW/m²
		Upper Layer	Lower Layer	
Routine – Elevated temperatures, but not direct thermal radiation	25 (max)	N/A	< 100	< 1
Hazardous – Where firefighters would be expected to operate for a short period of time in high temperatures in combination with direct thermal radiation	10 (max)	N/A	< 120	< 3
Extreme – These conditions would be encountered in a snatch rescue situation or a retreat from a flashover	1 (max)	< 280	< 160	< 4 – 4.5
Critical – Firefighters would not be expected to operate in these conditions, but could be encountered. Considered to be life threatening	< 1	N/A	> 235	> 10

While firefighters can search under fire conditions which are untenable to building occupants, it is unlikely that the occupants will survive in this atmosphere, therefore, these conditions do not constitute a satisfactory design criteria for occupant safety. Search and rescue cannot be undertaken in a compartment which has reached flashover and it is not expected that occupants will survive in such an environment. When the smoke layer is less than 1.0m above the floor, search speed becomes hampered and time to undertake this task increases.

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4.3.1 Fire Brigade Intervention Model

A Fire Brigade Intervention Model (FBIM) is not to be undertaken as part of this assessment nor deemed necessary given the nature of the Performance Solution. However, Fire Brigade Intervention (FBI) will be discussed qualitatively for a duration of 1,800 seconds against the tenability criteria detailed in Section 4.3.2. Given the building is located in an urban environment served by permanently manned fire stations, a period of 1,800 seconds is considered appropriated for the purposed of assessing Fire Brigade Intervention.

4.3.2 Fire Brigade Intervention within the Building

Assessment of Fire Brigade intervention within the building is carried out using an absolute quantitative analysis using deterministic data.

The tenability criteria for fire fighting intervention, requires that conditions be maintained so that the temperature and the level of radiation do not endanger Fire Brigade personnel who are within the building fighting the fire. These conditions correspond to the Fire Brigade's hazardous condition, where firefighters would be expected to operate for a short period of time, as detailed in Table 4.1. The time at which untenable conditions for fire fighting operations occurs will be determined via appropriate Primary Study, as detailed in Section 5.3.

The tenability criteria for Fire Brigade intervention can be simplified into following criteria:

a. The radiant heat from the smoke layer does not exceed 3.0kW/m². This equates to a temperature greater than 200°C from a smoke layer height of 2.0m or greater, however 200°C is to be used in this instance.

b. The temperature of air where fire-fighters are exposed within the smoke layer (i.e. smoke layer height less than or equal to 1.5m) is less than 120°C.

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5. Modelling Parameters and Modelled Scenarios

5.1 General

Given the objectives of the NCC, the selected design fires, Fire Scenarios and Egress Scenarios are based on those scenarios considered to be the worst credible and most likely to test the proposed building solution.

This section simplifies the building system, design fires, Fire Scenarios and Egress Scenarios to enable modelling to be undertaken on a practical level for the proposed building solution. All design criteria are based on the practice nominated in the IFEG and practical simplifications have been utilised to maintain a simple analysis that is representative of a real fire and life safety situation.

The modelling in this report represents a similar architectural layout to that of the Penrith site, due to the inclusion of full-height walls. The modelled scenarios herein represent a Smoke Zone with a smaller overall area, and a reduced rate of Smoke Exhaust. Both these measures enhance the conservatism of the modelling. A Smoke Zone with reduced area means that the size of the smoke reservoir has reduced. Therefore, a smoke layer will descend faster for a given fire, and times to untenable conditions will be evaluated in a conservative manner. Equally, as the model only simulates the effect of 49.8m^3/s of smoke exhaust capacity, the rate of smoke removal from the building is also modelled conservatively.

5.2 Modelling Parameters

5.2.1 Modelling Tools

5.2.1.1 Device Activation Tool

Hand calculation tools have been developed that rely on the convective effects produced by a fire to calculate the response (activation) time of ceiling mounted fire detectors and fire sprinklers. These tools are based on the studies undertaken by Alpert [10] and Heskestad and Bill [11].

These tools will also be used to determine peak fire sizes (where fire sprinkler controlled and/or suppressed fire scenarios are proposed), which will then be utilised within FDS modelling.

5.2.1.2 Fire Dynamics Simulator (FDS)

The computer program Fire Dynamics Simulator (FDS) (Version 6.1.2), will be used to calculate the evolving distribution of smoke, fire gases and temperature throughout the modelled compartments of a building during a Fire Scenario. This program was produced by the National Institute of Standards & Technology (NIST), Building and Fire Research Laboratory. Refer to Appendix H for further discussion on FDS.

Due to the fact that FDS requires high computing power to undertake the analysis, model simplifications are implemented. These simplifications include, but are not limited to the following:

- Obstructions (i.e. walls, floors ceilings and fit-out items) and obstruction holes are dimensioned to suit the largest mesh size.
- Obstructions (i.e. walls, floors ceilings and fit-out items) are smooth and inert.
- The fire is assumed to be located in the same location throughout the analysis (i.e. no fire spread).
- The combustible material is homogeneous.

A grid analysis has also been undertaken to determine the appropriate fire mesh grid size and physical fire area to be used for the FDS modelling. The fire mesh size and physical fire area calculations are contained in Appendix H and the fire mesh size is summarised in Table 5.5 of the Fire Scenario section.

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5.2.2 Fire Alarm Activation

A fire alarm is considered to occur on activation of an active fire safety system, these being a point type smoke or heat detector, multi aspirating smoke detection system (MASDS) or a fire sprinkler head. The parameters to determine activation are as discussed below.

5.2.2.1 Point Type Smoke Detectors

Where it is proposed to model the Fire Scenario using the FDS program and point type smoke detection system is to be included as part of the model, the activation times will be calculated using the Obscuration Method.

Obscuration Method

AS 1603.2 specifies the requirements for the design, construction and performance of point type smoke detectors. The sensitivity of the detector is determined by the amount of smoke measured using a standard test method at which time the detector registers an alarm state (i.e. the condition under which the fire alarm circuit of the detector signals an alarm). Photoelectric smoke detectors must have a nominal sensitivity, when tested in accordance with AS 2362.17 (Sensitivity test), between 0% obscuration/meter (% obs/m) and 15% obs/m. Upon review of the majority of available point type detectors, it is evident that on average, point type detectors have a sensitivity of approximately 5% obs/m.

Based on the aforementioned it is assumed that **detection occurs when a smoke sensitivity of 5% obs/m** is calculated within the upper smoke layer.

5.2.2.2 Multi-Point Aspirating Smoke Detection System (MASDS)

MASDS is provided through the existing Main Trading floor and will be retained for the proposed Re-Use project. Even though MASDS is expected to provide an earlier response to the presence of smoke due to its active sampling, for the sake of simplicity and consistency, the MASDS will be modelled in FDS as point type smoke detectors with a 5% obs/m sensitivity setting, at the appropriate spacing of the MASDS sampling points. This is considered to be a conservative approach.

5.2.2.3 Fire Sprinkler Heads

Where it is proposed to provide a fire sprinkler system, the activation times will be calculated using FDS. The parameters to be modelled to determine activation summarised in Table 5.1:

Table 5.1 – Fire Sprinkler Parameters

Parameter	Performance Building Solution
High Hazard Sprinklers	
Nominal Release Temperature	141°C
RTI	$50m^{½}s^{½}$
C Factor*	$0.8(ms)^{½}$
Maximum Design Spacing	3.70m x 2.43m (2.214m radial distance from fire)
*Based upon review of the majority of fire sprinklers and on AS 4118.1.1:1996 a C Factor of $0.8(ms)^{½}$ is considered appropriate for both fast response and standard response fire sprinkler heads.	

5.2.3 Design Fires

The proposed design fire is to be used to assess the proposed Performance Solution and form part of the Fire Scenarios detailed in Section 5.3.

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5.2.3.1 Schematic Design Fire

The following schematic design fire will be used to assess the Performance Solution qualitatively where specific design fires are not defined.

General

The fire growth rate of an actual fire is dependent on many factors which include the size and location of the ignition source, orientation of the burning object, the types of objects (fuel) and its proximity to other objects, walls and openings. Fires in rooms or other compartments are often summarised in terms of the stages of fire development as shown in Figure 5.1. However, not all fires go through all of these stages, due to a lack of fuel, ventilation, or intervention by a fire sprinkler system activating, occupants or Fire Brigade occurs.

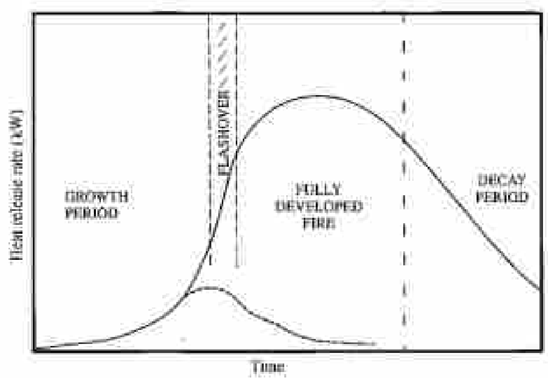

Figure 5.1 – Stages of Fire Development [12]

The following sections provide a brief description of each of the stages.

Incipient Phase

The incipient phase precedes ignition. During the incipient phase the heating of fuel produces smoke. A fire is considered to be in the incipient phase if it is 20kW or less [8]. The incipient phase is generally not modelled, the phase duration can vary between seconds and days and as such is not relied upon in modelled scenarios.

Occupants may become aware of a fire due to visual, or olfactory cues, or an alarm activated by a smoke detection system during this stage.

Ignition

There are three ignition sources which may start a fire: pilot ignition from a spark or small flame, spontaneous ignition due to sufficiently high temperatures and a flammable vapour/air mixture, or spontaneous combustion in bulk fuels.

Ignition is considered to occur when the fuel source moves from the incipient phase to self-sustaining combustion with increased output of heat and smoke.

Growth Phase

The growth phase begins once the fuel has been ignited and has reached self-sustaining flaming combustion. The growth rate of the resulting fire is determined by the properties of the fuel and is controlled by the rate of flame spread. The fire will continue to grow independently of the enclosure until it becomes limited by either the surface area of the fuel (fuel controlled), or the ventilation conditions (ventilation controlled). The duration of the growth phase can be between few minutes and several hours.

Occupants will generally be alerted to the fire by an alarm activated by a smoke detection system if the growth phase is relatively slow (i.e. smouldering) or a heat detection system or sprinkler system during this stage.

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During the growth phase, the heat release rate Q (MW) is modelled as a t^2 fire is given by [8]:

$$\mathbf{Q = 1{,}055 \times [t/k]^2} \text{ – Equation 1}$$

where t is the time (seconds and k is the growth time (seconds). The numerical value of k is the time in seconds for the fire to reach a heat output of 1.055MW.

An alternate formula to describe the HRR Q (MW) for a t^2 fire is by:

$$\mathbf{Q = \alpha t^2} \text{ – Equation 2}$$

Where α is the fire intensity coefficient (MW/s^2).

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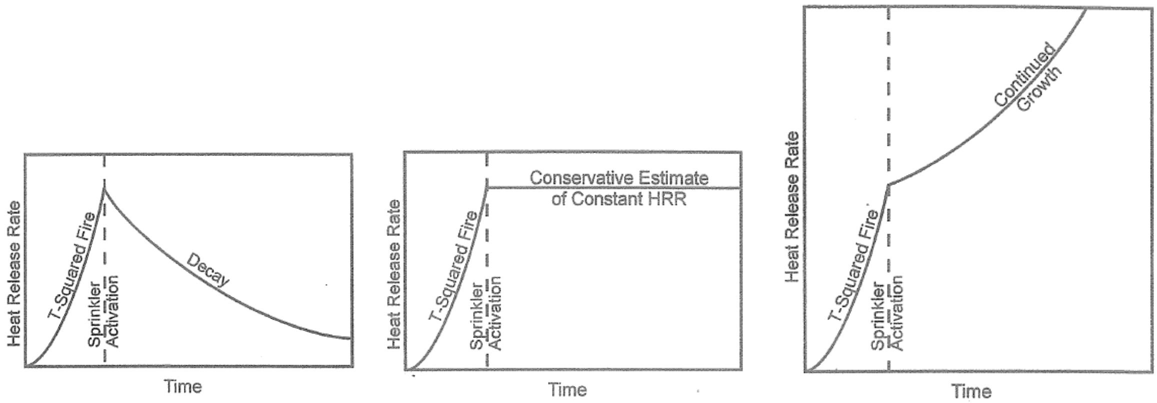
Values of α used:

- Slow 2.93×10^{-6} MW/s²
- Medium 1.17×10^{-5} MW/s²
- Fast 4.66×10^{-5} MW/s²
- Ultra Fast 1.874×10^{-4} MW/s²

Fire Sprinkler Activation

Automatic fire sprinkler systems are designed to operate during the growth phase. When fire sprinklers operate, the fire will either be extinguished, as shown in Figure 5.2(a), be controlled and no longer increase in size, as shown in Figure 5.2(b) or overwhelm the fire sprinkler system and continue to grow, as shown in Figure 5.2(c).



(a) Extinguishes Fire (b) Controls Fire (c) Overpowered by Fire

Figure 5.2 – Fire Sprinkler Activation [13]

It is considered that fire sprinkler failure is highly unlikely, as discussed in Appendix F; therefore, where fire sprinkler protection is modelled, it is assumed to control the fire. Furthermore, research conducted by CIBSE [14] and Warrington [15] showed that the upper layer temperatures are not likely to exceed 100°C during a fire sprinkler controlled fire and 200°C during a fire sprinkler shielded fire.

Decay Phase

Once 80% of the fuel load is consumed the fire is considered to have entered the decay phase. The fire intensity decreases as the maximum burning rate can no longer be sustained and the fire becomes fuel controlled until it extinguishes. The length of the decay phase is governed by the type of fuel. Plastics and other liquid fuel fires will have a very short decay phase, wood and other charring materials will have a longer decay phase.

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5.2.3.2 Retail Fire – Fire Sprinkler Protected (General)

Project 6 recommends that the primary design fire, when considering the impact of smoke on occupants, be a relevant (Category C2–1 – Category C2–4) sprinklered fire. Project 6 also provides estimated probabilities of different types of sprinklered fires for various retail areas as reproduced in Figure 5.3.

TABLE 11.1 PROBABILITY OF OCCURRENCE OF TYPE OF SPRINKLERED FIRES*

Area of Fire Origin	*Type of Sprinklered Fire*			
	C2-4	*C2-3*	*C2-2*	*C2-1*
Specialty Shops (FSG6)	0.015	0.015	-	0.97
Major Stores (FSG3):				
Department Stores	0.02	-	-	0.98
Variety Stores	0.025	0.475	0.50	-
Major Toy Store	0.45	0.45	0.10	-
Major Sports Store	0.025	0.225	0.25	0.50
Supermarkets	0.025	-	0.025	0.95
Storage Areas[#]:				
Storage—major stores (FSG14)	0.50	-	0.50	-
Storage—Specialty Shops (FSG18)	0.015	0.015	-	0.97
Other Areas[#]:				
Structural Areas (FSG9 , FSG12)	0.25	0.25	0.25	0.25
Service/Equipment Areas (FSG21)	-	0.25	0.25	0.50
Service Facilities (FSG27)	-	-	0.95	0.05

* Assuming the occurrence of a sprinklered fire

Figure 5.3 – Probability of Occurrence based on Fire Category [7]

Project 6 defines each category of fire as follows:

Category C2–4 fire – Is considered to give rise to the greatest rate of smoke generation. Corresponds to that associated with *high* racking with stacked goods on top such that the total height is within 1,000mm of the ceiling or soffit where the closest sprinkler heads are *not* located over or between the racks. The contents of the racks are assumed to be substantially non–cellulosic.

Category C2–3 fire – Is identical to that described above except that the racking is lower (up to 2m below ceiling or soffit if there is no ceiling), then there will not be as great an interference with the application of water to the fire. It is estimated that the rate of smoke production in this case will be about 50% of that associated with an "C2–4" fire.

Category C2–2 fire – This type of sprinklered fire may be assumed to arise when there is racking corresponding to the "C2–4" or "C2–3" situations but that the sprinklers are positioned above or between the racks. These situations are considered to give a smoke production rate equal to 25% of that associated with an "C2–4" fire.

Category C2–1 fire – These are fires where the water is applied to the seat of the fire and there is an absence of racking. It is also assumed that a ceiling is present having a height of not more than 4m. They are considered to be identical to the sprinklered fires experienced with Project 6 Tests 5 – 9 and are not considered to present a threat to the occupants.

As is evident from Figure 5.3, relatively few "C2–4" fires are expected, and the majority of fires will be "C2–1" type fires. This is confirmed by an analysis of several major shopping centres which indicates that the average probability of having a "C2–4" fire, given the occurrence of a sprinklered fire, is between 0.02–0.05 [7]. It is also important to note that although suppression of a fire may not have not occurred within the actual test (i.e. the fire was controlled), the amount of smoke produced is reduced, as is evident by the description of each fire category above.

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The buoyancy of smoke is a function of its temperature. Project 6 notes, that in close proximity to seat of the fire, the 'washing' effect of the sprinklers appears to reduce the buoyancy of the smoke. "However, tests have shown that away from the sprinklers, the smoke will be buoyant provided the temperature of the smoke is slightly higher than the adjacent ambient air. For fires such as a C2-4 fire, the smoke will remain buoyant for substantial distances, whereas for lesser fires, this may not be the case."

The fire growth rate depends significantly on the fuel load and internal venting conditions. Tests conducted at the Scientific Services Laboratory (SSL) – Project 6 showed the different conditions and the effectiveness of fire sprinklers at controlling or suppressing the fire intensity and fire spread. NFPA 92B [16], Project 6 and Table B3 of the Milke and Klote publication 'Smoke Management in Large Spaces' [17], provides the following expected fire growth rates for various fuel packages:

- Wood pallets stacked to 4.8m high: fast t^2 growth rate
- Cartons on pallets, rack storage, 4.5m to 9m high: medium to fast t^2 growth rate
- Paper products densely packed in cartons, rack storage 6m high: slow to medium t^2 growth rate
- Polystyrene toy parts in cartons, stacked to 4.5m high: fast t^2 growth rate
- Polyethylene bottles packed in cartons, stacked 4.5m high: ultra-fast t^2 growth rate
- Polyethylene jars packed in cartons, compartmented, stacked 4.5m high: ultra-fast t^2 growth rate

Given the aforementioned, the fire growth rate will be modelled as follows:

- fast t^2 fire within the retail trading (Front of House) area
- ultra-fast t^2 fire within Back of House (B.O.H) areas

The modelled fire will be based upon a C2-4 fire, where the "washing" effect of the fire sprinklers is not incorporated. Furthermore, the level of racking within is considered to shield the fire seat from the direct action of the fire sprinklers. Therefore, the Heat Release Rate will be modelled as a fast t^2 fire growth until fire sprinkler activation.

5.2.3.3 Sprinkler Controlled Front of House Fire – High Hazard Fire Sprinkler System

Within the relevant front of house (i.e. retail trading) areas, the heat release rate for high Hazard (i.e. control mode) fire sprinklers will be modelled as a fast t^2 fire growth until sprinkler activation within front of house areas. Following sprinkler activation, a delay for the fire sprinkler system to control the fire is added to the assessment, and therefore the fire will continue to grow for 30 seconds after fire sprinkler activation. The heat release rate will then be modelled as a steady state-controlled fire for the remainder of the modelled durations, as shown in Figure 5.4.

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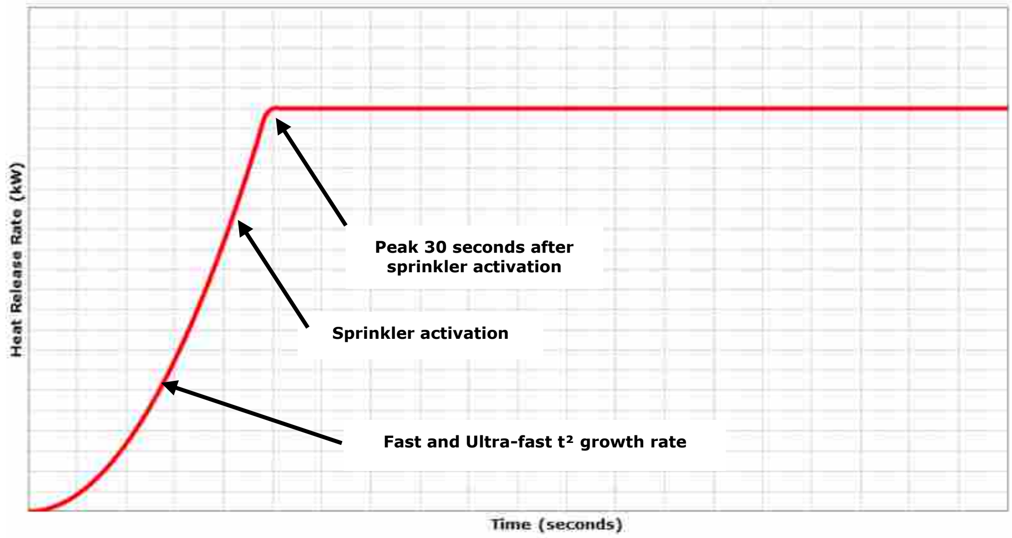

Figure 5.4 – Typical Heat Release Rate for a High Hazard Sprinkler System Fire (including Retail and BoH Storage Areas)

5.2.3.4 Back of House Sprinkler Controlled Fire – High Hazard Sprinkler System

Within Back of House tenancy areas where rack storage may be present, the heat release rate for High Hazard (i.e. control mode) fire sprinklers will be modelled as an ultra-fast t^2 fire growth until sprinkler activation. Following sprinkler activation, a delay for the fire sprinkler system to control the fire is added to the assessment, and therefore the fire will continue to grow for 30 seconds after fire sprinkler activation. The heat release rate will then be modelled as a steady state- controlled fire for the remainder of the modelled durations, as shown in Figure 5.4.

5.2.4 Smoke Exhaust

Smoke exhaust quantities will be determined based on satisfying the requirements of the Acceptance Criteria. The smoke extraction system within the fire affected area will be modelled as operation on activation of the fire sprinkler system, with a 30 second delay following sprinkler activation to allow for fire sprinkler system flow switch activation and fire control system polling, and another 20 seconds exhaust fan ramp up time.

The proposed smoke exhaust fan locations for the model are as shown in Figure 5.5. Note that the proposed smoke extraction rate within the Penrith site is $64.8m^3/s$.

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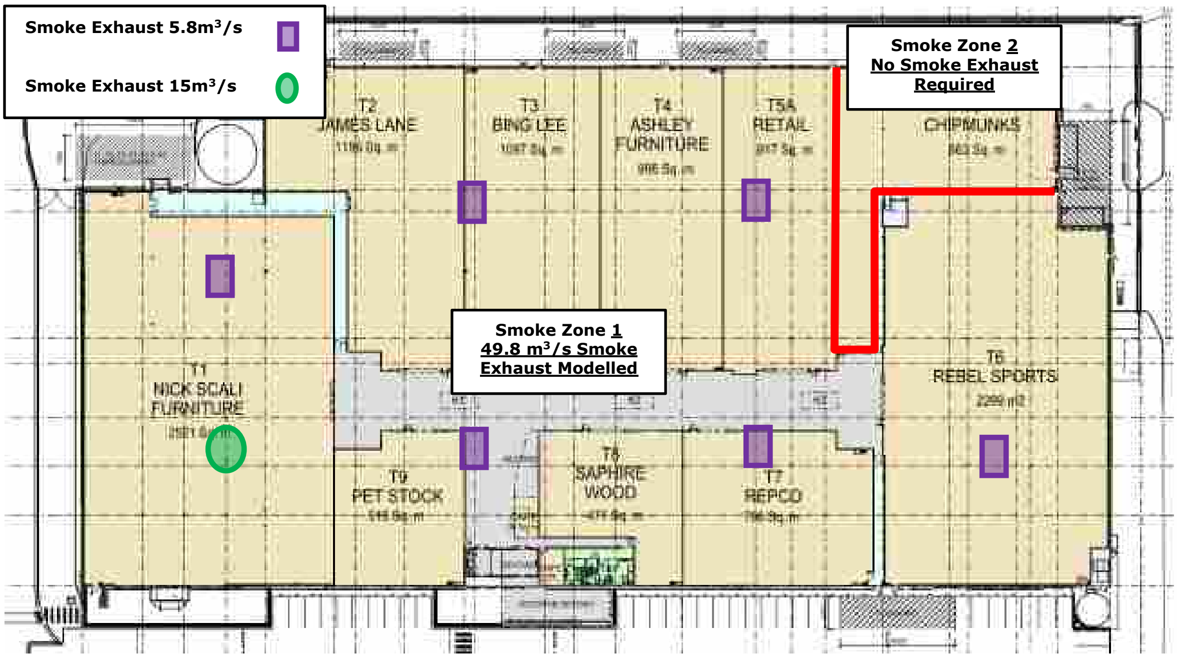

Figure 5.5 – Proposed Smoke Exhaust Fan Locations

5.2.5 Ventilation Conditions

5.2.5.1 Make-up Air Provisions

Low level make-up air will be provided less than 3.6m above finished floor level via operable louvres in the external walls of the building, distributed in accordance with the architectural drawings. The louvres will be inter-locked with the smoke exhaust fans to open on activation of the smoke exhaust system (and will fail open on power failure).

For the purpose of the computer smoke modelling, the louvres are assumed to have an aerodynamic efficiency of 0.6 and will be sized such that the maximum make-up air face velocity at the louvres is 2.5m/s, i.e. the total effective free area of the louvres (in m^2) will not be less than 40% of the total smoke exhaust capacity (in m^3/s).

5.2.5.2 Tenancy Entry Doors

The entry doors into each tenancy from the mall will be modelled for fire scenarios as an opening 3.0m wide by 2.0m high, located centrally at the front of the tenancy. This is representative of after-hours operating conditions, whereby an effective free area of not less than 40% is achieved by the roller shutters located at each tenancy entry. Although the modelled tenancy walls only extend to 4.8m above floor level, the size and location of tenancy entry doors has an impact on the movement of make-up air through the building. Therefore, by utilising the worst case interior ventilation conditions for the modelling a conservative approach is achieved.

5.2.5.3 Draft Curtains

For the purposes of the computer modelling draft curtains have been ignored. This is because draft curtains follow the ridgeline of the roof, thus are unlikely to have an impact on the descent of the smoke layer.

5.2.6 Visibility

The following parameters detailed below control smoke production and visibility conditions.

Soot Yield: 0.08g/g

SFPE (Table 3-4.16) [18] provides soot yields for various materials.

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Table 5.2 lists the soot yields available for the most common materials within the area(s) being considered.

Table 5.2 – Soot Yields

Material	Soot Yield (g/g)	Material	Soot Yield (g/g)
Retail Tenancy			
Wood	0.015	Wool	0.008
PMMA	0.022	PE	0.060
Polyester	0.091	Nylon	0.075
Corrugated boxes with PET	0.053	Polystyrene*	0.193
*Average value			

Based on the aforementioned soot yield values and considering it is very unlikely that there would be 100% of one material, an average soot yield value will be modelled. FDS also requires that a chemical formula be specified as part of the combustion parameters. Table 5.3 specifies the parameters to be modelled.

Table 5.3 – Modelled Combustion Parameters

Location/Area	Soot Yield (g/g)	Chemical Formula
Retail Areas	0.08	Polyurethane ($C_1H_{1.74}O_{0.32}N_{0.07}$)

Visibility Factor – C:

A 'C' value of 3 is proposed where based on light reflecting signs and surfaces [19].

5.2.7 Modelled System Delays

Table 5.4 provides details of the modelled system delays (refer Appendix G and the Fire Engineering Outcomes) that will be used in the modelled Fire Scenarios.

Table 5.4 – Model System Delays

Detection Device	Alarm Verification Delay (seconds)	Smoke Exhaust System Ramp (seconds)
Smoke Alarm (including MASDS)	10	N/A
Heat Detector	10	N/A
Fire Sprinkler Head	30	20

5.3 Fire Scenarios

For the purposes of assessment of the proposed Performance Solution, representative Fire Scenarios are proposed to be analysed as summarised in Table 5.5.

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Table 5.5 – Design Fire Scenarios

Fire Scenario	Description
1 (Primary Study)	**Intent:** To determine tenability based on the proposed smoke hazard management system for a fire located centrally within the main trading floor of the building in Smoke Zone 1 **Fire Location:** Centre of Tenancy(s) within existing main trading floor of building **Compartment Characteristics:** As per architectural drawings **Software:** FDS **Model Duration:** 1,800 seconds (30 minutes) **Design Fire:** Front of House Sprinkler Controlled Retail design fire (fast t^2) as detailed in Section 5.2 **Peak HRR:** 12.0MW, as calculated in Appendix E **Fire Mesh Grid Size:** Fire: 0.25m x 0.25m x 0.25m (x, y, z) as calculated in Appendix H **Fire Area:** 3.0m x 3.0m, as calculated in Appendix H **Soot Yield:** 0.08 g/g **Detection:** Smoke detection as detailed in Section 5.2.2 **Sprinklers:** High Hazard sprinklers (RTI = $50m^{1/2}s^{1/2}$) as detailed in Section 5.2.2 at 3.7m by 2.43m spacing (2.21m radial distance from fire) **Smoke Exhaust:** $49.8m^3/s$ **Other:** The make-up air is provided via louvres at low level as detailed in Section 5.2.5
2 (Sensitivity Study)	**Intent:** To determine tenability based on the proposed smoke hazard management system for a fire located in a Back of House Tenancy Storage area within the existing Trade Centre end of the building protected by a High Hazard fire sprinkler system in Smoke Zone 1 **Fire Location:** Back of House (BoH) Area within existing Trade Centre end of the building **Compartment Characteristics:** As per architectural drawings **Software:** FDS **Model Duration:** 1,800 seconds (30 minutes) **Design Fire:** BoH Sprinkler Controlled design fire (ultra-fast t^2) as detailed in Section 5.2 **Peak HRR:** 14MW, as calculated in Appendix E **Fire Mesh Grid Size:** Fire: 0.25m x 0.25m x 0.25m (x, y, z) as calculated in **Fire Area:** 3.0m x 3.0m, as calculated in **Soot Yield:** 0.08 g/g **Detection:** Smoke detection as detailed in Section 5.2.5 **Sprinklers:** High Hazard fast response fire sprinklers (RTI = $50m^{1/2}s^{1/2}$) as detailed in Section 5.2.2 at 3.70x 2.43m spacing (2.214 radial distance from fire) **Smoke Exhaust:** $49.8m^3/s$ **Other**: The make-up air is provided via louvres at low level as detailed in Section 5.2.5

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Fire Scenario	Description
3 (Primary Study)	**Intent:** To determine tenability based on the proposed smoke hazard management system for a fire located in the Front of House Retail tenancy in Smoke Zone 1 **Fire Location:** Front of House Retail Area **Compartment Characteristics:** As per architectural drawings **Software:** FDS **Model Duration:** 1,800 seconds (30 minutes) **Design Fire:** Retail FoH Sprinkler Controlled design fire (fast t^2) as detailed in Section 5.2.3.7 **Peak HRR:** 12MW, as calculated in Appendix E **Fire Mesh Grid Size: Fire:** 0.25m x 0.25m x 0.25m (x, y, z) as calculated in Appendix H **Fire Area:** 3.0m x 3.0m, as calculated in Appendix H **Soot Yield:** 0.08g/g **Detection:** Smoke detection as detailed in Section 5.2.2 **Sprinklers:** High Hazard fast response fire sprinklers (RTI = $50m^{½}s^{½}$) as detailed in Section 5.2.2 at 3.70x 2.43m spacing (2.214 radial distance from fire) **Smoke Exhaust:** $49.8m^3/s$ **Other:** The make-up air is provided via louvres at low level as detailed in Section 5.2.5
4 (Sensitivity Study)	**Intent:** To determine tenability based on the proposed smoke hazard management system for a fire located in a Back of House Tenancy Storage area within the existing Trade Centre end of the building protected by a High Hazard fire sprinkler system in Smoke Zone 1 **Fire Location:** Back of House (BoH) Area within existing Trade Centre end of the building **Compartment Characteristics:** As per architectural drawings **Software:** FDS **Model Duration:** 1,800 seconds (30 minutes) **Design Fire:** BoH Sprinkler Controlled design fire (ultra-fast t^2) as detailed in Section 5.2 **Peak HRR:** 14MW, as calculated in Appendix E **Fire Mesh Grid Size:** Fire: 0.25m x 0.25m x 0.25m (x, y, z) (as calculated in **Fire Area:** 3.0m x 3.0m, as calculated in **Soot Yield:** 0.08 g/g **Detection:** Smoke detection as detailed in Section 5.2.5 **Sprinklers:** High Hazard fast response fire sprinklers (RTI = $50m^{½s½)}$ as detailed in Section 5.2.2 at 3.70x 2.43m spacing (2.214 radial distance from fire) **Smoke Exhaust:** $49.8m^3/s$ **Other**: The make-up air is provided via louvres at low level as detailed in Section 5.2.5

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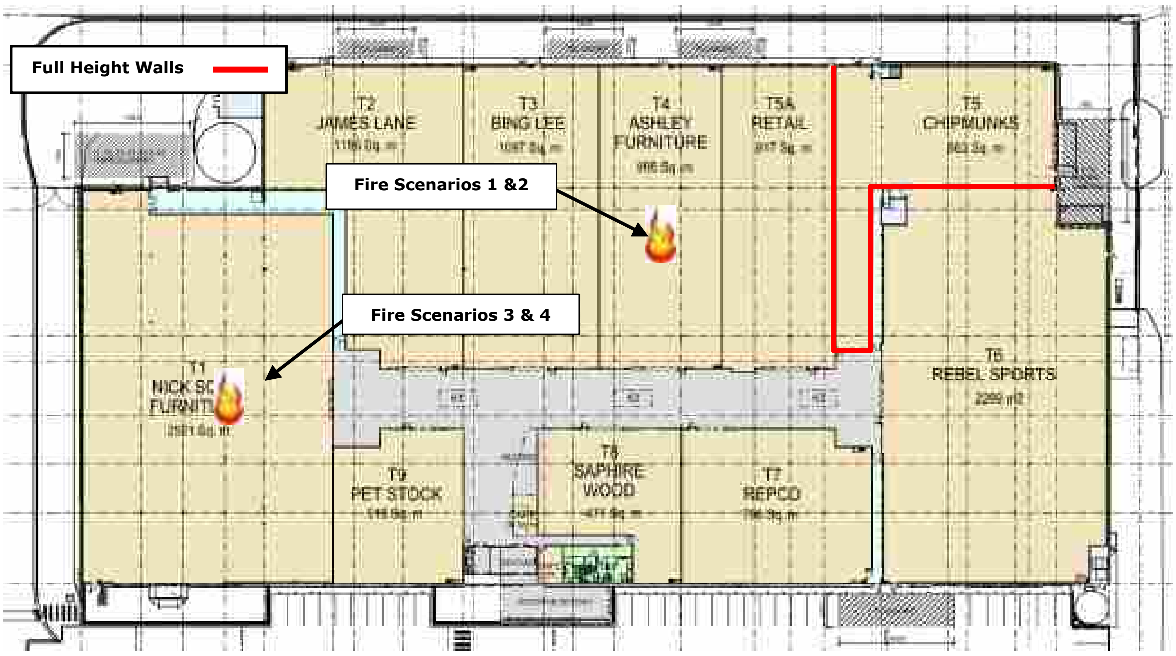

Figure 5.6 – Proposed Fire Scenario Location (Type 1 Floor Plan)

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5.3.1 Discounted Fire Scenarios

Other Fire Scenarios considered and discounted are summarised in Table 5.6.

Table 5.6 – Discounted Fire Scenarios

Fire Scenario	Description
Fire sprinkler failure	Refer to Appendix F for justification.
A fire in a fire escape corridor or stair	This is considered unlikely as all such fire escape stairs, public corridors and egress paths are to be kept clear of items that constitute a fuel load or that impede occupant egress. This is to be maintained as part of the Essential Safety Measures.
Electrical switchboard fire	Electrical switchboard compartmentation is to meet NCC DTS requirements.
Slow and Medium t^2 Fire	Given the function or use of the environment(s), a slow t^2 fire and medium t^2 fire are considered not to be the worst credible design fire for the environment(s).
Café Fire	Preliminary assessment has shown that the fire size and sprinkler activation time of High Hazard sprinkler heads (with an activation temperature of 141°C) below drop ceilings will be less than that of the ESFR/Storage sprinklers below the building ceiling level, therefore this is not considered to be the worst credible design fire for the environment.

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5.4 Egress Scenarios

As discussed in Section 4.2.2, the Required Safe Evacuation Time (RSET) is the time required for the last occupant to evacuate the occupied space to a place of safety. RSET is determined via the following equation:

$RSET = t_a + t_p + t_t$

where: t_a is the alarm time

t_p is the pre–movement time

t_t is the travel time

Alarm Time, t_a

The alarm time is the time at which occupants are made aware of a fire event. During a fire event occupants become aware of the fire incident via cues. These cues are generally visual, olfactory or by hearing an alarm.

The fire engineering assessment assumes that the alarm time will include:

- activation of the installed fire safety system, generally being a smoke detection system (i.e. point type smoke or thermal detectors or MASDS) or fire sprinkler system.
- Visual cue of the fire or hot smoke layer. Research [20] suggests that when the hot smoke layer height descends to approximately 5% of the compartment ceiling/roof height, occupants will become aware of the fire. Where the height of the space to be modelled is greater than 4m,a hot smoke layer depth of 10% of the ceiling/roof height will be assumed for occupants to become aware of the fire.

Pre–Movement Time, t_p

The occupants may not immediately associate the cue available to them with a fire–related emergency or may carry out a wide variety of delay causing actions (eg. further investigation). The time span between the recognition of cues and the initiation of the movement towards safety is referred to as the pre–movement time.

Remote from the Fire

Table 5.7, which reproduced from the SFPE Handbook of Fire Protection Engineering [18], provides pre-movement times based on the type of occupancy, the location of occupants relative to the fire and the warning system installed.

Table 5.7 – Recommended Pre-Movement Times Based on SFPE [18]

Pre-Movement Time, T_p (minutes)		
Warning system using live directives over a voice system (W1)	Warning system using non-directive voice system with trained staff (W2)	Warning system using fire alarm signal (W3)
Shops, Museums, Leisure-Sport Centres and Other Assembly Buildings (Occupants awake but may be unfamiliar with the building, the alarm system and evacuation procedure)		
< 2	3	> 6

Close Proximity to the Fire

Occupants within the compartment of fire origin, who are exposed to direct fire cues (i.e. can see/hear the fire and/or see/smell smoke), are considered to recognise the threat more readily than occupants remote from the fire who receive an indirect cue (i.e. the BOWS). Occupants who are able to recognise the threat presented by the fire are expected to have a significantly reduced pre-movement time.

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The Fire Engineering Design Guide (FEDG) [8] states that there are many documented cases in which the visual cues associated with a fire were not sufficient for people to respond, however, it does also state that in regard to pre-movement times, if people can see the fire or smoke then they are more likely to respond immediately.

The parameters that influence pre-movement time are varied, however the function and use of the building or space is considered to have a significant influence on the evacuation process, eg. occupants in a residential building may be asleep at the time of the incident, delaying evacuation, whereas occupants of a factory are expected to be able-bodied workers awake and alert at the time of the incident, which helps reduce the evacuation time.

In order to determine an appropriate pre-movement time for occupants who are in the compartment of origin and who are exposed to direct visual fire cues, literature relating to shopping centre evacuations was reviewed.

A study by Shields and Boyce [21] of unannounced trial evacuations in four (4) United Kingdom department stores involving hundreds of shoppers found that mean pre-movement times ranged from 25 seconds to 37 seconds, with a standard deviation of between 13 seconds and 19 seconds. The results of the studies are reproduced in Figure 5.7 and Figure 5.8 below.

Pre-movement times for four stores

Store	Pre-movement time (s)			Number of customers
	Mean	Standard deviation	Range	
Royal Av	37	19	3–95	122
Queen St	31	18	4–100	122
Sprucefield	25	14	1–55	95
Culverhouse	25	13	2–60	71

Figure 5.7 – Pre-movement Times from UK Department Store Unannounced Trial Evacuations

Mean pre-movement times by department

Department	Mean pre-movement time (s)			
	Royal avenue	Queen street	Sprucefield	Culverhouse
Foodhall	42.9	38.5	22.1	45.0
Lingerie	18.0	23.3	29.0	19.0
Childrenswear	22.4	—	29.5	37.0
Household	—	—	19.3	34.8
Menswear	26.6	26.3	22.3	23.6
Ladies shoes	23.0	—	36.0	—
Ladieswear	45.6	26.2	27.3	18.2
Customer services	—	23.1	—	19.0

Figure 5.8 – Pre-movement Times by Department Store and by Department

The studies were based on a W3 warning system (i.e. no voice address facility) and no direct visual cues were present (i.e. no smoke or flames). Consequently the results of the study can be considered conservative in terms of estimating pre-movement time for occupants in the compartment of origin when the smoke layer has descended below 10% of the ceiling height and the building has a W2 voice address fire alarm system.

Therefore a truncated pre-movement time of 60 seconds will be applied for occupants who are considered to be able to see the smoke or fire. Occupants are assumed to see smoke when the smoke layer descends to 10% of the ceiling height.

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Summary

Based on the aforementioned, Table 5.8 details the pre–movement times that will be used:

Table 5.8 – Pre-Movement Time

Pre-Movement Time, t_p		
Area/Level	**Occupants Remote From Fire Location**	**Occupants Can Clearly See Smoke and Flames**
Retail	180 seconds (3 minutes)	60 seconds (1 minute)

Travel Time, t_t

The time span between the initiation and completion of the movement to a place of safety is referred to as the travel time.

The travel time can be either the time required to travel from the furthest point on a floor to the exit (Movement Time, t_m), or the time required for all occupants to pass through the exits (Queuing Time, t_q), whichever is the greater. Note that movement time and queuing time are not cumulative; therefore the longer of the two (2) calculated times will be taken as the travel time.

For the purposes of calculating Queuing Time, it is assumed that a percentage of the occupants in each tenancy will egress from the tenancy via the main entry doors into the malls, and will then egress the building via exits into the malls. This percentage of occupants will vary depending on the specific scenario, refer Section 5.4.1 for further detail.

The travel time will be determined via either computer modelling or hand calculations. Where hand calculations are proposed, the following formula will be utilised in the egress calculations and are based on methods outlined in the SFPE Handbook [18].

Movement Time Calculations

$t_m = d/S$

where: d = distance (m)

S = speed of movement (m/s)

Queuing Time Calculations

$t_q = P/F_c$

where: t_q = queuing time

P = population

$F_c = F_s W_e$

where: F_c = calculated flow (persons/s)

F_s = specific flow (persons/s/m)

W_e = effective width (m)

Parameters

The following assumptions have been made for the above values:

a. Distance, d

The distance will be based on the maximum travel distance occupants are required to travel to reach an exit and will be measured from architectural drawings.

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b. Speed of Movement, S

Studies undertaken by Shields [22] indicates that the mean travel velocity of occupants without a disability was 1.24m/s. This is also supported by travel speeds detailed in the FEDG whereby travel speeds of 1.22m/s are specified for working, storage, etc., areas.

Based on the characteristics of the building and occupants an average uncongested walking velocity of **1m/s** is widely accepted for egress movement on level ground, ramps and stairs and corresponds with the design data recommendations within the Fire Engineering Design.

c. Population, P

The population will be based on the number of occupants evacuating from the area/part of the building. Population numbers will be based on Project 6 [7] Occupancy Loads, as detailed in Section 2.1. Given the building is classified as a Retail building (Class 6) and will consist of a number of individual retail tenancies with associated BoH storage, occupancy loads are unlikely to exceed the Occupancy Load distributions prescribed within the Project 6 [7] Report. Therefore the use of Project 6 [7] occupancy loads is considered appropriate.

d. Specific Flow, F_s

Table 5.9 summarises the specific flow provided in Table 3-13.5 of the SFPE Handbook [18]

Table 5.9 – Specific Flow, F_s

Exit Route Element	Persons/s/m of Effective Width
Corridor, Aisle, Ramp, Doorways	1.3
Stair – 190mm riser / 254mm tread	0.94
Stair – 178mm riser / 279mm tread	1.01
Stair – 165mm riser / 305mm tread	1.09
Stair – 165mm riser / 330mm tread	1.16

For the purposes of the egress modelling the following parameters will be used:

- Flow through doorways and corridors – 1.3 persons/m/s
- Flow through stairs – 0.9 persons/m/s

e. Effective Width, W_e

The effective width will be based on the number of exits available from the area/part of the building being evacuated. The effective width is the clear width of each exit less the boundary layer. When the exit under consideration is a doorway, the effective width of the doorway will be the clear width less 300mm.

The effective width will be calculated based on Project 6 [7] Occupancy Loads as stated in Table 2.4.

5.4.1 Summary of Egress Scenarios

For the purposes of assessment of the proposed Performance Solution representative Egress Scenarios are proposed to be analysed, as summarised in Table 5.11.

Occupant Egress Distributions

The distribution of occupants that egress via the mall will be modelled as 50% of occupants within each tenancy that has another egress point, regardless whether the occupant distributions have been calculated using Project 6 Occupant Loads or NCC DTS Table D1.13 Occupant Loads. This is based on a number of considerations as follows, refer Table 5.10.

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Project 6 occupant loads for retail and mall areas are half of that required by NCC DTS Table 1.13 occupant loads (m^2 per person). Thus any variation to occupant egress distributions using Project 6 occupant loads, will always result in less than or the same number of people using the mall exits as the Table D1.13 occupant loads. Therefore a Sensitivity Study egress scenario utilising Project 6 occupant loads, which varies the distribution of occupants egressing via the mall is not a worst credible scenario and need not be considered.

Furthermore the use of NCC DTS Table D1.13 occupant loads is considered a sensitivity study egress scenario. Sensitivity Studies are designed to assess the impact of varying Primary Study parameters within the model. These studies are considered less likely to occur than Primary Studies. It is even less feasible for the variation of only Sensitivity Study parameters to be carried out as a Sensitivity Study, i.e. it is less feasible that varied occupant distribution with Table D1.13 occupant loads will occur as a scenario. Therefore this scenario need not be considered.

Finally it is likely that queuing will occur in the mall egress points as the proposed aggregate egress width from the mall area is typically between 2m-3m in width. It is anticipated that occupants will observe the queuing and look for an alternative exit, i.e. a secondary exit within the tenancy from which they came. Thus an occupant distribution of 50% egressing via the mall is considered acceptable to account for occupants that will return to tenancies and egress via the back of tenancy exit.

Table 5.10 – Summary of Egress Scenario Occupant Distributions

Egress Scenario Type	Occupant Density	Mall Exit	Tenancy Exit
Primary Study	Project 6	50%	50%
Sensitivity Study	NCC DTS Table D1.13	50%	50%

Mall Egress Occupant Distribution: Use of Service Corridors/Passageways

Two (2) Service corridors/Passageways are proposed from the mall area in conjunction with the main entry doors. This is to improve the egress provisions and account for after-hours egress. A proportion of occupants egressing the building via the Mall area will use these Service Corridors/Passageways as a means of egress.

The distribution of these occupants is calculated using the ratio of egress width provided. The main entry doors are proposed to be provided with approximately 4.8m of egress width, whilst approximately 1.5m is provided within the one (1) Service Corridor/Passageway and 1.3m is provided within the other Service Corridor/Passageway. As a result 66% of occupants that egress via the mall are calculated to use the main entry doors for egress, 19% of occupants egress via one (1) Service Corridor/Passageway and 16% egress via the other Service Corridor/Passageway. For fire scenarios whereby the main entrance doors are unusable, it is assumed that 100% of occupants egressing via the mall use the Service corridors/Passageways.

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Table 5.11 – Summary of Egress Scenarios

Egress Scenario	Description
A (Primary Study)	**Intent:** To determine Required Safe Egress Time (RSET) time from the building based on increased travel distance to an exit, increased distance between alternative exits, reduced aggregate egress capacity, using <u>Project 6 occupancy loads</u> **Modelling Tool:** Hand Calculation as detailed in Section 4.2.2 (assume 50% of tenancy occupants will exit via the mall) **Alarm Time:** As determined from Fire Scenario 1 **Pre-movement Time:** 180s (all occupants assumed to be remote from the fire) **Distance:** 170m (70m +100m) **Speed of Movement:** 1m/s **Population:** As detailed in Section 2 **Specific Flow:** 1.3 persons/m/s **Effective Width:** As per architectural drawings
B (Sensitivity Study)	**Intent:** To determine Required Safe Egress Time (RSET) from the building based on increase travel distance to an exit, increased distance between exits, reduced aggregate egress capacity, using <u>NCC DTS Clause D1.13 occupancy loads</u> **Modelling Tool:** Hand Calculation as detailed in Section 4.2.2 (assume 50% of tenancy occupants will exit via the mall) **Alarm Time:** As determined from Fire Scenario 1 **Pre-movement Time:** 180s **Distance:** 170m (70m +100m) **Speed of Movement:** 1m/s **Population:** As detailed in Section 2 **Specific Flow:** 1.3 persons/m/s **Effective Width:** As per architectural drawings
C (Sensitivity Study)	**Intent:** To determine Required Safe Egress Time (RSET) from the building based on increase in exit travel distance, increased distance between exits, reduced unobstructed aggregate egress width, using <u>Project 6 occupancy loads where the main entrance doors become unusable</u> **Modelling Tool:** Hand Calculation as detailed in Section 4.2.2 (assume 50% of tenancy occupants will exit via the service corridors within the mall) **Alarm Time:** As determined from Fire Scenario 1 **Pre-movement Time:** 180s (all occupants assumed to be remote from the fire) **Distance:** 170m (70m +100m) **Speed of Movement:** 1m/s **Population:** As detailed in Section 2 **Specific Flow:** 1.3 persons/m/s **Effective Width:** As per architectural drawings

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Egress Scenario	Description
D (Primary Study)	**Intent:** To determine Required Safe Egress Time (RSET) time from the building based on increased travel distance to an exit, increased distance between alternative exits, reduced aggregate egress capacity, using Project 6 occupancy loads **Modelling Tool:** Hand Calculation as detailed in Section 4.2.2 (assume 50% of tenancy occupants will exit via the mall) **Alarm Time:** As determined from Fire Scenario 2 **Pre-movement Time:** 180s (all occupants assumed to be remote from the fire) **Distance:** 170m (70m +100m) **Speed of Movement:** 1m/s **Population:** As detailed in Section 2 **Specific Flow:** 1.3 persons/m/s **Effective Width:** As per architectural drawings
E (Primary Study)	**Intent:** To determine Required Safe Egress Time (RSET) time from the building based on increased travel distance to an exit, increased distance between alternative exits, reduced aggregate egress capacity, using Project 6 occupancy loads **Modelling Tool:** Hand Calculation as detailed in Section 4.2.2 (assume 50% of tenancy occupants will exit via the mall) **Alarm Time:** As determined from Fire Scenario 3 **Pre-movement Time:** 180s (all occupants assumed to be remote from the fire) **Distance:** 170m (70m +100m) **Speed of Movement:** 1m/s **Population:** As detailed in Section 2 **Specific Flow:** 1.3 persons/m/s **Effective Width:** As per architectural drawings
F (Primary Study)	**Intent:** To determine Required Safe Egress Time (RSET) time from the building based on increased travel distance to an exit, increased distance between alternative exits, reduced aggregate egress capacity and on Project 6 occupancy loads **Modelling Tool:** Hand Calculation as detailed in Section 4.2.2 (assume 50% of tenancy occupants will exit via the mall) **Alarm Time:** As determined from Fire Scenario 4 **Pre-movement Time:** 180s (all occupants assumed to be remote from the fire) **Distance:** 170m (70m +100m) **Speed of Movement:** 1m/s **Population:** As detailed in Section 2 **Specific Flow:** 1.3 persons/m/s **Effective Width:** As per architectural drawings

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5.5 Summary of Fire and Egress Scenarios

Table 5.12 summarises the Fire Scenarios and Egress Scenarios utilised in the assessment, along with the relevant Acceptance Criterion for each scenario.

Table 5.12 - Summary of Fire and Egress Scenarios

Scenario	Fire Scenario	Egress Scenario	Acceptance Criteria
1A	1	A	ASET/RSET ≥ 1.5
1B	1	B*	ASET/RSET ≥ 1.0
1C	1	C*	ASET/RSET ≥ 1.0
2D	2*	D	ASET/RSET ≥ 1.0
3E	3	E	ASET/RSET ≥ 1.5
4F	4*	F	ASET/RSET ≥ 1.0
* Sensitivity Study component			

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6. Fire and Egress Modelling

6.1 General

The fire and egress modelling undertaken within this document specifically addresses the effects of fire and smoke within the various areas detailed in Section 5.3. With regards to the relevant NCC Performance Requirements, these scenarios will be used to assess the impact of the proposed Performance Solutions on:

- the life safety of the occupants during an evacuation; and
- the ability of the Fire Brigade to intervene.

6.2 Fire Modelling

6.2.1 Fire Scenario 1: Main Trading Floor Central Tenancy Fire (Smoke Zone 1) – Primary Study

6.2.1.1 Modelling Configuration

Fire Scenario 1 represents the Performance Building Solution associated with the Main Trading Floor of Smoke Zone 1 when the installed fire safety systems are considered to operate. The intent of this modelled fire scenario is to assess the level of safety provided to occupants during an evacuation.

The key model inputs for Fire Scenario 1 are summarised as follows:

a. The Fire Scenario has been modelled using FDS, refer Appendix H for details.

b. The model comprises a single (1) compartment, as shown in Figure 6.1, with the floor area and volume of the compartment reflecting the dimensions of the representative model which consists of the worst-case dimensions (smallest total floor area and smallest roof height). The model encompasses the whole building.

c. Simulation time of 1,800 seconds (30 minutes).

d. The following computational mesh dimensions were specified (x,y,z), as calculated in Appendix H:

    i. Fire Mesh: 0.25m × 0.25m × 0.25m – Incorporates the fire burner

    ii. Near Field Mesh: 0.5m × 0.5m × 0.5m – Meshes adjacent to fire mesh

    iii. Far Field Mesh: 0.5m × 0.5m × 0.5m – Meshes not adjacent to fire mesh

e. The fire has been modelled as a burner, with the following specifications:

    i. Located 1.0m Above Finished Floor Level (AFFL) within the central tenancy, as shown Figure 6.1.

    ii. Dimensions of 3.0m x 3.0m.

    iii. Growth rate as detailed in Section 5.2 and peak Heat Release Rate (HRR) as calculated in Appendix E.

f. Mechanical exhaust has been modelled as a surface, with the following specifications:

    i. Within Smoke Zone 1, there are seven (7) fans, six (6) each with an exhaust rate of $5.8m^3/s$ and a single fan with an exhaust rate of $15m^3/s$. Each fan is located 0.5m below roof level , as shown in Figure 6.1.

g. Makeup air for the mechanical exhaust has been modelled evenly distributed across two (2) sides of the compartment.

h. Smoke detectors located above the fire (first row, 100mm below ceiling level), as shown in Figure 6.1. The parameters and spacing for the detector have been modelled as detailed in Section 5.2.2.

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i. Fire sprinkler heads located above the fire (first row, 100mm below ceiling level), as shown in Figure 6.1. The parameters and spacing for the detector have been modelled as detailed in Section 5.2.2.

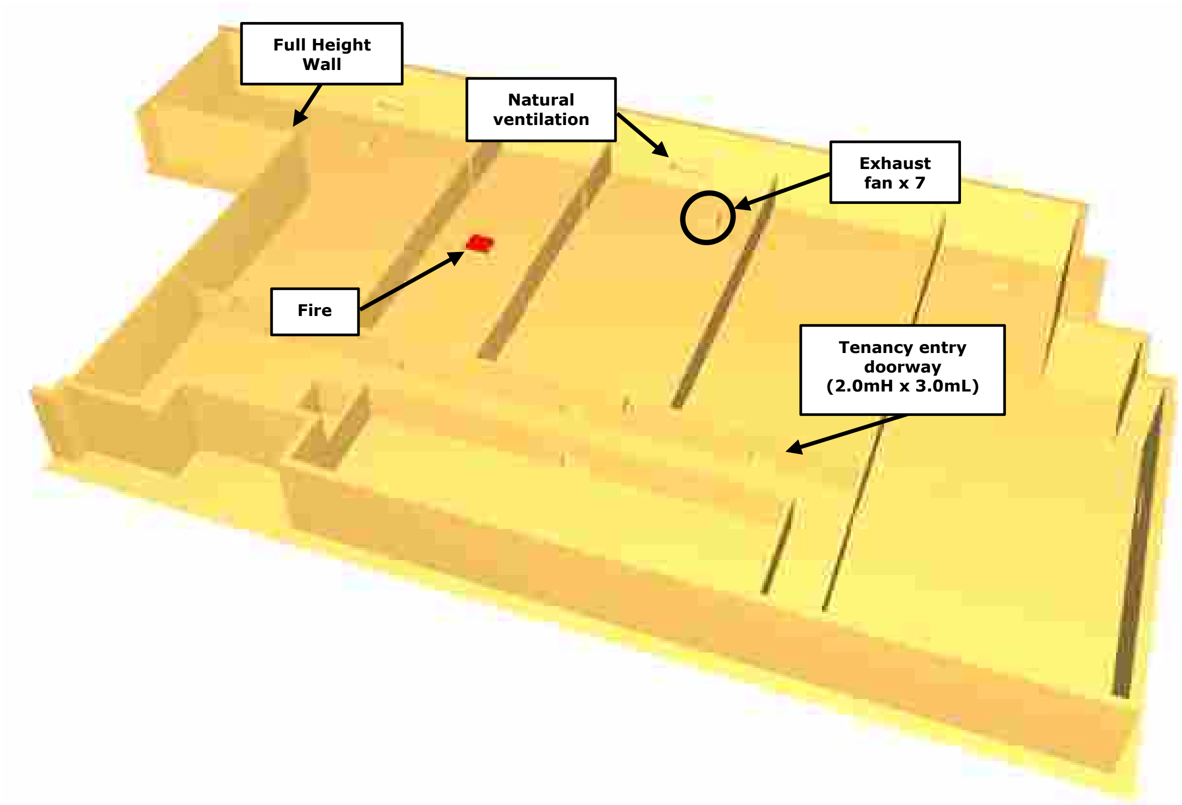

Figure 6.1 - SmokeView Model Output

6.2.1.2 Device Activation

Smoke Detectors

Smoke detectors have been modelled within FDS as previously discussed. Table 6.1 summarises the calculated activation times for the modelled devices.

Table 6.1 – Device Activation Times

Device Number	Activation Time (seconds)	
	Smoke Detector	Fire Sprinkler
1	85	316
2	89	383
3	75	407
4	72	391

The smoke detectors modelled within FDS are used to determine the time at which the occupant warning system initiates and fire brigade notification occurs.

Summary

Table 6.2 summarises the first-activated device associated with each event and the corresponding calculated activation time.

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Table 6.2 – Event Times

Event	Device	Time (Seconds)
Occupant Warning System Initiates	Smoke Detector	82 (includes 10 second delay)
Fire Brigade Notification	Smoke Detector	82 (includes 10 second delay)
Smoke Exhaust Actuates	Smoke Detector	82 (includes 10 second delay)
Peak Heat Release Rate Reached	Fire Sprinkler	346 (includes 30 second delay)

6.2.1.3 Heat Release Rate

As previously discussed in Section 5, the actual heat release rate for the Fire Scenario has been modelled as shown in Figure 6.2, based on calculated fire sprinkler activation times and delays.

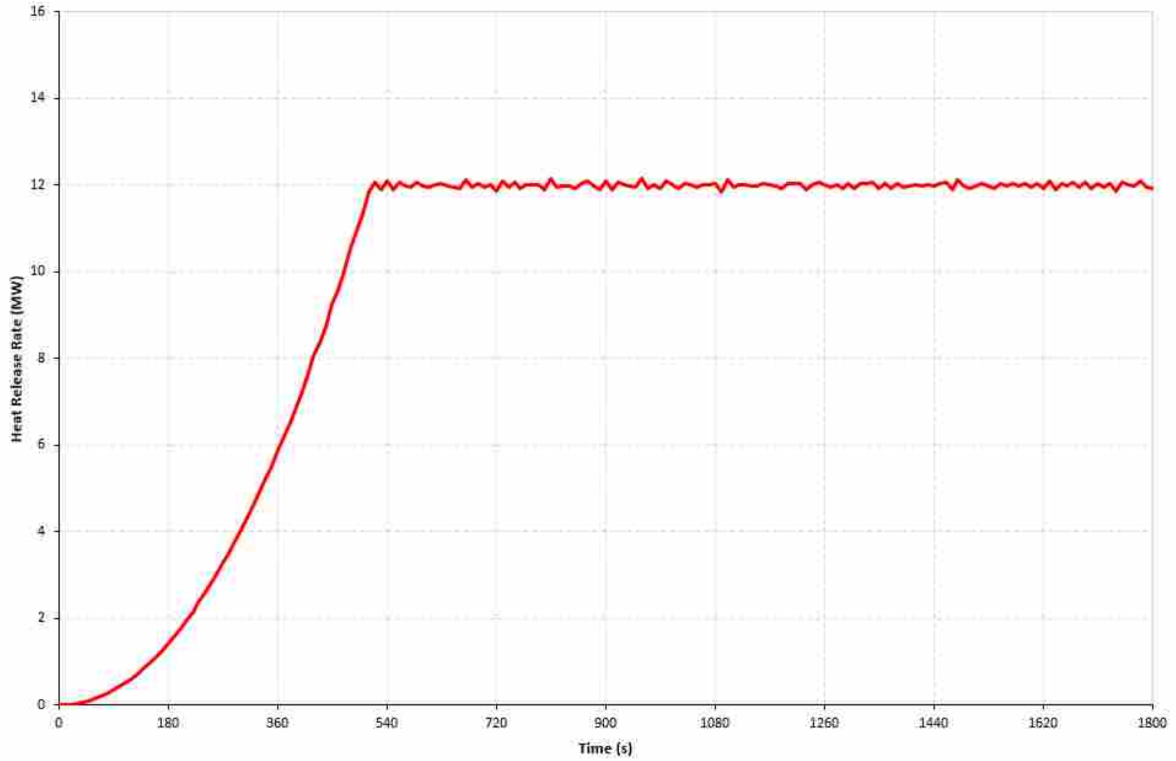

Figure 6.2 – Heat Release Rate

6.2.1.4 Fire and Smoke Conditions

As per the Occupant Life Safety Assessment Methodology detailed in Section 4.2, tenable conditions are determined by satisfying the parameters of the criteria relating to the temperatures and level of visibility at a height above and below 2.0m Above Finished Floor Level (AFFL).

Temperature Conditions

The Occupant Life Safety Assessment Methodology requires that the temperature of the upper layer does not exceed 180°C and the temperature of the air where the occupants are directly exposed (i.e. 2.0m AFFL) does not exceed 60°C.

Using the key model inputs, the temperatures throughout the modelled space are calculated for the modelled duration using FDS. These temperatures are output in specific 'slices' corresponding to:

- the area where the maximum upper layer temperature is to occur (i.e. ceiling jet); and
- the temperatures achieved at 2.0m AFFL.

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Figure 6.3 and Figure 6.4 show these temperature 'slices' at the end of modelled duration, and it is evident that:

- temperatures only exceed 180°C in the area immediately around the fire plume; and
- the temperatures directly experienced by the occupants (i.e. at 2.0m AFFL) only exceed 60°C in the area immediately around the fire plume.

During the early stages of a fire, as occupants would have direct cues to the fire, it is expected that they would inherently move away from the fire affected area to avoid the threat (i.e. natural instinct). Therefore, based on the temperature criteria, it is considered that untenable conditions do not occur within the modelled duration.

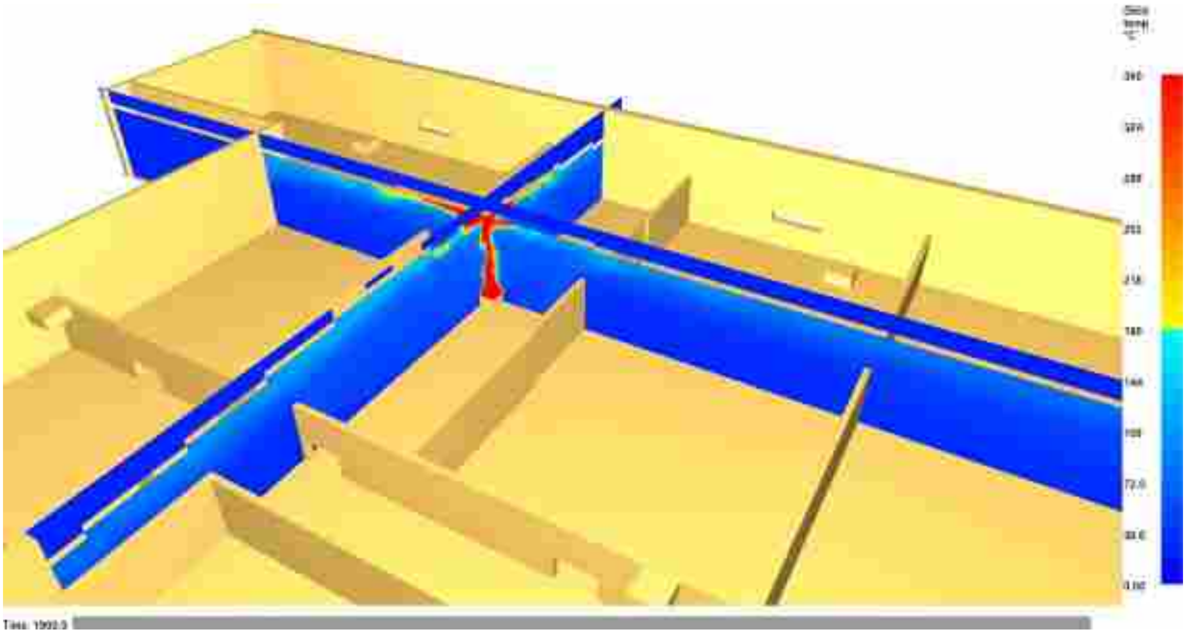

Figure 6.3 – Ceiling Jet Temperature at End of Model Duration

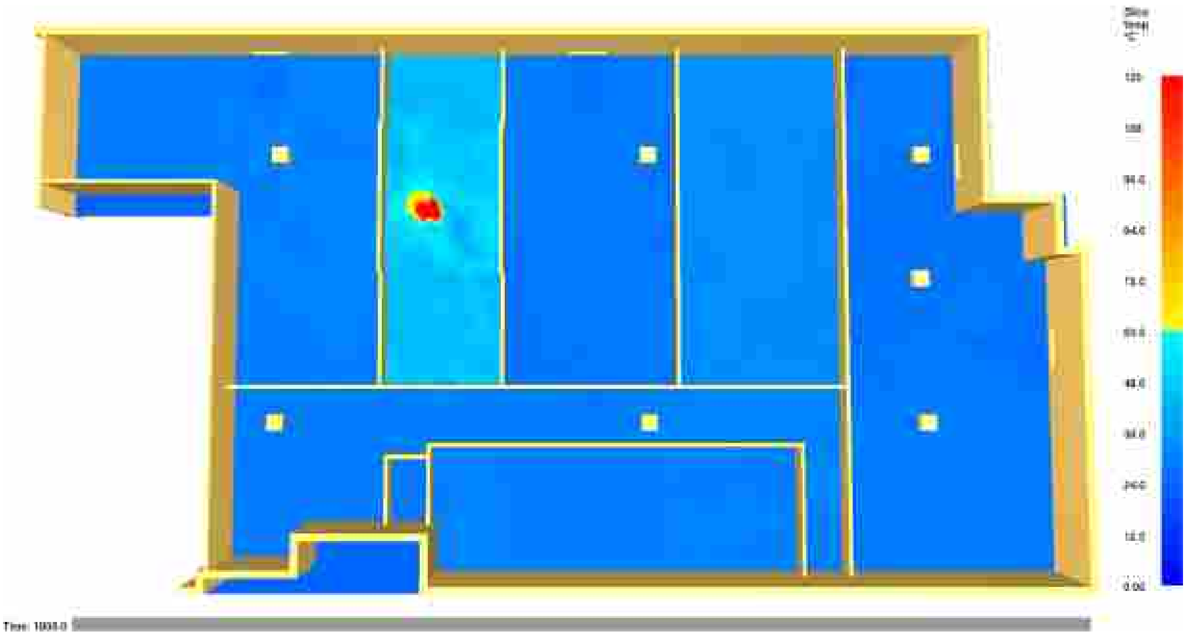

Figure 6.4 – Temperature at 2.0m at End of Model Duration

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<u>Visibility</u>

The Occupant Life Safety Assessment Methodology requires that the visibility be assessed below 2.0m AFFL (i.e., where occupants may be present) and that it be maintained above 10m.

From Figure 6.5, it is evident that the Mall, most tenancy exits and the Main Entrance are available at 740 seconds. However, from Figure 6.6, it is evident that at 840 seconds, conditions within part of the Mall have become untenable.

Given the aforementioned, it is considered that Smoke Zone 1 becomes untenable at 740 seconds.

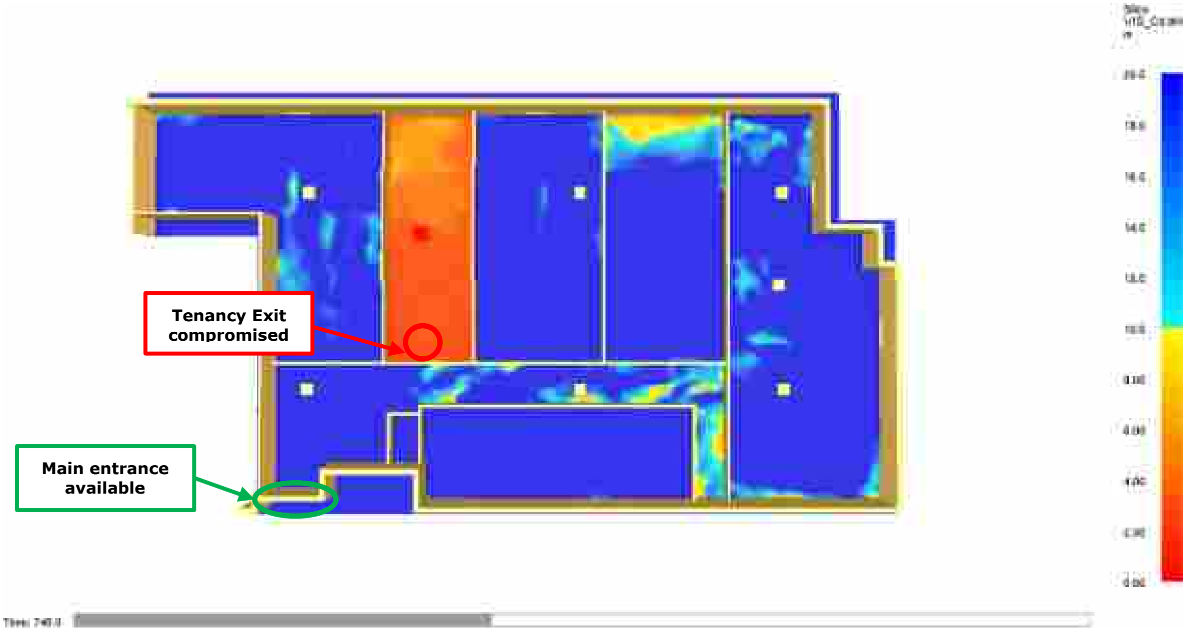

Figure 6.5 – Visibility at 740 seconds

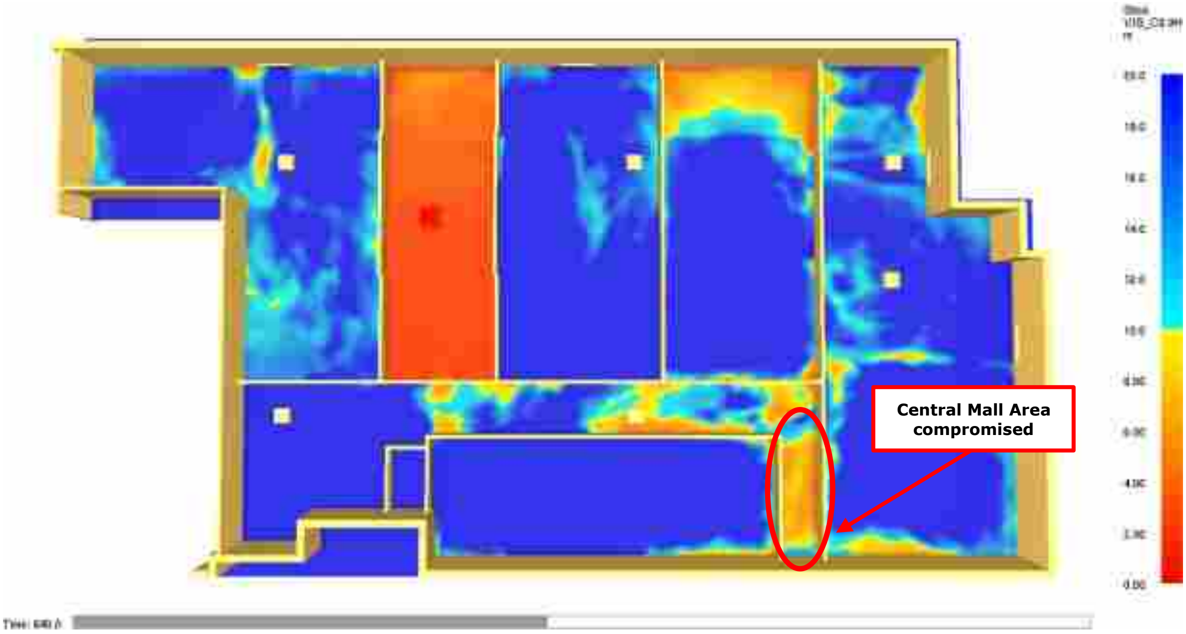

Figure 6.6 - Visibility at 840 seconds

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Fire Brigade Intervention

The Fire Brigade Intervention acceptance criteria, as detailed in Section 4.3, requires that the upper temperature does not exceed 200°C. Based on the modelled Fire Scenario, it is evident from Figure 6.3, that the temperature is greater than 200°C, only the area immediately around the fire plume. It is therefore considered that Fire Brigade intervention limits based on Condition 1 are not exceeded within Smoke Zone 1.

Additionally, as detailed in Section 4.3, the Fire Brigade Intervention acceptance criteria requires that the temperature which Fire Fighters could be directly exposed to (i.e. at 1.5m above the floor level) does not exceed 120°C. Figure 6.7 indicates the temperature profile at a height of 1.5m above the Finished Floor Level (FFL). It is evident that only the area around the fire plume is expected to exceed temperatures of 120°C (as indicated by the red colour), therefore, Fire Brigade intervention limits based on temperatures exceeding 120°C at 1.5m are not considered to be exceeded.

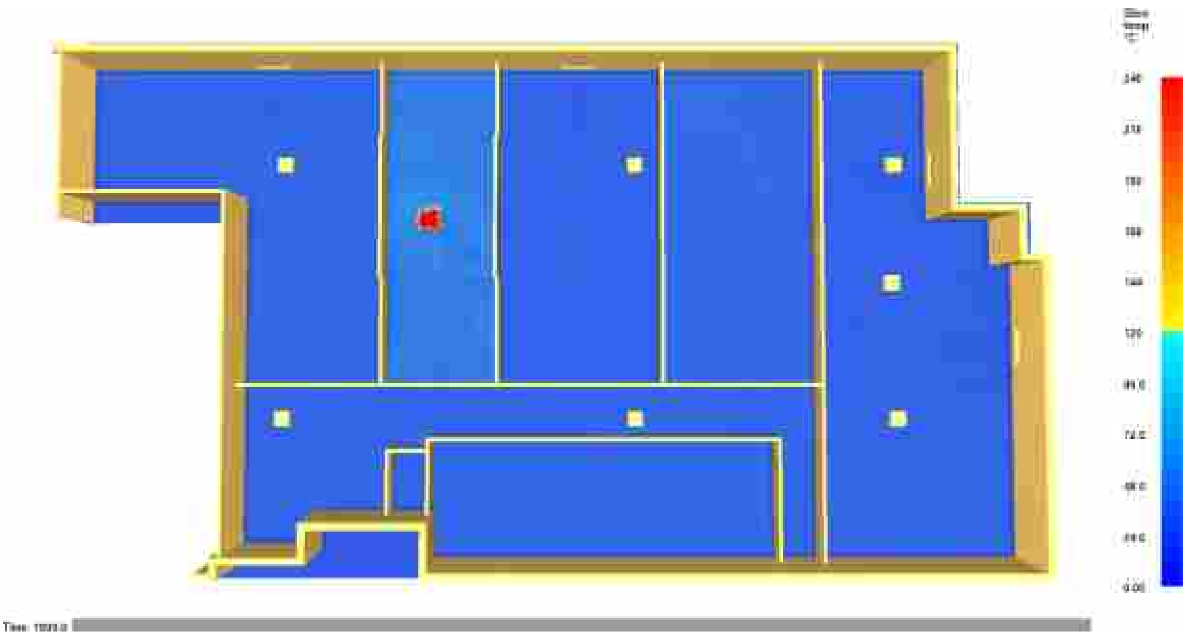

Figure 6.7 – Temperature at 1.5m at End of Model Duration (1,800s)

6.2.1.5 Summary

Based on the Fire Scenario modelled, untenable conditions are calculated not to occur before 740 seconds based on the visibility criterion Therefore, the Available Safe Egress Time (ASET) is calculated to be 740 seconds.

Note that Fire Brigade Intervention limits are not exceeded for the modelled duration.

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6.2.2 Fire Scenario 2: Main Trading Floor Back of House Fire (Smoke Zone 1) – Sensitivity Study

6.2.2.1 Modelling Configuration

Fire Scenario 2 represents the Performance Building Solution associated with Smoke Zone 1 when the installed fire safety systems are considered to operate. The intent of this modelled fire scenario is to assess the level of safety provided to occupants during an evacuation.

The key model inputs for Fire Scenario 2 are identical to Fire Scenario 1 with the following exceptions:

a. The Fire Scenario has been modelled using FDS, refer Appendix H for details.

b. The fire has been modelled as a burner, with the following specifications:

   i. Growth rate as detailed in Section 5 and peak Heat Release Rate (HRR) as calculated in Appendix E.

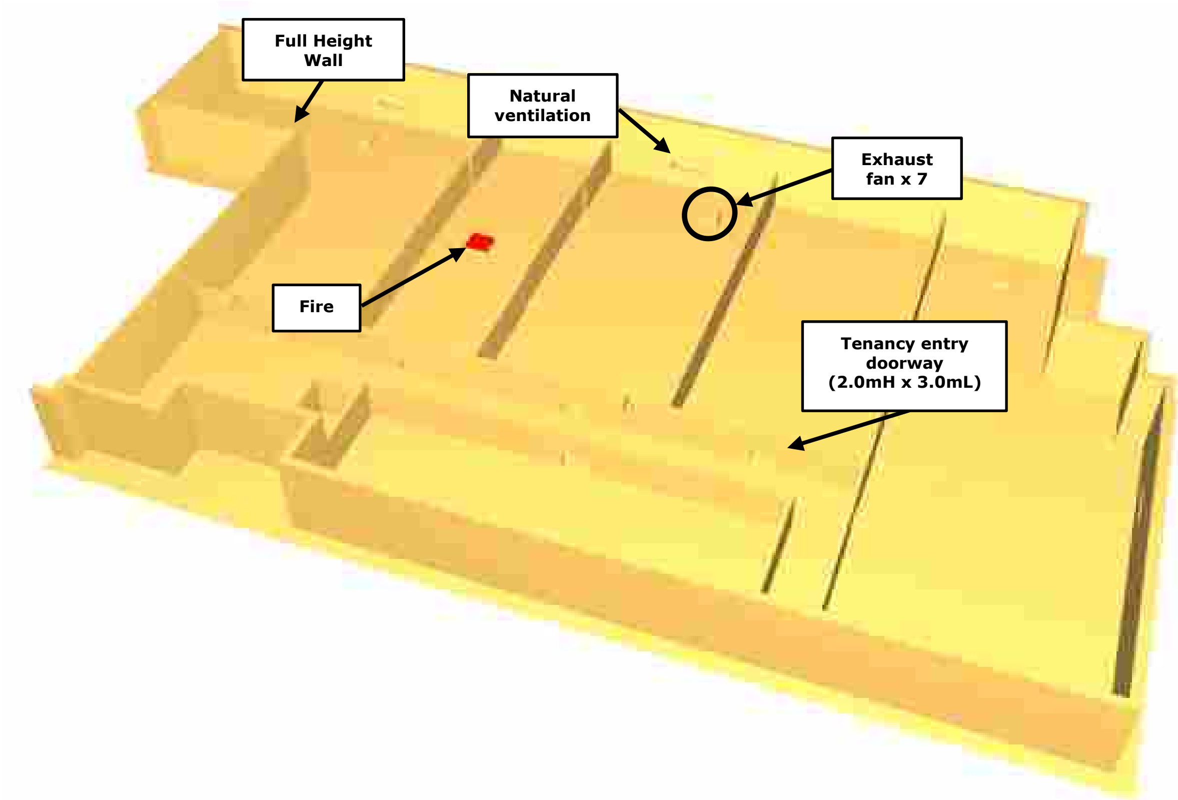

Figure 6.8 - SmokeView Model Output

6.2.2.2 Device Activation

Smoke Detectors

Smoke detectors have been modelled within FDS as previously discussed. Table 6.3 summarises the calculated activation times for the modelled devices.

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Table 6.3 – Device Activation Times

Device Number	Activation Time (seconds)	
	Smoke Detector	Fire Sprinkler
1	63	184
2	70	200
3	55	248
4	58	212

The smoke detectors modelled within FDS are used to determine the time at which the occupant warning system initiates and fire brigade notification occurs.

Summary

Table 6.4 summarises the first-activated device associated with each event and the corresponding calculated activation time.

Table 6.4 – Event Times

Event	Device	Time (Seconds)
Occupant Warning System Initiates	Smoke Detector	65 (includes 10 second delay)
Fire Brigade Notification	Smoke Detector	65 (includes 10 second delay)
Smoke Exhaust Actuates	Smoke Detector	65 (includes 10 second delay)
Peak Heat Release Rate Reached	Fire Sprinkler	214 (includes 30 second delay)

6.2.2.3 Heat Release Rate

As previously discussed in Section 5, the actual heat release rate for the Fire Scenario has been modelled as shown in **Error! Reference source not found.**, based on calculated fire sprinkler activation times and delays.

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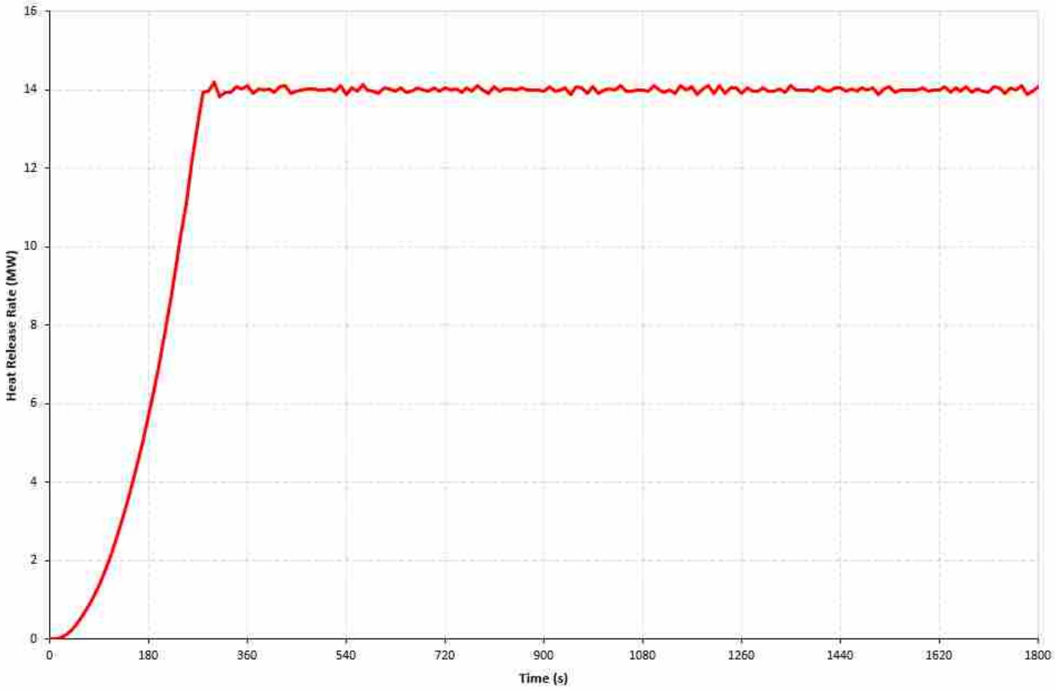

Figure 6.9 - Heat Release Rate

6.2.2.4 Fire and Smoke Conditions

As per the Occupant Life Safety Assessment Methodology detailed in Section 4.2, tenable conditions are determined by satisfying the parameters of the criteria relating to the temperatures and level of visibility at a height above and below 2.0m Above Finished Floor Level (AFFL).

<u>Temperature Conditions</u>

The Occupant Life Safety Assessment Methodology requires that the temperature of the upper layer does not exceed 180°C and the temperature of the air where the occupants are directly exposed (i.e. 2.0m AFFL) does not exceed 60°C.

Using the key model inputs, the temperatures throughout the modelled space are calculated for the modelled duration using FDS. These temperatures are output in specific 'slices' corresponding to:

- the area where the maximum upper layer temperature is to occur (i.e. ceiling jet); and
- the temperatures achieved at 2.0m AFFL.

Figure 6.10 and Figure 6.11 show these temperature 'slices' at the end of the modelled duration, and it is evident that:

- temperatures only exceed 180°C in the area immediately around the fire plume and dissipate quickly within the ceiling jet; and
- the temperatures directly experienced by the occupants (i.e. at 2.0m AFFL) only exceed 60°C in the area immediately around the fire plume.

During the early stages of a fire, as occupants would have direct cues to the fire, it is expected that they would inherently move away from the fire affected area to avoid the threat (i.e. natural instinct). Therefore, based on the temperature criteria, it is considered that untenable conditions do not occur within the modelled duration.

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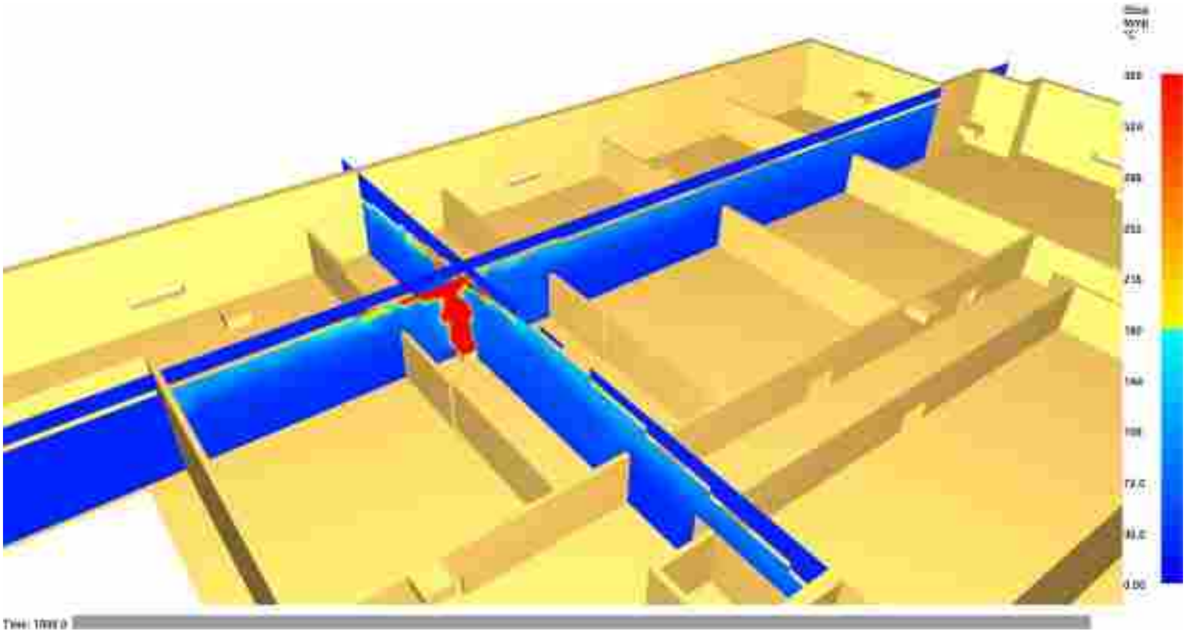

Figure 6.10 – Ceiling Jet Temperature at 1,800 seconds

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Version: 1, Version Date: 22/06/2020

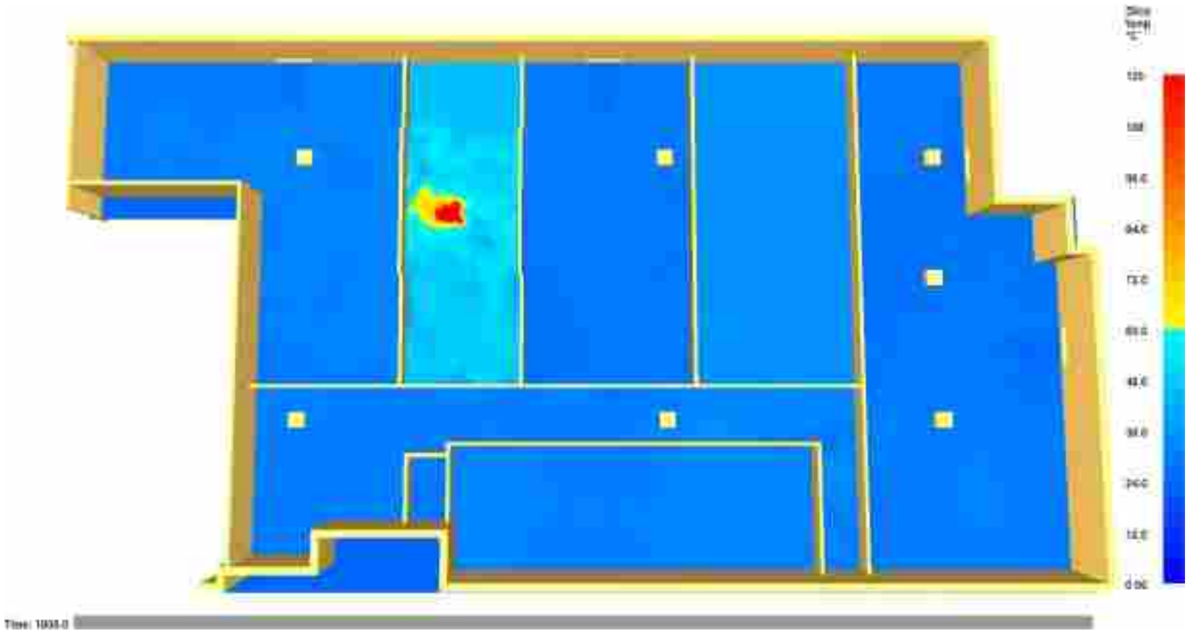

Figure 6.11 – Temperature at 2.0m at 1,800 seconds

Visibility

The Occupant Life Safety Assessment Methodology requires that the visibility be assessed below 2.0m AFFL (i.e., where occupants may be present) and that it be maintained above 10m.

From Figure 6.12, it is evident that all external exits and most tenancy exits are available at 540 seconds. However, from Figure 6.13, it is evident that at 640 seconds, an exit and the central mall area have become blocked.

Given the aforementioned, it is considered that Smoke Zone 1 becomes untenable at 540 seconds.

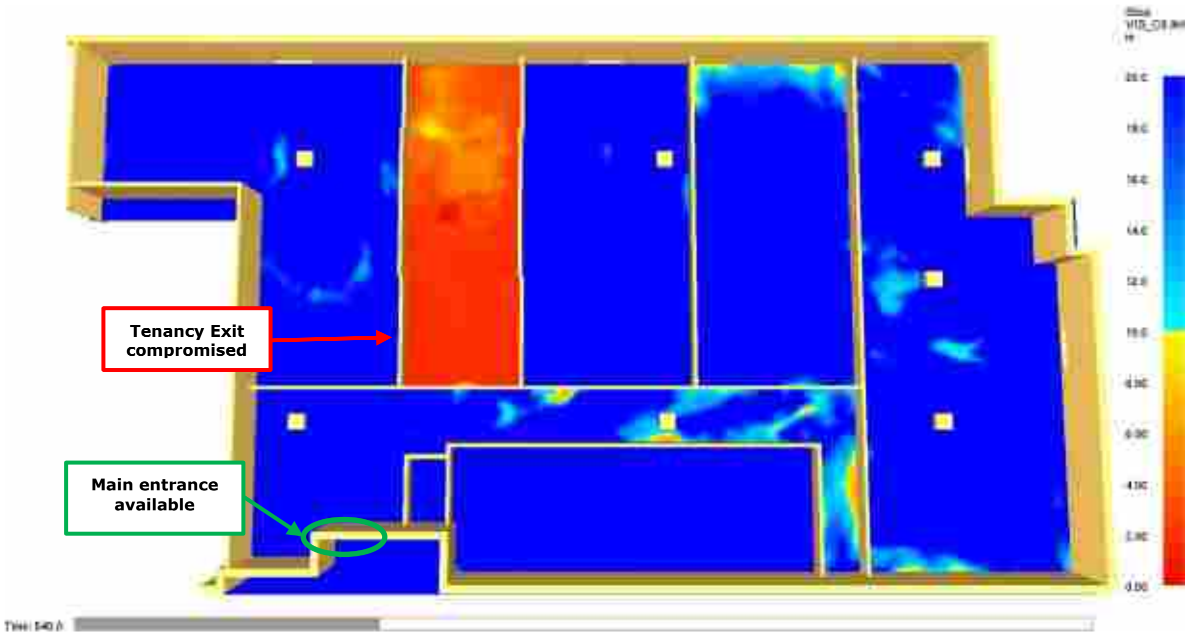

Figure 6.12 – Visibility at 540 seconds

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

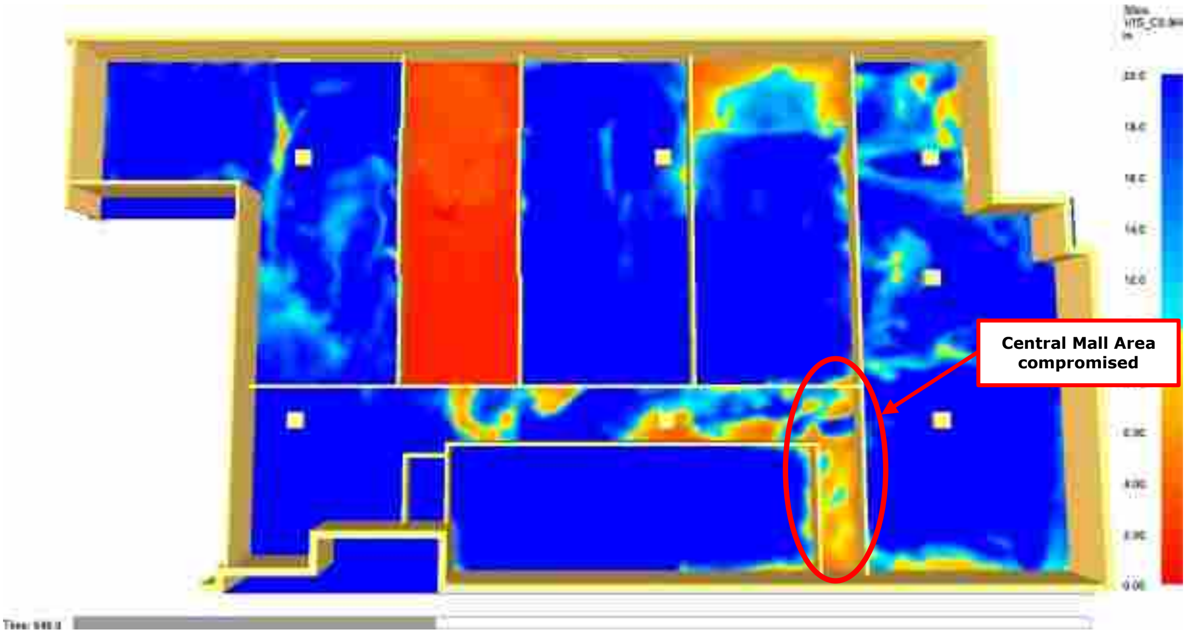

Figure 6.13 - Visibility at 640 seconds

6.2.2.5 Summary

Based on the Fire Scenario modelled, untenable conditions are calculated not to occur before 540 seconds based on the visibility criterion. Therefore, the Available Safe Egress Time (ASET) is calculated to be 540 seconds.

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6.2.3 Fire Scenario 3: Main Trading Floor Retail Tenancy (Smoke Zone 1) –Primary Study

6.2.3.1 Modelling Configuration

Fire Scenario 3 represents the Performance Building Solution associated with the Main Trading Floor of Smoke Zone 1 when the installed fire safety systems are considered to operate. The intent of this modelled fire scenario is to assess the level of safety provided to occupants during an evacuation.

The key model inputs for Fire Scenario 3 are summarised as follows:

a. The Fire Scenario has been modelled using FDS, refer Section 5 for details.

b. The model comprises a single (1) compartment, as shown in Figure 6.14.

c. Simulation time of 1,800 seconds (30 minutes).

d. The following computational mesh dimensions were specified (x,y,z), as calculated in Appendix H:

   i. Fire Mesh: 0.25m × 0.25m × 0.25m – Incorporates the fire burner

   ii. Near Field Mesh: 0.5m × 0.5m × 0.5m – Meshes adjacent to fire mesh

   iii. Far Field Mesh: 0.5m × 0.5m × 0.5m – Meshes not adjacent to fire mesh

e. The fire has been modelled as a burner, with the following specifications:

   i. Located 1.0m Above Finished Floor Level (AFFL) within the existing Trade Centre end of the building, as shown Figure 6.14.

   ii. Dimensions of 3.0m x 3.0m.

   iii. Growth rate as detailed in Section 5.2.3.3 and peak Heat Release Rate (HRR) as calculated in Appendix E.

f. Mechanical exhaust has been modelled as a surface, with the following specifications:

   i. Within Smoke Zone 1, there are seven (7) fans, six (6) each with an exhaust rate of $5.8m^3/s$ and a single fan with an exhaust rate of $15m^3/s$. Each fan is located 0.5m below roof level, as shown in Figure 6.14.

g. Makeup air for the mechanical exhaust has been modelled evenly distributed across two (2) sides of Smoke Zone 1.

h. Smoke detectors located above the fire (first row, 100mm below ceiling level), as shown in Figure 6.14. The parameters and spacing for the detector have been modelled as detailed in Section5.2.2.

i. Fire sprinkler heads located above the fire (first row, 100mm below ceiling level), as shown in Figure 6.14. The parameters and spacing for the detector have been modelled as detailed in Section5.2.2.

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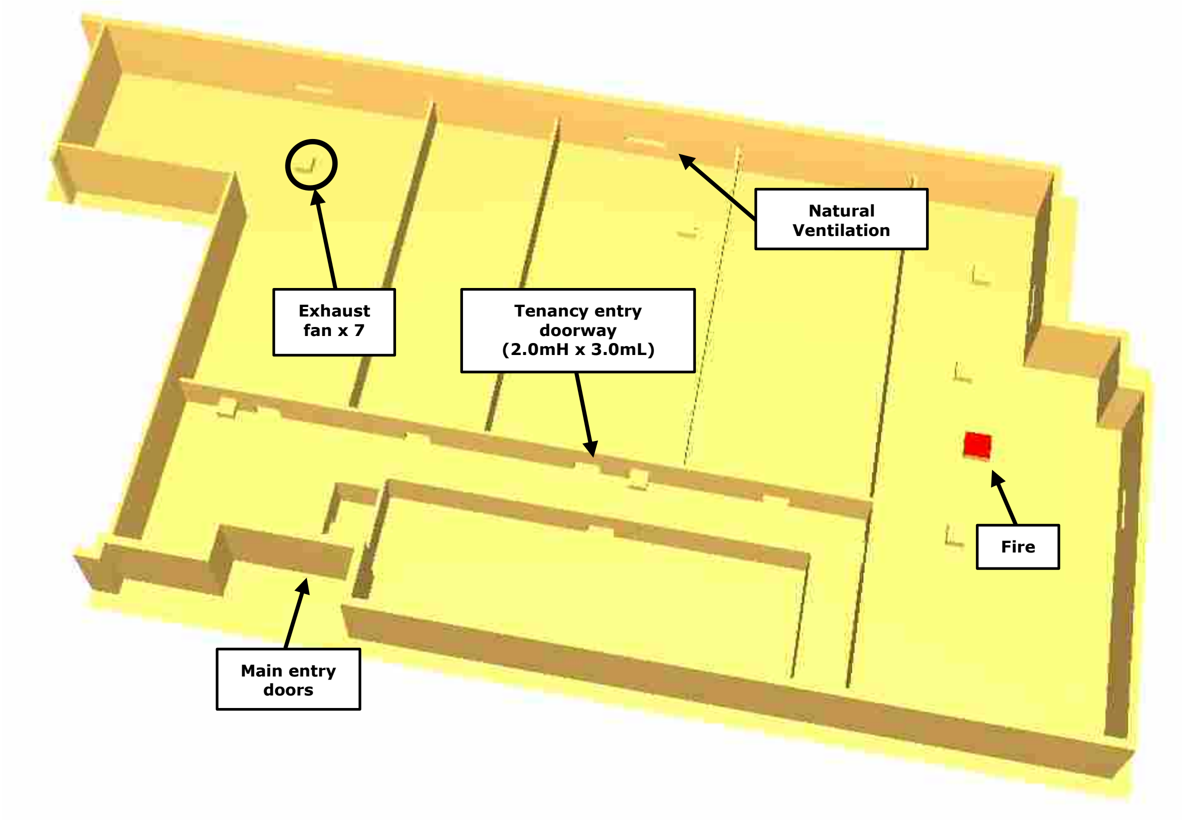

Figure 6.14 – SmokeView Model Output

6.2.3.2 Device Activation

Smoke Detectors

Fire sprinklers and smoke detectors have been modelled within FDS as previously discussed. Table 6.5 summarises the calculated activation times for the modelled devices.

Table 6.5 – Device Activation Times

Device Number	Activation Time (seconds)	
	Smoke Detector	Fire Sprinkler
1	108	407
2	100	415
3	74	390
4	77	410

The smoke detectors modelled within FDS are used to determine the time at which the occupant warning system initiates and fire brigade notification occurs.

Summary

Table 6.6 summarises the first-activated device associated with each event and the corresponding calculated activation time.

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Table 6.6 – Event Times

Event	Device	Time (Seconds)
Occupant Warning System Initiates	Smoke Detector	84 (includes 10 second delay)
Fire Brigade Notification	Smoke Detector	84 (includes 10 second delay)
Smoke Exhaust Actuates	Smoke Detector	84 (includes 10 second delay)
Peak Heat Release Rate Reached	Fire Sprinkler	420 (includes 30 second delay)

6.2.3.3 Heat Release Rate

As previously discussed in Section 5, the actual heat release rate for the Fire Scenario has been modelled as shown in Figure 6.15, based on calculated fire sprinkler activation times and delays.

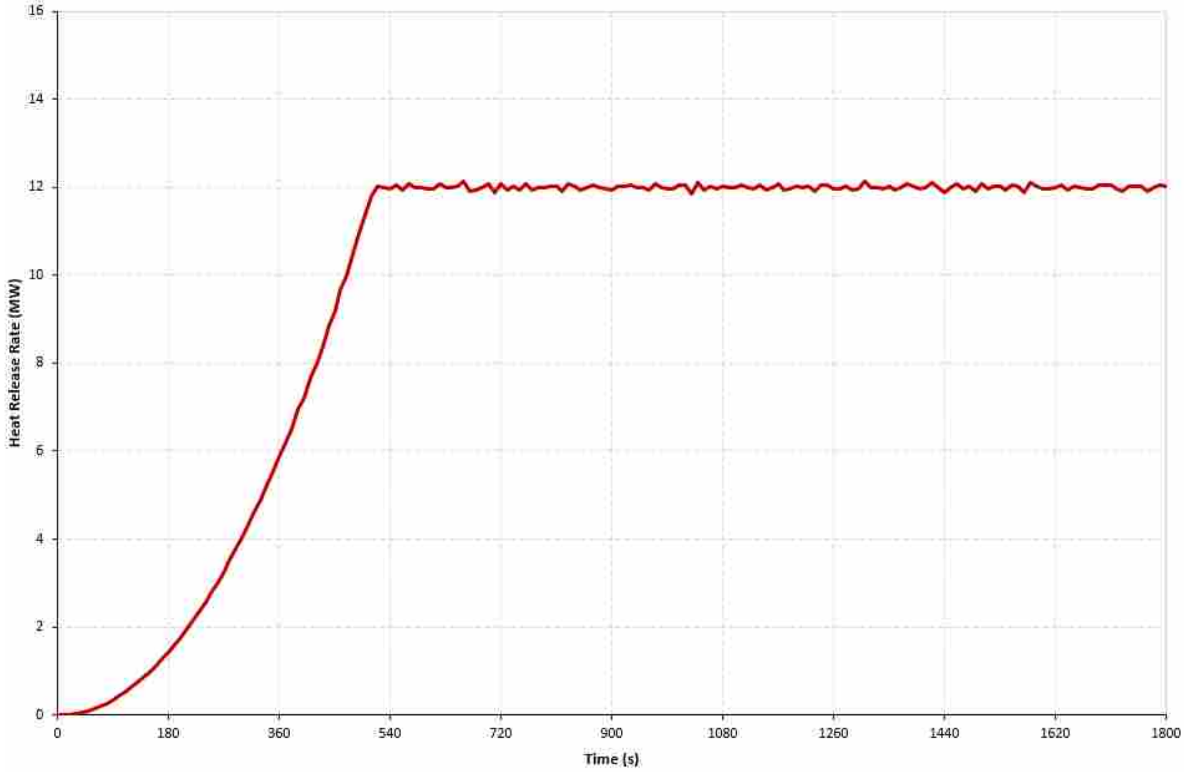

Figure 6.15 – Heat Release Rate

6.2.3.4 Fire and Smoke Conditions

As per the Occupant Life Safety Assessment Methodology detailed in Section 4.2, tenable conditions are determined by satisfying the parameters of the criteria relating to the temperatures and level of visibility at a height above and below 2.0m Above Finished Floor Level (AFFL).

<u>Temperature Conditions</u>

The Occupant Life Safety Assessment Methodology requires that the temperature of the upper layer does not exceed 180°C and the temperature of the air where the occupants are directly exposed (i.e. 2.0m AFFL) does not exceed 60°C.

Using the key model inputs, the temperatures throughout the modelled space are calculated for the modelled duration using FDS. These temperatures are output in specific 'slices' corresponding to:

- the area where the maximum upper layer temperature is to occur (i.e. ceiling jet); and the temperatures achieved at 2.0m AFFL

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Figure 6.16 and Figure 6.17 show these temperature 'slices' at the end of the modelled duration, and it is evident that:

- temperatures only exceed 180°C in the area immediately around the fire plume; and
- the temperatures directly experienced by the occupants (i.e. at 2.0m AFFL) only exceed 60°C in the area immediately around the fire plume.

During the early stages of a fire, as occupants would have direct cues to the fire, it is expected that they would inherently move away from the fire affected area to avoid the threat (i.e. natural instinct). Therefore, based on the temperature criteria, it is considered that untenable conditions do not occur within the modelled duration.

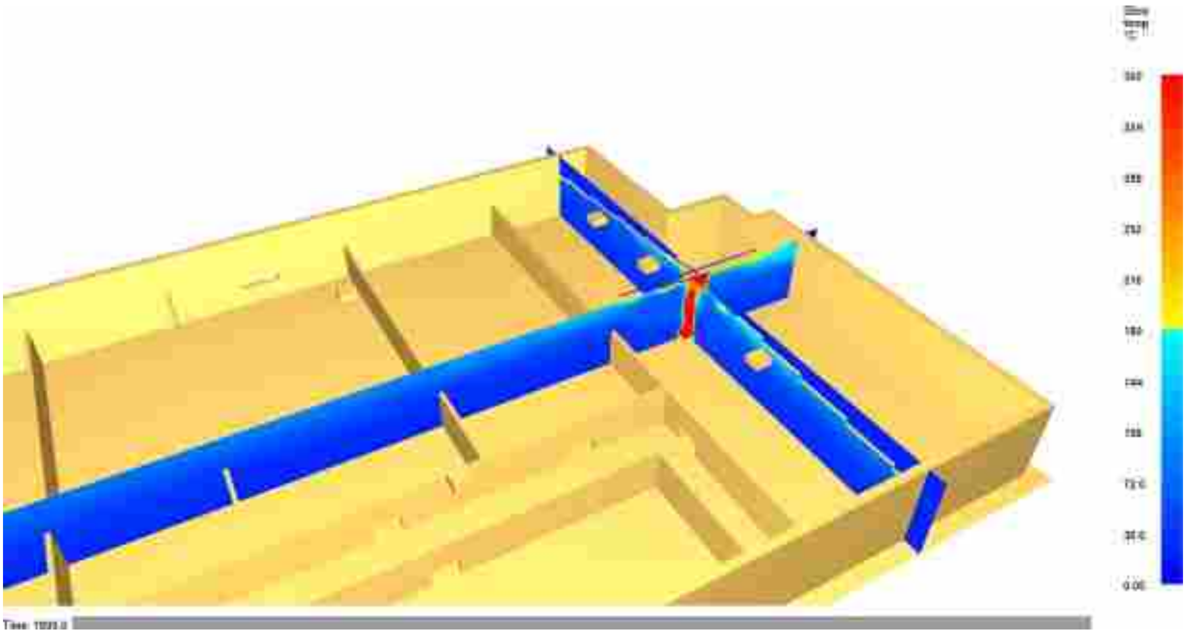

Figure 6.16 – Ceiling Jet Temperature at End of Model Duration (1,800s)

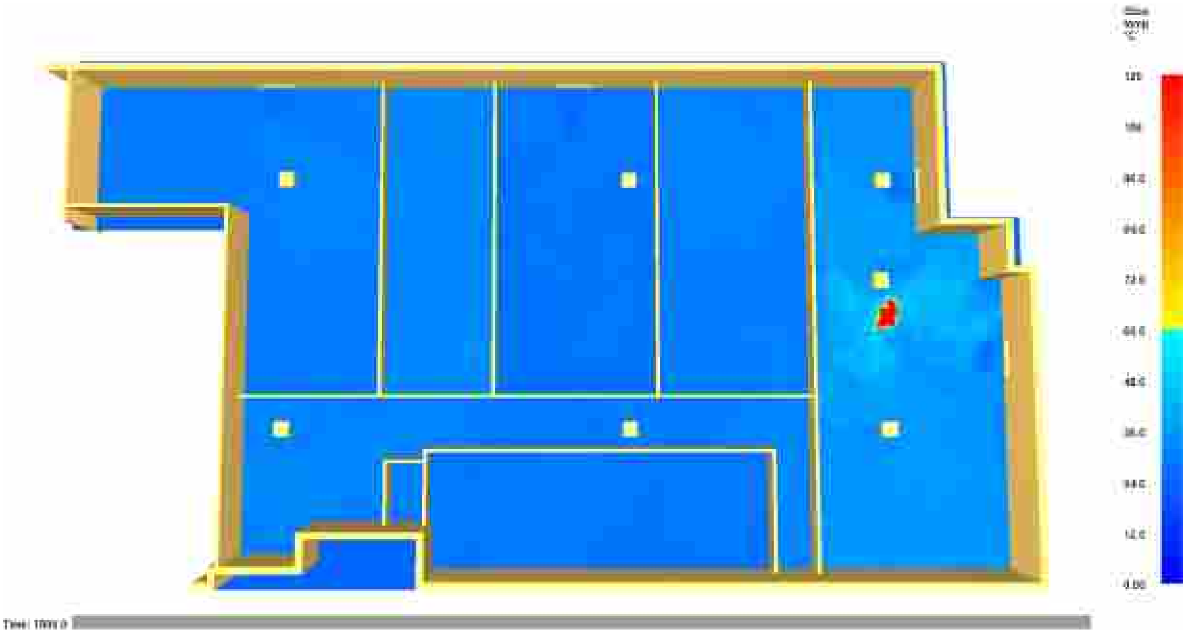

Figure 6.17 – Temperature at 2.0m at End of Model Duration (1,800s)

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Visibility

The Occupant Life Safety Assessment Methodology requires that the visibility be assessed below 2.0m AFFL (i.e., where occupants may be present) and that it be maintained above 10m.

From Figure 6.18 it is evident that all external exits and most tenancy exits are available at 750 seconds. However, from Figure 6.19, it is evident that at 850 seconds, some tenancy exits and portions of the mall have become blocked.

Given the aforementioned, it is considered that Smoke Zone 1 becomes untenable at 750 seconds.

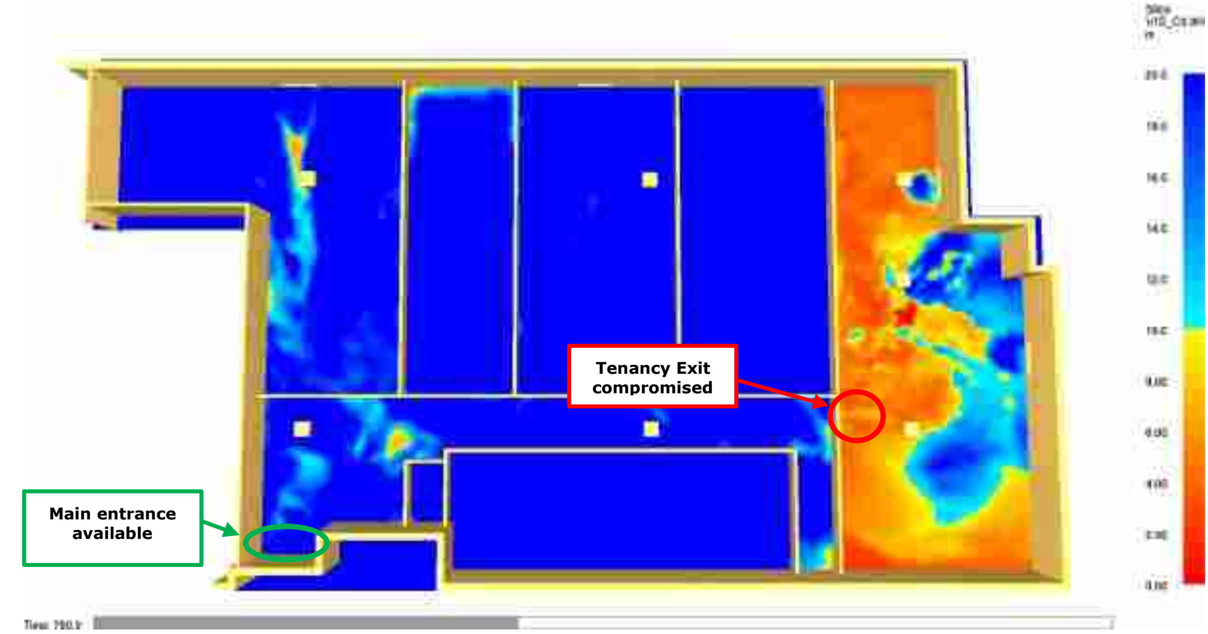

Figure 6.18 – Visibility at 750 seconds

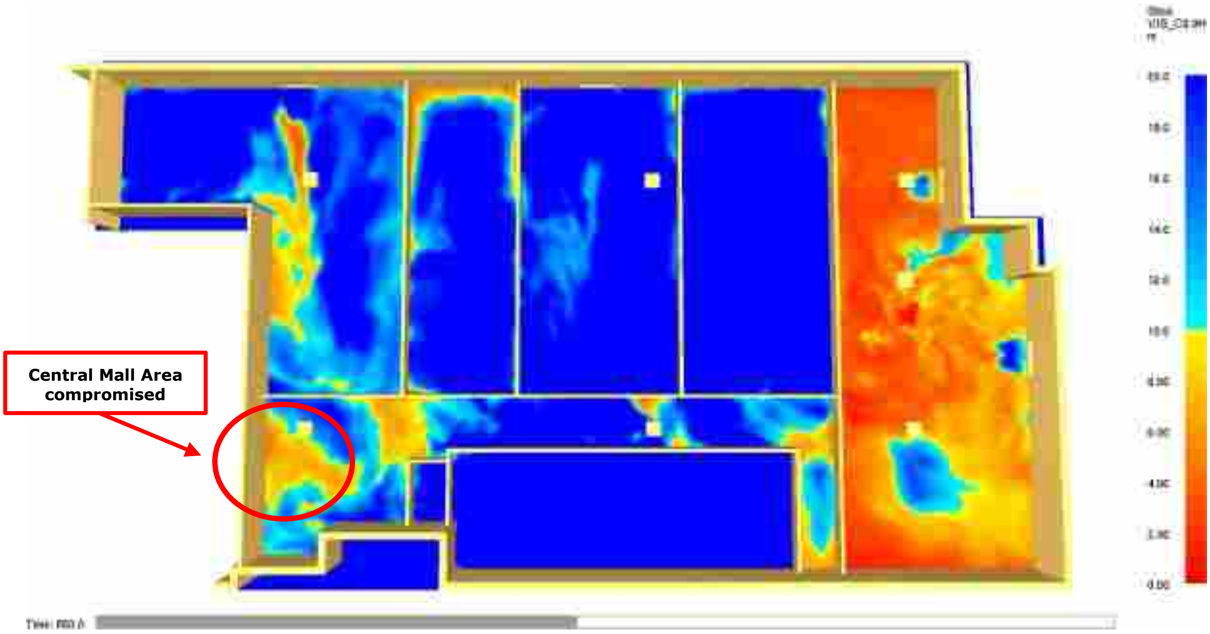

Figure 6.19 - Visibility at 850 seconds

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<u>Fire Brigade Intervention</u>

The Fire Brigade Intervention acceptance criteria, detailed in Section 4.3, requires that the upper temperature does not exceed 200°C. Based on the modelled Fire Scenario, it is evident from Figure 6.16, that the temperature is greater than 200°C, only the area immediately around the fire plume. It is therefore considered that fire brigade intervention limits based on Condition 1 are not exceeded within Smoke Zone 1.

Additionally, as detailed in Section 4.3, the Fire Brigade Intervention acceptance criteria requires that the temperature which Fire Fighters could be directly exposed to (i.e. at 1.5m above the floor level) does not exceed 120°C. Figure 6.20 indicates the temperature profile at a height of 1.5m above the Finished Floor Level (FFL). It is evident that only the area around the fire plume is expected to exceed temperatures of 120°C (as indicated by the red colour), therefore, fire brigade intervention limits based on temperatures exceeding 120°C at 1.5m are not considered to be exceeded.

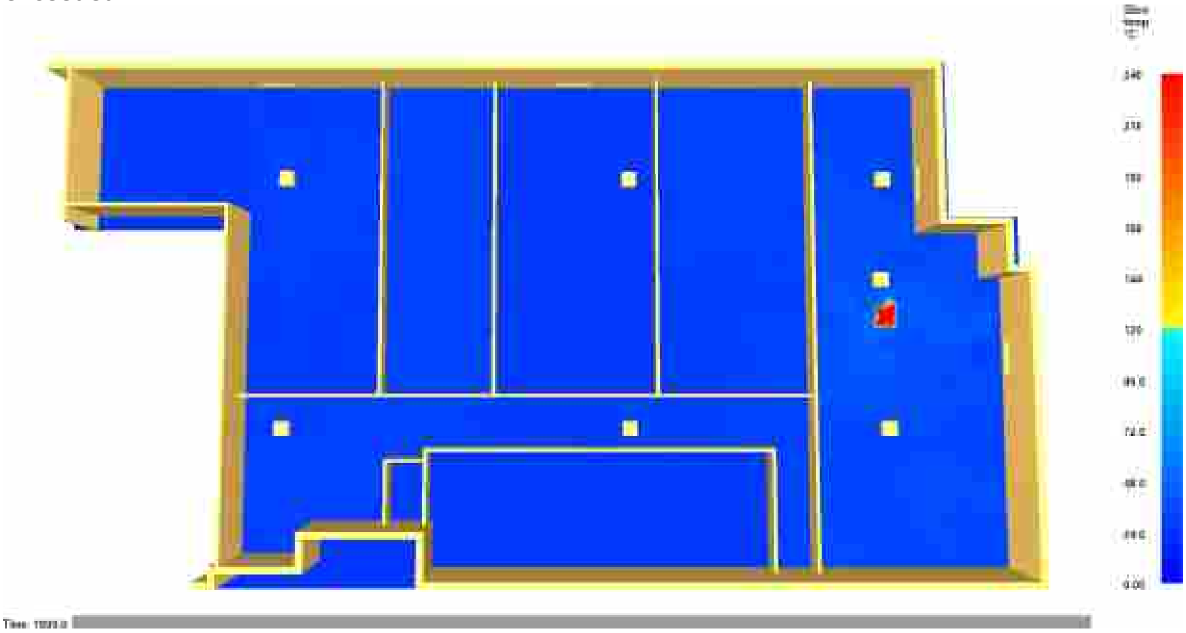

Figure 6.20 – Temperature at 1.5m at End of Model Duration

6.2.3.5 Summary

Based on the Fire Scenario modelled, untenable conditions are calculated not to occur before 750 seconds based on the visibility criterion. Therefore, the Available Safe Egress Time (ASET) is calculated to be 750 seconds.

Note that Fire Brigade Intervention limits are not exceeded for the modelled duration.

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6.2.4 Fire Scenario 4: Main Trading Floor Back of House Fire (Smoke Zone 1) – Sensitivity Study

6.2.4.1 Modelling Configuration

Fire Scenario 6 represents the Performance Building Solution associated with the Back of House area in the existing Trade Centre end of the building when the installed fire safety systems are considered to operate. The intent of this modelled fire scenario is to assess the level of safety provided to occupants during an evacuation.

The key model inputs for Fire Scenario 6 are summarised as follows:

a. The Fire Scenario has been modelled using FDS, refer Appendix H for details.

b. The model comprises a single (1) compartment, as shown in Figure 6.21, with the floor area and volume of the compartment reflecting the dimensions of the representative model which consists of the worst-case dimensions (smallest total floor area and smallest roof height) as discussed in Section 5. The model encompasses Smoke Zone 1.

c. Simulation time of 1,800 seconds (30 minutes).

d. The following computational mesh dimensions were specified (x,y,z):

   i. Fire Mesh: 0.25m × 0.25m × 0.25m – Incorporates the fire burner

   ii. Near Field Mesh: 0.25m × 0.25m × 0.25m – Meshes adjacent to fire mesh

   iii. Far Field Mesh: 0.25m × 0.25m × 0.25m – Meshes not adjacent to fire mesh

e. The fire has been modelled as a burner, with the following specifications:

   i. Located 1.0m Above Finished Floor Level (AFFL) within the existing Trade Centre end of the building, as shown in Figure 6.21.

   ii. Dimensions of 3.0m x 3.0m.

   iii. Growth rate as detailed in Section 5.2 and peak Heat Release Rate (HRR) as calculated in Appendix E.

f. Mechanical exhaust has been modelled as a surface, with the following specifications:

   i. Within Smoke Zone 1, there are seven (7) fans, six (6) each with an exhaust rate of $5.8m^3/s$ and a single fan with an exhaust rate of $15m^3/s$. Each fan is located 0.5m below roof level, as shown in Figure 6.21.

g. Makeup air for the mechanical exhaust has been modelled evenly distributed across two (2) sides of the building.

   i. Smoke detectors located above the fire (first row, 100mm below ceiling level), as shown Figure 6.21. The parameters and spacing for the detector have been modelled as detailed in Section5.2.2.

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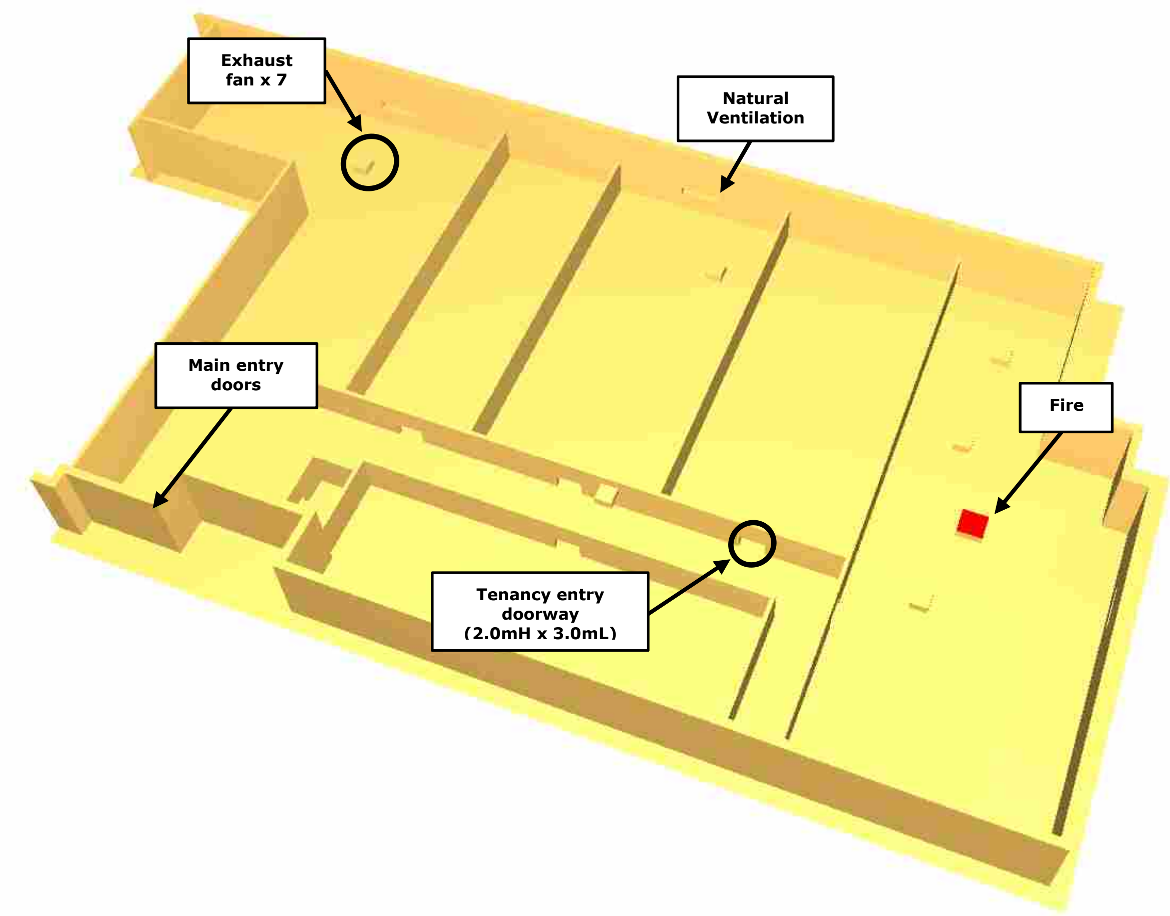

Figure 6.21 - SmokeView Model Output

6.2.4.2 Device Activation

Smoke Detectors

Smoke detectors have been modelled within FDS as previously discussed. Table 6.7 summarises the calculated activation times for the modelled devices.

Table 6.7 – Device Activation Times

Device Number	Activation Time (seconds)	
	Smoke Detector	Fire Sprinkler
1	76	206
2	74	214
3	59	220
4	59	222

The smoke detectors modelled within FDS are used to determine the time at which the occupant warning system initiates and fire brigade notification occurs.

Summary

Table 6.8 summarises the first-activated device associated with each event and the corresponding calculated activation time.

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Table 6.8 – Event Times

Event	Device	Time (Seconds)
Occupant Warning System Initiates	Smoke Detector	69 (includes 10 second delay)
Fire Brigade Notification	Smoke Detector	69 (includes 10 second delay)
Smoke Exhaust Actuates	Smoke Detector	69 (includes 10 second delay)
Peak Heat Release Rate Reached	Fire Sprinkler	236 (includes 30 second delay)

6.2.4.3 Heat Release Rate

As previously discussed in Section 5, the actual heat release rate for the Fire Scenario has been modelled as shown in Figure 6.22, based on calculated fire sprinkler activation times and delays.

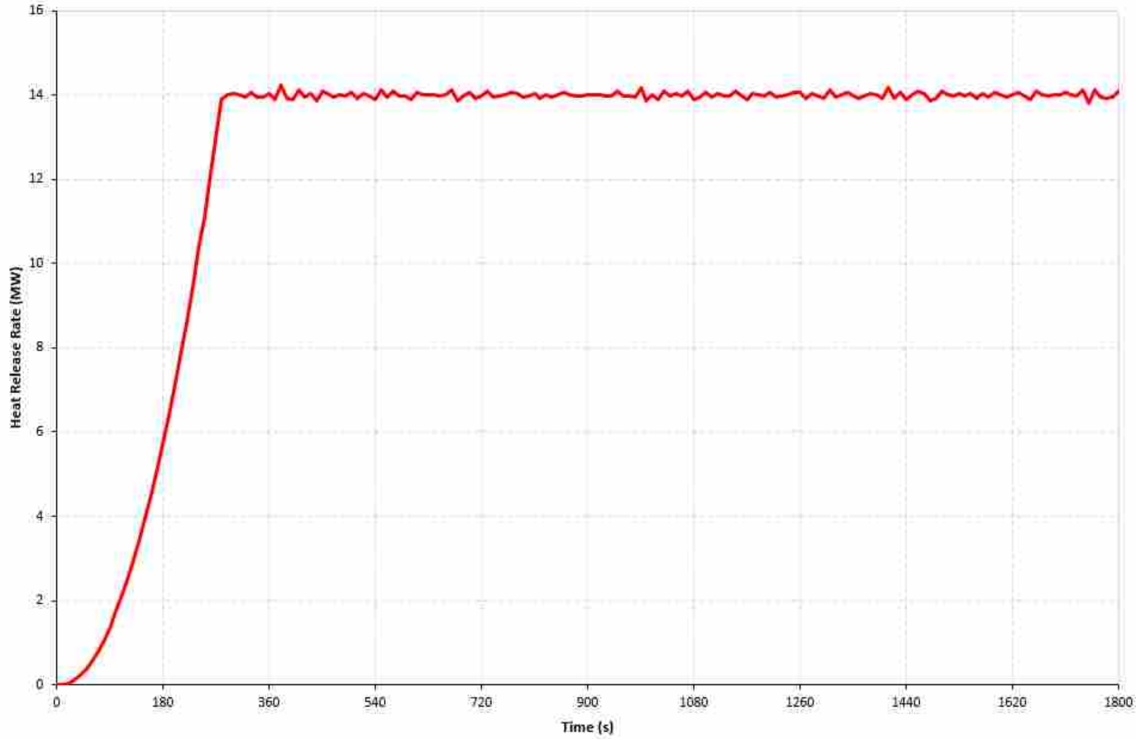

Figure 6.22 – Heat Release Rate

6.2.4.4 Fire and Smoke Conditions

As per the Occupant Life Safety Assessment Methodology detailed in Section 4.2, tenable conditions are determined by satisfying the parameters of the criteria relating to the temperatures and level of visibility at a height above and below 2.0m Above Finished Floor Level (AFFL).

<u>Temperature Conditions</u>

The Occupant Life Safety Assessment Methodology requires that the temperature of the upper layer does not exceed 180°C and the temperature of the air where the occupants are directly exposed (i.e. 2.0m AFFL) does not exceed 60°C.

Using the key model inputs, the temperatures throughout the modelled space are calculated for the modelled duration using FDS. These temperatures are output in specific 'slices' corresponding to:

- the area where the maximum upper layer temperature is to occur (i.e. ceiling jet); and
- the temperatures achieved at 2.0m AFFL.

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Figure 6.23 and Figure 6.24 show these temperature 'slices' at the end of the modelled duration, and it is evident that:

- temperatures only exceed 180°C in the area immediately around the fire plume; and
- the temperatures directly experienced by the occupants (i.e. at 2.0m AFFL) only exceed 60°C in the area immediately around the fire plume.

During the early stages of a fire, as occupants would have direct cues to the fire, it is expected that they would inherently move away from the fire affected area to avoid the threat (i.e. natural instinct). Therefore, based on the temperature criteria, it is considered that untenable conditions do not occur within the modelled duration.

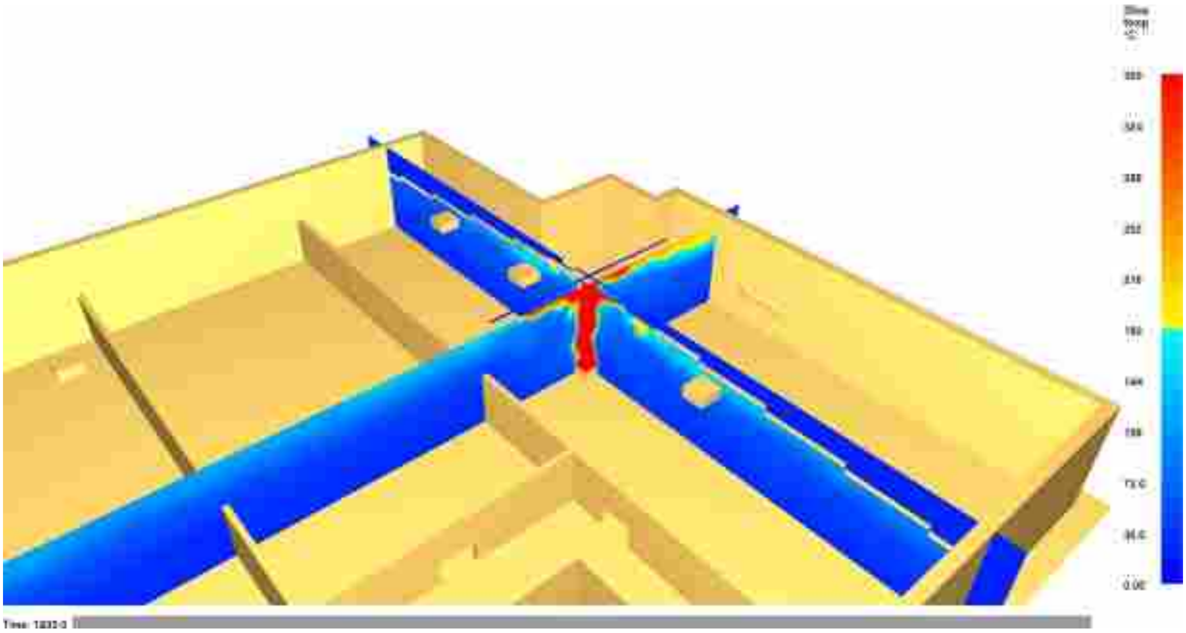

Figure 6.23 – Ceiling Jet Temperature at End of Model Duration (1,800s)

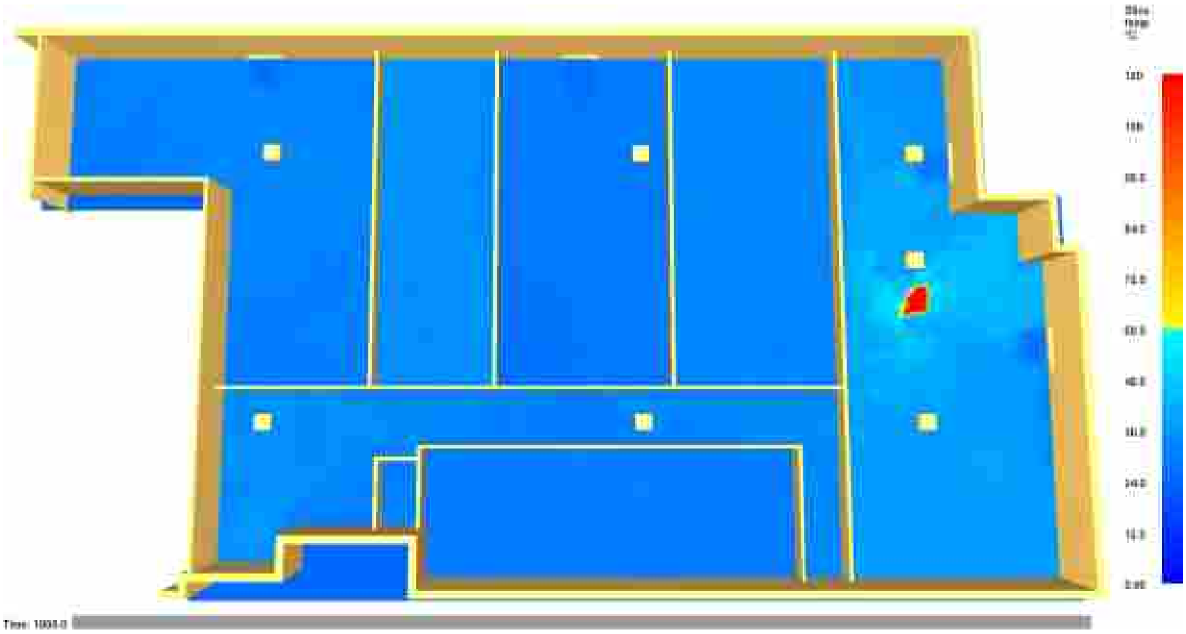

Figure 6.24 – Temperature at 2.0m at End of Model Duration (1,800s)

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Visibility

The Occupant Life Safety Assessment Methodology requires that the visibility be assessed below 2.0m AFFL (i.e. where occupants may be present) and that it be maintained above 10m.

From Figure 6.25 it is evident that a loss in visibility occurs in an area of the tenancy where the fire is located, however the majority of exits and the Mall are considered available at 550 seconds. However, from Figure 6.26, it is evident that at 650 seconds, some tenancy exits and portions of the Mall have become blocked.

Given the aforementioned, it is considered that Smoke Zone 1 becomes untenable at 550 seconds.

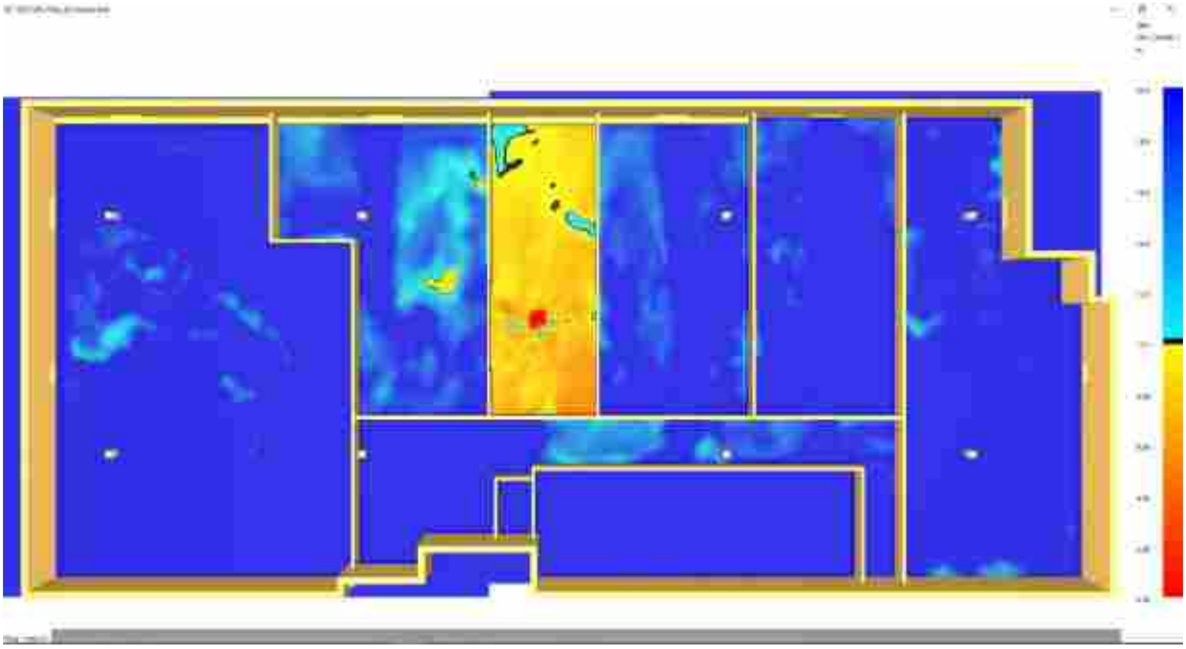

Figure 6.25 – Visibility at 550 seconds

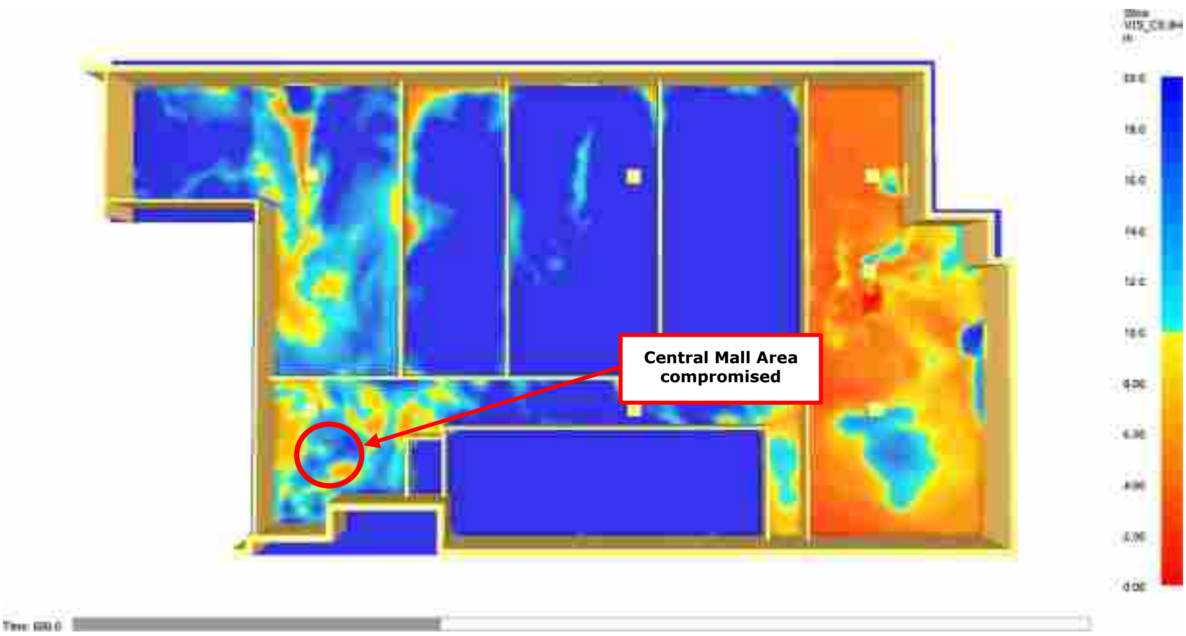

Figure 6.26 - Visibility at 650 seconds

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6.2.4.5 Summary

Based on the Fire Scenario modelled, untenable conditions are calculated not to occur before 550 seconds based on the visibility criterion . Therefore, the Available Safe Egress Time (ASET) is calculated to be 550 seconds.

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6.3 Egress Modelling

6.3.1 General

To determine the Required Safe Evacuation Time (RSET), human egress modelling has been undertaken.

Occupant evacuation has been undertaken for all tenancy's within the building, including the mall and café areas of the building and it is considered that occupants are safe once they have reached outside. Note that travel beneath external awnings is, for the purpose of this assessment, considered to be outside.

6.3.2 Occupant Modelling

The time taken to evacuate the building is given by:

RSET = T_a (alarm time) + T_p (pre-movement time) + T_t (travel time)

6.3.2.1 *Alarm Time, T_a*

In the event of a fire incident within the building, the **smoke detection** system will provide warning of a fire incident via initiating the Building Occupant Warning System (BOWS), and notifying Fire Brigade.

It is noted that staff or occupants within the fire vicinity may notice a fire prior to the activation of the BOWS and either undertake minor fire intervention or alert other occupants to initiate evacuation. This has been ignored in this instance and is considered to be a conservative assumption.

Based on the modelled Fire Scenarios in Section 5.3 and 0, the calculated alarm times are summarised in Table 6.9.

6.3.2.2 Pre-Movement Time, T_p

As discussed in Section 5, the pre-movement time for occupants are as follows:

- **180 seconds** is considered for all occupants remote from the fire (i.e. not in the tenancy of fire origin).
- **60 seconds** is considered for occupants (patrons) that are able to clearly see smoke and flames at a distance (i.e. within the tenancy of fire origin)

6.3.2.3 Travel Time, T_t

Based on the nature of the areas to be evacuated and the expected population densities during evacuation, it is considered that occupant evacuation may produce significant congestion or queuing at the exits. Therefore, to determine a maximum egress time, both a queuing time and movement time have been calculated based on the method detailed in Section 4.2.

Based on the modelled Egress Scenarios, the calculated travel times are summarised in Table 6.9. Results of the queuing time and movement time are provided in Table 6.9. It is important to note that the travel time is the greater of either the queuing time or the movement time, not the summation of both.

6.3.2.4 Evacuation Time Summary, RSET

Based on the above RSET equation components, the maximum time occupants take to evacuate relevant parts of the building is calculated to be as summarised in Table 6.9.

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Table 6.9 – Required Safe Egress Time

Evacuation Component	Alarm Time, T_a	Pre-Movement Time, T_p	Travel Time, T_t	RSET
Egress Scenario	Time (seconds)			
A	82	180	170	432
B	82	180	286	548
C	82	180	226	488
D	65	180	170	415
E	84	180	170	434
F	69	180	170	419

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7. Performance Solutions

The following sections detail the various aspects of the proposed Performance Solution and its deviation from the NCC DTS Solution, the relevant NCC Performance Requirements that need to be complied with, the Assessment and Analysis Methods and Methodologies, and Acceptance Criteria for each NCC DTS departure.

7.1 Perimeter Vehicular Access

7.1.1 General

This assessment addresses Item 1.

7.1.2 NCC DTS Requirements

NCC DTS Clause C2.4(b) requires that vehicular access is provided to all sides to a large isolated building, have a minimum unobstructed width of 6m, be continuous so as to enable travel in a forward direction with no part of its furthest boundary more than 18m from the building.

7.1.3 Proposed Compliance Solution

It is proposed that perimeter vehicular access must be in accordance with NCC DTS requirements, as shown in Figure 7.1, with the following exceptions:

i. The perimeter vehicular access is permitted to be non-continuous on the South-west side of the building

ii. The perimeter vehicular access is permitted to reduce in width to not less than 4.5m, in localised areas on the North-west and South-west side of the building.

As part of the Performance Solution, it is recognised that:

- access to all corners of the building can be achieved;
- the building is provided with an Early Suppression Fast Response (EFSR) fire sprinkler system;
- the building is provided with a smoke exhaust system; and
- the area surrounding the building is relatively free of combustible materials.

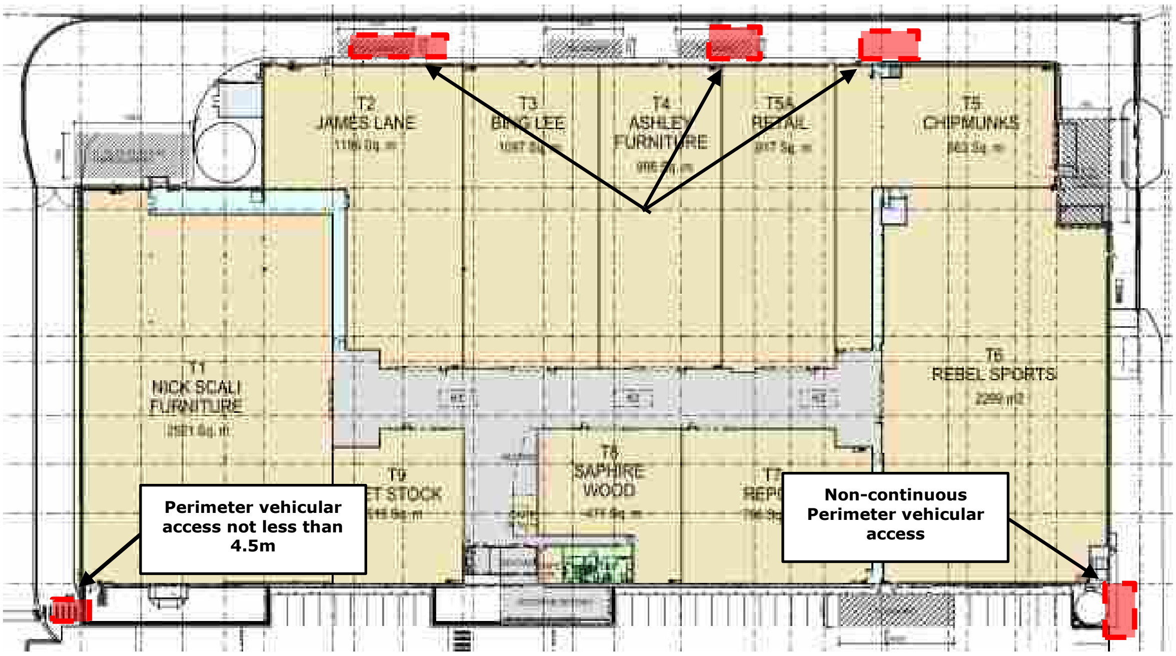

Figure 7.1 – Vehicular Access

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The building is also provided with an automatic fire sprinkler system, a smoke detection and alarm system, a Building Occupant Warning System (BOWS), a fire hydrant system, a fire hose reel system and fire extinguishers.

Refer to the Fire Engineering Outcomes section for detailed fire safety measures which form part of the proposed Compliance Solution.

7.1.4 Code Compliance and Assessment Methods

Compliance with the NCC Performance Requirements is to be achieved via Clause A0.3(a), as detailed in Section 1.2.

Assessment Method A0.5, as detailed in Section 1.2, will be utilised, as appropriate, to demonstrate that the Performance Solution complies with the relevant Performance Requirements determined in accordance with A0.7.

The Performance Solution is required to meet NCC Performance Requirement CP9.

7.1.5 Analysis Methods, Assessment Methodology and Acceptance Criteria

Compliance with the NCC Performance Requirements is to be achieved using a qualitative analysis method based on the measures provided to facilitate Fire Brigade intervention.

Acceptance will be demonstrated where the vehicular perimeter access provisions will not unduly impact upon Fire Brigade intervention.

7.1.6 Intent

The intent of NCC DTS Clause 2.4(b), as stipulated by the Guide to the NCC, is to set the minimum requirements for the provision of vehicular access for the Fire Brigade.

By achieving the minimum requirements, it is considered that the Fire Brigade are provided with sufficient access to and around a building.

Performance Requirement CP9, as stipulated by the Guide to the NCC and in the context to the Performance Solution, deal with the Fire Brigade assess to and around a building. A building must be provided with sufficient access to and around the perimeter to:

- enable fighting of the fire;
- assist with evacuation; and
- stop fire spread to another building.

7.1.7 Assessment

As detailed in Section 2.1, the development is a Large Isolated Building (LIB), and therefore is required to be provided with perimeter vehicular access for Fire Brigade Appliances to facilitate Fire Brigade intervention.

The function or use of the building is a Class 6 Retail Tenancy building consisting of bulky goods stores accessed from a shared mall. The goods are expected to be stored in shelving or display units throughout each tenancy and the fuel load is expected to vary depending on the function or use of each tenancy, as discussed in Section 3. This is considered to be typical for a NCC DTS Class 6 building.

The building has a floor area of approximately 13,425m² (i.e.,185m long by 65m wide) which is typical for these type of facilities.

The building is provided with compliant fire hydrant coverage, fire hose reel coverage and portable fire extinguishers. The fire safety systems installed are considered to be appropriate to the function of the building, the size of the fire compartments.

Given the function or use of the building, the materials stored within the building, the active fire safety systems and fire compartment size, the fire load and intensity will be in line with what would be expected for a Class 6.

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Based on the interpretation of performance requirements and the description provided in the Guide to the NCC, the fire hazard associated with perimeter vehicular access to and around a building relates to:

- the spread of fire to another building;
- the ability of the Fire Brigade to undertake fire-fighting measures and assist with evacuation, where necessary (i.e. Fire Brigade intervention); and
- occupant evacuation.

7.1.7.1 Spread of Fire

The separation of the building to the boundary is in accordance with the provisions of the NCC DTS, therefore it is considered that the spread of fire will be contained to the building of origin.

7.1.7.2 Fire Brigade Intervention

Perimeter vehicular access is possible to 100% of the perimeter of the building which will allow the clear access to all exit and entry points and will facilitate Fire Brigade operations. However due to provision for loading bays and bollards, portions of the perimeter access road are less than 6m in width and non-continuous access is provided to the South-West side of the building.

Therefore, the following assessment addresses, with regard to Fire Brigade intervention, a reduction in perimeter vehicular access width and non-continuous perimeter vehicular access.

Access Width

A Fire Brigade appliance is approximately 2.5m in width. However, upon deployment of the stabilising jacks (if available), the required width increases to approximately 6m.

The perimeter vehicular access on the North side of the building, as shown in Figure 7.1, includes areas that reduce to not less than 4.5m wide. This narrowing is due to the provision of loading bays and construction of bollards. Therefore the narrowing is localised only and spans a length of not more than 7m in each narrowed point along the side of the building. It is recognised that the aforementioned stabilising jacks are localised points that protrude from the appliance and therefore given that the reduced access width is localised, the stabilising jacks will be able to be deployed either around or on either side of the loading bays and hard stand area and the coverage of the building will not be unduly impacted.

Non-Continuous Access

A Fire Brigade appliance is considered to be long vehicle and has limited manoeuvrability. During an emergency such as a fire, to facilitate fire-fighting operations, a continuous perimeter vehicular access provides the driver of the Fire Brigade appliance with the ability to drive round without needing to reverse.

The perimeter vehicular access is obstructed by landscaping and car-parking facilities. Figure 7.2 indicates that whilst the perimeter access road is non-continuous, Fire Brigade appliances are able to travel in a forward direction using the car-park access road on the South-west corner of the building. Furthermore fire brigade appliances are able to be setup and deployed from all corners of the building. This is considered to provide the attending Fire Brigade with sufficient access around the building and adequate coverage of the building.

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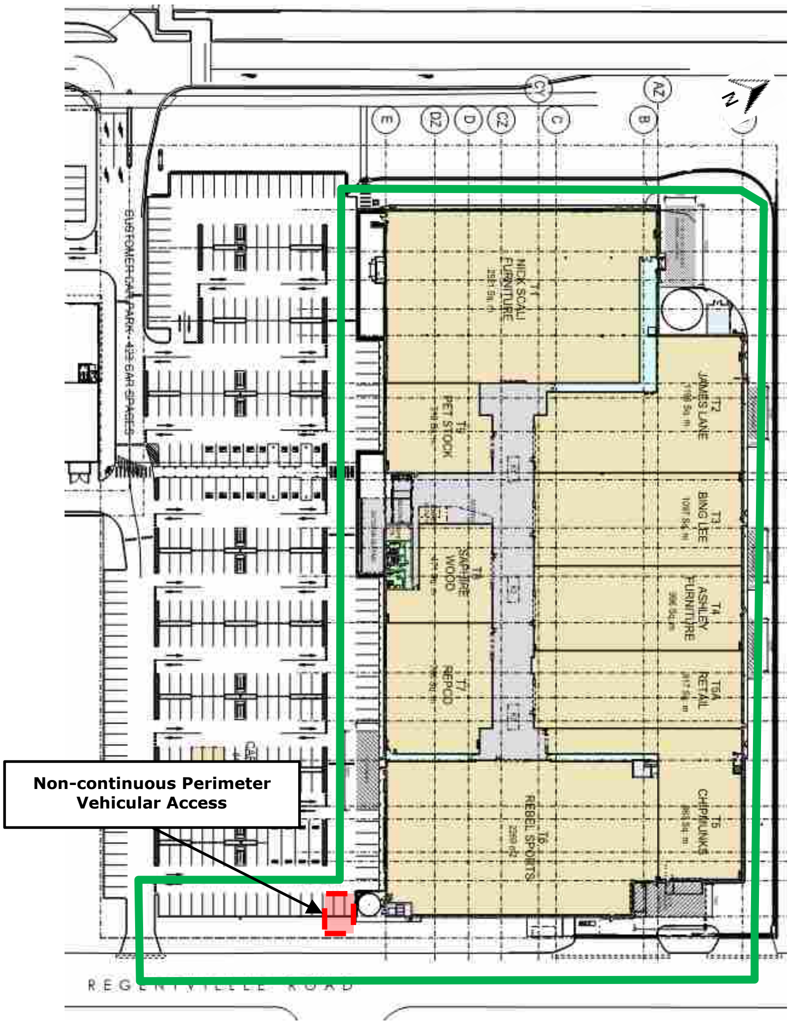

Figure 7.2 – Perimeter Vehicular Access

7.1.7.3 Occupant Evacuation

Furthermore, the occupants within the building will be predominantly patrons; hence it is considered that the occupants will be able bodied, awake, alert and aware of their surroundings. NCC DTS compliant exit signage and lighting and staff within the building will help occupants navigate to the nearest exit. Therefore, the likelihood of occupants requiring assistance by the Fire Brigade to evacuate is low.

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7.1.8 Conclusion

Table 7.1 provides a review of the relevant considerations of the identified Performance Requirement CP9, so that compliance with the NCC can be achieved.

Table 7.1 – Performance Requirement CP9

Performance Requirement	Comment
CP9 – Access must be provided to and around a building, to the degree necessary, for Fire Brigade vehicles and personnel to facilitate Fire Brigade intervention appropriate to -	
the function and use of the building	Class 6, Class 9b. Considered when defining parameters such as Fire Brigade requirements, occupant characteristics, fire loads and fire hazards, and safety measures for the building.
the fire load	Addressed as part of assessment – fire load and intensity will be in line with what would be expected in a building with the considered function or use.
the potential fire intensity	
the fire hazard	Considered as part of the assessment. Fire Brigade are given sufficient access around the building and adequate coverage of the building to undertake effective fire fighter intervention.
any active fire safety systems installed within the building	Considered as part of the assessment. ESFR/Storage system installed. This is considered to reduce the risk of fire spread and maintain conditions within the building to facilitate Fire Brigade intervention. Fire Hydrant coverage is NCC DTS compliant.
the size of the fire compartment	Considered as part of the assessment to be typical for the function or use.

Based on the assessment and proposed fire safety measures, the parameters discussed above are considered not to unduly affect the ability of Fire Brigade to undertake fire-fighting operations.

Therefore, it is considered that Performance Requirement CP9 is satisfied.

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7.2 Egress Provisions

7.2.1 General

This assessment addresses Items 3, 4 and 5.

7.2.2 NCC DTS Requirements

NCC DTS Clause D1.4(c) requires that for Class 6 parts of a building, no point on a floor must be more than 20m from an exit, or a point from which travel is different directions to two (2) exits is available, in which case the maximum distance to one (1) of those exits must not exceed 40m.

NCC Clause D1.5 requires that exits that are required as alternative means of egress must be not more than 60m apart.

NCC DTS Clause D1.6(d) requires that an exit or path of travel to an exit, where the storey or mezzanine accommodates more than 200 persons that the aggregate unobstructed width, except doorways, must be increased to:

a. 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

b. in any other case 2m plus 500mm for every 75 persons (or part) in excess of 200.

7.2.3 Proposed Compliance Solution

It is proposed that the exit travel distance from any point on a floor to an exit, or to a point from which travel in different directions to two (2) exits is available, is permitted to be not more than 30m, and to the nearest exit, when travel in different directions to two (2) exits is available, is permitted to be not more than 70m.

It is also proposed that exits required as alternative means of egress be not more than 100m apart.

Furthermore, the aggregate unobstructed egress width is proposed to be reduced to 17m.

As part of the Performance Solution, it is proposed that the smoke hazard management system, inclusive of the smoke exhaust rates and the initiation of the occupant warning system will be designed to maintain tenable conditions within evacuation routes for the duration of the occupant evacuation.

It is also proposed that the smoke hazard management system will maintain tenable conditions for Fire Brigade intervention in terms of temperature.

The building is also provided with an automatic fire sprinkler system, a smoke detection and alarm system, a Building Occupant Warning System (BOWS), a fire hydrant system, a fire hose reel system and fire extinguishers.

Refer to the Fire Engineering Outcomes section for detailed fire safety measures which form part of the proposed Compliance Solution.

7.2.4 Code Compliance and Assessment Methods

Compliance with the NCC Performance Requirements is to be achieved via Clause A0.3(a), as detailed in Section 1.2.

Assessment Method A0.5(b)(ii) as detailed in Section 1.2, will be utilised, as appropriate, to demonstrate that the Performance Solution complies with the relevant Performance Requirements determined in accordance with A0.7.

The Performance Solution is required to meet NCC Performance Requirements DP4, DP6 and EP2.2.

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7.2.5 Analysis Methods, Assessment Methodology and Acceptance Criteria

Compliance with the Performance Requirement will be achieved using a quantitative analysis method based on the occupant life safety assessment method and Fire Brigade intervention assessment method detailed in Section 4 and Scenarios detailed in Section 5.3 and summarised in Table 7.2

The assessment methodology is to compare the ratio of the Available Safe Evacuation Time (ASET) with the Required Safe Egress Time (RSET) for the proposed Performance Solution, ASET/RSET.

Table 7.2 – Summary of Fire and/or Egress Scenarios

Scenario	Fire Scenario	Egress Scenario	Acceptance Criteria
1A	1	A	ASET/RSET ≥ 1.5
1B	1	B*	ASET/RSET ≥ 1.0
1C	1	C*	ASET/RSET ≥ 1.0
2D	2*	D	ASET/RSET ≥ 1.0
3E	3	E	ASET/RSET ≥ 1.5
4F	4*	F	ASET/RSET ≥ 1.0
* Sensitivity Study component			

7.2.6 Intent

The intent of NCC DTS Clause D1.4, as stipulated by the Guide to the NCC, is to maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate.

The intent of the NCC DTS Clause D1.5, as stipulated by the Guide to the NCC, is to require that if an exit is inaccessible, access to any required alternative exit must be available within a reasonable distance. The minimum distance minimises the risk of fire spreading to block the alternative exit, whilst the maximum distance between alternative exits minimises the need to travel too far to reach an exit.

The intent of the NCC DTS Clause D1.6, as stipulated by the Guide to the NCC, is to require exits and paths of travel to an exit to have dimensions to allow all occupants to evacuate safely within a reasonable time. The minimum constructed height is considered to be a reasonable minimum for most people to safely gain egress, and the required exit path or travel widths have been determine 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.

By achieving the proximity to the exits as stipulated in Clause D1.4, distance between exits as stipulated in Clause D1.5 and the unobstructed egress width as stipulated in Clause D1.6, it is considered that occupants will be able reach an exit within a sufficient timeframe and before untenable conditions are reached within the egress path.

Performance Requirements DP4, DP6 and EP2.2, as stipulated by the Guide to the NCC and in context to the Performance Solution, deal with the time required for occupants to reach an exit and the conditions within these evacuation route(s) during the evacuation period.

To safeguard occupants from illness or injury while evacuating in an emergency, tenable conditions within these evacuation routes must be maintained for the duration required for occupant evacuation (i.e. time to reach an exit).

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7.2.7 Assessment

The NCC DTS travel distances are based on an assumption of what are considered 'reasonable' distances to be travelled by occupants in reaching an exit, as stated in the Guide to the NCC.

The following assessment addresses the travel distance to the point of choice, nearest exit and the distance between alternative exits within the building. The occupants are considered to have reached a 'safe place' as defined by the NCC and remote from a fires location when they reach road or open space.

As discussed in Section 2.1, the function or use of the building is primarily a Retail Tenancy space. The function or use of this part of the building can differ substantially.

Based on the departure, the performance requirements to be achieved and the description provided in the Guide to the NCC, the fire hazard associated with an increased exit travel distance in a Class 6 building relates to:

- the spread of fire and/or its products into the egress paths;
- the time for the detection of the fire and/or its products; and
- the impact of the fire and/or its products on the occupants.

Within Class 6 parts of a building it is considered that the occupants will be awake, alert and be aware of their surroundings.

The Building Solution comprises a number of fire safety systems. Two of the primary active fire safety systems are smoke exhaust and fire sprinklers. Within the compartments being assessed, which the smoke exhaust system is the subject of a Performance Solution; however, the fire sprinkler system is expected to be NCC DTS compliant. The NCC DTS requirements for smoke exhaust, particularly reservoir sizes and the associated requirements for smoke baffles, present difficulties from a construction and operational perspective, and hence the smoke exhaust system has been designed from a performance framework.

In order to show that the proposed smoke hazard management strategy will maintain tenable conditions in evacuation routes for the duration of occupant evacuation, fire, smoke and occupant evacuation modelling was undertaken in Section 6.

Sensitivity studies were also undertaken which considered a fire sprinkler controlled shielded fire (i.e. steady heat release rate) and a second row fire sprinkler head operation (i.e. larger fire size).

Table 7.3 summarises the results of the fire modelling and evacuation modelling undertaken in Section 6.

Table 7.3 – ASET vs RSET

Scenario	ASET (sec)	RSET (sec)	Safety Factor		Acceptable (Yes/No)
			Achieved	Required	
1A	740	432	1.7	1.5	**Yes**
1B	740	548	1.3	1.0	**Yes**
1C	740	488	1.5	1.0	**Yes**
2D	540	415	1.3	1.0	**Yes**
3E	750	434	1.7	1.5	**Yes**
4F	550	419	1.3	1.0	**Yes**

The outcomes of the Available Safe Egress Time (ASET) versus Required Safe Egress Time (RSET) analysis indicate that tenable conditions are maintained for a sufficient duration to allow occupants to safely evacuate. The models show that a safety factor of at least 1.5 is achieved, and that a safety factor of at least 1.0 is achieved for the sensitivity scenarios.

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The positive impact of fire brigade intervention has not been incorporated into the assessment or the analyses. This is considered to be a conservative assumption. However, the modelling results shown in Section 6 also indicates that the conditions for fire fighter intervention are maintained for the duration of the analysis (1,800 seconds).

Although not forming part of the acceptance criteria, visibility for Fire Brigade Intervention has also been assessed. The results show that visibility is retained at 10m or more for the majority of scenarios, and as discussed in Section 6, conditions are considered applicable for Brigade Intervention in all cases.

7.2.8 Conclusion

Table 7.4 to Table 7.6 provide a review of the relevant considerations of the identified Performance Requirements DP4, DP6 and EP2.2, so that compliance with the NCC can be achieved.

Table 7.4 – Performance Requirement DP4

Performance Requirement	Comment
DP4 – Exits must be provided from a building to allow occupants to evacuate safely, with their number, location and dimensions being appropriate to -	
the travel distance	Addressed as part of assessment – demonstrated to show conditions are maintained for occupant evacuation.
the number, mobility and other characteristics of occupants	The dominant occupant characteristics are discussed as part of the project description with their parameters defined in the Egress Scenarios section. Addressed as part of assessment – demonstrated to show conditions are maintained for occupant evacuation.
the function and use of the building	Retail. Considered when defining parameters such as occupant characteristics, fire loads and fire hazards, and safety measures for the building.
height of the building	Travel to direct outside, therefore considered not directly relevant to compliance issue under assessment.
whether the exits is above or below ground level	

Table 7.5 – Performance Requirement DP6

Performance Requirement	Comment
DP6 – So that occupants can safely evacuate the building, paths of travel to exits must have dimensions appropriate to -	
the number, mobility and other characteristics of occupants	The dominant occupant characteristics are discussed as part of the project description with their parameters defined in the Egress Scenarios section. Addressed as part of assessment – demonstrated to provide at least an equivalent level of safety to NCC DTS compliant solution.
the function and use of the building	Retail. Considered when defining parameters such as occupant characteristics, fire loads and fire hazards, and safety measures for the building.

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Table 7.6 – Performance Requirement EP2.2

Performance Requirement	Comment
EP2.2(a) – In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building so that –	
the temperatures will not endanger human life	Addressed as part of the assessment to show conditions are maintained for occupant evacuation.
the level of visibility will enable the evacuation route to be determined	
the level of toxicity will not endanger human life	
EP2.2(b) – The period of time occupants take to evacuate referred to in (a) must be appropriate to –	
the number, mobility and other characteristics of occupants	The dominant occupant characteristics are discussed as part of the project description with their parameters defined in the Egress Scenarios section. Addressed as part of assessment – demonstrated to show conditions are maintained for occupant evacuation.
the function and use of the building	Retail. Considered when defining parameters such as occupant characteristics, fire loads and fire hazards, and safety measures for the building.
the travel distance and other characteristics of the building	Addressed as part of assessment – demonstrated to show conditions are maintained for occupant evacuation.
the fire load	Addressed as part of assessment – fire load, intensity and hazards are in line with what would be expected in a building with the considered function or use.
the potential fire intensity	
the fire hazard	
any active fire safety systems installed within the building	Considered as part of the assessment – when assessing parameters and outcomes (i.e., alarm time and fire size).

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Performance Requirement	Comment
Fire Brigade intervention	The positive impact of the Fire Brigade Intervention has not been incorporated. This is considered to be a conservative assumption. Appropriate fire fighting services have been provided to enable Fire Brigade Intervention.

Based on the assessment, the proposed fire safety measures and the considerations discussed above the travel distance, location of exits and exit width provisions are considered not to unduly impact the ability of the occupants to safely evacuate the building.

Therefore, it is considered that Performance Requirements DP4, DP6 and EP2.2 are satisfied.

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7.3 Fire Sprinkler System

7.3.1 General

This assessment addresses Item 7.

7.3.2 NCC DTS Requirements

NCC DTS Clause E1.5 requires that a sprinkler system must:

a. Be installed in a building or part of a building when required, dependent on the occupancy classification; and

b. Comply with Specification E1.5.

7.3.3 Proposed Compliance Solution

It is proposed that the existing Early Suppression Fast Response (ESFR)/Storage (i.e. RTI < $50m^{½}s^{½}$) sprinkler system is permitted to be retained throughout the building for protection of Ordinary Hazard risk in accordance with NFPA 13.

Additionally it is proposed that where there is an architectural or building feature that presents a limitation to ESFR/Storage type sprinklers, another appropriate fire sprinkler system type is permitted to be installed e.g. spray type sprinklers to drop ceilings.

Furthermore draft curtains must be provided to separate different sprinkler types, e.g. ESFR/Storage type sprinkler and High Hazard type sprinklers, in accordance with NFPA 13.

The building is also provided with a smoke detection and alarm system, a Building Occupant Warning System (BOWS), a fire hydrant system, a fire hose reel system, fire extinguishers and a smoke exhaust system.

Refer to the Fire Engineering Outcomes section for detailed fire safety measures which form part of the proposed Compliance Solution.

7.3.4 Code Compliance and Assessment Methods

Compliance with the NCC Performance Requirements is to be achieved via Clause A0.3(a), as detailed in Section 1.2.

Assessment Method A0.5(b)(ii), as detailed in Section 1.2, will be utilised, as appropriate, to demonstrate that the Performance Solution complies with the relevant Performance Requirements determined in accordance with A0.7.

The Performance Solution is required to meet NCC Performance Requirement EP1.4.

7.3.5 Analysis Methods and Acceptance Criteria

Compliance with the Performance Requirement will be achieved using a qualitative analysis method based on the comparison of ESFR/Storage fire sprinkler requirements under AS 2118.1-1999 with NFPA13.

Acceptance will be demonstrated where the retention of the existing early suppression fast response (ESFR)/Storage (i.e. RTI < $50m^{½}s^{½}$) sprinkler system will not unduly impact on the ability of the occupants to safely evacuate the building, on Fire Brigade intervention and on the likelihood of fire spread.

7.3.6 Intent

The intent of the NCC DTS Clause E1.5, as stipulated by the Guide to the NCC, is to require the installation of suitable fire sprinkler systems where necessary to address specific hazards. These are used in buildings to contain and extinguish fire. When an automatic suppression system operates it not only controls or limits the fire development, but statistics show that, in most cases, the fire is extinguished before the Fire Brigade arrives at the building. It should be noted that the provision regarding an effective height of 25m, recognises the effective operation height for Fire Brigade ladders and other firefighting and rescue equipment.

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7.3.7 Assessment

The following assessment addresses the retention of Early Suppression Fast Response (ESFR)/Storage (i.e. RTI <50m½s½) sprinkler heads throughout the building for protection of Ordinary Hazard storage risk in accordance with NFPA 13.

As detailed in Section 2.1, the development is a Large Isolated Building (LIB), and therefore is required to be protected throughout with an automatic fire sprinkler suppression system, installed to the degree necessary, to control the development and spread of fire.

The function of the existing building was primarily a Class 6 retail warehouse building for the sale of hardware, appliances, building materials and supplies and nursery goods. The goods stored within the building were stored in high-piled storage arrangements, therefore an Early Suppression Fast Response (ESFR)/Storage Early Suppression Fast Response (ESFR)/Storage (i.e. RTI <50m½s½) fire sprinkler system is installed throughout relevant areas of the building.

ESFR/Storage fire sprinkler systems are designed to be quick-acting, high-performance and discharge a large volume of water at a high speed directly onto a fire to suppress it before the fire is fully developed. As a result the need for in-rack sprinklers is reduced or eliminated, thus ESFR/Storage sprinklers are considered to be a cost effective NCC DTS compliant fire sprinkler system for the existing layout of the building.

The proposed redevelopment consists of alterations to the existing building such that the function or use of the building remains a Class 6 retail building. However the interior is proposed to consist of multiple bulky goods stores accessed from a shared mall. The goods are expected to be stored in low-piled shelving or display units throughout each tenancy. The result of the removal of the high-piled storage arrangements is that the fire hazard is downgraded from High Hazard to Ordinary Hazard. As a result ESFR/Storage fire sprinkler systems are not required for the new proposed storage arrangements in accordance with the Australian Standard AS2118.1 - 1998.

However AS2118.1-1998 Clause 2.3.3.3 states that *"Occupant classification and the commodities to be protected by ESFR sprinkler systems shall be in accordance with the requirements of NFPA 13 – 1999".* NFPA 13 allows the use of ESFR/Storage sprinkler heads for the protection of light and ordinary hazard occupancies provided specific design criteria is met, such as storage height. NFPA 13 Clause 8.4.6.6 states *ESFR sprinklers designed to meet any criteria in Chapter 12 through Chapter 20 shall be permitted to protect light and ordinary hazard occupancies.*

The proposed redevelopment is considered Ordinary Hazard Occupancy (Group 2). NFPA 13 specifies that the storage of most commodities must not exceed the following stockpile height requirements (NFPA 13 Clause 5.3.2):

- Stockpiles with moderate heat release rates must not exceed 3.7m in height
- Stockpiles with high heat release rates must not exceed 2.4m in height

Given the proposed storage arrangements within the redevelopment are to consist of low piled storage, the redevelopment must meet the requirements of NFPA 13 *Chapter 13: Protection of Miscellaneous and Low-Piled Storage* whereby storage up to 3.7m is considered low-piled storage.

NFPA 13 Chapter 13 is inherently included within NFPA 13 Clause 8.4.6.6, thus provided the requirements of Chapter 13 and Ordinary Hazard (Group 2) are satisfied, the retention of ESFR/Storage fire sprinkler systems is considered acceptable for the proposed redevelopment. This includes maximum storage height, maximum ceiling height, commodity type, flow rate and duration.

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7.3.8 Conclusion

Table 7.7 provides a review of the relevant considerations of the identified Performance Requirements EP1.4 so that compliance with the NCC can be achieved.

Table 7.7 – Performance Requirement EP1.4

Performance Requirement	Comment
EP1.4 – An automatic fire suppression system must be installed to the degree necessary to control the development and spread of fire appropriate to –	
The size of the fire compartment	Not addressed as part of the assessment – the size of the compartment is not required to determine compliance with NFPA 13.
The function or use of the building	Retail. Considered when defining parameters such as occupant characteristics, fire loads and fire hazards, and safety measures for the building.
The fire hazard	Considered as part of the assessment – fire hazards are used to determine the parameters of the assessment.
The height of the building	Not considered as part of the assessment – the building structure is retained as part of the redevelopment thus storage of commodities must comply with the building height limitations posed in NFPA13.

Based on the assessment and proposed fire safety measures, the proposed ESFR/Storage fire sprinkler system retention strategy is considered not to unduly impact on the ability of the occupants to evacuate, Fire Brigade Intervention or the likelihood of fire spread.

Therefore, it is considered that Performance Requirement EP1.4 is satisfied.

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7.4 Smoke Exhaust System

7.4.1 General

This assessment addresses Item 8.

7.4.2 NCC DTS Requirements

NCC DTS Table E2.2b requires that where the floor area of a Class 6 part of a fire compartment is more than 2000m², the fire compartment, including the enclosed common walkway or Mall, must be provided with—

a. an automatic smoke exhaust system complying with Specification E2.2b; or

b. automatic smoke-and-heat vents complying with Specification E2.2c, if the building is single (1) storey; or

c. if the floor area of the fire compartment is not more than 3,500m² and the building has a rise in storeys of not more than 2, a sprinkler system complying with Specification E1.5.

7.4.3 Proposed Compliance Solution

It is proposed that smoke hazard management is to be provided throughout in accordance with NCC DTS Specification E2.2b with the following modifications:

- Rationalised smoke exhaust quantities to the building.
- Each Smoke Zone is to be treated as a single smoke reservoir (i.e. smoke baffles are not provided).

As part of the Performance Solution, it is proposed that the smoke hazard management system, inclusive of the smoke exhaust actuation and rates and the initiation of the occupant warning system will be designed to maintain tenable conditions within evacuation routes for the duration of occupant evacuation.

It is also proposed that the smoke hazard management system will maintain tenable conditions for Fire Brigade intervention in terms of temperature.

The building is also provided with a fire sprinkler system, a smoke detection and alarm system, a Building Occupant Warning System (BOWS), smoke exhaust system, a fire hydrant system, a fire hose reel system and fire extinguishers.

Refer to the Fire Engineering Outcomes section for detailed fire safety measures which form part of the proposed Compliance Solution.

7.4.4 Code Compliance and Assessment Methods

Compliance with the NCC Performance Requirements is to be achieved via Clause A0.3(a), as detailed in Section 1.2.

Assessment Method A0.5(b)(ii) as detailed in Section 1.2, will be utilised, as appropriate, to demonstrate that the Performance Solution complies with the relevant Performance Requirements determined in accordance with A0.7.

The Performance Solution is required to meet NCC Performance Requirement EP2.2.

7.4.5 Analysis Methods, Assessment Methodology and Acceptance Criteria

Rationalised Smoke Exhaust System

Compliance with the Performance Requirement will be achieved using a quantitative analysis method based on the occupant life safety assessment method and Scenarios detailed in Section 5.3 and summarised in Table 7.8.

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Occupant Life Safety

The assessment methodology is to compare the ratio of the Available Safe Evacuation Time (ASET) with the Required Safe Egress Time (RSET) for the proposed Performance Solution, ASET/RSET.

Table 7.8 – Summary of Fire and/or Egress Scenarios

Scenario	Fire Scenario	Egress Scenario	Acceptance Criteria
1A	1	A	ASET/RSET ≥ 1.5
1B	1	B*	ASET/RSET ≥ 1.0
1C	1	C*	ASET/RSET ≥ 1.0
2D	2*	D	ASET/RSET ≥ 1.0
3E	3	E	ASET/RSET ≥ 1.5
4F	4*	F	ASET/RSET ≥ 1.0
* Sensitivity Study component			

Fire Brigade intervention

The assessment methodology is to assess the Fire Brigade temperature-based tenability limit.

Acceptance will be demonstrated if tenability is maintained for the modelled duration of the primary analysis.

Omission of Smoke Exhaust from Smoke Zone 2

Compliance with the Performance Requirement will be achieved using a qualitative analysis method based on occupant life safety and Fire Brigade Intervention.

Acceptance will be demonstrated where the omission of smoke exhaust from a single building part (Tenancy T5) will not unduly impact upon occupant life safety or Fire Brigade Intervention.

7.4.6 Intent

The intent of NCC DTS Clause E2.2, as stipulated in the Guide to the NCC, is to specify the requirements for minimising the smoke risks.

Furthermore, in order to minimise the smoke risks associated with the occupancy, the intent of NCC Specification E2.2b is to:

a. specify the capacity and exhaust rates required of mechanical smoke exhaust systems;

b. specify the operational requirements for smoke exhaust fans;

c. specify the requirements for smoke reservoirs, to enable the containment of smoke in the upper levels of compartments;

d. make sure that exhaust fans and vents do not draw clean air up through the smoke layer;

e. provide air to replace that being exhausted by the smoke exhaust system;

f. specify the control requirements for smoke exhaust systems and automatic make-up air arrangements; and

g. clarify the location of the requirements for the installation of a smoke detection system.

The relevant NCC Performance Requirement (EP2.2) specifically relates to evacuation route conditions. The conditions within the evacuation route must be maintained for the period of time occupants take to evacuate the affected fire compartment, so that they are not overcome by the effects of fire.

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It is stated by the Guide to the NCC, that occupants must be given time to evacuate before the onset of untenable conditions. The NCC DTS requirements for the use of mechanical exhaust for smoke hazard management is therefore intended to prolong tenability relative to the fire hazard and evacuation time for occupants.

7.4.7 Assessment

As discussed in Section 2.1, the function or use of the building is primarily a Retail Tenancy space. The function or use of this part of the building can differ substantially.

The fire load, as discussed in Section 3, is expected to range from 300MJ/m² to 1,000MJ/m² for a Retail Tenancy building. The active fire safety systems installed (i.e. fire hydrant system, fire hose reels and portable fire extinguishers) comply with the NCC DTS requirements for a Class 6 building with a rise in storeys of 2, except where modified by this document. Therefore, the potential fire intensity and the fire hazards in this building are in line with that of an NCC DTS Retail Tenancy building.

Based on the departure, the performance requirements to be achieved and the description provided in the Guide to the NCC, the fire hazard associated with an increased exit travel distance in a Class 6 building relates to:

- the spread of fire and/or its products into the egress paths;
- the time for the detection of the fire and/or its products;
- the impact of the fire and/or its products on the occupants; and
- the impact on the ability of the Fire Brigade to intervene.

Within Class 6 parts of a building it is considered that the occupants will be awake, alert and be aware of their surroundings.

The Building Solution comprises a number of fire safety systems. Two of the primary active fire safety systems are smoke exhaust and fire sprinklers. Within the compartments being assessed, which the smoke exhaust system and the fire sprinkler system is the subject of a Performance Solution. The NCC DTS requirements for smoke exhaust, particularly reservoir sizes and the associated requirements for smoke baffles, present difficulties from a construction and operational perspective, and hence the smoke exhaust system has been designed from a performance framework.

In order to show that the proposed smoke hazard management strategy will maintain tenable conditions in evacuation routes for the duration of occupant evacuation, fire, smoke and occupant evacuation modelling was undertaken in Section 6.

The modelling considered the following aspects of the smoke hazard management system:

a. Rationalised capacity and exhaust rates required for the mechanical smoke exhaust system;

b. The number and location of the exhaust points;

c. Extent of low level free area for make-up air.

Table 7.9 summarises the results of the fire modelling and evacuation modelling undertaken in Section 6.

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Table 7.9 – ASET vs RSET

Scenario	ASET (sec)	RSET (sec)	Safety Factor		Acceptable (Yes/No)
			Achieved	Required	
1A	740	432	1.7	1.5	**Yes**
1B	740	548	1.3	1.0	**Yes**
1C	740	488	1.5	1.0	**Yes**
2D	540	415	1.3	1.0	**Yes**
3E	750	434	1.7	1.5	**Yes**
4F	550	419	1.3	1.0	**Yes**

The outcomes of the Available Safe Egress Time (ASET) versus Required Safe Egress Time (RSET) analysis indicate that tenable conditions are maintained for a sufficient duration to allow occupants to safely evacuate. The models show that a safety factor of at least 1.5 is achieved, and that a safety factor of at least 1.0 is achieved for the sensitivity scenarios.

The positive impact of fire brigade intervention has not been incorporated into the assessment or the analyses. This is considered to be a conservative assumption. However, the modelling result shown in Section 6 also indicates that the tenability criteria for fire fighter life safety are maintained for the duration of the analysis (1,800 seconds).

Omission of Smoke Exhaust Fans

The building is considered to have a volume which is greater than 108,000m^3, and as a result is required to be provided with smoke exhaust throughout. However, one tenancy (T5) is not provided with smoke exhaust as part of the performance-based solution.

The building is divided into two (2) separate smoke compartments. Smoke Zone 1 is provided with smoke exhaust fans at roof level. The Performance Solution relates to Smoke Zone 2 (Tenancy T5). This compartment is less than 1,000m^2 in area, and is accessed directly via the Mall, as shown in Figure 7.3.

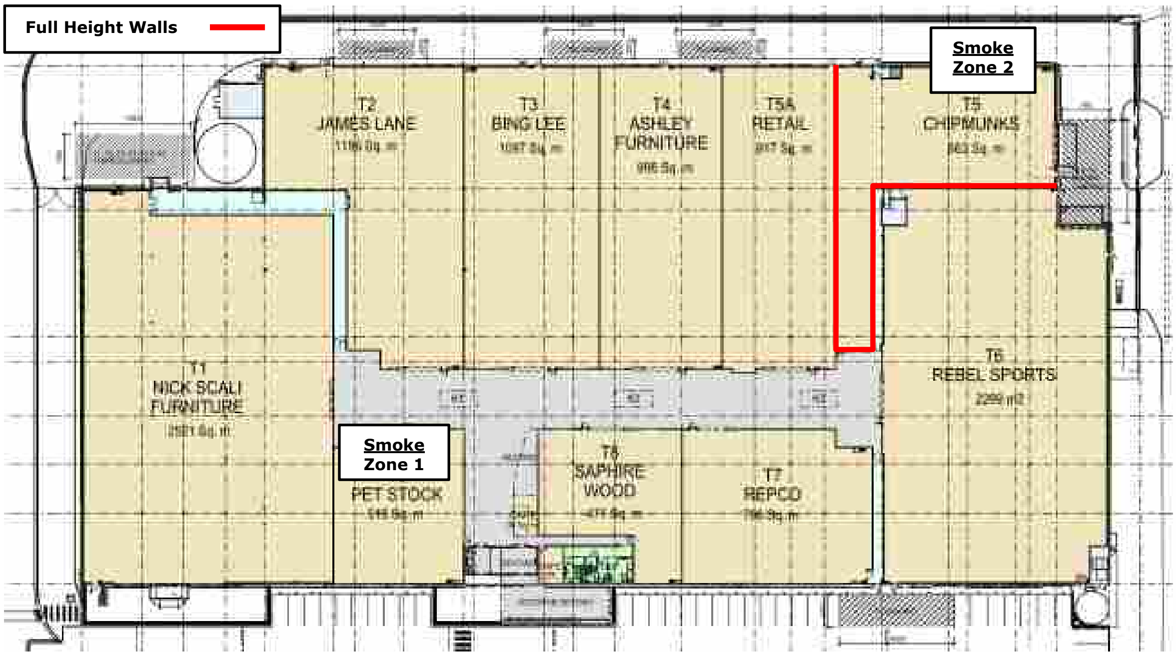

Figure 7.3 - Full Height Wall Locations

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Class 6 SOU which:

a. has a floor area of not more than 1,000m^2, and

b. opens onto the enclosed common mall,

is <u>not</u> required to be provided with smoke exhaust fans.

However, as this is a Large Isolated Building (LIB) with a volume greater than 108,000m^3, the smoke exhaust system is required to be provided throughout the building. Nevertheless, in terms of occupant life safety within the tenancy of fire origin, the total volume of the building is of minor consequence, and the level of safety in the compartment not provided with smoke exhaust fans is considered the same as for a similar tenancy in a LIB less than 108,000m^3 in volume.

As part of the Performance Solution, the areas of the building not provided with smoke exhaust are to be provided with a smoke detection system spaced in accordance with AS 1670.1-2015. In the event of a fire within the subject tenancy not provided with smoke exhaust fans, it is expected that occupants will become aware of the fire in its early stages due to the increased level of smoke detection. Also, the tenancy includes multiple exits directly to outside, as well as the main entrance leading to the Mall. It is expected that due to the relatively small size of the tenancy (863m^2), and the availability of exits, upon fire alarm occupants will be able to reach the outside the tenancy (either directly outside the building, or via the Mall entrance into an area served by smoke exhaust) before conditions become untenable. Furthermore, the building is provided with a fire sprinkler system, a fire hydrant system, a fire hose reel system and fire extinguishers.

Considering the above information, the omission of smoke fans from Tenancy T5 is not expected to negatively impact upon occupant life safety, or Fire Brigade Intervention.

The positive impact of Fire Brigade Intervention has not been incorporated into the assessment or the analyses. This is considered to be a conservative assumption. However, the modelling results shown in Section 6 also indicate that the conditions for fire fighter intervention are maintained for the duration of the analyses (1,800 seconds) within all Primary Studies.

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7.4.8 Conclusion

Table 7.10 provides a review of the relevant considerations of the identified Performance Requirements EP2.2, so that compliance with the NCC can be achieved.

Table 7.10 – Performance Requirement EP2.2

Performance Requirement	Comment
EP2.2(a) – In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building so that –	
the temperatures will not endanger human life	Addressed as part of the assessment to show conditions are maintained for occupant evacuation.
the level of visibility will enable the evacuation route to be determined	
the level of toxicity will not endanger human life	
EP2.2(b) – The period of time occupants take to evacuate referred to in (a) must be appropriate to –	
the number, mobility and other characteristics of occupants	The dominant occupant characteristics are discussed as part of the project description with their parameters defined in the Egress Scenarios section. Addressed as part of assessment – demonstrated to show conditions are maintained for occupant evacuation.
the function and use of the building	Retail, Assembly. Considered when defining parameters such as occupant characteristics, fire loads and fire hazards, and safety measures for the building.
the travel distance and other characteristics of the building	Addressed as part of assessment – demonstrated to show conditions are maintained for occupant evacuation.
the fire load	Addressed as part of assessment – fire load, intensity and hazards are in line with what would be expected in a building with the considered function or use.
the potential fire intensity	
the fire hazard	
any active fire safety systems installed within the building	Considered as part of the assessment – when assessing parameters and outcomes (i.e., alarm time and fire size).
Fire Brigade intervention	The positive impact of the Fire Brigade Intervention has not been incorporated. This is considered to be a conservative assumption. Appropriate fire fighting services have been provided to enable Fire Brigade Intervention.

Based on the assessment and proposed fire safety measures, the proposed smoke hazard management strategy, including omission of smoke exhaust, is considered not to unduly affect the parameters discussed above in maintaining conditions in any evacuation route for the period of time occupants take to evacuate.

Therefore, it is considered that Performance Requirement EP2.2 is satisfied.

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8. Conclusion

Based on the analysis and assessment undertaken throughout the document, and implementation of the Fire Engineering Outcomes, the Performance Solution is considered to meet the relevant NCC Performance Requirements.

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Appendix A Glossary

This document is to be read in conjunction with the definitions of terms listed in Part A1 of the NCC [1] and the following definitions set by Omnii Pty Ltd. The definitions listed here overrules any difference arising between the NCC and the list below.

Note that the definitions listed below may or may not necessarily apply specifically to this particular project in this instance.

Performance Solution

A Building Solution which complies with the Performance Requirements other than by reason of satisfying the Deemed-to-Satisfy Provisions.

Assessment Method

A method used for determining that a Building Solution complies with the Performance Requirements.

Available Safe Evacuation Time (ASET)

The time between ignition of a Fire and the onset of untenable conditions in a specific part of a building.

Building Solution

A solution which complies with the Performance Requirements and is:

(a) a Performance Solution; or

(b) a solution which complies with the Deemed-to-Satisfy Provisions; or

(c) a combination of (a) and (b).

A Building Solution will comply with the NCC if it satisfies the Performance Requirements.

Comparative

Analysis that compares a Performance Solution to a NCC DTS building of similar geometry and use. It evaluates whether the Performance Solution is equivalent to (or better than) the DTS building.

DTS: Deemed-to-Satisfy (Provisions)

The prescriptive provisions of a code that are deemed to meet the Performance Requirements.

Design Fire

A mathematical representation of a Fire that is characterised by the variation of heat output with time and is used as the basis for assessing Fire Safety Strategy.

Design Fire Scenario

A Fire Scenario that is used as the basis for a design fire.

Deterministic Method

A methodology based on physical relationships derived from scientific theories and empirical results that for a given set of conditions will always produce the same outcome.

Engineering Judgement

Process exercised by a professional who is qualified because of training, experience and recognised skills to complement, supplement, accept or reject elements of a quantitative analysis.

Evacuation

The process of occupants becoming aware of a fire-related emergency and going through a number of behavioural stages before and/or while they travel to reach a place of safety, internal or external, to their building.

Expert Judgement

The process exercised by an appropriate person who is qualified, because of training, experience and recognised skills to complement, supplement and assess a Performance Solution using qualitative analysis or Engineering judgement.

Fire

The process of combustion.

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Fire Engineering Brief (FEB)

A documented process that defines the scope of work for the fire engineering assessment and the basis for analysis as agreed by stakeholders.

Fire Engineering Report (FER)

A document which is to detail the analysis, arguments, calculations and modelling used to verify the design meets the relevant Performance Requirements.

Fire Safety Strategy

One or any combination of the methods used in a building to:

(a) warn people of an emergency,

(b) provide for safe evacuation,

(c) restrict the spread of fire, or

(d) extinguish a fire.

It includes both active and passive systems.

Fire Scenario

The ignition, growth, spread, decay or burnout of a Fire in a building as modified by the Fire Safety Strategy of the building. A Fire Scenario is described by the times of occurrence of the events that comprise the Fire Scenario.

Fire Source Feature (FSF)

A Fire Source Feature (FSF) means:

(a) The far boundary of a road, river, lake or the like adjoining the allotment, or

(b) A side or rear boundary of the allotment, or

(c) An external wall of another building on the same allotment which is not a Class 10 building.

Flaming Fire

A fire involving the production of flames (including flashover fires).

Flashover

The rapid transition from a localised fire to the combustion of all exposed surfaces within a room or compartment.

Fuel Load

The quantity of combustible material within a room or compartment measured in terms of calorific value.

Hazard

The outcome of a particular set of circumstances that has the potential to give rise to unwanted consequences.

Performance Requirement

A requirement which states the level of performance which a Building Solution must meet.

Place of Safety

A place within a building or within the vicinity of a building, from which people may disperse after escaping the effects of a fire. It may be an open space (such as an open court) or a public space (such as a foyer or roadway.

Probabilistic Method

A methodology that relies on the performance of various fire safety systems and measures and assigned frequency of occurrence. A probabilistic method may also incorporate stochastic distributions, in lieu of discrete variables.

Qualitative Analysis

Analysis that involves a non-numerical and conceptual evaluation of the identified processes.

Quantitative Analysis

Analysis that involves numerical evaluation of the identified processes.

Rate of Heat Release (RHR) or Heat Release Rate (HRR)

The rate at which heat is released by fire.

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Required Safe Evacuation Time (RSET)

The time required for safe evacuation of occupants to a place of safety prior to the onset of untenable conditions.

Response Time

The time it takes occupants to respond to an alarm or cues and egress the building.

Risk

The product of the likelihood and consequence of a hazardous event.

Sensitivity Analysis

A guide to the level of accuracy and/or criticality of individual parameters determined by investigating the response of the output parameters to changes in these individual parameters.

Smoke

The airborne solid and liquid particles and gases evolved when a material undergoes pyrolysis or combustion, together with the quantity of air that is entrained or otherwise mixed into the mass.

Smouldering Fire

The solid phase combustion of a material without flames and with smoke and heat production.

Sub-System

A part of a Fire Safety System that comprises Fire Safety measures to protect against a particular hazard (eg smoke spread). Note: The IFEG defines six sub-systems. This also comprises the Fire Safety Strategy.

Tenable Conditions

Environmental conditions associated with a fire in which human life is sustainable.

To The Degree Necessary

Consideration of all the criteria referred to in the Performance Requirement to determine the outcome appropriate to the circumstances, whereby in certain situations it may not be necessary to incorporate any specific measures to meet the Performance Requirement.

Untenable Conditions

Environmental conditions associated with a fire in which human life is not sustainable.

Zone Model

A fire model that divides an enclosure into one or more zones and simulates the emission phenomena, the movement of smoke and the concentrations of toxic species in various enclosures so that times of critical events, such as the detection of the fire and the development of untenable conditions, can be estimated.

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Appendix B Regulatory Report

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BUILDING CODE OF AUSTRALIA REPORT

Masters Repurposing
72/82 Mulgoa Road, Jamistown NSW
Prepared for Home Consortium

Revision A dated 7/12/2016

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7.12.16	A	19	Preliminary	Joel Lewis	Geoffrey Pearce	7.12.16

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Executive Summary

Development Overview

The proposed development is for the repurposing of the Masters located at 72/82 Mulgoa Road, Jamistown NSW for Home Consortium. The existing building is large single storey retail & trade building of approximately 11,618m2 in floor area.

The proposed development seeks to modify the existing building to incorporate nine no.9 new bulky goods tenancies with a common mall area and café.

Compliance Summary Overview

As Accredited Certifiers, we have reviewed architectural design documents prepared by The Buchan Group (refer appendix A) for compliance with the Building Code of Australia 2016, and the state-based legislative provisions relating to existing buildings.

The compliance approach for the repurposing can be summarised as follows:

(1) Establish the original building design principles through a detailed review of the available documentation and approvals history for the site; and
(2) Undertake a detailed BCA compliance assessment of the proposed works to assess the implications of the changes on the original compliance approach adopted for the building; and
(3) Engage with the project Fire Safety Engineer in areas where the original fire safety outcomes need to be reanalysed as part of the proposed works.

Performance Solutions

The assessment of the design documentation for the repurposing works has revealed that the following areas are required to be assessed against the relevant performance requirements of the BCA. The submission for Construction Certificate will need to include verification from a suitably accredited fire for the following:

No.	Alternative Solution Description	DTS Clause	Performance Requirement
1.	Extended travel distances of up to 95m in lieu of 40m where two exits are available. Extended travel distance between exits of 100m in lieu of 60m.	D1.4, D1.5	DP1.4 & EP2.2
2.	Smoke exhaust system to be rationalised on a performance basis.	E2.2	DP4 & EP2.2
3.	Aggregate egress width of 17m has been provided in lieu of 29.5m. To be addressed through a Fire Engineered Performance Solution or further design development.	D1.6	DP6

The fire engineered solution relating to EP2.2 will need to be approved after consultation with the NSW Fire Brigade as part of the Construction Certificate process.

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The application for Construction Certificate shall be assessed under the relevant provisions of the Environmental Planning & Assessment Act 1979 (As Amended) and the Environmental Planning & Assessment Regulation 2000.

Assessed by,

Joel Lewis
McKenzie Group Consulting

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1 INTRODUCTION

The proposed development is for the repurposing of the existing Masters store located at 72/82 Mulgoa Road, Jamistown NSW for Home Consortium. The existing building is large single storey retail and trade building of approximately 11,618m2 in floor area, and from the information available was originally constructed in the year 2014 under BCA 2014 provisions.

The proposed development seeks to modify the existing building to incorporate nine no.9 new retail tenancies with a common mall area and Café.

This report is based upon the review of the design documentation listed in Appendix A of this Report. The report is intended as an overview of the relevant provisions of the Building Code of Australia for assistance only. Detailed drawings and associated review will still be required as the final design is developed.

1.1 Applicable Legislation

The applicable legislation governing the design of buildings is the Environmental Planning and Assessment Act 1979. This Act requires that all new building works must be designed to comply with the BCA.

The version of the BCA applicable to the development, is version that in place at the time of the application to the Certifying authority for the Construction Certificate.

Therefore the applicable BCA year to the proposed work is BCA 2016.

1.2 Upgrade to Existing Buildings

The local authority when assessing the development application may require that the existing building be brought into partial on full compliance with the current provisions at the BCA. The trigger for upgrade includes:

- Where the building works, together with any other works completed or authorised within the previous 3 years, represents more than half the total volume of the building; or

- Where Council are not satisfied that the measures contained in the building are adequate for the safety of the present use of the building.

As mentioned above, it is recommended that an upgrade strategy that has been agreed upon by the design team be submitted as part of the Development Application process. This is to include the upgrade works proposed, the alternate solutions proposed and a schedule of items that are not being altered and not proposed to be upgraded. Timing for proposed upgrade works should also be included in the strategy.

The State Environmental Planning Policy (Exempt and Complying Development Codes) 2008 have the following requirements for commercial alterations and additions:

(a) If the building that is being altered is subject to an alternative solution relating to a fire safety requirement—the alteration must be consistent with that alternative solution,
(b) if the alteration involves an area of more than 500m^{2}of commercial premises, or an area of more than 1,000m^2 of premises used for light industry or a warehouse or distribution centre—that area must:
(i) Comply with the requirements set out in DP2–DP5 of Volume 1 of the *Building Code of Australia*, and
(ii) comply with the number of sanitary and other facilities set out in FP2.1, FP2.5 and FP2.6 of Volume 1 of the *Building Code of Australia*, and
(iii) Comply with the light and ventilation requirements set out in FP4.1–FP4.5 of Volume 1 of the *Building Code of Australia*,

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2 PERFORMANCE SOLUTIONS

A review of the Occupancy Permit and the original Fire Engineering Report prepared by AECOM has identified that the original development was subject to performance solutions for the following items:

Existing Performance Solutions

No.	Alternative Solution Description	DTS Clause	Performance Requirement
Main Floor Area			
1.	Egress from the main floor area exceeds DtS limits of: ▪ 20 m to a point of choice, up to 30 m ▪ 40 m to an exit, up to 70 m	D1.4	DP4
2.	The distance between exits exceeds the DtS limit of 60 m, up to 100 m.	D1.5	DP4
3.	The smoke reservoir area is approximately 8,490 m², where the DtS limit is 2,000 m2	E2.2b	EP2.2
4.	The automatic sliding doors at the main entrance will not be provided with fail safe on fire trip during out of hours trading.	D2.19	DP2
5.	The communications/server room containing uninterruptible power supply (UPS) batteries exceeding 24 V and 10 Ah is not proposed to be enclosed in 2 hour fire rated construction.	C2.12	CP6
External Trade and Receiving Areas			
6.	The distance between alternative exits in the External Trade Area exceeds the DtS limit of 60 m, up to 65 m	D1.5	DP4, EP2.2
7.	The smoke reservoir area for the combined Trade/Receiving area is approximately 2,790 m2, where the DtS limit is 2,000 m2.	E2.2	EP2.2
8.	Activation of smoke exhaust is by sprinklers instead of smoke detectors as per the BCA DtS provisions	E2.2	EP2.2
Garden Area			
9.	The distance between alternative exits is over the DtS limit of 60 m, up to 80 m.	D1.5	DP4, EP2.2
10.	Sprinklers are not proposed under the shade sails of the garden.	E.15	EP1.4

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	This non-sprinklered area will not be fire separated from the sprinklered main floor area.		
11.	No smoke exhaust fans will be provided in the garden centre.	E2.2	EP2.2
Admin Areas			
12.	No smoke exhaust will be provided in the admin areas	E2.2	EP1.4
Fire Brigade Vehicle Access			
13.	Due to the location of the carpark access road from Regentville Road, continuous access is not available to the southeast of the building. Some parts of the emergency access route do not achieve 6 m access width due to the location of required bollards along the northeast elevation.	C2.4	CP9

Based on a review of the current design scheme for the building, the following performance solutions (which vary from the existing solutions) are to be considered by the project Fire Safety Engineer.

3 PRELIMINARIES

3.1 Building Assessment Data

Summary of Construction Determination: -

Part of Project	
Classification	6
Number of Storeys	1
Rise In Storeys	1
Type of Construction	Type C (Large isolated Building)
Effective Height (m)	<12m
Climate Zone	6

Summary of the floor areas and relevant populations where applicable: -

Part of Project	BCA Classification	Approx. Floor Area (m^2)	Approximate Volume (m^3)	Assumed Population
Tennant 1	6	1,274	TBC	425

Tennant 2	6	1,648	TBC	550
Tennant3	6	700	TBC	234
Tennant 4	6	361	TBC	121
Tennant 5	6	1,036	TBC	346
Tennant 6	6	1,750	TBC	584
Tennant 7	6	385	TBC	129
Tennant 8	6	385	TBC	129
Tennant 9	6	560	TBC	187
Ancillary Café	6	35	TBC	35
Mall	6	1,025	TBC	342
Total	**6**	**9,159**	**TBC**	**3,082**

Notes:
1. The above populations have been based on the floor areas and calculations in accordance with Table D1.13 of the BCA.
2. 30% has been allowed off the specified floor areas to allow for racking and back of house areas

3.2 Structural Provisions — BCA B1

Any new structural works associated with the project (e.g. closing in the garden roof) are to comply with the applicable requirements of AS/NZS 1170.0-2002, AS/NZS 1170-1-2002, and AS/NZS1170.2-2011.

Pursuant to Clause B1.2 (Table B1.2a and B1.b) of the BCA the importance level of the building is expected to be Level 2.

The structural engineer will need to consider the existing and any proposed precast walls to ensure they be designed to collapse inwards as per the requirements of BCA Clause C1.11, Specification C1.11.

Where fire shield walls are required to protect external fire hydrants, the design of panel is to ensure that a minimum 90/90/90 FRL can be achieved as per AS2419.1, alternatively the report and consent of the fire authority may be required to vary this requirement.

4 FIRE PROTECTION

4.1 Fire Compartmentation — BCA C1.1

As the existing building exceeds the floor area and volume limitations of the BCA, the building is considered a large isolated building and the following provisions apply:

- Automatic sprinkler protection to AS2118.1 and BCA specifications E1.5 is required throughout the entire building; and
- Perimeter emergency vehicular access 6m wide located within 18m of the entire building perimeter.

It is noted that the existing perimeter vehicle access is not BCA deemed to satisfy and that a Fire Engineered Performance Solution is in place.

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4.2 Fire Resistance — BCA C1.1

The existing building should have been constructed in accordance with the relevant provisions of Specification C1.1 applicable to Type C Construction. Based on the proximity of the building to fire source features, no building elements would have been required to achieve an FRL.

The repurposing scope of works does not impose any additional fire rated construction requirements to that which would have existed at the time of construction.

4.3 Fire Hazard Properties — BCA C1.10 and BCA C1.12

The fire hazard properties of fixed surface linings and mechanical ductwork will also need to be addressed within the detailed documentation phase pursuant to specification C1.10 Building Code of Australia. The following requirements apply:

<u>Sprinkler Protected Areas</u>

- Floor Coverings – Critical radiant Flux not less than 1.2 kW/m^2;
- Wall and Ceiling Linings – Material Group No. 1, 2 or 3;
- Other Materials – Spread of Flame Index not exceeding 9 and Smoke Developed Index not exceeding 8;
- Rigid and flexible air handling ductwork must comply with AS4254 parts 1 & 2 2012.

5 EGRESS PROVISIONS

5.1 Provisions for Escape — BCA D1

The egress provisions from the building comprise external perimeter doorways, most of which are proposed to be retained. As outlined below a detailed reassessment of the egress provisions has been undertaken to assess the implications of existing egress measures.

5.2 Exit Travel Distances — BCA D1.4 and D1.5

The prescribed travel distances to exits are as follows under the BCA:

<u>Class 5-9</u>

- For Class 5 or 6 tenancies that open directly to the outside, a maximum distance of 30m to a single exit is permitted.
- 20m to a single exit or point of choice and where two exits are provided, a maximum of 40m to one of those exits; and
- Exits shall be located to not be more than 60m apart and not closer than 9m

The original building included extended travel distances and distances between alternative exits. As the repurposing works will alter the existing egress a measure, a reassessment has been completed which has revealed the following:

- Extended travel distances of up to 95m in lieu of 40m where two exits are available.
- Up to 100m between alternative exits in lieu of 60m.

The Fire Safety Engineer will need to assess/reassess the above extended travel distances and distances between alternative exits as a performance solution using BCA Performance Requirements DP4 and EP2.2.

5.3 Dimensions of Exits — BCA D1.6

Minimum dimensions of 1000mm and 2000mm height to be provided within exits, with the paths of travel should provide a minimum width of 1000mm.

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The following table summarises the exit widths required by BCA Clause D1.6:

Area	Number of People	Exit Width Required	Exit Width Provided
Tennant 1	425	3.5m	1m
Tennant 2	550	4.5m	2m
Tennant3	234	2.5m	0m
Tennant 4	121	1.25m	0m
Tennant 5	346	4m	1m
Tennant 6	584	5m	5m
Tennant 7	129	1.5m	0m
Tennant 8	129	1.5m	0m
Tennant 9	187	2m	0m
Café	35	1m	0m
Mall	342	3m	8m
Total Population	**3,082**	**29.75m**	**17m**

Fire engineering may be sought for additional reduced aggregate egress width or additional doors may be provided.

Doorways are permitted to contain a clear opening width of the required width of the exit minus 250mm, with a height of 1980mm as part of egress requirements. Access for persons with disabilities however requires a clear doorway opening width of 850mm (i.e minimum 920 mm doors).

5.4 Balustrading and Handrails — BCA D2.16 and BCA D2.17

Generally

Balustrading to a height of 1000mm with a maximum opening of 125mm in any direction should be provided adjacent to balconies, landings, corridors etc. where located adjacent to a change in level exceeding 1000mm.

The public stairs and ramps located along an accessible path of travel should be designed in accordance with the requirements of AS1428.1 for persons with disabilities. This requires a handrail on each side of the stair and ramp and for the handrail to extend approximately 550mm – 600mm past the last tread / end of ramp.

5.5 Slip Resistance

Pursuant to Clause D2.14 of the BCA, the following provisions relate to slip resistance of stairway treads and ramp surfaces:

Application	Surface conditions	
	Dry	Wet

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Ramp steeper than 1:14	P4 or R11	P5 or R12
Ramp not steeper than 1:14	P3 or R10	P4 or R11
Tread or landing surface	P3 or R10	P4 or R11
Nosing or landing edge strip	P3	P4

5.6 Sliding Doors & Roller Shutter Doors

Power operated sliding doors that open directly to open space must open automatically if there is a power failure to the door or on the activation of the fire or smoke alarm anywhere in the fire compartment linked to the door.

Roller shutter doors must not be fitted within a required exit or door forming part of a required exit unless the building or part has a floor area not more than 200m², and the doorway is the only required exit from the building or part, and the door is held in the open position while the building or part is lawfully occupied.

6 ACCESS FOR PEOPLE WITH DISABILITIES

6.1 General Building Access Requirements BCA D3.1

Access for people with disabilities shall be provided to and within all areas normally used by the occupants in accordance with the requirements of Clause D3.2, D3.3 and D3.4 of the BCA 2016. Parts of the building required to be accessible shall comply with the requirements of:-

- AS1428.1-2009 General Requirements for Access – New Building Work;
- AS1428.4-2009 Tactile Ground Surface Indicators
- AS2890.6-2009 Car Parking for People with Disabilities

6.2 Provision for Access to Buildings

The BCA prescribes access to be provided to and within the building as follows:

- Via the principle public entry and at least 50% of all other entrances
- From designated car parking spaces for the use of occupants with a disability.
- All areas used by the public.

In buildings over 500m2 in floor area, a non-accessible entrance must not be located more than 50m from an accessible entrance.

Given the relatively recent construction of the building, the external access ways are expected to generally comply with current provisions.

6.3 Provisions for Access within Buildings BCA D3.3

Within the building the following are required;

- Door circulation space as per AS1428.1 Clause 13.3;
- Doorways must have a clear opening of 850mm (920mm minimum door leaf);
- Passing spaces (1.8m wide passages) must be provided at maximum of 20m intervals
- Within 2.0m of end access ways/corridors, turning areas spaces are required to be provided.
- Carpet pile height of not more than 11mm to an adjacent surface
- Any glazed capable of being mistaken for a doorway or opening must be clearly marked (or contain chair rail, hand rail or transom as per AS 1288 requirements)

The base building design would generally comply with the prescriptive provisions of the BCA with additional ongoing review being undertaken to determine compliant door widths, doorway and corridor circulation, etc.

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6.4 Car parking — BCA D3.5

Accessible car parking spaces are required to be provided within the off-street car park based on a ratio of 1 space per 50 car spaces (where up to 1000 car spaces are proposed). The existing carpark layout includes 345 spaces, thus requiring 7 dedicated car spaces.

The current carpark layout includes 8 dedicated spaces, which currently complies with the above requirements

Car spaces shall be designed in accordance with AS2890.6. The car park spaces shall be a minimum 2.4m wide x 5.4m (long). The same provisions apply to the shared spaces.

6.5 Tactile Indicators — BCA D3.8

Tactile indicators are required to be provided to warn occupants of all stairs (except Fire Isolated stairs) and ramps regardless of public nature or private environment and where an overhead obstruction occurs less than 2.0m above the finished floor level.

7 FIRE SERVICES AND EQUIPMENT

The following section of this report describes the essential fire safety measures and the minimum performance requirements of those measures and is based on the existing information available for the building which outlines the existing measures currently in place.

7.1 Fire Hydrants — BCA E1.3

A system of Fire Hydrants is understood to be provided in accordance with BCA Clause E1.3 and AS2419.1-2005, including a booster assembly. To be confirmed by review of the Annual Fire Safety Statement

The details of this existing system will need to be reviewed in relation to the following:

- The suitability of the existing booster and pump room locations;
- The presence of a fire hydrant ring main with accessible isolated valve locations;
- Confirmation as to the current standard of performance meets the requirements of AS2419.1-2005
- Coverage, design, pressures and flows to be demonstrated they are sufficient for base build and fit it out works.

7.2 Fire Hose Reels — BCA E1.4

A fire hose reel system is understood to have been provided in accordance with BCA Clause E1.4 and AS2441-2005. To be confirmed by review of the Annual Fire Safety Statement.

An assessment of fire hose reel coverage for the new layout will need to be undertaken, ensuring the appropriate flexibility is include for future tenant fitout, from the Hydraulic Consultant.

7.3 Fire Extinguishers

BCA Table E.6 details when portable fire extinguishers are required:

Occupancy Class	Risk Class (as defined in AS 2444)
General provisions	(a) To cover Class AE or E fire risks associated with emergency services switchboards. (b) To cover Class F fire risks involving cooking oils and fats in kitchens. (c) To cover Class B fire risks in locations where flammable liquids in excess of 50 litres are stored or used (not excluding

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Occupancy Class	Risk Class (as defined in AS 2444)
	that held in fuel tanks of vehicles).

7.4 Automatic Sprinkler Protection — BCA E1.5

Automatic sprinkler protection is required to Specification E1.5 and AS2118.1-1999 throughout the entire building. To be confirmed by review of the Annual Fire Safety Statement.

An assessment of the suitability of the existing installation is to be undertaken by the fire services consultant as part of the repurposing works.

Other items to note:

- Project fire engineer to determine whether fast response sprinkler heads will be required. in accordance with the outcomes of the Fire Engineering Report.
- Location of the sprinkler control valves and sprinkler zones are to be documented by fire services engineer.
- The capacity of the on-site static storage tank is to be determined and confirmed by the fire services engineer.
- The sprinkler hazard classification is to be determined by the fire services engineer.
- Coverage, and design to be demonstrated they are sufficient for base build and fit it out works.

7.5 Exit Signs and Emergency Lighting — BCA E4.2 and BCA E4.5

Emergency Lighting and Exit Signs indicating exit location paths of travel to exits to be provided in accordance with AS2293.1-2005 to suit the new layout.

7.6 Smoke Hazard Management — BCA E2.2

The building requires an automatic smoke exhaust system complying with BCA Specification E2.2b. It is understood that the building includes a performance based smoke exhaust system utilising Fusion Fans which were assessed as part of the original Fire Engineering Report, including:

- Rationalisation of smoke exhaust performance through Fire Engineering process to meet performance requirement EP2.2

The repurposing works seek to subdivide the building into a number of smaller retail tenancies separated by part-height intertenancy walls, with a common mall area. Whilst the building will still effectively operate as one smoke reservoir, the impact of this redesign on smoke exhaust performance and occupant/fire brigade safety will need to be reassessed by the Fire Safety Engineer as part of the project.

Based on the new internal building layout, smoke hazard management provisions required are as follows:

- Common mall; and
- Tenancies greater than 1000m² in floor area opening into the mall.

The following DTS provisions are referenced in BCA Specification E2.2a & E2.2b:

- Smoke detectors are to be installed in location as prescribed by AS1670.1-2015
- Activate a building occupant warning system designed as per the requirements of Clause 6 of Specification E2.2a.
- Smoke reservoirs are not permitted to exceed 2000m² or 60m in length in enclosed malls, unless addressed through a Fire Engineered Performance Solution.
- A provision for make-up air via automatic or permanent ventilation openings needs to be considered and articulated through the Fire Engineering process.

Variations to the above requirements will need to be presented by the mechanical services engineer and supported by the project fire engineer.

8 HEALTH AND AMENITY

8.1 Sanitary Facilities — BCA F2.2 and BCA F2.3

Retail

Sanitary facilities are required to be provided for employees and the public in accordance with BCA Clause F2.3 requirements.

The exact number of staff is to be provided by Home Consortium for further analysis.

The anticipated design populations are as follows:

- Staff – Assume 125 persons
- Public – Assume 3,082 persons

The above numbers are based on a ratio of 25:1, public to staff.

Public

For the main part of the building, to cater for up to 2685 patrons, which includes patrons within all tenancies (including cafe), the following minimum sanitary facilities are required:

Sanitary Facilities Required			
	WC	Urinals	Basins
Male	8	18	10
Female	19	-	10
Accessible	1	-	1

It is noted the proposed amenities shown is sufficient for the public numbers above.

Staff

For staff:

To cater for up to 88 staff occupying the tenancies, the following minimum sanitary facilities are required:

Sanitary Facilities Required			
	WC	Urinals	Basins
Male	3	3	2
Female	4	-	3
Accessible	1	-	1

Notes
The Unisex facilities provided for people with disabilities may be counted once for each sex. These facilities are to be provided in accordance with AS1428.1-2009.

8.2 Floor Wastes — BCA F1.11

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Floor wastes are required to be provided where wall hung urinals are provided and the floor shall be sloped towards these wastes.

8.3 Light and Ventilation — BCA Part F4

The implications of the redesign on light and ventilation provisions will need to assess including:

- New or altered mechanical ventilation systems must comply with AS1668.2-2012
- New or altered artificial lighting must comply with AS/NZS1680.0-2009

If tenancy fit out works over 500m2 are carried out under the State Environmental Planning Policy (Exempt and Complying Development Codes) 2008 the light and ventilation is required to comply with the light and ventilation requirements set out in FP4.1–FP4.5 of Volume 1 of the Building Code of Australia.

9 ENERGY EFFICIENCY

The existing building is assumed to have been assessed against the relevant provisions of BCA Section J, as applicable at the time construction. The proposed works do not seek to significantly alter the existing building fabric, and as the use has not changed, a reassessment and/or upgrade to meet current Section J requirements is not considered necessary.

The following approach should be adopted with respect to Section J compliance for the project:

- The new roof and walls of the garden centre (which are to be enclosed) shall comply with current Section J1 requirements
- New or altered mechanical ventilation and air conditioning systems shall comply with current Section J5 requirements;
- New or altered artificial lighting and power installations shall comply with current Section J6 requirements.
- Energy monitoring facilities shall comply with Section J8 requirements.

Appendix A - Design Documentation

The following documentation was used in the assessment and preparation of this report: -

Drawing No.	Title	Date	Drawn By	Revision
ATP-10001	Site Plan	21/11/16	The Buchan Group	P01
ATP-20001	Floor Plan	21/11/16	The Buchan Group	P01
ATP-20002	Roof Plan	21/11/16	The Buchan Group	P01
ATP-40001	Elevations	21/11/16	The Buchan Group	P01
ATP-50001	Sections	21/11/16	The Buchan Group	P01

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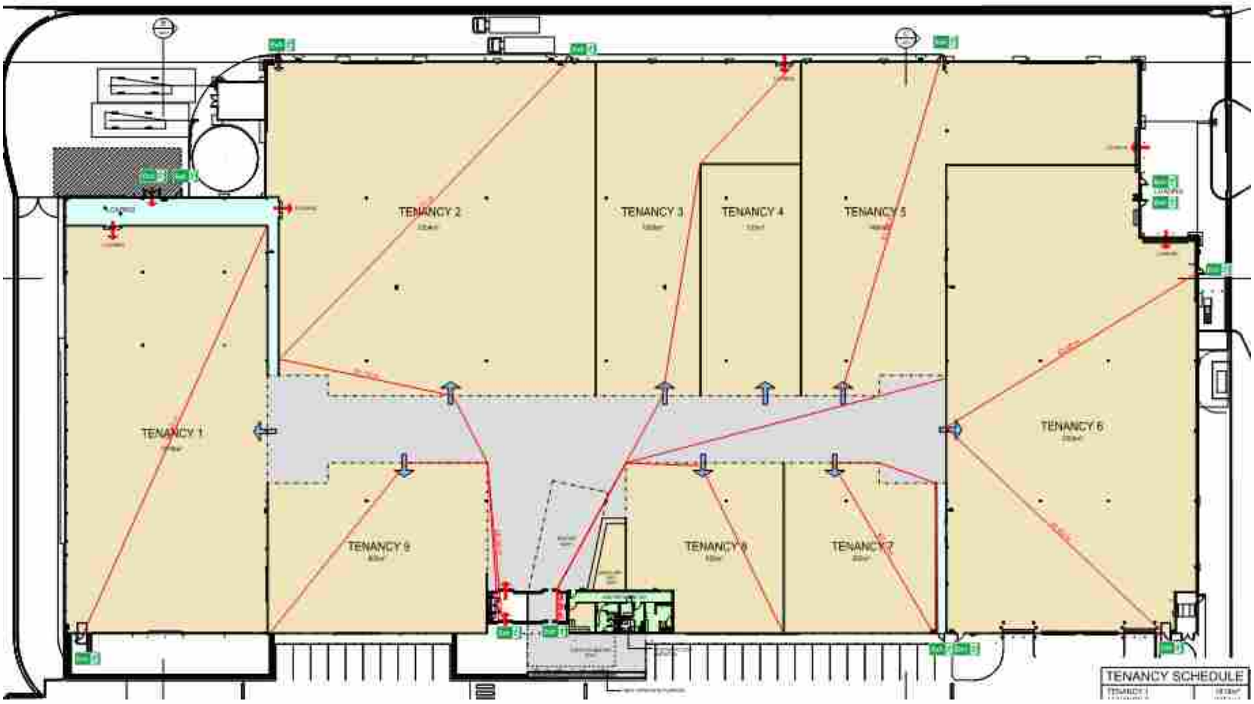
Appendix B – Fire Resistance Levels
Table 5 TYPE C CONSTRUCTION: FRL OF BUILDING ELEMENTS

Building element	**Class of building—FRL: (in minutes)**			
	Structural adequacy/Integrity/Insulation			
	2, 3 or 4 part	**5, 7a or 9**	**6**	**7b or 8**
EXTERNAL WALL (including any column and other building element incorporated therein) or other external building element, where the distance from any *fire-source feature* to which it is exposed is—				
Less than 1.5 m	90/ 90/ 90	90/ 90/ 90	90/ 90/ 90	90/ 90/ 90
1.5 to less than 3 m	–/–/–	60/ 60/ 60	60/ 60/ 60	60/ 60/ 60
3 m or more	–/–/–	–/–/–	–/–/–	–/–/–
EXTERNAL COLUMN not incorporated in an *external wall*, where the distance from any *fire-source feature* to which it is exposed is—				
Less than 1.5 m	90/–/–	90/–/–	90/–/–	90/–/–
1.5 to less than 3 m	–/–/–	60/–/–	60/–/–	60/–/–
3 m or more	–/–/–	–/–/–	–/–/–	–/–/–
COMMON WALLS and FIRE WALLS—	90/ 90/ 90	90/ 90/ 90	90/ 90/ 90	90/ 90/ 90
INTERNAL WALLS-				
Bounding *public corridors*, public lobbies and the like—	60 / 60/ 60	–/–/–	–/–/–	–/–/–
Between or bounding *sole-occupancy units*—	60/ 60/ 60	–/–/–	–/–/–	–/–/–
Bounding a stair if *required* to be rated—	60/ 60/ 60	60/ 60/ 60	60/ 60/ 60	60/ 60/ 60
ROOFS	–/–/–	–/–/–	–/–/–	–/–/–

Appendix C – BCA Mark Up's



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Appendix C Existing Fire Engineering Report

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Masters Penrith, FER
Hydrox Nominees Pty Ltd
25-Aug-2014
Doc No. 60323569-FRFE-0001_B

Masters Home Improvement, Penrith

Fire Engineering Report

Strictly Confidential
Prepared for Aurrum

Masters Home Improvement, Penrith

Fire Engineering Report

Client: Hydrox Nominees Pty Ltd

ABN: 21 066 891 207

Prepared by

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25-Aug-2014

Job No.: 60323569

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Quality Information

Document Masters Home Improvement, Penrith

Ref 60323569

Date 25-Aug-2014

Prepared by Alex Duffy

Reviewed by Jessica Tang

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	31-July-2014	Draft for design team review	Jonathan Gormley Principal Fire Safety Engineer	
B	25-Aug-2014	Updated following design team review	Jonathan Gormley Principal Fire Safety Engineer	Jonathan Gormley.

For and on behalf of AECOM Australia Pty Ltd, this Fire Engineering Report has been reviewed by an Accredited C10 Fire Safety Engineer, Jonathan Gormley (BPB 2154).

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Executive Summary

This Fire Engineering Report (FER) relates to the construction of the new Masters Home Improvement Store, 72/82 Mulgoa Road, Jamisontown, NSW 2750. The building consists of the following areas: main floor area, semi external garden area, an external trade area, a receiving area and ancillary administration areas,

AECOM Australia Pty Ltd (AECOM) has been appointed by Hydrox Nominees Pty Ltd to develop Fire Engineered Alternative Solutions to the Building Code of Australia (BCA) Deemed-to-Satisfy (DtS) provisions identified in Table 1. These variations to DtS provisions have been identified by the BCA Consultant/Certifying Authority, Vic Lilli & Partners. This is to demonstrate that the building meets the Performance Requirements of the BCA.

Table 1 Summary of Alternative Solutions and Mitigation Measures

No.	DtS Non-Compliance *(Performance Requirements)*	Description	Alternative Solution
Main Floor Area			
1.	D1.4 - Travel distance *(DP4)*	Egress from the main floor area exceeds the DtS limits of: • 20 m to a point of choice, up to 30 m. • 40 m to an exit, up to 70 m.	The main floor area is to be provided with an aspirating smoke detection system, ESFR sprinkler system, and smoke exhaust system with 46 m³/s total smoke exhaust rate. The exhaust rate will be distributed across 4 exhaust points. This facilitates occupant evacuation before the onset of untenable conditions. Make-up air is to be provided from doors that are connected to the trade/receiving area and garden centre, which will automatically trip open upon smoke detection in either of the spaces. The make-up air will have a total effective clear area of 20 m^2.
2.	D1.5 - Distance between alternative exits *(DP4)*	The distance between alternative exits is over the DtS limit of 60 m, up to 100 m.	
3.	E2.2 - Smoke reservoir size *(EP2.2)*	The smoke reservoir area is approximately 8,490 m^2, where the DtS limit is 2,000 m^2.	
4.	D2.19 (b) (iv) – Operation of main entry / exit sliding doors *(DP2)*	The automatic sliding doors at the main entrance will not be provided with fail safe on fire trip during out of hours trading.	The qualitative solution is based on the following: - The automatic sliding exit doors will be openable via a push button device located adjacent to the door. - Appropriate identification signage will be provided adjacent to the push button, identifying the use of the button to open the door. - In the event of a fire alarm and power failure to the building and the failure of the backup battery supply to the doors the automatic doors will failsafe to the open position.
5.	C2.12 – Separation of UPS system *(CP6)*	The communications/server room containing uninterruptible power supply (UPS) batteries exceeding 24 V and 10 Ah is not proposed to be enclosed in 2 hour fire rated construction.	The qualitative solution is based on the following: - The proposed batteries in the UPS room will release less hydrogen gas and are suitable for use in confined/poorly ventilated spaces, reducing risks of fire/explosion. - The UPS room is provided with fire safety measures including smoke detection and sprinklers

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No.	DtS Non-Compliance *(Performance Requirements)*	Description	Alternative Solution
External Trade and Receiving Areas			
6.	D1.5 – Distance between exits *(DP4, EP2.2)*	The distance between alternative exits in the External Trade Area exceeds the DtS limit of 60 m, up to 65 m	The area is to be provided with a smoke exhaust system with 30 m³/s of smoke exhaust, activated by ESFR sprinklers. This will maintain a higher steady state smoke layer than a BCA DtS compliant arrangement, and sprinklers will activate prior to stead state conditions.
7.	E2.2 – Smoke Reservoir Size *(EP2.2)*	The smoke reservoir area for the combined Trade/Receiving area is approximately 2,790 m^2, where the DtS limit is 2,000 m^2.	
8.	E2.2 – Activation of Smoke Control *(EP2.2)*	Activation of smoke exhaust is by sprinklers instead of smoke detectors as per the BCA DtS provisions	
Garden Area			
9.	D1.5 – Distance between alternative exits *(DP4 and EP2.2)*	The distance between alternative exits is over the DtS limit of 60 m, up to 80 m.	The garden centre is to be provided with an ESFR sprinkler system under the metal roof (but not under the shade sails or where the roof is open). The fuel loads in the space comprise mostly of non-combustibles, and the open area of the roof will provide over 16x the area required for DtS natural ventilation.
10.	E1.5 - Partial omission of sprinklers *(EP1.4)*	Sprinklers are not proposed under the shade sails of the garden. This non-sprinklered area will not be fire separated from the sprinklered main floor area.	
11.	E2.2 - Omission of mechanical smoke exhaust *(EP2.2)*	No smoke exhaust fans will be provided in the garden centre.	
Admin Areas			
12.	E2.2 - Omission of smoke exhaust *(EP1.4)*	No smoke exhaust will be provided in the admin areas.	Smoke exhaust will not be provided based on the small floor area of the admin accommodations. In the event of a fire in the admin areas, smoke will vent into the Main Floor Area and/or the External Trade/Receiving Area where it will rise to roof level and will be extracted by the smoke exhaust system serving the space. Additionally the travel distance in the areas will meet the BCA DtS provisions and the areas will be protected with light hazard sprinkler system with fast response heads.

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No.	DtS Non-Compliance *(Performance Requirements)*	Description	Alternative Solution
Fire Brigade Vehicle Access			
13.	C2.4 – Fire brigade vehicle access *(CP9)*	Due to the location of the carpark access road from Regentville Road, continuous access is not available to the southeast of the building. Some parts of the emergency access route do not achieve 6 m access width due to the location of required bollards along the northeast elevation.	Fire brigade vehicles will be capable of travelling in a forward direction around the entire building. Fire brigade vehicles will be able to park and set up operations to effectively combat a fire at any location within the building.

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1.0 Introduction

1.1 The Report

This FER relates to the construction of the new Masters Home Improvement Store, 72/82 Mulgoa Road, Jamisontown, NSW 2750. The building consists of the Main Floor area, semi external Garden area, an External Trade area, Receiving area and ancillary Administration areas.

The Retail Tenancies located on the southern portion of the site are not included in this FER.

1.2 Scope

AECOM has been appointed by Hydrox Nominees Pty Ltd to develop Fire Engineered Alternative Solutions to the BCA DtS provisions identified in Table 1. This is to demonstrate that the building meets the Performance Requirements of the BCA.

This FER includes analysis to support and justify these fire engineered solutions. Variations to DtS provisions have been identified by the Certifying Authority, Vic Lilli & Partners.

1.3 Project Stakeholders

Project stakeholders participating in the fire engineering process are listed in Table 2.

Table 2 Project Stakeholders

Name	Company	Role	Contact Details
Shaylie Walton	Hydrox Nominees P/L	Project Manager	04 0868 0989
Jennifer Johnston	Leffler Simes Architects	Architect	02 9909 3344
Claude Concha	Richard Crookes Constructions	Contractor	02 9902 4671
Dean Morton	Vic Lilli & Partners	BCA Consultant/Certifying Authority	04 3777 4390
TBC	Fire and Rescue New South Wales	Referral Authority	02 9742 7400
George Pattalis	Acor Consultants	Hydraulics / Fire Services	02 8934 0000
Alex Clulee	Fusion HVAC P/L	Mechanical Engineer	07 3118 5536
Todd Halliday	Northrop Consulting Engineers P/L	Structural Engineer	02 6285 1822
Jonathan Gormley	AECOM	Fire Safety Engineer	02 8934 0000

1.4 Fire Brigade Referral

The Fire Brigade have their own charter for the protection of life, property and environment.

Under Clause 144 of the NSW Environmental Planning and Assessment Regulation 2000, the design for buildings of a certain size must be referred to Fire and Rescue New South Wales (FRNSW) where Alternative Solutions are developed to meet the Performance Requirements contained in Category 2 fire safety provisions (CP9, EP1.3, EP1.4, EP1.6, EP2.2 and EP3.2). As this development triggers a Category 2 measure, based on the building size, the Fire Brigade referral process must be followed before a Construction Certificate can be issued by the Certifying Authority.

The FEBQ was submitted to FRNSW on 21/07/2014 and is registered under Reference no. BFS14/1495 (Job Number 6393).

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2.0 Reference Information

2.1 Regulatory Framework

The following New South Wales Legislation is applicable:

1. NSW Environmental Planning and Assessment Act, 1979 and subsequent amendments.
2. NSW Environmental Planning and Assessment Regulation, 2000 and subsequent amendments.

This FER has been prepared by AECOM to meet the legislative requirements of the NSW Environmental Planning and Assessment Regulations 2000, to support the application for a Construction Certificate (CC). Vic Lilli is the Certifying Authority for purposes of assessing an application for a CC for this project.

2.2 References

1. BCA 2014, Australia Building Codes Board (ABCB), 2014 and subsequent amendments
2. International Fire Engineering Guidelines (IFEG), ABCB, 2005
3. Guide to the BCA (GBCA), ABCB, 2014
4. SFPE Handbook of Fire Protection Engineering 4th Edition, 2008
5. CIBSE Guide E: Fire Safety Engineering, 2010 Edition
6. NSW Fire Brigades Guide Sheet No. 5 – Hardstand Areas for NSWFB Appliances. 15th Feb 2010
7. AMETEK solid state controls, Selection and Sizing of Batteries for UPS Backup, 2011 <http://www.solidstatecontrolsinc.com/techhpapers/pdfs/selectionsizingups.pdf>
8. Guidance Note on Room Size Limits when using Fire Zone Models for Smoke-Filling Calculations, Wade C.A, 2008

2.3 Design Team Documentation

1. Building Code of Australia Assessment Report, Masters Home Improvement – Mulgoa Road Penrith NSW, Reference J140183, Dated 10 July 2014.
2. AECOM FEBQ: 60323569-FBFE-0001_A - FEBQ, submitted to FRNSW on 21 July 2014.
3. Fire Services Information including Drawings as attached in Appendix F.
4. Architectural drawings by Leffler Simes Architects as per Table 3.

Table 3 Architectural Drawings

Drawing Number	Title	Rev	Date
3116-GA100	Site Plan	P3	21/07/2014
3116-GA200	Ground Floor Plan	P3	21/07/2014
3116-GA201	Roof Plan	P3	21/07/2014
3116-GA300	Elevations	P2	21/07/2014
3116-GA310	Overall Sections - 1	P2	21/07/2014
3116-GA311	Overall Sections - 2	P2	21/07/2014

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3.0 Building and Occupant Characteristics

3.1 Site Layout

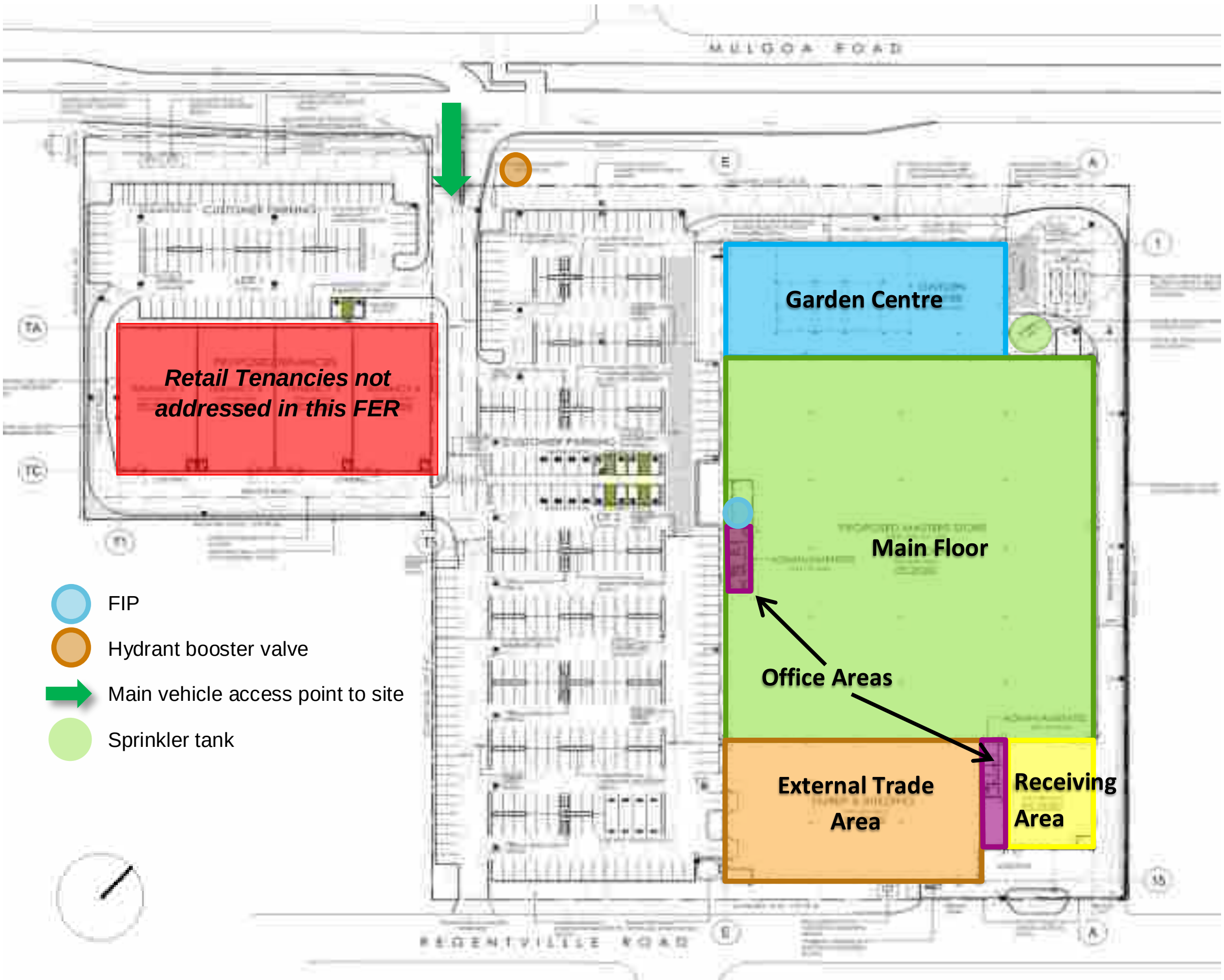

Figure 1 Site Layout

3.2 BCA DtS Reference Criteria

Table 4 BCA Deemed-to-Satisfy (DtS) reference criteria

BCA Clause		Description or Requirements
A3.2	Classification	Class 6 (retail)
C1.2	Rise in Storeys	One
A1.1	Effective Height	0 m
C1.1	Type of Construction	Type C - Large Isolated Building
C2.2	Floor Area	~13,518 m²

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3.3 Occupant Characteristics

Occupants of the building will be staff and customers. Staff will have a degree of emergency response training, however, customers may be unfamiliar with the location of exits and egress routes. Occupant characteristics are further described in Appendix A.

3.4 Population

The population for fire engineering assessments will be calculated based on BCA DtS Clause D1.13(c) [any other suitable means]. A design population of 1,865 will be adopted for the building based on the following table.

Space	Classification	Area (m²)	m² per person	Population
Main Floor	Retail (6)	8,490	6*	1,415
External Trade	Warehouse (7b)	2,203	30 (BCA Table D1.13)	74
Garden Centre	Retail (6)	1,960	6*	327
Receiving	Warehouse (7b)	584	30 (BCA Table D1.13)	20
Office	Office (5)	107 + 174 = 281	10 (BCA Table D1.13)	29
			Total	1,865

*The Fire Code Reform, Fire Safety in Shopping Centres 1998, supports an area per person in retail spaces of 6 m²/person.

A population of 1,865 requires a DtS compliant width of 13.5 m (which allows for 1925 people). Exit widths of at least 14 m are currently proposed from public areas of the tenancy, which is BCA DtS compliant for a population of 2,150.

The aggregate exit width from the retail space will therefore provide more capacity than DtS for the design population.

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4.0 Fire Hazards, Preventative and Protective Measures

4.1 Fire Hazards

Table 5 tabulates the notable hazards to occupants associated with the proposed design.

Table 5 Potential hazards to occupants associated with the building design

Hazard type	Details
Ignition sources	**Main floor retail area, trade area and receiving area** - Electrical & mechanical equipment - Repair & maintenance including hot works - Forklift, scissor lifts - Unauthorised smoking - Arson (deliberate or accidental) - Heating appliances **Garden Centre** - Electrical & mechanical equipment - Repair & maintenance including hot works - Forklift, scissor lifts - Arson (deliberate or accidental) - Unauthorised smoking **Office** - Electrical & mechanical equipment - Unauthorised smoking - Heating appliances - Arson (deliberate or accidental)
Fuel sources	**Main floor retail area, trade area and receiving area** - Vertically stacked retail goods, e.g. hardware, DIY products, gardening products etc. - Stored goods - Aerosol and flammable liquids **Garden Centre** - Vegetation - Pallets - Miscellaneous packaging **Office** - Office contents and furnishings - Linings and coverings - Rubbish bins **Battery Room** - Electrical equipment - Unauthorised smoking - Arson

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4.2 Preventative and Protective Measures

Table 6 includes the proposed preventative and protective measures. An overview of the Fire Brigade Access / Fire Services Strategy and the Smoke Control Strategy are provided in Figure 2 and Figure 3, respectively.

Table 6 Preventative and Protective Measures in Relation to Fire Safety

Preventative and Protective Measures	Details
Fire Initiation and Development and Control *IFEG Sub-system A*	- Electrical safety equipment - Regular plant maintenance
Smoke Development & Spread & Control *IFEG Sub-system B*	- Mechanical smoke exhaust will be provided in the Main Floor Area. The total exhaust rate for this area is 46 m³/s over 4 exhaust points in order to support Alternative Solutions in the main floor area. Activation of the smoke exhaust and inlet air provisions will be by aspirating smoke detection or sprinklers. - Mechanical smoke exhaust will be provided in the External Trade Area. The exhaust rate for this area is 30 m³/s over 2 exhaust points in order to support Alternative Solutions in the External Trade area. Activation of the smoke exhaust will be by sprinklers within the External Trade area, as well as sprinklers within the Admin area located within the External Trade area. - Make-up air will be provided to the main floor area from various openings including automatic doors, louvers and roller shutters that connect the External Trade /receiving area and garden area to the main floor. The combined clear effective area of these openings is at least 20 m^2. This limits the velocities to 2.5 m/s or below as per BCA DtS provisions. (Refer to Figure 3 for the locations of the make-up air). - Full height subdividing walls will be installed between the main floor area and the External Trade, Receiving area and Garden Area to mitigate the spread of smoke and fire. - The insulated wall panels subdividing the building should have all openings around penetrations and the junctions of the wall and the remainder of the building smoke stopped with non-combustible material to prevent the free passage of smoke. They should also incorporate smoke dampers where air-handling ducts penetrate the wall unless the duct forms part of a smoke hazard management system required to continue air movement through the duct during a fire.
Fire Spread and Impact Control *IFEG Sub-system C*	- The full height subdividing walls are FM Global Class 1 certified for fire resistance. These will provide an inherent amount of fire resistance, although they would not provide a specific FRL.
Fire Detection, Warning and Suppression *IFEG Sub-system D*	- ESFR sprinklers will be provided in the main floor, external trade and receiving areas, plus areas of the garden centre that are covered by a metal roof. These will be installed to NFPA 101 Standards. - Light hazard sprinklers will be provided to the offices in accordance with AS 2118.1-1999. - An aspirating smoke detection system will be provided in the main floor area. The smoke detectors for activation of the smoke exhaust system will have a sensitivity in accordance with AS 1668.1-1998. - A building occupant warning system will be provided throughout, installed in accordance with AS 1670.1-2004 and AS 2118.1-1999. - Portable fire extinguishers and fire hose reels will be provided throughout the development to facilitate first aid fire fighting. These will be installed to AS 2444-2001 and AS 2441-2005, respectively.

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Preventative and Protective Measures	Details
Occupant Evacuation and Control *IFEG Sub-system E*	- Evacuation plans and staff training - Emergency lighting and signage to AS 2293.1-2005.
Fire Services Intervention *IFEG Sub-system F*	Fire brigade provisions include: - Fire Control Centre to be located at the main entrance into the building. - Sprinkler tank will be located at the north corner of the building. - Hydrant booster will be located at the main entrance to the site from Mulgoa Rd.

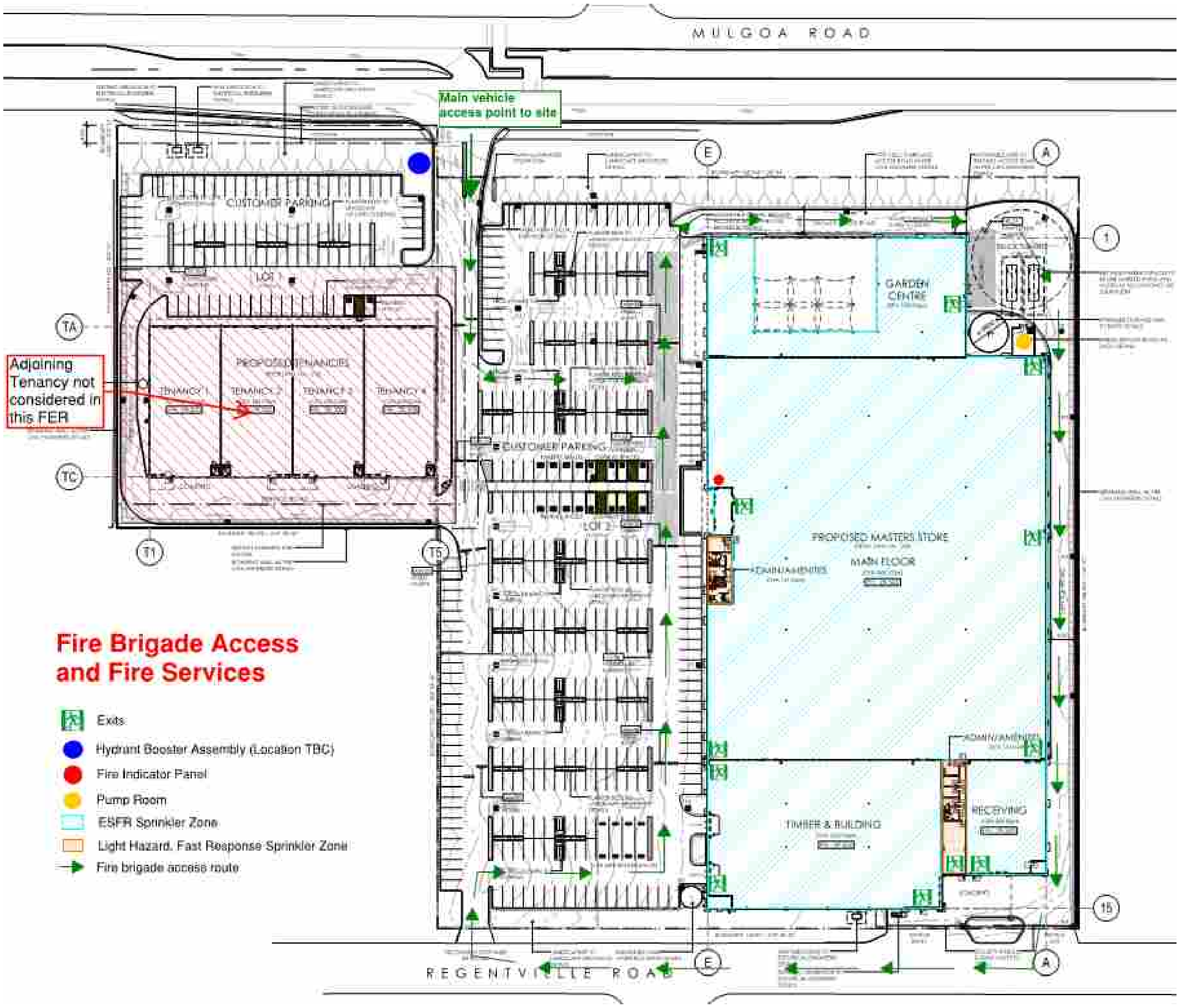

Figure 2 **Fire Brigade Intervention and Fire Services Strategy**

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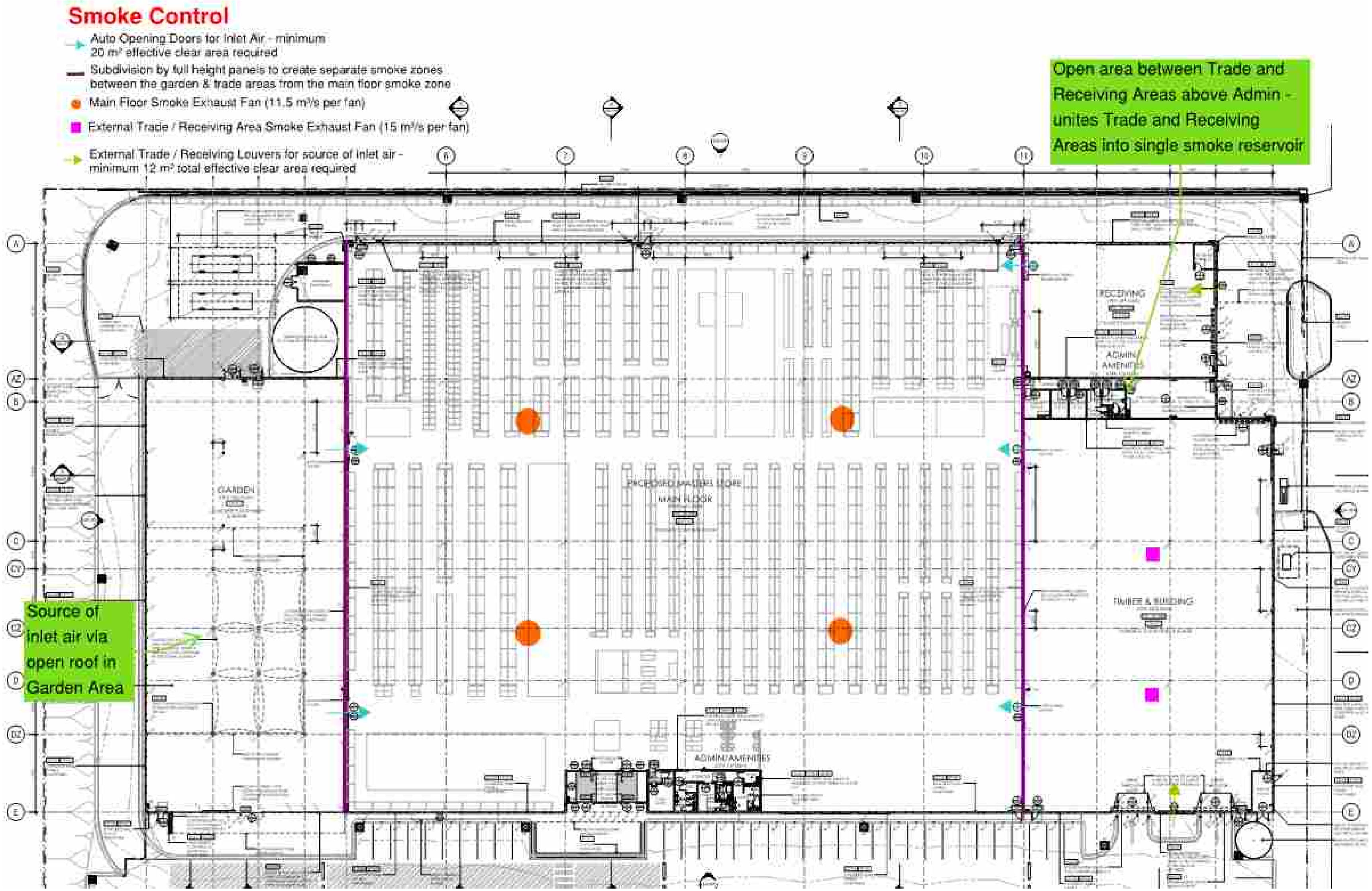

Figure 3 Smoke Control Strategy

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5.0 Alternative Solutions 1–3 – Main Floor Area

5.1 Overview of Variations to the BCA DtS Provisions

No.	Performance Requirement	DtS Non-Compliance	Description
1.	DP4	Travel distance *[D1.4]*	Egress from the main floor area exceeds the DtS limits of: • 20 m to a point of choice, up to 30 m • 40 m to an exit, up to 70 m
2.	DP4	Distance between alternative exits *[D1.5]*	The distance between alternative exits is over the DtS limit of 60 m, up to 100 m
3.	EP2.2	Smoke reservoir size *[Spec E2.2b]*	The smoke reservoir area is 8,490 m², where the DtS limit is 2,000 m²

5.2 Intent of the BCA DtS Provisions

The following outlines the intent of the BCA for the fire engineering solutions to the BCA DtS provisions in the main floor area. The methods for demonstrating that the design meets the intent are also identified.

Alternative Solution – Travel distance (D1.4)

For a Class 5 to 9 building, the travel distance to an exit is limited to 40 m to meet the BCA DtS provisions. The Guide to the BCA (GBCA) identifies that *"travel distances are based on an assumption of what is considered 'reasonable' distances to be travelled by occupants in reaching an exit"*. They are specified in order to:

- "allow people to evacuate in a reasonable time, assuming that they are not asleep"
- "to maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate"

Retail spaces typically have a higher occupant density, which results in queuing at exits, where the queuing time may exceed the travel time. Queuing is expected due to the larger occupancy in the space. This has been compared against travel time and a quantitative Required Safe Egress Time (RSET) versus the Available Safe Egress Time (ASET) analysis has been carried out to demonstrate that occupants will have ample escape time.

Alternative Solution – Distance between alternative exits (D1.5)

For the building classifications (Class 6), the distance between alternative exits is limited to 60 m to meet the BCA DtS provisions. The GBCA states that this clause is *"to require that if an exit is inaccessible, access to any required alternative exit must be available within a reasonable distance."*

A quantitative assessment of the RSET versus ASET analysis has been carried out to demonstrate that occupants will have ample escape time.

Alternative Solution – Maximum smoke reservoir area (Spec E2.2b)

The BCA DtS smoke reservoir size is limited to 2,000 m². The GBCA states that: *"smoke reservoirs are necessary to contain the hot layer in the upper levels of compartments, thus preventing the lateral spread of smoke resulting in excessive cooling and downward mixing of the smoke with the relatively clear layer below which:*

- *enables occupants to make their way through the comparatively clear air below the hot smoke layer; and*
- *maintains the smoke above any openings between compartments, thus minimising the risk that smoke will migrate to other areas."*
- *where to maximise the effectiveness of smoke reservoirs, the horizontal area formed by a reservoir is limited by to 2,000 m²."*

ASET versus RSET analysis has been carried out to demonstrate that smoke movement, in particular as a result of additional smoke cooling and downward mixing of smoke, will not affect occupant egress. To achieve this,

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Computational Fluid Dynamics (CFD) modelling is used to assess conditions in the main floor area, including the effects smoke cooling through lateral movement heat loss through the surrounding roof and walls.

5.3 Assessment

A performance based smoke exhaust system will be installed in the main floor area in order to maintain tenable conditions during evacuation. 46 m³/s of smoke exhaust over 4 exhaust points will be provided for this purpose. Inlet air locations and areas for the smoke extract system are shown in Figure 3.

A quantitative assessment has been carried out to investigate the effect of fire and smoke on occupancy life safety and to verify the design.

The RSET has been compared to the ASET. ASET analysis was carried out using Fire Dynamics Simulator (FDS) Version 6, which is a Computational Fluid Dynamics software. Inputs for the modelling are detailed in Appendix C. The RSET has been determined using desktop calculations as detailed below.

5.3.1 Required Safe Egress Time (RSET)

The total required safe egress time from the main floor area is **398 s**. The time to escape is based on:

- **Detection Time** – Calculated based upon the activation time of a smoke detector in the FDS model for the design case. VESDA product brochures[1] have indicated that VESDA systems have a sensitivity range of 0.005 to 20 %obs/m depending on the level of alarm. A sensitivity of 3%obs/m is used to model the aspirating detection system proposed for the main floor area. A detection time of 28 s was obtained (See Appendix B).

  It is noted that while this approach does not represent the actual detection time of the aspirated detection system, it is a more conservative approach because an aspirated detection system will operate quicker than the detection time obtained from the simulation.

  In addition to this, a transport delay of 90 s has also been included to the total detection time to account for the time it takes for the smoke to travel along the sampling pipe.

  Therefore a total detection time of **118 s** (28 + 90) has been used for the detection time in the RSET calculation.

- **Pre-Movement Time** – Taken as **180 s** for occupants in the retail premises based on CIBSE Guide E.

- **Movement (Travel) Time** – Calculated as **100 s.**

  The movement time is based on an assessment of the occupant flow rates through doors, travel distances and walking speed (accounting for occupants with mobility difficulty). Calculations are shown in Appendix D. The calculations show that the governing factor is travel time to exits, which is calculated to be **100 s.**

5.3.2 Available Safe Egress Time (ASET)

The following design fires will be adopted for ASET analysis. A design fire and a redundancy case have been modelled. Fires have been modelled in a corner of the store in both cases, which provides conservatism as smoke has further to travel to reach the edge of the smoke reservoir. From experience of FDS modelling of other Masters stores, this location provides more conservative results than a fire in the centre of the space.

Table 7 Design fires [calculations outlined in Appendix B]

Scenario	Location	Growth Behaviour	Fire Growth Rate	Ceiling Height (m)	Peak HRR (MW)
Design Fire 1	Main Floor Area (corner)	ESFR sprinkler controlled – 1st row activation	t² Ultra-Fast	9.3 m	**5 MW**
Redundancy Case Delayed sprinkler activation	Main Floor Area (corner)	ESFR sprinkler controlled – 2nd row activation	t² Ultra-Fast	9.3 m	**10 MW**

Fire size calculations are based on ESFR sprinklers with an RTI of 50 $m^{1/2}s^{-1/2}$, activation temperature of 101 °C and an average ceiling height of 9.3 m.

[1] Xtralis 2009, *VESDA Buys Time: Aspirating Smoke Detection,* product brochure, Xtralis AG, USA

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An Ultra-Fast fire growth rate has been adopted. CIBSE Guide E and other international standards consider an ultra-fast t^2 growth rate to be appropriate for warehouses with vertically stored goods.

In line with the intent of the BCA (discussed in Section 5.2), the assessment has assumed that the fuel is flat on the ground at 0 m. This maximises the height of rise and perimeter of the smoke plume and the entrainment of cool air into it, resulting in a greater volume of cool smoke in the space. This represents conservative assumptions.

5.3.3 Results Summary

Table 8 demonstrates that occupants in the main floor area have ample time available to make their escape before conditions become untenable. Appendix C presents snapshots of visibility results at the ASET time.

This has been compared to the calculated RSET to demonstrate that escape conditions will be tenable in the event of a fire.

Table 8 ASET vs RSET comparison

Scenario	ASET	RSET	Target Minimum Factor of Safety	Factor of Safety Achieved
Design Fire	610 s	398 s	1.5	**1.5**
Redundancy Case	475 s	398 s	1	**1.2**

5.4 Compliance with BCA Performance Requirements

The assessment meets the intent of the BCA and the relevant Performance Requirements which are as follows:

- BCA Performance Requirement DP4

  The BCA requires that exits must be provided from a building to allow occupants to evacuate safely based on occupant numbers, the distance to exits and the dimensions of exits. The quantitative ASET versus RSET analysis demonstrates that the BCA Performance Requirements are met.

- BCA Performance Requirement EP2.2

  In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building. The quantitative ASET versus RSET analysis demonstrates that the BCA Performance Requirements are met.

5.5 Compliance with BCA Methods of Assessment

- Design complies with the BCA Performance Requirements ➔ Clause A0.5 (b) (i) of the BCA.
- Assessment methods comprise of 'other verification methods as the appropriate authority accepts for determining compliance with the Performance Requirements' ➔ Clause A0.9 (b) (ii).

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6.0 Alternative Solution 4 – Main Entry Doors

6.1 Overview of Variations to the BCA DtS Provisions

No.	Performance Requirement	DtS Non-Compliance	Description
4.	DP2	Operation of main entry/exit sliding doors *[D2.19(b)(iv)]*	The automatic sliding doors at the main entrance will not be provided with fail safe on fire trip during out of hours trading.

6.2 Intent of the BCA DtS Provisions

The intent of Clause D2.19 b (iv) is explained in the Guide to the BCA and captures the main objectives:

"*so that people can move safely to and within a building, it must have –*

b) Any doors installed to avoid the risk of occupants –

- *Having their egress impeded; or*
- *Being trapped in the building.*

6.3 Assessment

The sliding doors at the main entrance will not be provided with fail safe on fire trip during out of hours trading as the automatic opening of the doors would breach the security of the building. However, during trading hours within the store, the sliding doors at the main entrance will be power operated to fail safe open as per DtS requirements of D2.19 (b) (iv).

It is also expected that the store will have no or low occupancy in the building during out of trading hours. In the event that occupants need to escape via the main entrance sliding doors, a battery backed-up push button will be located adjacent to the doors. Occupants can open the doors and exit through the automatic sliding doors by using the push button. In addition, appropriate signage will be located adjacent to the doors to help the occupants to locate the push button.

Furthermore, in the event of a fire alarm, power failure to the building and failure of the battery supply to the doors all occurring the automatic doors will be configured to automatically reset to the open position.

Therefore it is deemed that the performance requirements of BCA have been met.

6.4 Compliance with BCA Performance Requirements

The assessment meets the intent of the BCA and the relevant Performance Requirement which is as follows:

- BCA Performance Requirement DP2

  So that people can move safely to and within a building, it must have – any doors installed to avoid the risk of occupants having their egress impeded or being trapped in the building.

6.5 Compliance with BCA Methods of Assessment

- Design complies with the BCA Performance Requirements ➔ Clause A0.5 (b) (i) of the BCA.
- Assessment methods comprise of 'other verification methods as the appropriate authority accepts for determining compliance with the Performance Requirements' ➔ Clause A0.9 (b) (ii)

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7.0 Alternative Solution 5 – Separation of UPS System

7.1 Overview of Variations to the BCA DtS Provisions

No.	Performance Requirement	DtS Non-Compliance	Description
5.	CP6	Separation of UPS System *[C2.12]*	The UPS batteries in the UPS room exceed 12 V and 10 Ah and will not be enclosed in construction achieving an FRL of 120/120/120 as per the BCA DtS provisions

7.2 Intent of the BCA DtS Provisions

The intent of fire rating rooms containing batteries is to limit the spread of fire from rooms containing equipment having a high potential for explosion. The communication/server room is proposed to contain a UPS, which is a piece of equipment containing battery power storage.

The GBCA outlines that the intent of Clause C2.12 is:

'to limit the spread of fire from service equipment having a high fire hazard or potential for explosion and to ensure emergency equipment continues to operate during fire'.

The UPS room does not contain any emergency equipment. In this case the GBCA further explains that;

'The types of equipment under C2.12 (a)(iv) and (v) have a high explosive potential. It is important that any fire in this type of equipment does not spread to other parts of the building.'

Therefore, the intent of the Clause is to limit the potential for an explosion. With batteries the fire/explosion hazard is typically related to the release of hydrogen during charging, which if left to accumulate, can result in an explosive environment forming. This was especially true for older style flooded batteries which release hydrogen during charging and particularly if overcharging occurs in rooms containing large banks of batteries.

7.3 Assessment

The intent of fire rating rooms containing batteries is to limit the spread of fire from rooms containing equipment having a high potential for explosion. The communication/server room is proposed to contain a UPS, which is a piece of equipment containing battery power storage.

The batteries will be VRLA (Valve-Regulated Lead-Acid) rechargeable batteries and the make and model of the UPS Battery is SYA16K16I (See Appendix G) which consists of :

- 16KVA UPS system;
- 4 x Battery modules as part of the SKU in parallel; and
- Each Battery module is 120V DC at 9Ah, therefore with four batteries in parallel the battery Amp-Hour Capacity (4 x 9 Ah = 36 Ah).

These sealed batteries will be contained within a cabinet containing all the UPS electronics in the UPS Room. The batteries will be contained within a metal enclosure, which is then placed within a second metal enclosure. When the batteries are not arranged in parallel the batteries will have the following specifications:

- Battery Voltage – 100 - 147 Vdc (120 Vdc nominal)
- Battery Amp-Hour Capacity – 9.0 Ah
- Battery Charge Power Rating – 300 W per installed Power Module
- Minimum Input Voltage to Charge – 124 Vac L-N
- Recharge Time (0% to 90%) – 3 hrs
- Dimensions of UPS cabinet – 1.5m high x 0.5m wide x 0.7m deep
- Battery Type – VRLA Rechargeable Battery HR. The batteries will use Absorbent Glass Matt (AGM) technology for efficient gas recombination.

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Batteries Proposed

As noted above the VRLA battery (Valve-Regulated Lead-Acid) will be provided in the UPS Room. These batteries are commonly known as a sealed battery and are classified as either;

- Absorbed Glass Mat (AGM) battery, which has the electrolyte absorbed in a fibre-glass mat separator.
- Gel battery, which has the electrolyte mixed with silica dust to form an immobilized gel.

Because of the construction, VRLA batteries do not require regular addition of water to the cells and vent less gas than flooded lead-acid batteries. This reduced venting is a benefit as they are suitable for use in confined or poorly ventilated spaces.

Although the words 'Valve-Regulated' are used to describe the batteries, this does not fully describe how the technology functions. The technology to reduce the gas emissions works through the use of the following process. The batteries are really recombinant batteries, as the oxygen evolved at the positive plates will largely recombine with the hydrogen ready to evolve on the negative plates, creating water and prevent water loss. The valve is a safety feature in the event that the hydrogen evolution becomes too great.

Fire Safety Systems Provided

The UPS Room will be provided with smoke detection which will provide occupants with early warning in the event of smoke production. Additionally, the provision of sprinkler coverage to the room is expected to be capable of containing non explosive fire scenarios, such as small electrical fires and containing the fire source to the room or fire origin, thus preventing spread to the remainder of the building.

Enclosure to UPS Room

The intent of the BCA Clause is to prevent an explosion affecting other areas of the building. The BCA DtS provisions recommend the provision of construction achieving an FRL 120/120/120, the Australian Standard AS1530.4-2004 for Fire-resistance test of elements of construction which the enclosing construction would comply to does not test the elements of construction (walls, floors, columns, etc.) to account for explosions. The elements of construction are tested in a test furnace under controlled conditions (temperature vs time). Therefore, an enclosing wall to the UPS room designed to achieve an FRL 120/120/120 would not be tested to account for an explosion scenario.

The ceiling/roof of the room is not fire rated and constructed of lightweight suspended ceiling tiles hanging from the mezzanine floor above. The suspended ceiling tile arrangement would not be considered an air tight construction, therefore in the event of a gas discharge from the safety valve there is a greater volume for the gas to disperse in the void above the comms room.

7.4 Compliance with BCA Performance Requirements

The assessment meets the intent of the BCA and the relevant Performance Requirements which are as follows:

- BCA Performance Requirement CP6

  The BCA requires that a building must have elements to avoid the spread of fire from service equipment having a high fire hazard or a potential for explosion resulting from a high fire hazard.

7.5 Compliance with BCA Methods of Assessment

- Design complies with the BCA Performance Requirements ➔ Clause A0.5 (b) (i) of the BCA.
- Assessment methods comprise of 'other verification methods as the appropriate authority accepts for determining compliance with the Performance Requirements' ➔ Clause A0.9 (b) (ii)

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8.0 Alternative Solutions 6 – 8 – External Trade & Receiving Areas

8.1 Overview of Variations to the BCA DtS Provisions

No.	Performance Requirement	DtS Non-Compliance	Description
6.	DP4, EP2.2	Travel Distance *[D1.4]*	The distance between alternative exits in the External Trade area exceeds the DtS limits of 60 m, up to 65 m
7.	EP2.2	Smoke Reservoir Size *[Spec E2.2]*	The smoke reservoir area for the combined External Trade /Receiving area is approximately 2,790 m^2, where the DtS limit is 2,000 m^2.
8.	EP2.2	Activation of Smoke Control *[Spec E2.2]*	Activation of smoke exhaust is by sprinklers instead of smoke detectors as per the BCA DtS provisions

8.2 Intent of the BCA DtS Provisions

Alternative Solution – Travel Distance (D1.4)

For a Class 5 to 9 building, the travel distance to an exit is limited to 40 m to meet the BCA DtS provisions. The Guide to the BCA (GBCA) identifies that *"travel distances are based on an assumption of what is considered 'reasonable' distances to be travelled by occupants in reaching an exit".* They are specified in order to:

- "allow people to evacuate in a reasonable time, assuming that they are not asleep"
- "to maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate"

Alternative Solution – Smoke reservoir size (Spec E2.2b)

The BCA DtS smoke reservoir size limit is 2,000 m^2. The GBCA states that: *"smoke reservoirs are necessary to contain the hot layer in the upper levels of compartments, thus preventing the lateral spread of smoke resulting in excessive cooling and downward mixing of the smoke with the relatively clear layer below which:*

- *"Enables occupants to make their way through the comparatively clear air below the hot smoke layer; and*
- *Maintains the smoke above any openings between compartments, thus minimising the risk that smoke will migrate to other areas.*
- *Where to maximise the effectiveness of smoke reservoirs, the horizontal area formed by a reservoir is limited by to 2,000 m^2."*

A comparative quantitative assessment has been carried out to demonstrate that the temperature of smoke in the reservoir will be sufficiently high such that it will be unlikely to lose buoyancy due to loss in temperature and downward mixing.

Alternative Solution – Activation of smoke control system (Spec E2.2b)

The BCA DtS provisions specify smoke control systems to be activated by smoke detection, and where practicable, sprinklers as well. The GBCA does not provide specific guidance on why smoke detectors are a minimum provision. However, it is noted that sprinklers typically activate slower than smoke detectors, which in some cases could adversely affect performance.

8.3 Assessment

8.3.1 Smoke Reservoir size and Activation of Smoke Control

The production of smoke is principally governed by fire size, fire perimeter and the height of rise of the smoke plume. Therefore an increased smoke reservoir area will not result in the production of a larger quantity of smoke. The concern associated with an increased smoke reservoir area is the possibility of smoke cooling in the space and deepening of the smoke layer. A larger smoke reservoir may however delay smoke layer deepening by increasing the time required to fill the volume with smoke.

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The proposed reservoir area is 2,790 m², which exceeds the DtS limit by 790 m². A DtS compliant reservoir size would require 20 m³/s of smoke exhaust to maintain a clear layer height of 2 m, estimated from BCA Specification E2.2b Figure 2.1. This is based on the BCA recommended fire size for a sprinklered class 6 building of 5 MW.

Additionally, DtS smoke exhaust provisions require that exhaust is activated by smoke detection. The proposed design will have smoke exhaust activated based on sprinklers. Detection time for each scenario has been calculated in Appendix B.

The proposed design will be provided 30 m³/s of smoke exhaust which is expected to provide at least equivalent performance to a DtS design despite sprinkler based activation. A quantitative assessment has been completed using the zone modelling software B-Risk to compare the performance of the DtS and proposed designs. Inputs are summarised in Table 9.

Table 9 Quantitative analysis inputs summary

Parameter	DtS Design	Proposed Design	Comments
Max. Reservoir Area	2,000 m²	2,790 m²	Design case is 790 m² more than DtS. The assessment aims to demonstrate that performance will be at least comparable.
Avg. Ceiling Height	8.5 m	8.5 m	
Smoke Exhaust Rate	20 m³/s	30 m³/s	
Activation of smoke exhaust	Smoke detectors	Sprinklers	Proposed Design activation time is longer than DtS, however smoke exhaust will activate before smoke fills down to 2 m above floor level. Hence activation time is not expected to affect performance of exhaust system.
Exhaust activation time	154 s (64 s detection + 90 s transport lag) Detection time based on smoke detection	247 s (157 s + 90 s alarm transmission) Detection time based on sprinklers	
Fire Size	5 MW (Ultra-fast t²) α = 0.188 kW/s²		As recommended by BCA Specification E2.2b Figure 2.1 for class 6 sprinklered building.
Simulation Run Time	1500 s		

8.3.2 Quantitative Analysis

The program “B-Risk” has been used to compute the smoke layer height and temperature in the External Trade and Receiving Areas. This has been completed for a DtS case and the proposed design. Inputs and calculations are shown in Appendix E, and results are summarised in Table 10.

Table 10 Quantitative analysis results summary

Scenario	Steady-state Smoke Layer Height	Smoke Temperature
DtS Design	**2.4 m**	91 °C
Proposed Design	**4.3 m**	70 °C

8.3.3 Extended Travel Distance

In regards to the extended travel distances, the additional 5 m between exits is supported through the large reservoir area and additional rate of smoke exhaust; Figure 2.1 of the BCA and calculations summarised in Table 10 show that for the design case, the smoke exhaust system will maintain a higher steady state smoke layer than a DtS design, which will be above 2 m.

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8.4 Conclusion

The quantitative analysis demonstrates that the proposed design is at least equivalent to a DtS design and hence the intent of the BCA is met.

8.5 Compliance with BCA Performance Requirements

The assessment meets the intent of the BCA and the relevant Performance Requirements which are as follows:

- BCA Performance Requirement DP4

  The BCA requires that exits must be provided from a building to allow occupants to evacuate safely based on occupant numbers, the distance to exits and the dimensions of exits. The quantitative ASET versus RSET analysis demonstrates that the BCA Performance Requirements are met.

- BCA Performance Requirement EP2.2

  In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building.

The quantitative, comparative assessment demonstrates that Performance Requirements are met at least as well as a DtS compliant design.

8.6 Compliance with BCA Methods of Assessment

Design is at least equivalent to the Deemed-to-Satisfy Provisions ➔ Clause A0.5 (b) (ii) of the BCA.

Assessment methods comprise of ‘Comparison with Deemed-to-Satisfy Provisions’ ➔ Clause A0.9 (c)

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9.0 Alternative Solutions 9 -11 – Garden Area

9.1 Overview of Variations to the BCA DtS Provisions

No.	Performance Requirement	DtS Non-Compliance	Description
9.	DP4 and EP2.2	Distance between alternative exits *[D1.5]*	The distance between alternative exits is over the DtS limit of 60 m, up to 80 m.
10.	EP1.4	Partial omission of sprinklers *[Specification E1.5 Part 3]*	Sprinklers are not proposed under the shade sails of the garden. The sprinklered and non-sprinklered areas will not be fire separated.
11.	EP2.2	Omission of mechanical smoke exhaust *[E2.2]*	No smoke exhaust fans will be provided in the garden centre.

9.2 Intent of the BCA DtS Provisions

The following outlines the intent of the BCA for the fire engineering solutions to the BCA DtS provisions in the garden area. The methods for demonstrating that the design meets the intent are also identified.

Alternative Solution – Distance between Alternative Exits (D1.5)

For the building classifications (Class 6), the distance between alternative exits is limited to 60 m to meet the BCA DtS provisions. The GBCA states that this clause is *"to require that if an exit is inaccessible, access to any required alternative exit must be available within a reasonable distance."*

Alternative Solution – Partial Omission of Sprinklers (Spec E1.5)

The GBCA explains that for non-sprinklered parts of a building, the BCA recommends separation from the rest of the building as *"if a fire starts in a non-sprinklered part of the building, its development will be uncontrolled… [and] reach a size which could over-ride the sprinkler system if it spreads to the sprinklered part of the building."*

The intent is hence to limit the uncontrolled spread and growth of a fire to the remainder of the building. The growth and spread of fire in non-sprinklered areas is dependent on the fuel load and layout, which is not considered in the BCA Clause.

Alternative Solution – Omission of Mechanical Smoke Exhaust (E2.2)

The intent of DtS Clause E2.2 relates to the Performance Requirement EP2.2. The GBCA explains that the intent of EP2.2 is that *"occupants must be given time to evacuate before the onset of untenable conditions."*

Mechanical smoke extract is recommended in Clause E2.2 to fulfil this intent of Performance Requirement EP2.2. It is considered that the Garden Centre layout fulfils this intent.

9.3 Assessment

9.3.1 Extended Distance between Alternative Exits

The additional distance between alternative exits is acceptable as the garden has multiple exits for evacuation which technically can involve travelling in different directions. Intermediate exits to the main floor area are also available which will provide additional redundancy to the design.

The space will be provided with ESFR sprinklers. The open roof will also ventilate and remove the smoke in the garden centre. As the space is partially external, smoke will not be able to build down in the space and impede routes to exit.

9.3.2 Partial Omission of Sprinklers

The garden centre will be provided with sprinkler protection (ESFR Sprinkler Heads) with the exception of the portion that does not have a roof as shown in Figure 3. The area will be partially covered with shade sails.

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The fire hazard associated with the garden centre is low as the majority of the fire load consists of vegetation, potting and organic materials used in gardening products. An example of a recently completed Masters Garden Centre is shown in Figure 4 and Figure 5 below. The proposed garden centre in Penrith will be similar and the photos indicate the nature of the fire load (plants on metal racking) beneath the non-sprinklered area.

The fire load densities outlined in the IFEG, which are reproduced in Table 11, indicate fire load densities associated with occupancies similar to the garden centre area of the building. These densities are significantly less than the fire load density associated with retail areas which is ~600 MJ/m^2.

Table 11 Fire load densities associated with the garden centre area

Type of occupancies	Fire load (MJ/m^2)
Clay, preparing	50
Fertiliser manufacturing	200
Flower sales	80
Pottery plant	200

In addition to the low fire load, the garden centre area that is not covered with sprinklers will be open to the sky above as shown in the photos below. This allows smoke and heat from a fire to readily vent to open air in the early stages, significantly reducing the likelihood of smoke and heat build-up within the space.

Figure 4 Example of the shade sails and open area of the garden centre with sprinkler omission.

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Figure 5 Example of the shade sails and open area of the garden centre with sprinkler omission.

9.3.3 Omission of Smoke Exhaust

The GBCA states that smoke exhaust is needed to *"to minimise the risks of smoke"*. Approximately 725 m² of the garden centre roof will be open area. This opening will allow smoke and heat to readily vent to open air. The opening equates to approximately 37% of the 1,960 m² plan area of the garden centre. This large opening will significantly reduce the build-up of smoke and heat in the garden centre.

In comparison, a naturally vented space designed to AS 2665 only requires a minimum area of ~45 m² of venting at roof level to maintain a clear layer of 4 m for a non-sprinkler controlled fire. The Masters Garden Centre will have more than 16 x the required ventilation.

Based on the above, it is not proposed to provide mechanical smoke exhaust in this area of the building, an alternative means of natural smoke venting has been provided.

9.4 Compliance with BCA Performance Requirements

The assessment meets the intent of the BCA and the relevant Performance Requirement which is as follows:

- BCA Performance Requirement DP4

  The BCA requires that exits must be provided from a building to allow occupants to evacuate safely based on occupant numbers, the distance to exits and the dimensions of exits. The analysis demonstrates that the BCA Performance Requirements are met.

- BCA Performance Requirement EP1.4

  The BCA requires that an automatic fire suppression system must be installed to control the development and spread of a fire appropriate to the size of the compartment, use of space, fire hazard and height of space. The qualitative analysis demonstrates that the BCA Performance Requirements is met.

- BCA Performance Requirement EP2.2

  In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building.

As the space is partially external, and due to other supporting factors discussed above, the design will meet the above Performance Requirements.

9.5 Compliance with BCA Methods of Assessment

- Design complies with the BCA Performance Requirements ➔ Clause A0.5 (b) (i) of the BCA.
- Assessment methods comprise of 'other verification methods as the appropriate authority accepts for determining compliance with the Performance Requirements ➔ Clause A0.9 (b) (ii).

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10.0 Alternative Solution 12 – Admin Areas

10.1 Overview of Variations to the BCA DtS Provisions

No.	Performance Requirement	DtS Non-Compliance	Description
12.	EP2.2	Omission of mechanical smoke exhaust *[E2.2]*	No smoke exhaust will be provided in the Admin areas.

10.2 Intent of the BCA DtS Provisions

Alternative Solution – Omission of Smoke Exhaust (E2.2)

The GBCA states that smoke exhaust is needed to *"to minimise the risks of smoke".* The DtS provision of a building wide smoke exhaust system is driven by the large area and volume of the rest of the building which results in the building being classified as a Large Isolated Building. Smoke exhaust would not need to be provided to meet DtS provisions to satisfy any specific design features in the office.

10.3 Assessment

The DtS provision of smoke control throughout the building is applicable because there are oversized fire compartments in the building and the building is therefore classified as a Large Isolated Building. If the main floor area was divided by fire resisting walls so that the building consisted of multiple fire compartments within the limits of Type C construction, smoke exhaust would not be needed in the office areas to meet the BCA DtS provisions.

If there is a fire in the office areas, the size of neighbouring spaces will not affect conditions for occupants in these spaces. No specific design features associated with the office would need smoke exhaust to meet BCA DtS provisions.

10.3.1 Admin Area within Main Floor Area (adjacent to Main Entrance)

Where the admin area is within the bounds of the main floor area, there will be an inherent amount of smoke separation between these spaces from the bounding construction and the relatively cellular nature of the admin rooms. In addition, in the event of a fire in the admin area, smoke escaping into the main floor area will be exhausted from high level. In the event of fire in the retail area, the occupant warning system will sound in the offices and therefore staff will be able to escape at the same time as retail shoppers.

10.3.2 Admin Area within External Trade and Receiving Areas

The Admin area is enclosed within the External Trade /Receiving area of the building. As the Admin area is single storey space, the External Trade area and the Receiving Area are connected at high level and form a single smoke reservoir. There will be an inherent amount of smoke separation between these spaces from the bounding construction and the relatively cellular nature of the admin area. In addition, In the event of a fire in the admin area, the smoke would vent into the External Trade /Receiving area and then rise to roof level where it would be extracted once the smoke exhaust fans operate. The smoke exhaust fans serving the External Trade/Receiving area will be designed to operate upon the activation of sprinklers in the Trade/Receiving area as well as in the Admin area.

10.4 Compliance with BCA Performance Requirements

The assessment meets the intent of the BCA and the relevant Performance Requirements which are as follows:

- BCA Performance Requirement EP2.2

  In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building.

The qualitative comparative assessment demonstrates that Performance Requirements are met at least as well as a DtS compliant design.

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10.5 Compliance with BCA Methods of Assessment

- Design complies with the BCA Performance Requirements ➔ Clause A0.5 (b) (i) of the BCA.
- Assessment methods comprise of 'other verification methods as the appropriate authority accepts for determining compliance with the Performance Requirements ➔ Clause A0.9 (b) (ii).

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11.0 Alternative Solution 13 – Fire Brigade Vehicle Access

11.1 Overview of Variations to the BCA DtS Provisions

No.	Performance Requirement	DtS Non-Compliance	Description
13.	CP9	Fire brigade vehicle access *[C2.4]*	The following departures from the DtS access route design are proposed: 1. Due to the location of the carpark access road from Regentville Road, continuous access is not available to the southeast of the building. 2. Localised areas of the emergency access route do not achieve 6 m access width due to the location of the bollards (protecting the fire exits) along the rear vehicle access route.

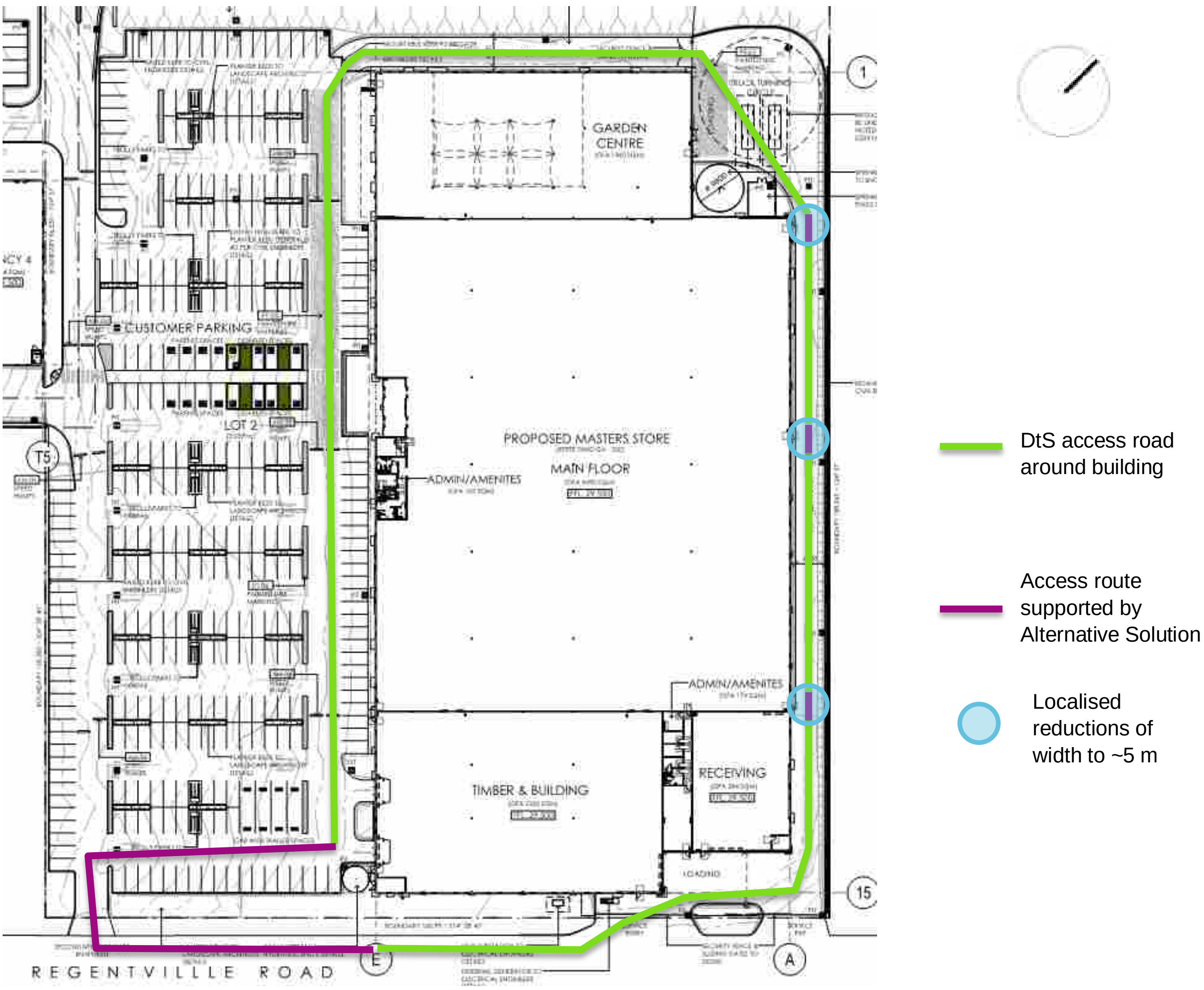

Figure 6 Overview of Alternative Solution 13

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11.2 Intent of the BCA DtS Provisions

The GBCA states the intent of this clause is *"to set the minimum requirements for open space around a building and the provision of vehicular access for the fire brigade."*

Furthermore, *"the required vehicular access must have access from the public road system and must have the width, height and loadbearing capacity to allow the passage in a forward direction around the entire building and parking of fire brigade vehicles."*

11.3 Assessment

The emergency vehicle access route around most of the building will comply with the DtS provisions of BCA Clause C2.4. However, the emergency vehicle access route to the southeast of the building will not fully comply with BCA Clause C2.4. This is due to the location of the secondary customer entry/exit accessed from Regentville Road, which requires fire appliances to briefly travel away from the building. Additionally, some parts of the emergency vehicle access route along the northeast elevation do not achieve the C2.4 provisions of 6 m access width due to the location of required bollards.

The following can be considered in regards to firefighting access:

- The emergency vehicle access route along the majority of the building elevation will comply with Clause C2.4 of the BCA and FRNSW Policy No. 4: Guidelines for emergency vehicle access.
- Fire appliances will be capable of travelling in a forward direction at all times around the building. Fire brigade personnel will be able to park the fire vehicle and set up operations on either Regentville Road or within the carpark. The arrangement will be within close proximity to the building for unobstructed pedestrian access to the fire affected portion of the building.
- As described in FRNSW Policy No. 4 (Figure 7), the width required for general appliance access is 4 m. While the pinch points along the access route will reduce the vehicle access width to a minimum of 5 m, this will not cause significant issues with regards to fire brigade access as the width provided still exceeds the 4 m requirement. Additionally, the rationale for 6 m width limitations is to allow the stabilisers of the aerial appliances to be lowered during fire fighting operation. As the majority of the vehicle access route is > 6m in width, fire brigade vehicles may be stabilised immediately beside pinch points in the event of a fire within the building in close proximity to these locations.
- The majority of the building will be provided with an ESFR sprinkler system in accordance with NFPA 101 Standards. The provision of ESFR sprinklers is a significant additional fire safety measure to that of a sprinkler system designed to AS2118.1. Within the main floor and trade area, the ESFR sprinklers will be designed as a high hazard category.

  ESFR sprinklers operate differently than most other types of sprinklers. While most other sprinklers are intended to control the growth of a fire, an ESFR sprinkler is designed to suppress a fire by using larger volumes of water to knock the fire back to the point of fire origin.
- The main floor area will be provided with a smoke control system. The combination of the smoke extract and the ESFR sprinkler controlled fire will maintain steady state compartment conditions and prevent flashover conditions developing within the building.
- The fire brigade hardstand arrangement to the suction points at the sprinkler tank will comply with FRNSW Guide Sheet No. 5 – Hardstand area for FRNSW appliances.
- The external walls will be designed to comply with Clause C1.11 of the BCA.
- Refer to Figure 2 in Section 4.2 for the Fire Brigade Access and Fire Services Strategy.

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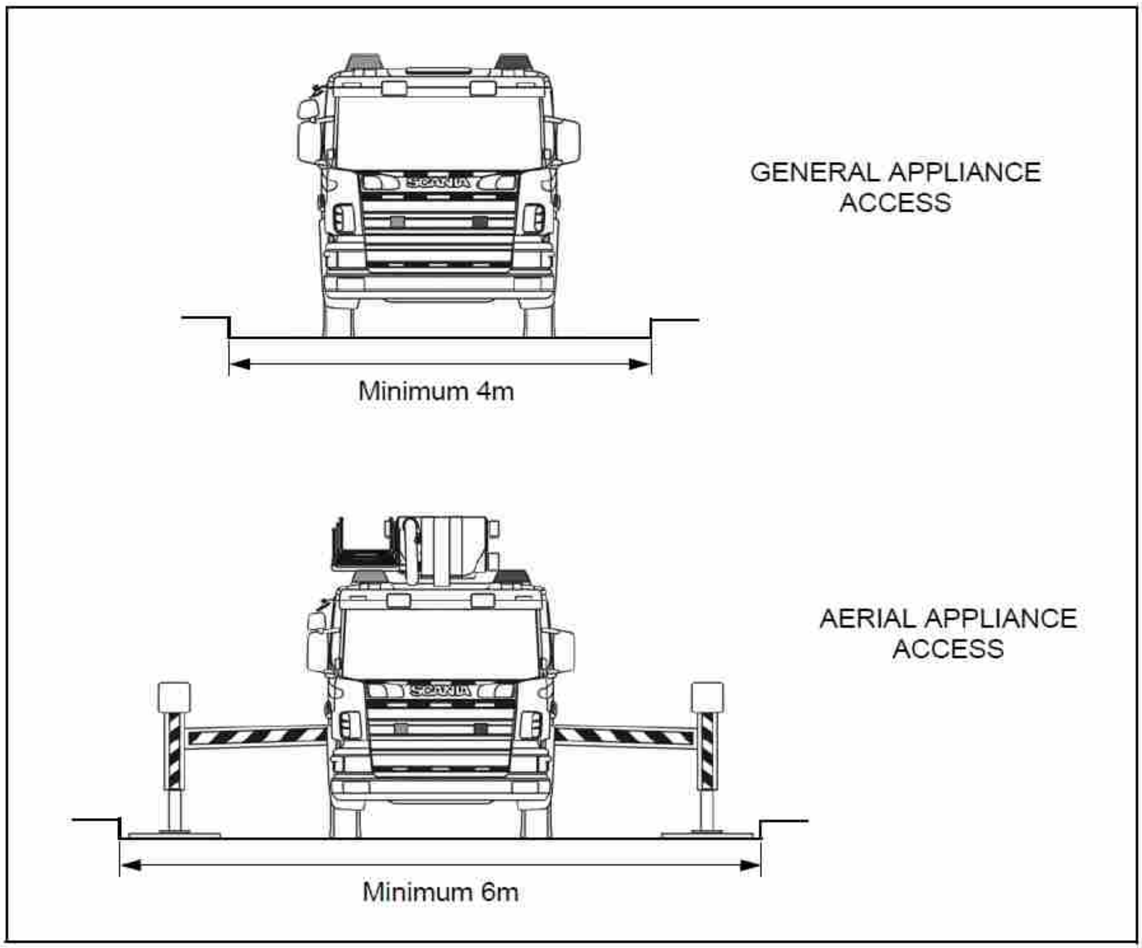

Figure 7 FRNSW Policy No. 4 - Minimum Carriageway Widths

11.4 Compliance with BCA Performance Requirements

The assessment meets the intent of the BCA and the relevant Performance Requirements which are as follows:

- BCA Performance Requirement CP9

  The BCA requires that access must be provided to and around the building, to the degree necessary, for fire brigade vehicles and personnel to facilitate fire brigade intervention.

11.5 Compliance with BCA Methods of Assessment

- Design complies with the BCA Performance Requirements ➔ Clause A0.5 (b) (i) of the BCA.
- Assessment methods comprise of 'other verification methods as the appropriate authority accepts for determining compliance with the Performance Requirements' ➔ Clause A0.9 (b) (ii).

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12.0 Conclusion

This FER documents the Fire Engineering Analysis for the Alternative Solutions to the BCA DtS provisions. The Fire Engineering Analysis demonstrated that the Alternative Solutions meet the Performance Requirements of the BCA.

This is subject to the mitigating measures identified in Table 1.

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13.0 Validity and Limitations

a) This report is consistent with the fire safety provisions, objectives and limitations of the BCA:

1) We have been informed that building features not part of an Alternative Solution (see Section 4.0) will comply with the DtS provisions of the BCA.

2) This report excludes the analysis and design of fires including incendiary ones involving accelerants, explosives and/or multiple ignition sources, or acts of terrorism.

3) Egress and fire safety provisions for persons with disabilities including compliance with the Disability Discrimination Act (DDA) were considered to the same degree as the BCA.

4) Unless stated otherwise, protection of property (other than adjoining property), business interruption or losses, personal or moral obligations of the owner/occupier, reputation, environmental impacts, broader community issues, amenity or non-fire related matters in the building such as health, security, energy efficiency, and occupational health & safety are specifically excluded from this analysis.

b) This report is not a compliance or conformance audit for any fire safety system. For example, operational checks of fire safety equipment, verification of construction techniques, fire resistance levels or the witnessing of fire drills or exercises are specifically excluded from the scope of this report.

c) The recommendations in this report are based on information provided by others. AECOM has not verified the accuracy and/or completeness of this information.

The recommendations, data and methodology apply to the subject building and must not be utilised for any other purpose. Any modifications or changes to the building, fire safety management system, or building usage from that described may invalidate the findings of this report necessitating a re-assessment.

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Appendix A

Occupant Characteristics

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Appendix A Occupant Characteristics

The building occupants can be broadly classified into 2 groups:

- Occupant group 1 – Staff members
- Occupant group 2 – Public, visitors, shoppers & patrons

Occupant Group 1 – Staff Members

Occupant Group 1 comprising staff is expected to have the following characteristics:

Table 12 Occupant Characteristics – Staff Members

Characteristic	Description
Distribution – age, gender, location	Staff are considered to be representative of the general population with no specific or unusual distributions applicable in gender and physical or mental attributes. The majority of occupants are expected to be between 16 and 65 years of age.
State of awareness	This occupant group is expected to be awake and conscious of their surroundings.
Familiarity – egress routes, group roles, training	This occupant group is generally expected to be familiar with egress routes, have particular group roles and have some emergency response training.
Mobility	The majority of this occupant group is considered to have a similar level of mobility as the general population and do not require special assistance for evacuation. Some minor percentage of this group may have some disabilities that may require some level of assistance for evacuation.

Occupant Group 2 – Public

Occupant Group 2 comprising the public, visitors, shoppers & patrons is expected to have the following characteristics:

Table 13 Occupant Characteristics - Public

Characteristic	Description
Distribution – age, gender, location	Shoppers are considered to be representative of the general population with no specific or unusual distributions applicable in gender, age and physical or mental attributes.
State of awareness	This occupant group is expected to be awake and conscious of their surroundings.
Familiarity – egress routes, group roles, training	This occupant group is generally expected to be unfamiliar with egress routes, have no particular group roles except for those associated with immediate family and friends, and have no emergency response training.
Mobility	This occupant group is considered to have a similar level of mobility as the general population. Some occupants may have mobility impairments that require wheel chairs, crutches or the like to evacuate on their own or with assistance from other people. Persons with disabilities and/or aged persons are not expected to require special assistance other than from their carers or relatives / staff members who may already be present.

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Appendix B

Smoke Detector & Sprinkler Activation Calculations

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Appendix B Smoke Detector & Sprinkler Activation Calculations

Main Floor Smoke detector activation time from FDS simulation

s	%/m	%/m	%/m	%/m
Time	SD	SD03	SD01	SD02
0.00	0.00	0.00	0.00	0.00
1.26	0.00	0.00	0.00	0.00
2.51	0.00	0.00	0.00	0.00
3.65	0.00	0.00	0.00	0.00
4.91	0.00	0.00	0.00	0.00
6.05	0.00	0.00	0.00	0.00
7.30	0.00	0.00	0.00	0.00
8.44	0.00	0.00	0.00	0.00
9.60	0.00	0.00	0.00	0.00
10.82	0.00	0.00	0.00	0.00
12.09	0.00	0.00	0.00	0.00
13.25	0.00	0.00	0.00	0.00
14.41	0.00	0.00	0.00	0.00
15.63	0.00	0.00	0.00	0.00
16.83	0.00	0.00	0.00	0.00
18.06	0.00	0.00	0.00	0.00
19.21	0.00	0.00	0.00	0.00
20.42	0.00	0.00	0.00	0.00
21.64	0.00	0.00	0.00	0.00
22.83	0.00	0.00	0.00	0.00
24.04	0.00	0.00	0.00	0.00
25.25	0.00	0.00	0.00	0.00
26.43	0.00	0.00	0.00	0.00
27.65	4.32	0.28	0.05	0.56
28.82	18.50	12.28	9.33	13.54

Detection time at approximately 28 seconds, when obscuration per meter of 3%/m is exceeded

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Sprinkler activation time calculated from Alpert's correlation

Alpert's correlation - Sprinkler activation

Theory

Alpert R L, *Calculation of response time of ceiling mounted fire detectors*, Fire Technology, 8(3), pages 181 - 195, 1972
Heskestad G and Bill R G, *Conduction heat-loss effect on thermal response of automatic sprinklers*, Fire Safety Journal, v.14, pages 113-125, 1988
As referenced in *The SFPE Handbook of Fire Protection Engineering* and *International Fire Engineering Guidelines*.

Assumptions:
* Flat smooth ceilings
* Unconfined gas flow
* Strong plume (flaming) fires
* Axisymmetric plumes (not near walls or corners)
* The heat sensitive element is located in the peak velocity and peak temperature region of the ceiling jet.

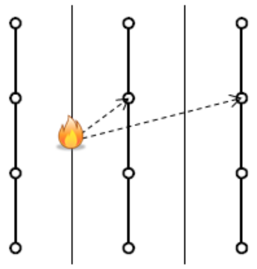
$$T_g - T_a = \frac{5.38\,(Q/r)^{2/3}}{H} \quad \circ C \qquad \text{where } \frac{r}{H} > 0.18$$

$$T_g - T_a = \frac{16.9\,Q^{2/3}}{H^{5/3}} \quad \circ C \qquad \text{where } \frac{r}{H} \le 0.18$$

$$u = \frac{0.20\,Q^{1/3} H^{1/2}}{r^{5/6}} \quad m/s \qquad \text{where } \frac{r}{H} > 0.15$$

$$u = 0.95\left(\frac{Q}{H}\right)^{1/3} \quad m/s \qquad \text{where } \frac{r}{H} \le 0.15$$

$$\frac{dT_d}{dt} = \frac{\sqrt{u}}{RTI}\left[(T_g - T_{room}) - \left(1 + \frac{C}{\sqrt{u}}\right)(T_d - T_{room})\right]$$



T_g = maximum, near ceiling, fire-gas temperature (°C)
T_a = ambient temperature (°C)
Q = total heat release rate of fire (kW)
r = radial distance from the axis of the fire plume (m)
H = height above the origin of the fire (m)
u = maximum, near ceiling, fire-gas velocity (m/s)
T_d = detector temperature (°C)
RTI = response time index ($m^{1/2}s^{1/2}$)
C = conduction factor ($m^{1/2}s^{-1/2}$)

Calculation

Enter ambient temperature (°C) 21

Scenario / fire location	Fire growth rate	Height above fire (m)	Radial distance (m)	Sprinkler activation temp (°C)	Response time index ($m^{1/2}s^{1/2}$)	Conduction factor ($m^{1/2}s^{-1/2}$)	Sprinkler activation time (s)	Fire HRR at activation (MW)
Design Fire	t2 (Ultrafast)	9.3	2.12	101	50	0	**157**	**4.62**
Redundancy Case	t2 (Ultrafast)	9.3	4.74	101	50	0	**229**	**9.84**

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DtS Trade & Receiving Area Smoke Detector activation time

Alpert's correlation - Detector activation

Theory

Alpert R L, *Calculation of response time of ceiling mounted fire detectors*, Fire Technology, 8(3), pages 181 - 195, 1972
Heskestad G and Bill R G, *Conduction heat-loss effect on thermal response of automatic sprinklers*, Fire Safety Journal, v.14, pages 113-125, 1988
As referenced in *The SFPE Handbook of Fire Protection Engineering* and *International Fire Engineering Guidelines*.

Assumptions:
* Flat smooth ceilings
* Unconfined gas flow
* Strong plume (flaming) fires
* Axisymmetric plumes (not near walls or corners)
* The heat sensitive element is located in the peak velocity and peak temperature region of the ceiling jet.

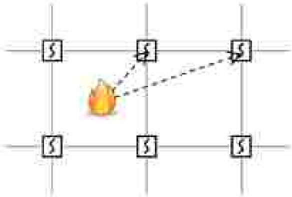
$$T_g - T_a = \frac{5.38\,(Q/r)^{2/3}}{H} \;\circ C \qquad \text{where } \frac{r}{H} > 0.18$$

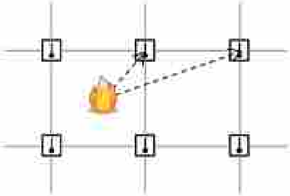
$$T_g - T_a = \frac{16.9\,Q^{2/3}}{H^{5/3}} \;\circ C \qquad \text{where } \frac{r}{H} \le 0.18$$

$$u = \frac{0.20\,Q^{1/3}H^{1/2}}{r^{5/6}} \;m/s \qquad \text{where } \frac{r}{H} > 0.15$$

$$u = 0.95\left(\frac{Q}{H}\right)^{1/3} \;m/s \qquad \text{where } \frac{r}{H} \le 0.15$$

$$\frac{dT_d}{dt} = \frac{\sqrt{u}}{RTI}\left[(T_g - T_d)\right]$$





T_g = maximum, near ceiling, fire-gas temperature (°C)
T_a = ambient temperature (°C)
Q = total heat release rate of fire (kW)
r = radial distance from the axis of the fire plume (m)
H = height above the origin of the fire (m)
u = maximum, near ceiling, fire-gas velocity (m/s)
T_d = detector temperature (°C)
RTI = response time index ($m^{1/2}s^{1/2}$)

Calculation

Enter ambient temperature (°C) 21

Scenario / fire location	Fire growth rate	Height above fire (m)	Radial distance (m)	Detector activation temp (°C)	Response time index ($m^{1/2}s^{1/2}$)	Detector activation time (s)	Fire HRR at activation (MW)
Design Fire	t2 (Ultrafast)	9.3	7.21	34	1	64	0.77

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Appendix C

CFD Modelling

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Appendix C CFD Modelling

Purpose of CFD Modelling

CFD has been carried out in order to support the following Fire Engineering Assessments in the Main Floor area:

No.	Performance Requirement	DtS Non-Compliance	Description
14.	DP4	Travel distance *[D1.4]*	Egress from the main floor area exceeds the DtS limits of: • 20 m to a point of choice, up to 30 m • 40 m to an exit, up to 70 m
15.	DP4	Distance between alternative exits *[D1.5]*	The distance between alternative exits is over the DtS limit of 60 m, up to 100 m
16.	EP2.2	Smoke reservoir size *[Spec E2.2b]*	The smoke reservoir area is 8,490 m², where the DtS limit is 2,000 m²

Modelling Geometry

The CFD Modelling that was carried out is represented in Figure 8. Only the Main floor area was modelled using CFD, with other portions of the building supported by calculations or zone modelling. Inlet air from the Trade Area and Garden Area are represented by openings at indicative locations.

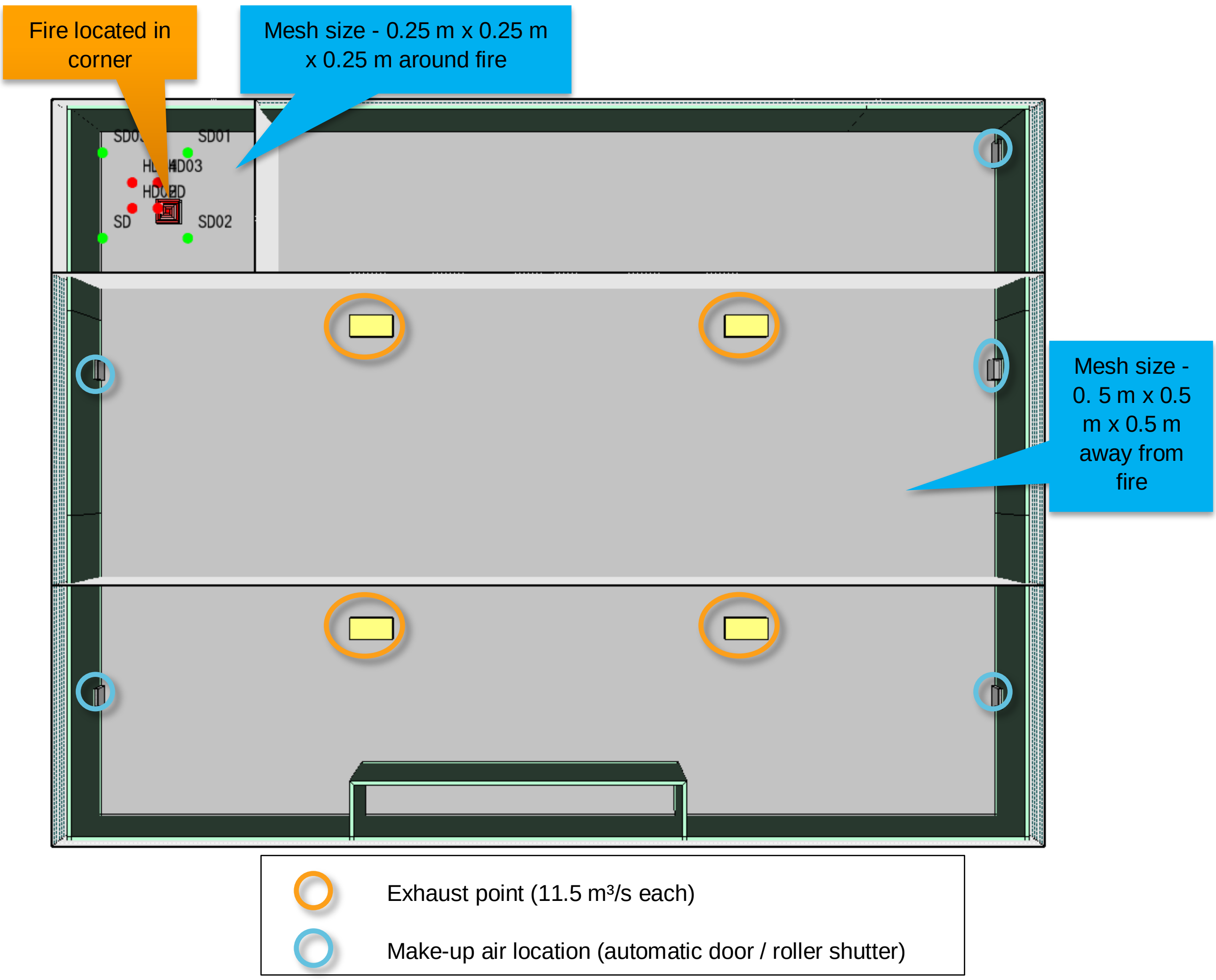

Figure 8 CFD Modelling Geometry of Main Floor Area

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Modelling Software

Computational Fluid Dynamic (CFD) was undertaken using Fire Dynamic Simulator (FDS) version 6. The software was developed by the building Fire Research Laboratory at National Institute of Standard and Technology (NIST) in the USA.

FDS models fire-driven fluid flow. The software solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow, with an emphasis on smoke and heat transport from fires. For further information on the background and modelling equations of FDS readers are referred to the FDS User Guide and Technical Guide. These can be downloaded from the NIST website at http://fire.nist.gov/fds/.

Modelling Assumptions

The major assumptions made in the CFD modelling are outlined as follows. Unless specified below, the default parameters of FDS were utilised.

Acceptance Criteria

The acceptance criteria are as follows:

Table 14 Proposed Acceptance Criteria (Generally from CIBSE Guide E 2010)

Criteria	Description
Hot Layer Height	The criteria for convective temperature and visibility will be applied if the hot layer falls below 2 m above floor level. The 2 m is referenced from BCA Spec E2.2b.
Visibility	10 m if the hot layer falls below 2 m above floor level, and 5 m whilst queuing within the immediate vicinity of an exit [in accordance with CIBSE Guide E].
Temperature (radiation)	< 2.5 kW/m², equivalent to 185 °C (0 m from the source). As sprinklers are provided it is not anticipated that smoke will reach this temperature.
Temperature (convection)	< 60 °C (based on saturated smoke – because there are sprinklers, this is appropriate).
Carbon monoxide	In the event that visibility falls below 10m – carbon monoxide (CO) concentration <1500 ppm.

Modelling Inputs

The major assumptions made in the CFD modelling are outlined as follows. Unless specified below, the default parameters of FDS were utilised.

Table 15 CFD Input

Fire		
Parameter	**Data Input or Assumptions**	**Comments**
Fire Size	Design Fire: 5 MW Redundancy Case: 10 MW	The design case is based on 1st row sprinklers controlling the fire size. An ultra-fast t^2 growth rate will be adopted. The redundancy case is based on delayed sprinkler activation, and assumes activation of sprinklers in the 2nd row.
Location	Fire in the corner of the room	
Fire Growth	An ultra-fast t^2 growth rate (α = 0.188 kW/s²) has been selected for each fire scenario.	Growth rate (α) adopted from IFEG.

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Burners	In each fire scenario the total burner area to be compiled from multiple smaller burners. For each scenario the model will seek to adopt a Heat Release Rate Per Unit Area (HRRPUA) in the region of 500-1000 kW/m².	Each burner ignites progressively from the centre of the fire until the full total fire size is reached. This allows the full HRR per unit area to be reached for each burner prior to the fire reaching its peak value, ensuring the fire is well resolved on the numerical grid.
Reaction Properties	Heat of Combustion = 25 MJ/kg SOOT_YIELD = 0.1 g/g CO_YIELD = 0.025 g/g Visibility Factor = 3	Values for reaction properties are based on Polyurethane, which is one of the default properties in FDS.
Ambient Conditions		
Parameter	**Data Input or Assumptions**	**Comments**
Temperature	Ambient Temperature of 21°C will be adopted.	
Wind	No external wind will be considered.	
Ventilation	**Smoke exhaust** 46 m³/s exhaust total, split across 4 extract points at high level (Design Fire and Redundancy Case) **Make-up Air** Make-up air will be provided to the main floor area from various openings including automatic doors, louvers and roller shutters that connect the trade/receiving area and garden area to the main floor. The combined clear effective area of these openings is at least 20 m^2. This limits the velocities to 2.5 m/s or below as per BCA DtS provisions.	
Geometry		
Parameter	**Data Input or Assumptions**	**Comments**
Material Properties	Walls shall be modelled as metal, concrete and plasterboard as appropriate.	
Computational		
Parameter	**Data Input or Assumptions**	**Comments**
Mesh Size	A uniform cell size of 0.25 m will be adopted in areas adjacent to the fire. This will be increased to 0.5 m away from the fire.	The mesh size used for the fire can be compared to the characteristic fire diameter (D*). The FDS manual cites a sensitivity study carried out where D*/dx values ranged from 4 to 16. These values were deemed in the particular examples to adequately resolve plume dynamics, along with other geometrical characteristics. A fire size of 5000 kW, modelled with a 0.25 m uniform cell sizes achieves a D*/dx value of ~7.34 which is within the desired range. For 10,000 kW D*/dx is 9.96.

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CFD Modelling Scenarios and Results Summary

Scenario	Details	Location	Peak HRR (MW)	ASET
Design Fire	Design case	Main floor area (corner)	5 MW	**610**
Redundancy Case	Delayed sprinkler control – HRR capped by 2nd row sprinklers	Main floor area (corner)	10 MW	**475**

Results – Design Fire

Figure 9 demonstrates visibility at 2 m above floor level at the onset of untenable conditions (610 s). This has been selected as the ASET. Results at the RSET plus a factor of safety (RSETx1.5 = 597 s) are provided in Figure 10 to demonstrate that tenability conditions are clearly met.

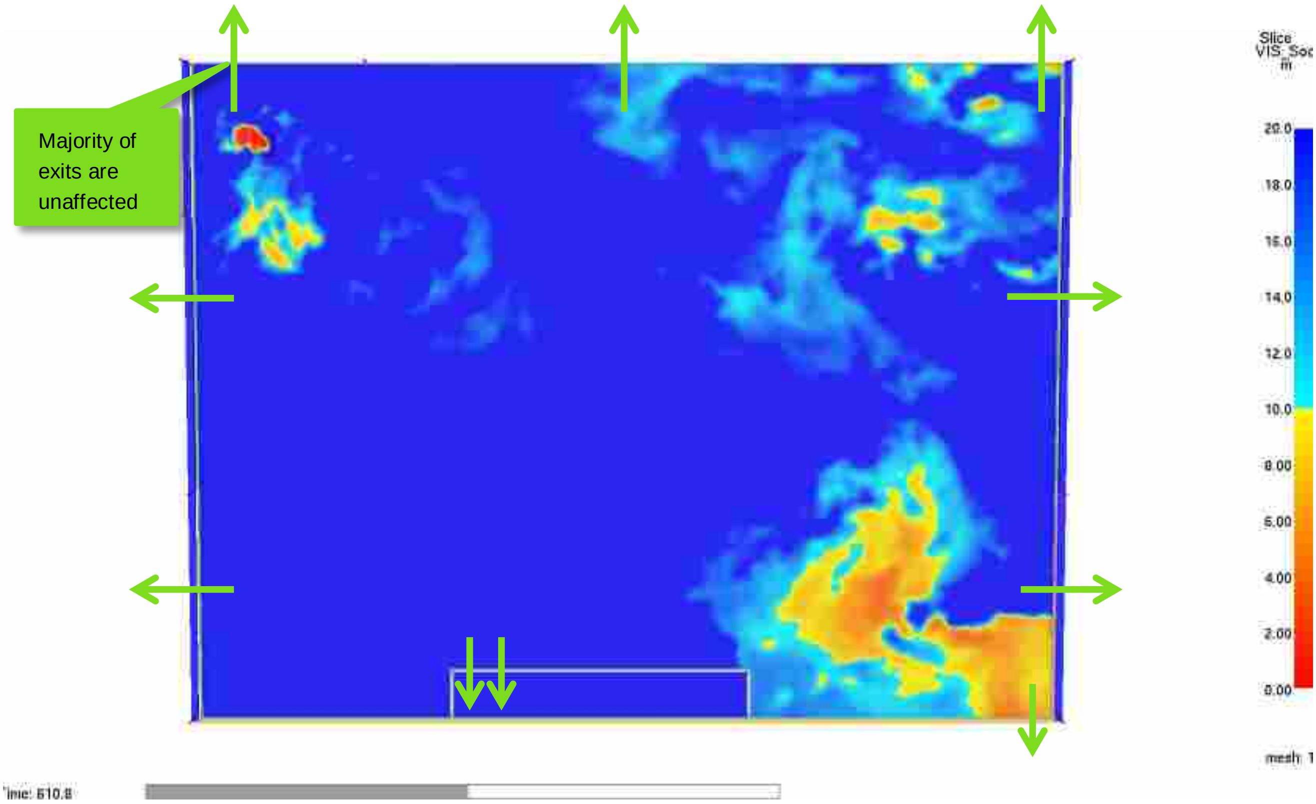

Figure 9 **Visibility Slice at ASET (610 s) 2 m above floor level (head height) across the Main Floor Area – Design Case**

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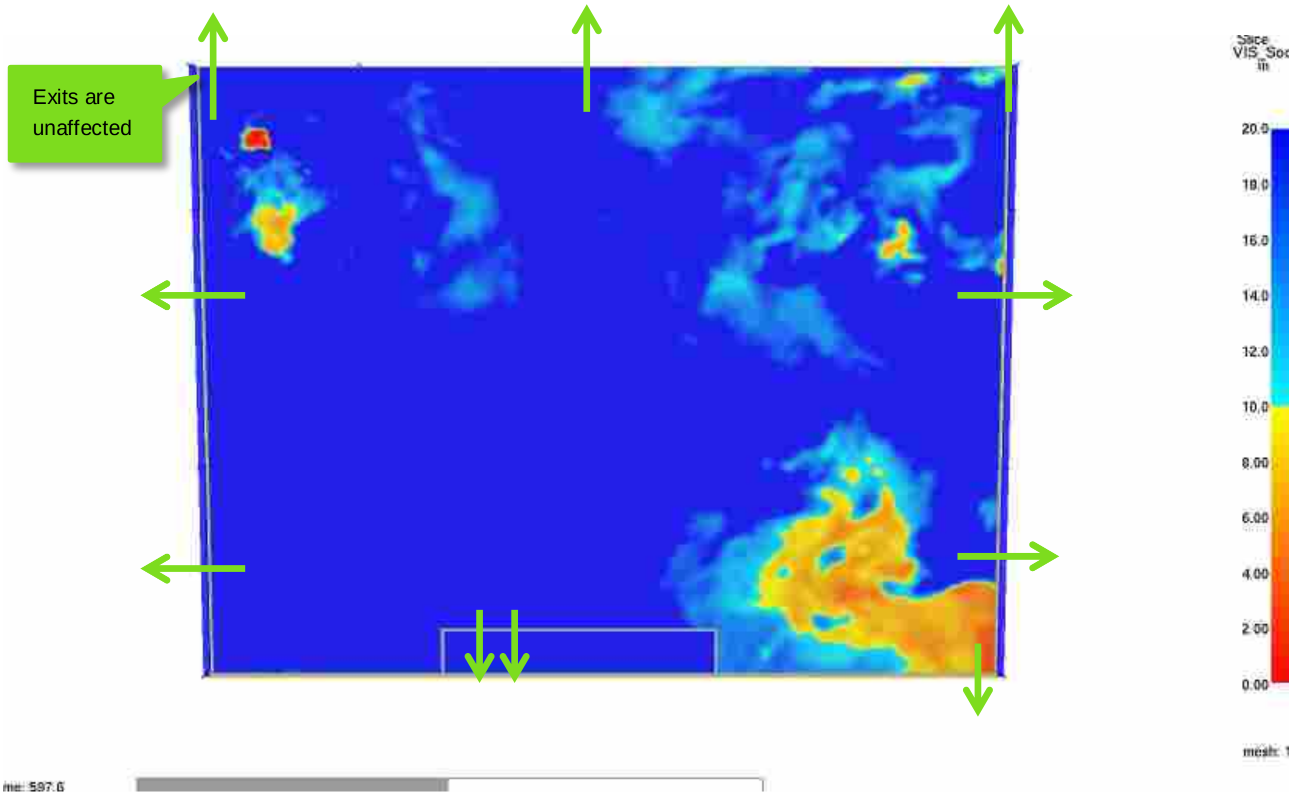

Figure 10 Visibility Slice at RSETx1.5 (597 s) 2 m above floor level (head height) across the Main Floor Area – Design Case

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Results – Redundancy Case

Figure 11 demonstrates visibility at 2 m above floor level at the onset of untenable conditions (475 s). This has been selected as the ASET. Results at the RSET (398 s) are provided in Figure 12 to demonstrate that tenability conditions are clearly met.

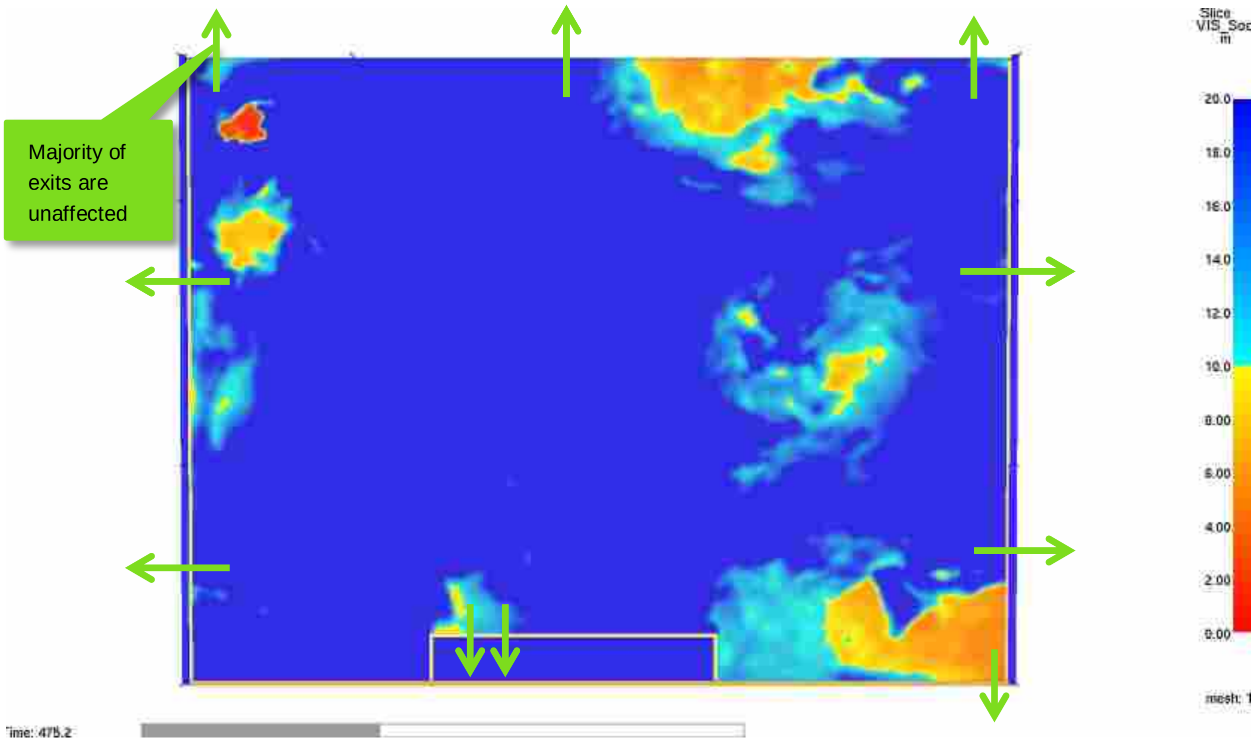

Figure 11 Visibility Slice at ASET (475 s) 2 m above floor level (head height) across the Main Floor Area – Redundancy Case

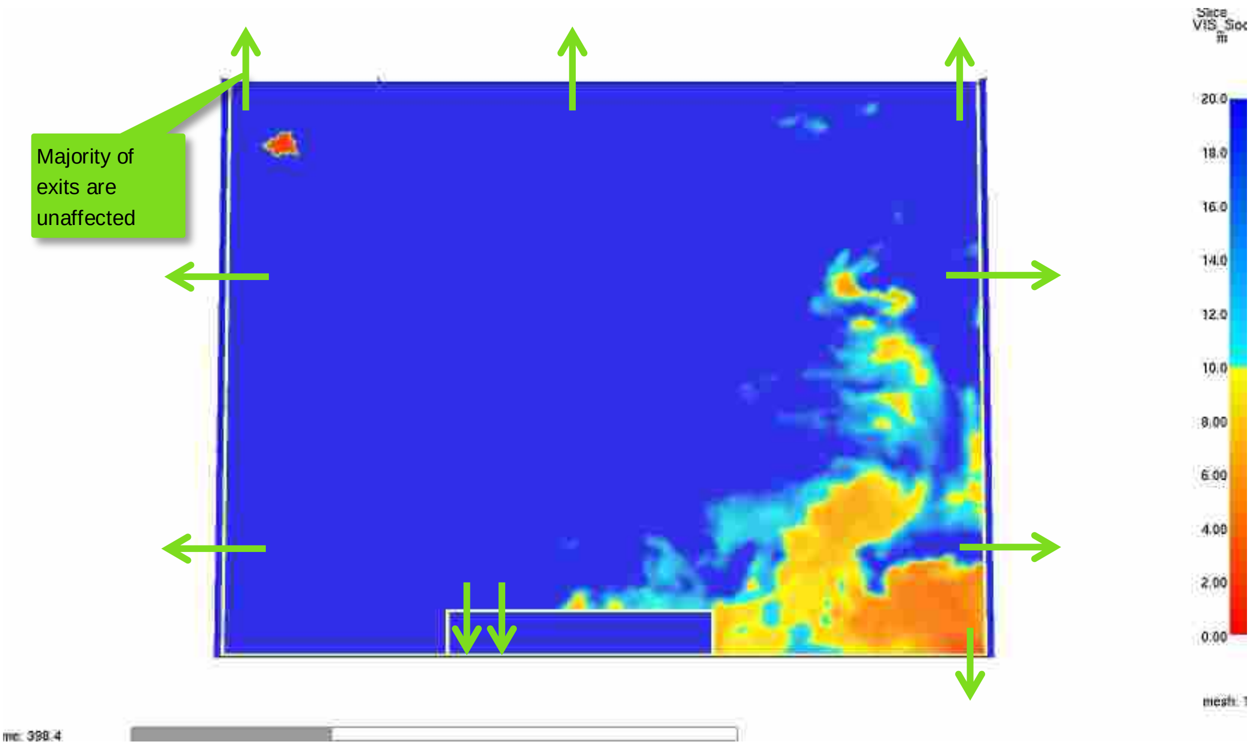

Figure 12 Visibility Slice at RSET (398 s) 2 m above floor level (head height) across the Main Floor Area – Redundancy Case

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Results – Conditions for Fire Brigade Intervention

Fire brigade personnel will not be impacted by reduced visibility to the same degree as egressing building occupants. Temperature within the fire affected area will have a more significant impact on firefighting, especially during later stages of the fire.

For the redundancy case, a temperature slice at 2 m above floor level is provided in Figure 13 to demonstrate that temperature conditions remain tenable for fire brigade intervention through the duration of the simulation. In addition, the carbon monoxide (CO) level of the smoke, indicated in Figure 14, is shown to be 150 ppm at the end of the simulation. This is significantly lower than the carbon monoxide acceptance criteria concentration of 1500 ppm.

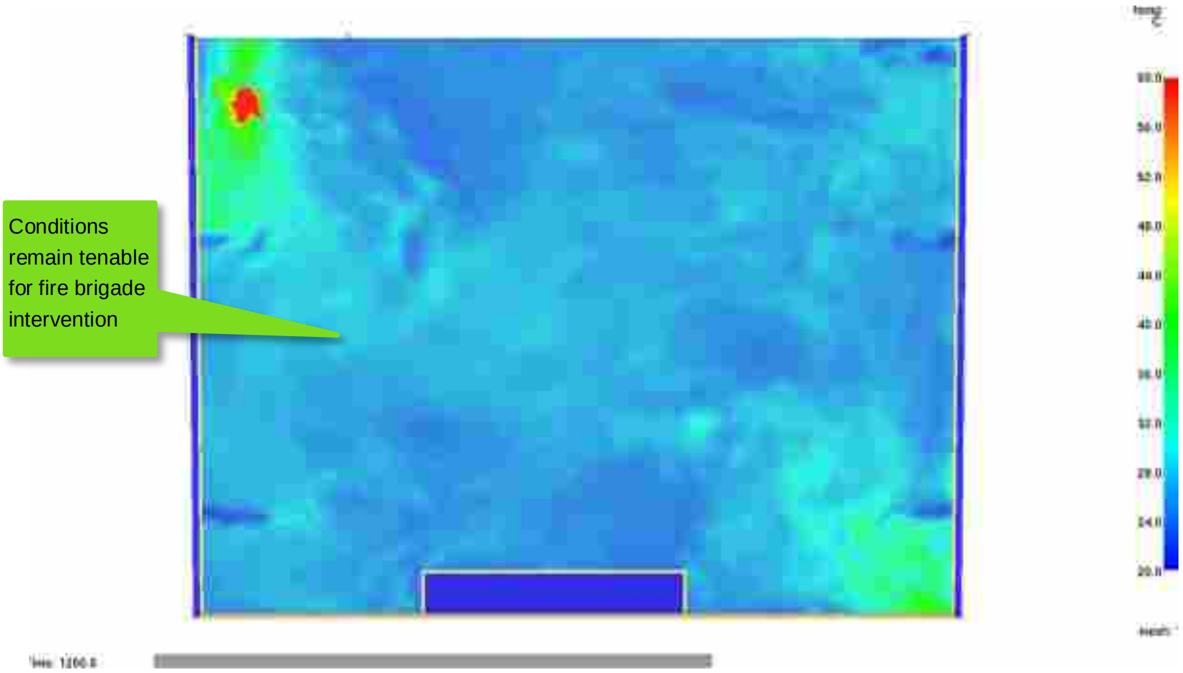

Figure 13 **Temperature Slice at End of Run (1200 s) 2 m above floor level (head height) across the Main Floor Area**

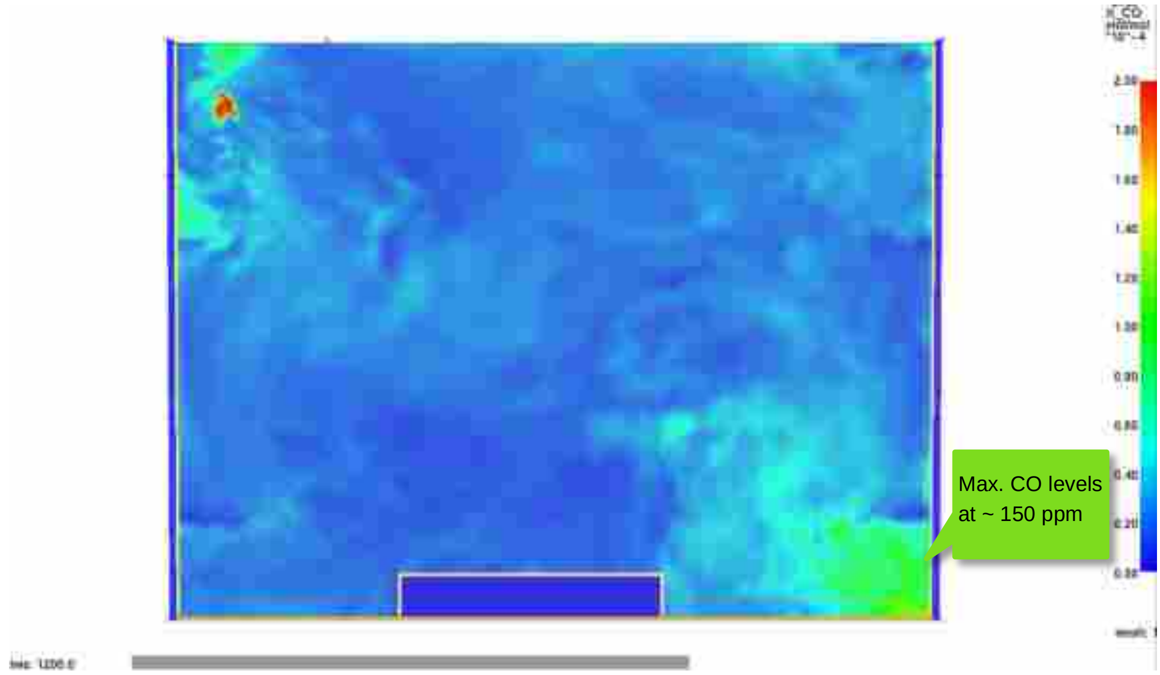

Figure 14 **CO Slice at End of Run (1200 s) 2 m above floor level (head height) across the Main Floor Area**

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Appendix D

Egress Width Calculations

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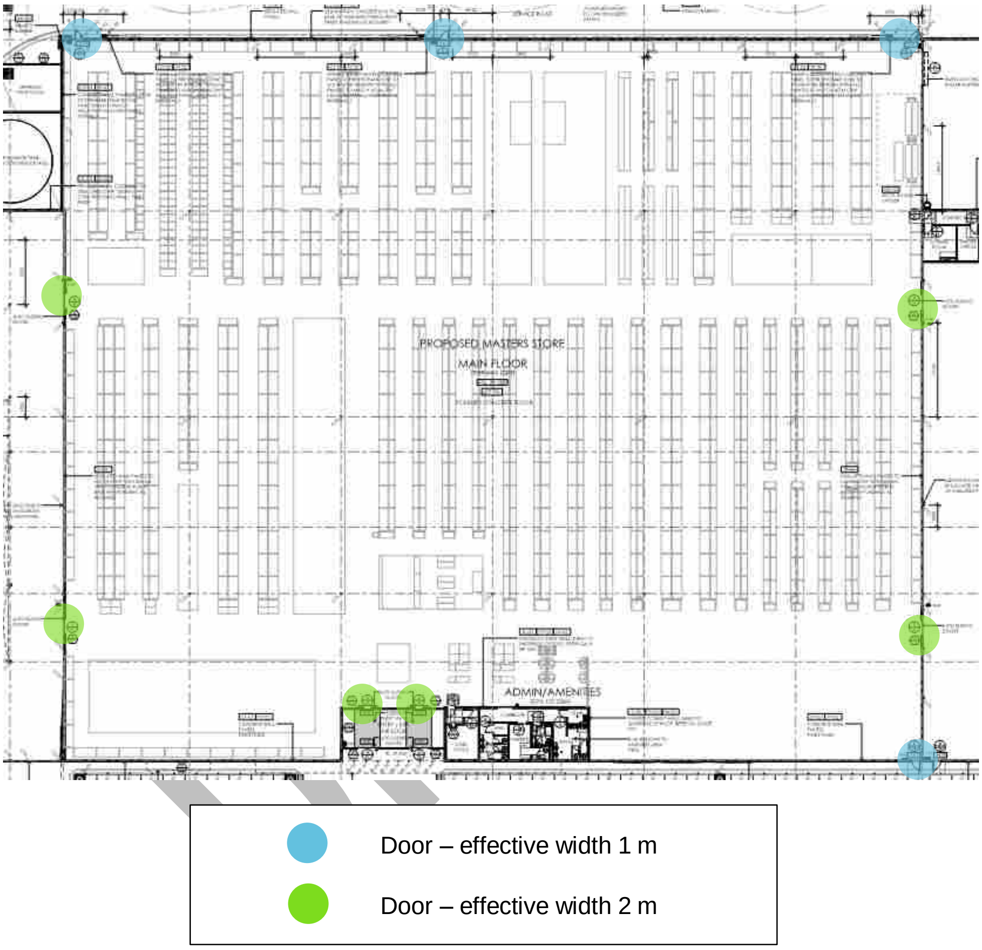
Appendix D Egress Width Calculations

Exits from Main Floor – Locations



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Egress Width Calculations - considering maximum travel distance to an exit

A horizontal travel speed of 1 m/s has been adopted based on the recommended walking speed for less densely occupied areas (more than 1 m²/s), identified in Chapter 13 of the SFPE Handbook of Fire Protection Engineering.

Evacuation - Hydraulic Flow / Effective Width

AECOM

Theory

Gwynne S. M. V. And Rosenbaum E. R., *Employing the Hydraulic Model in Assessing Emergency Movement*, Chapter 13, The SFPE Handbook of Fire Protection Engineering, 4th edition, 2008.

Assumptions of hydraulic flow and effective width concepts:

1. The prime controlling factor will be either the stairways or the door discharging from them.
2. Queuing will occur and therefore specific flow will be the maximum specific flow in some instances.
3. All occupants start egress at the same time.
4. The population will use all facilities in the optimum balance.

Input

Number of occupants	1415	
Type of stairs	Stairs (279.4mm tread, 177.8mm riser)	
Maximum travel distance to exit elements	70	m
Occupant horizontal travel speed	1	m/s
Use maximum specific flow through exit elements or calculated based on density?	Max Specific Flow	

Details of exit elements

Exit element	Exit type	Unobstructed width (m)
Main entry	Doors	2
Main exit	Doors	2
Intermediate Exit	Doors	2
Intermediate Exit	Doors	2
Intermediate Exit	Doors	2
Intermediate Exit	Doors	2
Exit to outside	Doors	1
Exit to outside	Doors	1
Exit to outside	Doors	1
Exit to outside	Doors	1

Results

Travel time	70.00	
Based on distance / walking speed	**70.0**	s
Queuing time	16	
Total unobstructed width of exits	13.20	m
Total effective width of exits	1.30	m
Weighted specific flow	17.16	persons / s / m effective width
Occupant flow	82.46	persons / s
Calculated queuing time	**87.4**	s
Queuing time exceeds travel time		
Calculated movement period	**87.4**	**s**
or	**1.5**	**mins**

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<u>Egress Width Calculations - considering maximum travel distance between alternative exits</u>

A horizontal travel speed of 1 m/s has been adopted based on the recommended walking speed for less densely occupied areas (more than 1 m²/s), identified in Chapter 13 of the SFPE Handbook of Fire Protection Engineering.

For added redundancy in the design, the travel time based on distance between alternative exits will be used in the RSET calculations for the Main Floor Area.

Evacuation - Hydraulic Flow / Effective Width

AECOM

Theory

Gwynne S. M. V. And Rosenbaum E. R., *Employing the Hydraulic Model in Assessing Emergency Movement*, Chapter 13, The SFPE Handbook of Fire Protection Engineering, 4th edition, 2008.

Assumptions of hydraulic flow and effective width concepts:

1. The prime controlling factor will be either the stairways or the door discharging from them.
2. Queuing will occur and therefore specific flow will be the maximum specific flow in some instances.
3. All occupants start egress at the same time.
4. The population will use all facilities in the optimum balance.

Input

Number of occupants	1415	
Type of stairs	Stairs (279.4mm tread, 177.8mm riser)	
Maximum travel distance to exit elements	100	m
Occupant horizontal travel speed	1	m/s
Use maximum specific flow through exit elements or calculated based on density?	Max Specific Flow	

Details of exit elements

Exit element	Exit type	Unobstructed width (m)
Main entry	Doors	2
Main exit	Doors	2
Intermediate Exit	Doors	2
Intermediate Exit	Doors	2
Intermediate Exit	Doors	2
Intermediate Exit	Doors	2
Exit to outside	Doors	1
Exit to outside	Doors	1
Exit to outside	Doors	1
Exit to outside	Doors	1

Results

Travel time

Based on distance / walking speed	**100.0**	s

Queuing time

Total unobstructed width of exits	16.00	m
Total effective width of exits	13.20	m
Weighted specific flow	1.30	persons / s / m effective width
Occupant flow	17.16	persons / s
Calculated queuing time	**82.5**	s

Travel time exceeds queuing time

Calculated movement period	**100.0**	**s**
or	**1.7**	**mins**

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Appendix E

B-Risk Modelling

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Appendix E B-Risk Modelling

Modelling Software

B-Risk is a multi-compartment (up to 10 rooms) fire model accommodating multiple vents, and multiple burning objects. The model aims to predict various fire phenomena in the upper and lower layers including temperatures, species concentrations, plume and vent flows, layer interface height, fractional effective dose, visibility and sprinkler/detector actuation. In addition, the model includes optional flame spread and fire growth models, for predicting the ignition of room lining materials and adds their contribution to the fire in the room. Further information may be found at http://www.branz.co.nz/cms_display.php?sn=75&st=1&pg=11643.

Preliminary Calculations

B-Risk zone models are dependent on compartment size. Certain software limitations impose a maximum compartment size for single-room zone models. Compartments that exceed these limitations must be modelled as multi-room zones. The limitation is determined by the following equations (Wade 2013).

$$\dot{Q}^* = \frac{\dot{Q}}{1110 H_e^{5/2}}$$

$$SF = \frac{A_f}{H_e^2}$$

Where:
H_e = Height of the Space (m)
A_f = Floor area of the Space (m²)

Modelling requirements are summarised in the following table.

Heat Release Rate Parameter ($\dot{Q}^*$)	Shape Factor (SF)	Required Case
$\dot{Q}^* \leq 0.15$	$0.4 \leq SF \leq 70$	Single-Room Zone Model
$\dot{Q}^* \leq 0.15$	$SF \geq 70$	Multi-Room Zone Model with each room $0.4 \leq SF \leq 70$

The calculations in the following table demonstrate that for the DtS Design and the Proposed Design a single-room zone model in required.

Parameter	DtS Design	Proposed Design
Heat Release Rate, $\dot{Q}$ (kW)	5000	
Average Ceiling Height, H_e (m)	8.5	
Floor Area, A_f (m²)	2,000	2,790
Heat Release Rate Parameter ($\dot{Q}^*$)	*0.021*	*0.02117*
Shape Factor (SF)	*27.7*	*38.6*
Required Case	**Single-Room Zone Model**	

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Modelling Inputs

A summary of the B-Risk modelling inputs is shown in the following table.

Parameter	DtS Design	Proposed Design
Max. Reservoir Area	2,000 m²	2,790 m²
Avg. Ceiling Height*	8.5 m	8.5 m
Smoke Exhaust Rate	20 m³/s	30 m³/s
Activation of smoke exhaust	Smoke detectors	Sprinklers
Exhaust activation time	154 s (64 s detection + 90 s transport lag) Detection time based on smoke detection	247 s (157 s + 90 s alarm transmission) Detection time based
Fire Size**	5.0 MW (Ultra-fast t²) α = 0.188 kW/s²	
Simulation Run Time	1500 s	

*Average ceiling height used for modelling in order to consider equivalent smoke reservoir volume in Proposed Design.
**Fire size based on sprinkler activation at maximum ceiling height – See Appendix B.

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Modelling Results

DtS Design

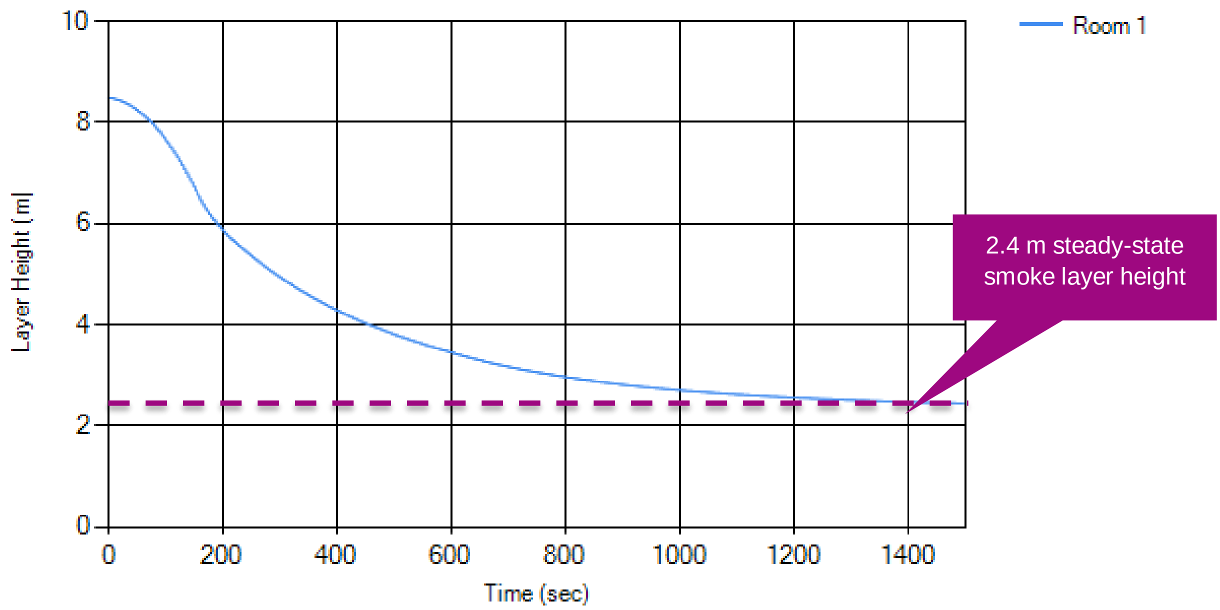

Figure 15 Smoke layer height for DtS case at 1500 s

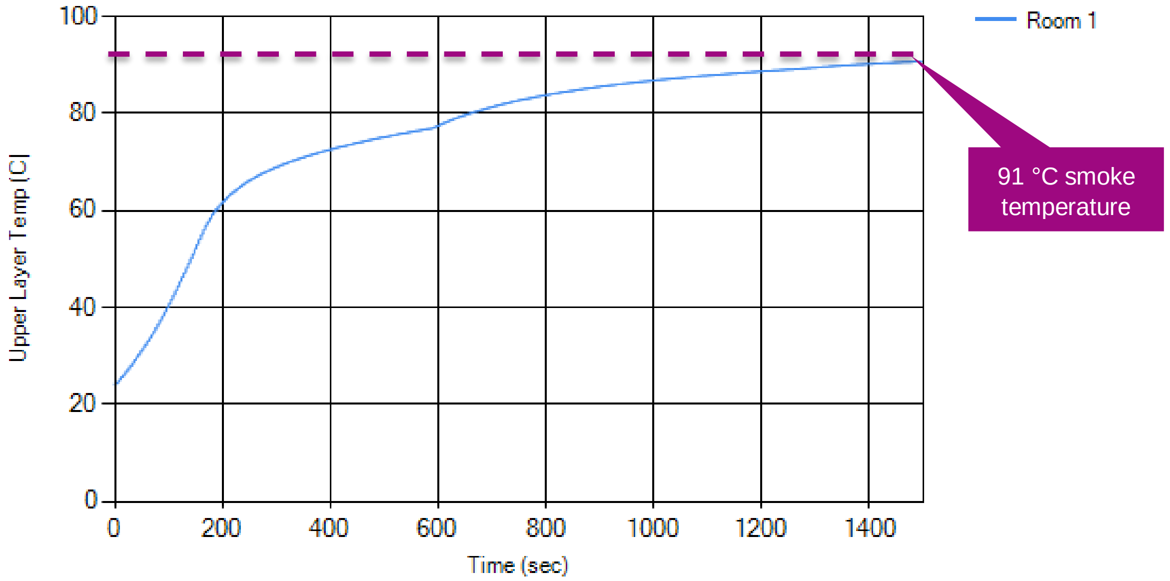

Figure 16 Smoke temperature for DtS case at 1500 s

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Proposed Design

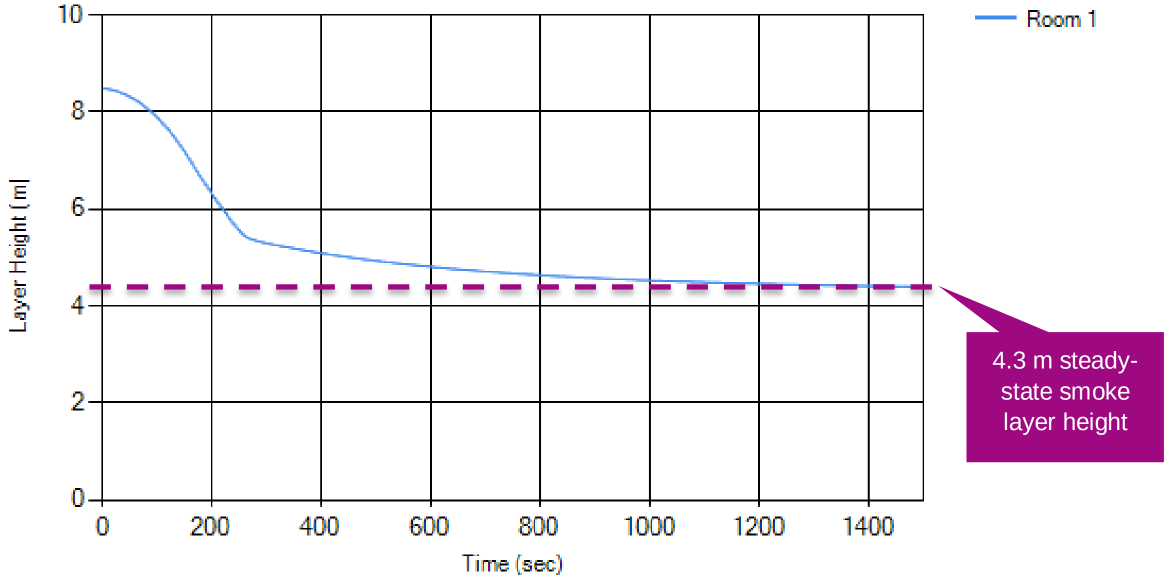

Figure 17 Smoke layer height for design case at 1500 s

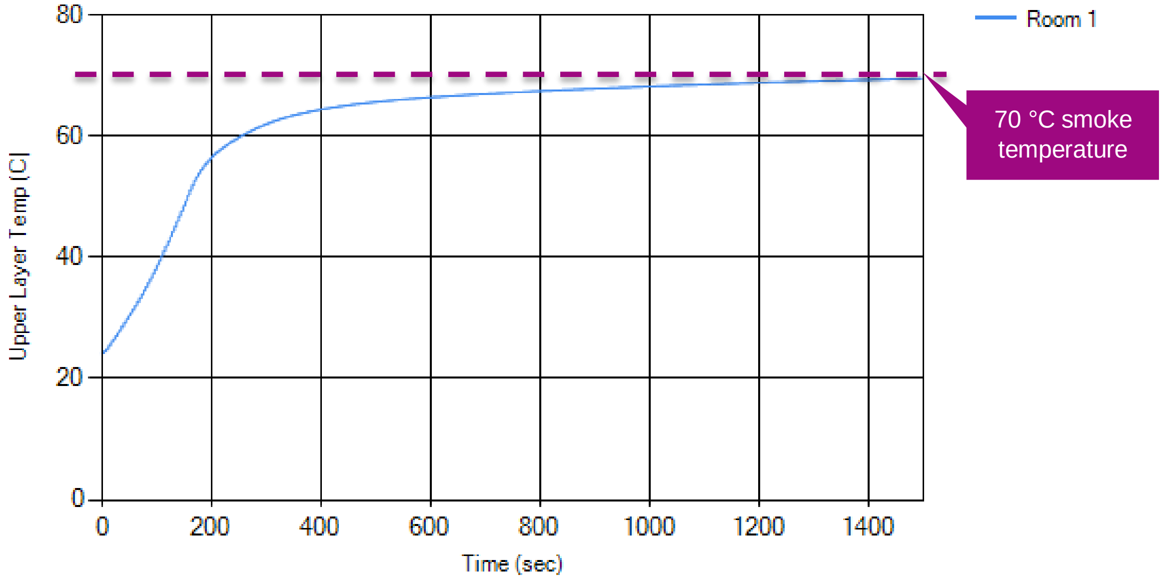

Figure 18 Smoke temperature for design case at 1500 s

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Modelling Inputs Code

DtS Design

```
Thursday,July 24,2014,02:41 PM
B-RISK Fire Simulator and Design Fire Tool (Ver 2013.15)

Input Filename :
Base File : P:\60323569_Masters_Pnrith\4. Tech work area\4.1 Fire Engineering\4.
Calculations + Analysis\2. Smoke Calcs\basemodel_Penrith_DtS\basemodel_Penrith_DtS.xml

User Mode : Risk Simulator


====================================================================
Description of Rooms
====================================================================
Room 1 : Room A
         Room Length (m) =                              64.00
         Room Width (m) =                               31.25
         Maximum Room Height (m) =                      8.50
         Minimum Room Height (m) =                      8.50
         Floor Elevation (m) =                          0.000
         Absolute X Position (m) =                      0.000
         Absolute Y Position (m) =                      0.000
         Room 1 has a flat ceiling.
         Shape Factor (Af/H^2) =                        27.7

         Wall Surface is concrete
         Wall Density (kg/m3) =                         2300.0
         Wall Conductivity (W/m.K) =                    1.200
         Wall Specific Heat (J/kg.K) =                  880
         Wall Emissivity =                              0.50
         Wall Thickness (mm) =                          100.0

         Ceiling Surface is concrete
         Ceiling Density (kg/m3) =                      2300.0
         Ceiling Conductivity (W/m.K) =                 1.200
         Ceiling Specific Heat (J/kg.K) =               880
         Ceiling Emissivity =                           0.50
         Ceiling Thickness (mm) =                       100.0

         Floor Surface is concrete
         Floor Density (kg/m3) =                        2300.0
         Floor Conductivity (W/m.K) =                   1.200
         Floor Specific Heat (J/kg.K) =                 880
         Floor Emissivity =                             0.50
         Floor Thickness = (mm)                         100.0

====================================================================
Wall Vents
====================================================================
Vent  1 : vent label
                   From room 1 to 2
                   Front face of room 1
                   Offset (m) =                         0.000
                   Vent Width (m) =                     6.000
                   Vent Height (m) =                    2.000
                   Vent Sill Height (m) =               0.000
                   Vent Soffit Height (m) =             2.000
                   Opening Time (sec) =                 0
                   Closing Time (sec) =                 0
                   Flow Coefficient (sec) =             0.680

====================================================================
Ceiling/Floor Vents
====================================================================
====================================================================
```


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```
Ambient Conditions
=====================================================================
Interior Temp (C) =                                         24.0
Exterior Temp (C) =                                         19.0
Relative Humidity (%) =                                     50

=====================================================================
Tenability Parameters
=====================================================================
Monitoring Height for Visibility and FED (m) =              2.00
Asphyxiant gas model =                                      FED(CO) C/VM2
Visibility calculations assume:                             reflective signs
Egress path segments for FED calculations
1. Start Time (sec)                                         0
1. End Time (sec)                                           600
1. Room                                                     1
2. Start Time (sec)                                         600
2. End Time (sec)                                           600
2. Room                                                     1
3. Start Time (sec)                                         600
3. End Time (sec)                                           600
3. Room                                                     1

=====================================================================
Sprinkler / Detector Parameters
=====================================================================
         Ceiling Jet model used is NIST JET.
         Sprinkler System Reliability                       1.000
         Sprinkler Probability of Suppression               1.000
         Sprinkler Cooling Coefficient                      1.000

=====================================================================
Smoke Detector Parameters
=====================================================================
         Smoke Detection System Reliability                 1.000


=====================================================================
Mechanical Ventilation (to/from outside)
=====================================================================
         Mech ventilation system reliability                1.000

         Fan ID =                                           1
         Room =                                             1
         Elevation (m)=                                     8.500
         Flow rate (m3/s)=                                  20.000
         Reliability (-)=                                   1.000
         Manual Start time =                                154
         Fan extracts air from room
         Maximum cross-pressure limit (Pa)=                 50.0


=====================================================================
Description of the Fire
=====================================================================
CO Yield pre-flashover(g/g) =                               0.040
Soot Alpha Coefficient =                                    2.50
Smoke Epsilon Coefficient =                                 1.20
Flame Emission Coefficient (1/m) =                          13.32
Fuel - Carbon Moles                                         3.00
Fuel - Hydrogen Moles                                       8.00
Fuel - Oxygen Moles                                         0.00
Fuel - Nitrogen Moles                                       0.00

Burning objects are manually positioned in room.

Burning Object No 1
100J NBSIR 88-3752
              Located in Room                               1
              Energy Yield (kJ/g) =                         19.0
```


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```
CO2 Yield (kg/kg fuel) =                          1.920
HCN Yield (kg/kg fuel) =                          0.000
H2O Yield (kg/kg fuel) =                          1.636
Soot Yield (kg/kg fuel) =                         0.227
Heat Release Rate Per Unit Area (kW/m2) =         250.0
Radiant Loss Fraction =                           0.30
Fire Elevation (m) =                              0.500
Fire Object Length (m) =                          4.000
Fire Object Width (m) =                           4.000
Fire Object Height (m) =                          0.000
Location, X-coordinate (m) =                      32.000
Location, Y-coordinate (m) =                      16.000
Fire Location (for entrainment) =                 centre
Plume behaviour is undisturbed

Time (sec)                Heat Release (kW)
 0                        0
 5.4                      6
 10.9                     22
 16.3                     50
 21.8                     89
 27.2                     139
 32.7                     200
 38.1                     272
 43.5                     356
 49                       450
 54.4                     556
 59.9                     672
 65.3                     800
 70.7                     939
 76.2                     1089
 81.6                     1250
 87.1                     1422
 92.5                     1606
 98                       1800
 103.4                    2006
 108.8                    2222
 114.3                    2450
 119.7                    2689
 125.2                    2939
 130.6                    3200
 136                      3472
 141.5                    3756
 146.9                    4050
 147.7                    4100
 149.6                    4200
 153.2                    4400
 156.6                    4600
 160                      4800
 163.3                    5000

====================================================================
Postflashover Inputs
====================================================================
Postflashover model is OFF.
```


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Proposed Design

```
Thursday,July 24,2014,02:40 PM
B-RISK Fire Simulator and Design Fire Tool (Ver 2013.15)

Input Filename : input1.xml
Base File : P:\60323569_Masters_Pnrith\4. Tech work area\4.1 Fire Engineering\4.
Calculations + Analysis\2. Smoke
Calcs\basemodel_Penrith_Proposed\basemodel_Penrith_Proposed.xml

User Mode : Risk Simulator



====================================================================
Description of Rooms
====================================================================
Room 1 : Room A
         Room Length (m) =                                  93.00
         Room Width (m) =                                   30.00
         Maximum Room Height (m) =                          8.50
         Minimum Room Height (m) =                          8.50
         Floor Elevation (m) =                              0.000
         Absolute X Position (m) =                          0.000
         Absolute Y Position (m) =                          0.000
         Room 1 has a flat ceiling.
         Shape Factor (Af/H^2) =                            38.6

         Wall Surface is concrete
         Wall Density (kg/m3) =                             2300.0
         Wall Conductivity (W/m.K) =                        1.200
         Wall Specific Heat (J/kg.K) =                      880
         Wall Emissivity =                                  0.50
         Wall Thickness (mm) =                              100.0

         Ceiling Surface is concrete
         Ceiling Density (kg/m3) =                          2300.0
         Ceiling Conductivity (W/m.K) =                     1.200
         Ceiling Specific Heat (J/kg.K) =                   880
         Ceiling Emissivity =                               0.50
         Ceiling Thickness (mm) =                           100.0

         Floor Surface is concrete
         Floor Density (kg/m3) =                            2300.0
         Floor Conductivity (W/m.K) =                       1.200
         Floor Specific Heat (J/kg.K) =                     880
         Floor Emissivity =                                 0.50
         Floor Thickness = (mm)                             100.0

====================================================================
Wall Vents
====================================================================
Vent  1 : vent label
                   From room 1 to 2
                   Front face of room 1
                   Offset (m) =                             0.000
                   Vent Width (m) =                         6.000
                   Vent Height (m) =                        2.000
                   Vent Sill Height (m) =                   0.000
                   Vent Soffit Height (m) =                 2.000
                   Opening Time (sec) =                     0
                   Closing Time (sec) =                     0
                   Flow Coefficient (sec) =                 0.680

====================================================================
Ceiling/Floor Vents
====================================================================
====================================================================
Ambient Conditions
```


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```
======================================================================
Interior Temp (C) =                                         24.0
Exterior Temp (C) =                                         19.0
Relative Humidity (%) =                                     50

======================================================================
Tenability Parameters
======================================================================
Monitoring Height for Visibility and FED (m) =              2.00
Asphyxiant gas model =                                      FED(CO) C/VM2
Visibility calculations assume:                             reflective signs
Egress path segments for FED calculations
1. Start Time (sec)                                         0
1. End Time (sec)                                           600
1. Room                                                     1
2. Start Time (sec)                                         600
2. End Time (sec)                                           600
2. Room                                                     1
3. Start Time (sec)                                         600
3. End Time (sec)                                           600
3. Room                                                     1

======================================================================
Sprinkler / Detector Parameters
======================================================================
         Ceiling Jet model used is NIST JET.
         Sprinkler System Reliability                       1.000
         Sprinkler Probability of Suppression               1.000
         Sprinkler Cooling Coefficient                      1.000

======================================================================
Smoke Detector Parameters
======================================================================
         Smoke Detection System Reliability                 1.000


======================================================================
Mechanical Ventilation (to/from outside)
======================================================================
         Mech ventilation system reliability                1.000

         Fan ID =                                           1
         Room =                                             1
         Elevation (m)=                                     8.500
         Flow rate (m3/s)=                                  30.000
         Reliability (-)=                                   1.000
         Manual Start time =                                247
         Fan extracts air from room
         Maximum cross-pressure limit (Pa)=                 50.0


======================================================================
Description of the Fire
======================================================================
CO Yield pre-flashover(g/g) =                               0.040
Soot Alpha Coefficient =                                    2.50
Smoke Epsilon Coefficient =                                 1.20
Flame Emission Coefficient (1/m) =                          13.32
Fuel - Carbon Moles                                         3.00
Fuel - Hydrogen Moles                                       8.00
Fuel - Oxygen Moles                                         0.00
Fuel - Nitrogen Moles                                       0.00

Burning objects are manually positioned in room.

Burning Object No 1
100J NBSIR 88-3752
              Located in Room                               1
              Energy Yield (kJ/g) =                         19.0
              CO2 Yield (kg/kg fuel) =                      1.920
```


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```
HCN Yield (kg/kg fuel) =                         0.000
H2O Yield (kg/kg fuel) =                         1.636
Soot Yield (kg/kg fuel) =                        0.227
Heat Release Rate Per Unit Area (kW/m2) =        250.0
Radiant Loss Fraction =                          0.30
Fire Elevation (m) =                             0.500
Fire Object Length (m) =                         4.000
Fire Object Width (m) =                          4.000
Fire Object Height (m) =                         0.000
Location, X-coordinate (m) =                     32.000
Location, Y-coordinate (m) =                     16.000
Fire Location (for entrainment) =                centre
Plume behaviour is undisturbed

Time (sec)                Heat Release (kW)
 0                        0
 5.4                      6
 10.9                     22
 16.3                     50
 21.8                     89
 27.2                     139
 32.7                     200
 38.1                     272
 43.5                     356
 49                       450
 54.4                     556
 59.9                     672
 65.3                     800
 70.7                     939
 76.2                     1089
 81.6                     1250
 87.1                     1422
 92.5                     1606
 98                       1800
 103.4                    2006
 108.8                    2222
 114.3                    2450
 119.7                    2689
 125.2                    2939
 130.6                    3200
 136                      3472
 141.5                    3756
 146.9                    4050
 147.7                    4100
 149.6                    4200
 153.2                    4400
 156.6                    4600
 160                      4800
 163.3                    5000

=====================================================================
Postflashover Inputs
=====================================================================
Postflashover model is OFF.
```


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Appendix F

Hydraulics Plan

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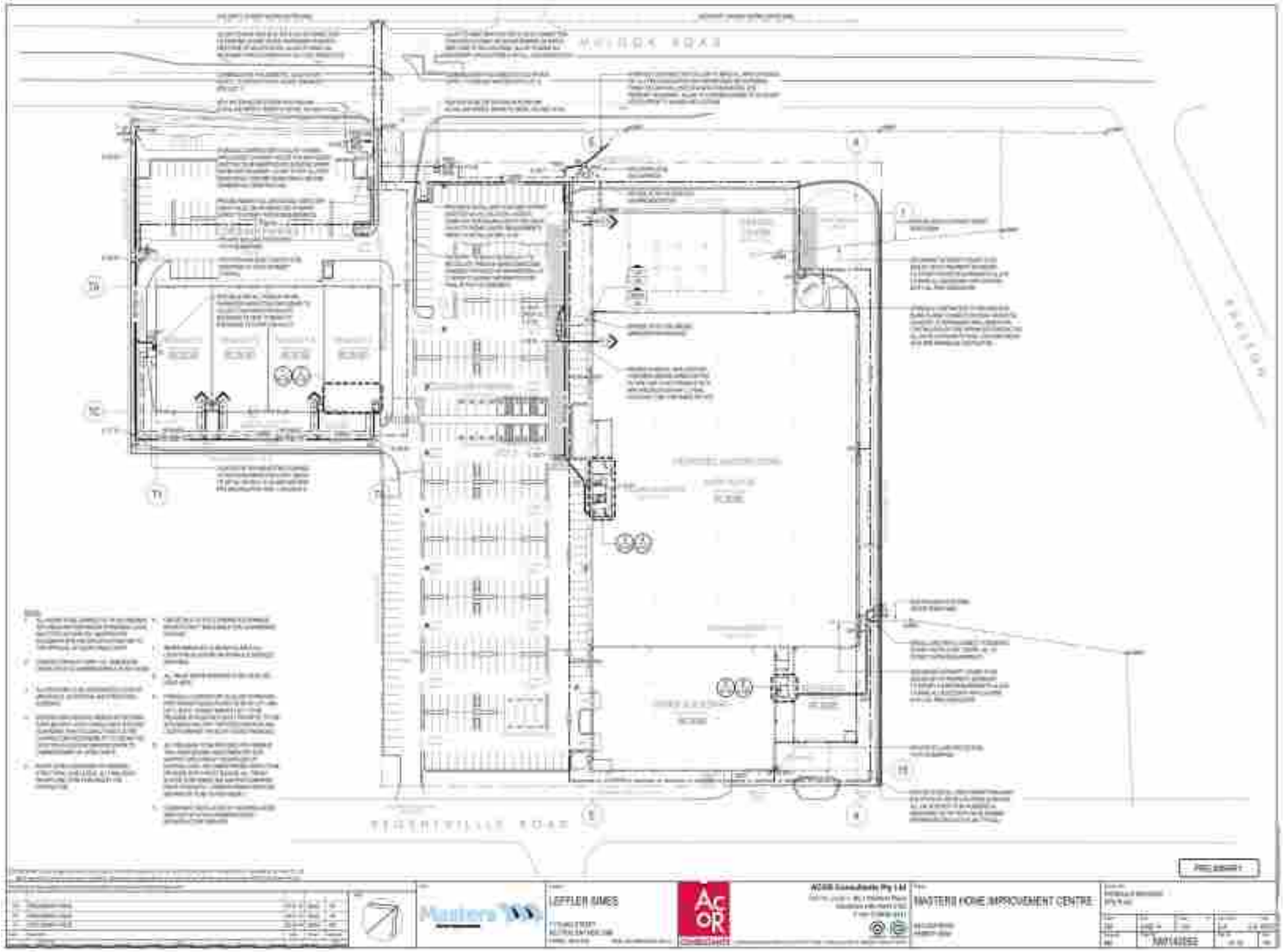
Appendix F Hydraulics Plan

Site Plan



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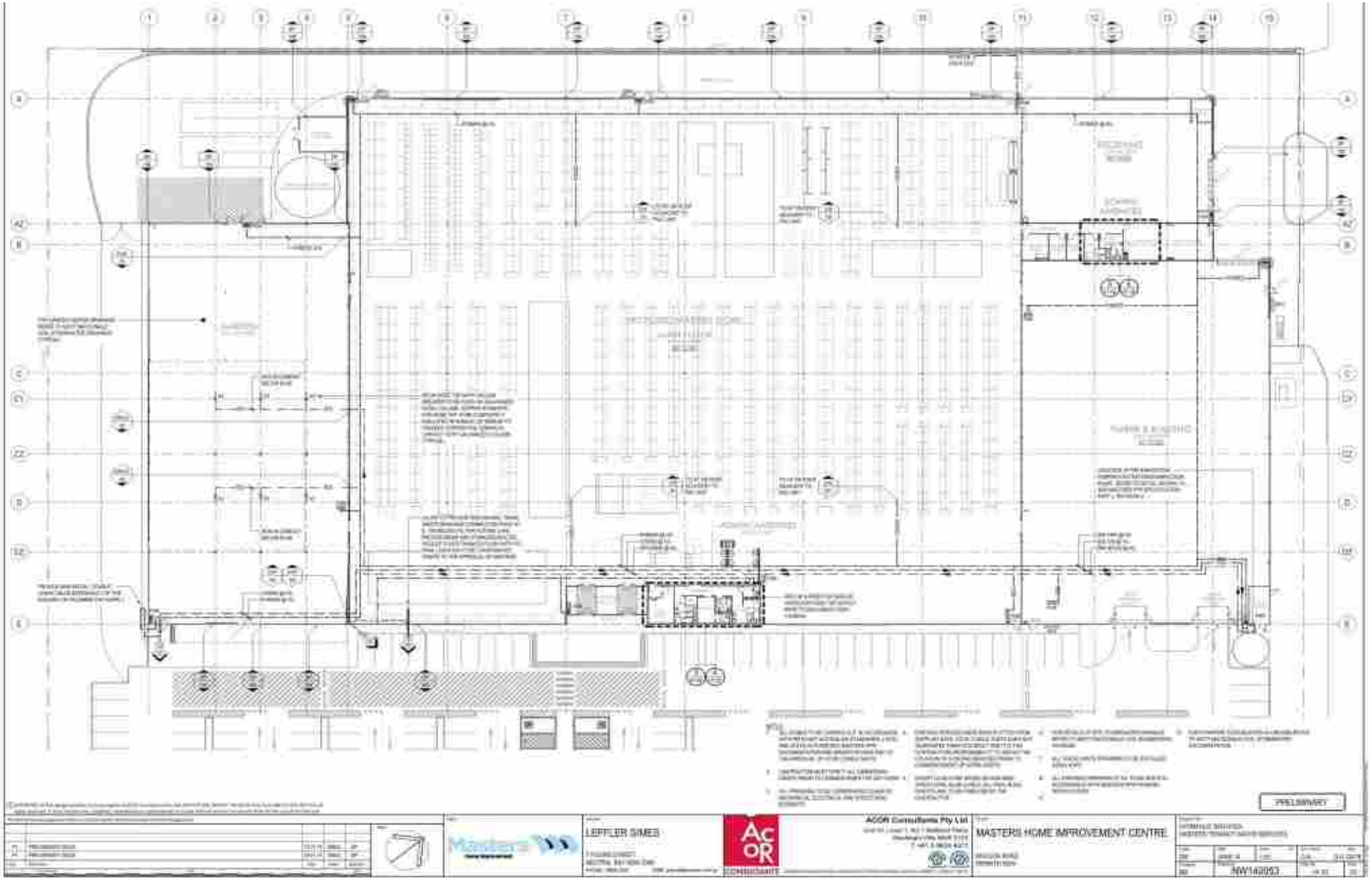
Fire Hydrant and Fire Hose Reel Layouts



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Sprinkler Layout

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Appendix G

Battery Product Information

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Appendix G Battery Product Information

Battery Specifications

Symmetra LX Model	16 kVA Extended Run Tower	16 kVA Tower	8 kVA Tower	16 kVA Rack-mount	8 kVA Rack-mount
SKU	SYA16K16IXR	SYA16K16I	SYA8K8I	SYA16K16RMI	SYA8K8RMI
Type	Maintenance-free, valve-regulated lead-acid battery with suspended electrolyte, leak-proof				
Battery Module SKU	SYBT5 (or optional SYBT5FR with flame-retardant case)				
Hot Swappable	Yes				
User-Replaceable	Yes				
Battery Voltage, Vdc	100 - 147 Vdc (120 Vdc nominal)				
Battery Amp-Hour Capacity	9.0 Ah				
Battery Charge Power Rating	300 W per installed Power Module				
Minimum Input Voltage to Charge	124 Vac L-N				
Recharge Time 0% to 90%[1]	7.5 hours	3 hours			
Automatic Self-Test	At turn-on, every 7 days, or every 14 days (user-selectable)				
Intelligent Battery Management	Yes				
Typical Battery Life	3 to 6 years				
Extended Runtime Option	Yes				
External Extended Run Frames	6 maximum	7 maximum			

[1] Systems configured with external extended run (XR) battery frames have longer recharge times.

990-4743 Symmetra LX 230 V Technical Specifications 13

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Battery Gassing Rates

Note: We recommend that room ventilation is based on maximum values.

Gassing Rates per Hour for a Single SYBT5 Battery Module	
Typical	**Maximum**
10.3 cm^3	18 cm^3

Battery Material Safety Data Sheet

Note: For Material Safety Data Sheet (MSDS), go to **http://nam-en.apc.com/app/answers/detail/a_id/564/kw/msds**.

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Compliance

Regulatory Approvals	C-tick, CE, EN 50091-1, EN 50091-2, EN 55022 Class A, EN 55024, EN 60950, GOST, IEC 60950, VDE

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Appendix H

Certificates

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Appendix H Certificates

Structural Certificate

NORTHROP

18 August 2014

Job Number: S141039

Mr Eoghan Grant
Richard Crookes Constructions
PO Box 1024
CROWS NEST NSW 1585

Dear Eoghan,

RE: Structural design certificate for Masters Penrith - 72-78 Mulgoa Rd

We, Northrop Engineers, being professional engineers, certify that structural drawings listed on the attached transmittal were based on the current project architects drawings and were prepared:

- under the supervision of a professional structural engineer certified under NPER; and
- in accordance with the relevant structural requirements of the Building Code of Australia.
- In accordance with the following design codes;
    - AS/NZS 1170 Structural Design Actions
    - AS3600 Concrete Structures Code
    - AS4100 Steel Structures Code

Further, we certify that concrete wall panels have a fire rating of 90/90/90 or greater and have been designed in accordance with Specification C1.11 of the B.C.A. to minimise, in the event of fire, the likelihood of external panels collapsing outwards.

Yours faithfully,

Todd Halliday
Principal
Structural Engineer
BE MIEAust CPEng NPER

On behalf of: Northrop Consulting Engineers Pty Ltd

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Mechanical Certificate

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+61 (07) 3118-5546
281 Montague Road
West End, QLD 4101
Australia

FUSIONHVAC

+64 (07) 210-1007
+ 64 (07) 838-3422
152 Ulster St
Hamilton 3200
New Zealand

Wednesday, August 20, 2014

Eoghan Grant - Project Manager
214 Willoughby Road
Naremburn
NSW 2065
Direct 02 9902 4400 Mobile 0417 042 247

Dear Sir,

Re: Masters Penrith CERTIFICATE OF DESIGN– For Mechanical Services and Smoke Exhaust

Pursuant to the provisions of Clause A2.2 of the Building Code of Australia, I hereby certify that parts of the above job as detailed below in accordance with normal engineering practices and meet the requirements of the Building Code of Australia, any relevant fire safety engineering report, relevant Australian Standards and relevant conditions of the Development Consent. This certification is limited to the following items:

- All Air Conditioning and Ventilation – Design is compliant with
  - Part J5 of the BCA 2013
  - Part F4.5 (b) of the BCA 2013
  - Australian Standard 1668.2 – 1991
    - Section G
    - Section 4
- Smoke Exhaust System Main Retail – Design is compliant with
  - BCA 2013 Specification E2.2b where applicable and,
  - Fire Engineering Report (Document Reference Lansdale-60323569 FRFE-0001_A) prepared by AECOM dated 31-7-2014
  - Australian Standard 1668.1 1998
- Smoke Exhaust System Trade Area – Deletion of Smoke Exhaust is compliant with
  - Fire Engineering Report (Document Reference Lansdale-60323569 FRFE-0001_A) prepared by AECOM dated 31-7-2014
- Certification of the fire protection controls to be completed by Fire Engineer
- This letter should be read in conjunction with the full set of the most recent construction issue site specific Fusion HVAC drawings.

I am an appropriately qualified and competent person in this area and as such can certify that the design and performance of the designed systems as detailed above.

I possess Indemnity Insurance to the satisfaction of the building owner or my principal.

Full Name of Designer: Kevin Harris
Qualifications: BSc (Mech) MIE Aust
Address of Designer: 281 Montague Road, West End, QLD 4101
Name of Employer: Fusion HVAC

Yours Faithfully

Kevin Harris BSc (Mech) MIE Aust

Fusion HVAC P/L
Level 1, 281 Montague Road,
West End,
QLD 4101
PO BOX 525, The Gap GPO, The Gap Brisbane 4061

T: +61 7 3118 5536 F: +61 7 3118 5546 M (Au): +61 424 228 598

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Appendix D Design Review Report

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FUSION HVAC

HOME CONSORTIUM
Building Roll out

Design review report
DA PHASE

FUSION HVAC

MRN028
PENRITH NSW

REVISION B 13DEC 2016

CONTACT :
Fusion HVAC Australia Pty Ltd
281 Montague Road
West End, QLD 4101
Australia
+61 7 3118 5536
ABN: 46 154 470 649

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

FUSION HVAC

HOME CONSORTIUM
Suite 2, Level 2, 24 Bay Street
DOUBLE BAY NSW 2018

ATTENTION: **Mr Patrick Leong**
Mr David Gutwenger

REGARDING: **HOME CONSORTIUM MASTERS REPURPOSE**
MRNB028 PENRITH
DA PHASE MECHANICAL DESIGN REVIEW

Dear Patrick and David

We write in relation the above site and the preliminary DA Concept plans received as listed below.

These comments are based on the information provided to date and our interpretation of the below documents and design criteria.

Please refer to the following pages.

CONTACT :
Fusion HVAC Australia Pty Ltd
281 Montague Road
West End, QLD 4101
Australia
+61 7 3118 5536 ABN: 46 154 470 649

FUSION HVAC

PROPOSAL BASIS / DESIGN INFORMATION

The following information has been reviewed, and design parameters used for preparation of our proposal.

Drawings Received:

Buchan Group Drawings 316152

ATP-1001	**P01**	**Site Plan**
ATP-2001	**P01**	**Floor Plan**
ATP-2002	**P01**	**Roof Plan**
ATP-4001	**P01**	**Elevations**
ATP-5001	**P01**	**Sections**

Specification: Comfort air conditioning based on existing construction for bulk open retail areas

Design and plant sizing is based on CAMEL COMFORT Weather data for location:
NSW PROSPECT DAM

Summer comfort design ambient conditions:
35.3 ^{0}C Dry bulb with co-incident 22.7 ^{0}C wet bulb temperature

Winter comfort design ambient conditions:
4.5 ^{0}C Dry bulb

Internal comfort design ambient conditions:
Cooling
24 ^{0}C Dry bulb temperature with nominal 55% Relative humidity.
Note that relative humidity is not directly controlled.

Heating
21 ^{0}C Dry bulb temperature

CONTACT :

Fusion HVAC Australia Pty Ltd
281 Montague Road
West End, QLD 4101
Australia
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Design Allowances

Lighting not exceeding	10 Watts per sqm
Internal equipment not exceeding	10 Watts per sqm

Note: Statistically approx 10 days per year where these conditions may be exceeded for some or all of the cooling day.

It is important to understand that peak load calculation is calculated based on this external data, with full lighting and equipment loads, and fresh air for occupants etc.

In real terms it is unlikely that all such factors occur together, however in the interests of practical sizing, this must be understood.

There may be occasions when the combination of internal load, ambient temperature etc lead to temperatures slightly above the design setpoint.

If we allow full occupancy as per AS1668.2 – the loads will be large, however the code indicates that the figures are conservative and that the property owner can advise better. The typical loading for ground floor retail would be almost 400 people for each of these spaces.

We have never seen (for example) an open plan furniture shop in normal day trading with anything approaching that, however the client needs to confirm.

Refer site specific notes below for Occupancy as they may be at variance.

EXISTING BUILDING JV3 MODEL

We have located Anderson Energy NCC Energy Efficiency Report for the site, Dated 3 July 2014. We have used details from this report for the thermal construction analysis. ***The Report is attached.***

TENANCY DESCRIPTIONS

The current plans provided for this space identify no tenancies of particularly high internal loads (eg Lighting / Electrical stores / Stores requiring kitchen exhaust or the like. If such tenancies are later added, additional plant may be required.

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FUSION HVAC

Existing Construction

We have located the original JV3/Energy report for this building.

On the basis of this, we have allowed existing building elements as follows:

Existing retail roof:
Galvanised steel total R Value R3.2
9.7% area of skylights, Ampelite THERMAL U Value 1.4 W/m2.K and Solar Heat Gain Coefficient 0.18

Walls:
Total wall R Value than R2.8

New Construction (Trade and Nursery areas)

We have worked on your advice as follows
Extended areas (Trade and Nursery)
R3.2 Insulated roof,
In this case specifically THERMAL skylights as above
Roof medium light colour.
External Walls R2.8 insulation, medium colour
all external doors autoclosing when AC is in operation.

no full height walls between existing and extended retail, or within between tenants. No closed ceilings.

Smoke Spill

Smoke exhaust Design is to be clarified by the Fire Engineer at this time. We have allowed for new Fusion Modulair units to be fitted with Smoke Exhaust decks (approx 10 m3/s each)

We also propose to re-use the existing trade area smoke exhaust fans SEF7 and 8, relocated as applicable.

Please see our attached design sketch for review / to be confirmed by the fire engineer

CONTACT:
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ABN: 46 154 470 649

KEY NOTES FOR THIS SITE:

The following is to assist the Architect, Fire Engineer and Certifier in their assessment of the site:

EXISTING MAIN RETAIL AREA

- The main retail area is currently served by FOUR Fusion FPA180 modules providing a cooling capacity 720 kW
- Based on our calculations of both heat load and the area covered by these modules it is not possible to relocate any of these units to a newly extended area

  SMOKE SPILL:
  As the current units are being maintained in the existing main retail area, the smoke spill rate for that area is unchanged.

- Public amenities with mechanical ventilation will be retained

TRADE END

- The previous trade end of the building will be served by one new FPA180 Fusion Modular unit.
- This unit will have 10m^3/s of smoke spill capacity.
- **SMOKE SPILL:**
  We will retain the existing smoke spill fan SEF-8 in it's current location to provide a total smoke spill for the new Trade extension area of 25 m^3/s

NURSERY END

- The Previous Nursery end will be served by one new FPA180 unit to meet it's calculated load.
- **SMOKE SPILL:**
  The existing SEF-7 roof mounted smoke spill fan will be relocated from the trade end to this end of the building.
  In conjunction with the Fusion unit listed above, it will provide a total of 25 m^3/s of available smoke spill to this end of the building

CONTACT:

Fusion HVAC Australia Pty Ltd
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Australia
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ABN: 46 154 470 649

GENERAL NOTES:

- **Section J Compliance:**
  The building would be constructed under a JV3 framework.

  Please note that the air conditioned / tempered space needs to be sealed relevant to naturally vented areas.

  We have not allowed for JV3 modelling or certification.

  We have not allowed to upgrade mechanical plant to meet any additional requirements to meet energy efficiency requirements.

- **Fire engineering**
  The fire engineer must review and comment on the proposed alterations to the smoke exhaust rates and locations.

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METERING and ENERGY USE

Energy Metering

The building is provided with an existing Building management system. This system will be reconfigured to a standardized arrangement during the repurposing phase.

The BMS is capable of receiving information from all Total / HVAC / Lighting meters on site

- The meters must be reticulated to the BMS in the comms room, by others, MODBUS RS485

GENERAL NOTES

The following items apply to all areas

- Generally the existing offices area will be demolished, with existing plant removed for other use. This will be detailed further at the detail design phase
- Safe access is to be provided onto the roof including walkways and roof protection to enable safe servicing of all roof mounted plant and equipment
- Provision of tundishes for AC systems adjacent all Fusion PAC units and all other air conditioning systems.
- Provision of service water taps adjacent all roof mounted equipment.(within 15m)
- Provision of acoustic or architectural screening etc if required for other DA conditions
- External colours: Fusion equipment will be provided in standard colours. Fusion air diffusion modules are already painted. We have not allowed to paint exposed duct etc.
- Provide shading to all windows to prevent the incidence of direct sunlight on occupants
- Doors to air conditioned spaces are to be self closing doors / autodoors.

CONTACT :
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REFER TO EXISTING FUSION DRAWINGS AXN3 M01, M02, M04, M05, M06, M42, M51, M52, M53, M91 FOR INFORMATION ONLY

REFER FUSION DRAWINGS AXQ9 MB31,32,33 FOR DETAILS OF FRAME / SUPPORT FOR RELOCATED FPA180 UNIT

REFER FUSION DRAWINGS 180-MB31,32,33 FOR DETAILS OF FRAME / SUPPORT FOR NEW FPA180 UNIT.

IMPORTANT: ALL MB31,32,33 DRAWINGS ARE FOR INFORMATION ONLY. STRUCTURAL DESIGN, DETAIL, CERTIFICATION BY STRUCTURAL

IMPORTANT: THIS IS A PRELIMINARY DOCUMENT FOR CONCEPT ONLY. FUSION WILL ONLY UNDERTAKE THE ATTENDANCE FOR RELOCATION AND INSTALLATION OF PAC UNITS IN THE SAME DAY. ALL STRUCTURAL SUPPORTS, FLASHINGS, POWER SUPPLIES, CONTROL CABLING MUST BE READY AT THAT TIME

IMPORTANT: PROVISION OF CRANE AND ALL DOGMEN, OFFLOADING FACILITIES (EG FRANNA ON SITE ETC) BY BUILDER.

LIFTING WEIGHTS ARE (APPROX) DIFFUSER SECTION LIFTED INTO PENETRATION IN ROOF BASE 400 kg
LIFTING WEIGHTS ARE (APPROX) FUSION PACKAGE UNIT LIFTED ONTO ROOF FRAME 3000 kg. SPREADER BARS ARE REQUIRED.

BUILDER'S ELECTRICIAN TO BE PRESENT TO DO TERMINATIONS TO MACHINES AT THAT TIME

FUSION AE ENGAGED FOR THE SUPPLY AND INSTALLATION OF THE FUSION UNITS BY HOMECO. ALL OTHER WORKS BY OTHERS

BUILDER PROVIDE TUNDISH ADJACENT ALL NEW AND RELOCATED PLANT. PROVIDE SERVICE WATER TAP ADJACENT ALSO.

IMPORTANT:
FIRE ENGINEERING, STRUCTURAL, ARCHITECTURAL, ELECTRICAL AND ELECTRICAL-MECHANICAL SKETCHES, BRIEFS AND SPECIFICATIONS MUST BE READ IN CONJUNCTION WITH THIS DOCUMENT. WHERE THERE IS A DISCREPANCY REFER TO US IMMEDIATELY IN WRITING.

RETAIN PUBLIC AMENITIES AND AREAS AS PER HOMECO SCOPE DOCUMENT.

NOTE: YOUR MECHANICAL DECOMMISSION/ DISCONNECT / REMOVE AND STORE FOR HOMECO DECISION ANY REDUNDANT EQUIPMENT. MAKE GOOD ANY PENETRATIONS ETC

IMPORTANT! CONTROL AND WIRING FOR ALL AIR CONDITIONING SYSTEMS AND LIGHTING IS UNDERTAKEN FROM CONTROLS DISTRUBUTED THROUGHOUT THE COMMS ROOM AND BUILDING DISTRIBUTION BOARDS. DO NOT REMOVE / DISCONNECT FOR SYETMS REMAINING.

REFER ALSO TO ELECTRICAL-MECHANICAL SKETCHES AND BRIEF

NOTES:

1.ALL SMOKE EXHAUST QUANTITES AND LOCATIONS TO BE VERIFIED BY THE FIRE ENGINEER

2.ALL SMOKE MAKEUP AIR RELIEF PATHS TO BE PROVIDED BY BUILDER TO FIRE ENGINEERS DETAILS

REFER TO FUSION DA DESIGN REPORT MRN028 FOR ADDITIONAL DESIGN DOCUMENTATION

FUSION HVAC
MRN028 DA PHASE DESIGN REVIEW

13 DECEMBER 2016

PROJECT
HOME - PENRITH

PROJECT NUMBER 316152 | DATE 21/11/16 | SCALE @ A1 1:250

STATUS TOWN PLANNING | PRELIMINARY

THE BUCHAN GROUP

DRAWING TITLE ROOF PLAN

DRAWING NUMBER ATP-20002

REVISION P01

File Name: HCP-TBG-ZA-00-DR-ATP-20002

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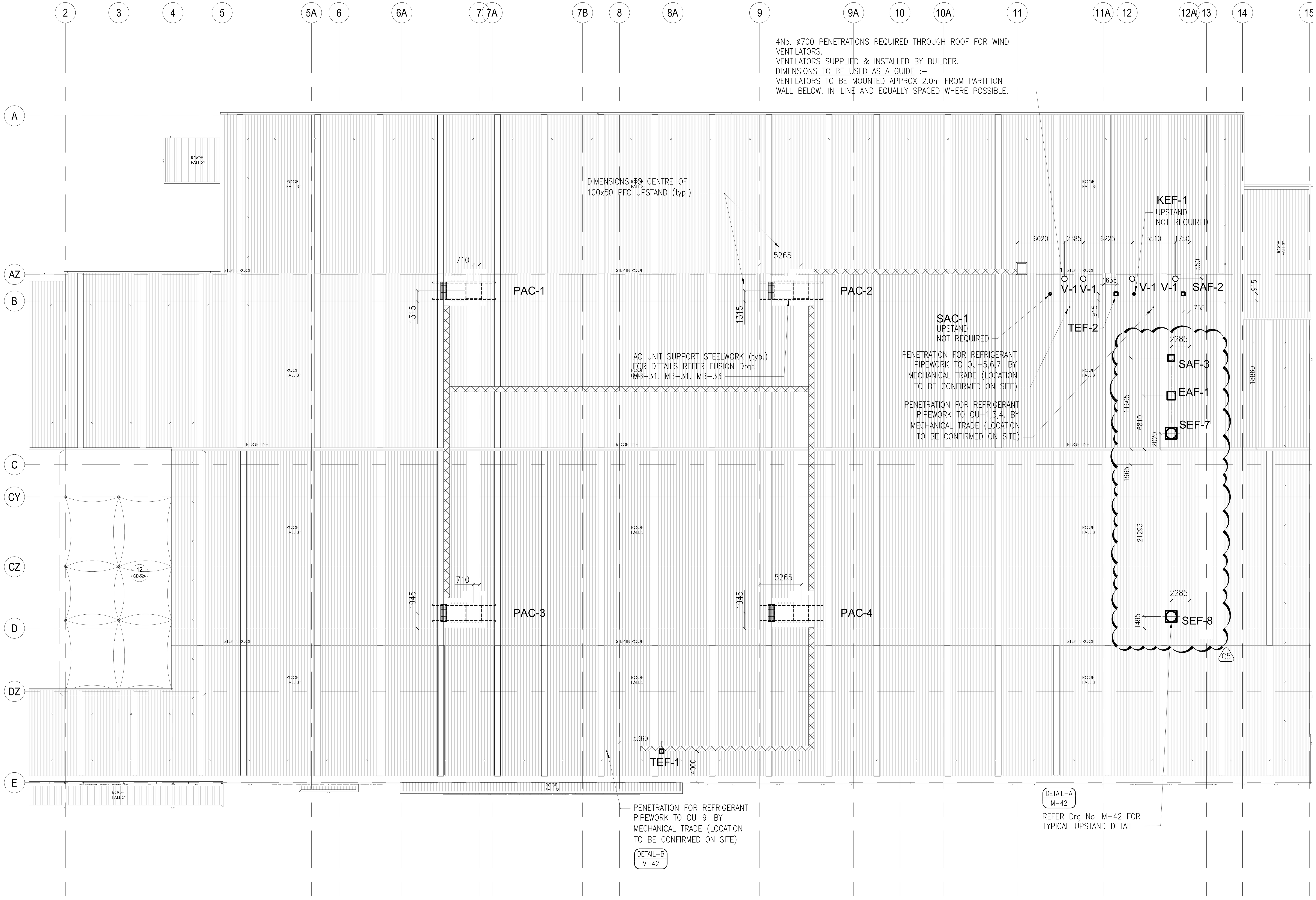

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NOTES

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2. Distribution Board locations to be confirmed by Electrical Consultant.
3. Flex duct to be correctly supported along it's length & cut to length.
4. The contractor is to ensure an air tight seal between eggcrate, supply grilles & their diffuser boxes.
5. All AC units & plenums to be mounted with rubber feet on brackets.
6. Typical Armaflex insulation to be used on all pipework is 25mm (internal) & 38mm Alu foil face (external).
7. Drawings produced in accordance with:

Architectural: 3116 GA200 Rev F
3116 GA201 Rev A
3116 GA310 Rev A
3116 GA311 Rev A
3116 GD600 Rev A
Control Plan Rev Q

Structural: S141039 S013 Rev B

Hydraulic: NW140053_H1.03 Rev 2
NW140053_H1.04 Rev 2

Fire: 32349-FS02-FS04 Rev A

Electrical: 140149-MAS-A-304 Rev A

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C5	FAN UPSTANDS RELOCATED	BJH	18.06.15
C4	RECEIVING OFFICE NOTE REMOVED	BJH	14.04.15
C3	REVISED TO LATEST ARCH LAYOUTS	DK	05.02.15
C2	DIMENSIONS ADJUSTED TO SUIT M-51	BJH	03.12.14
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

ALL DIMENSIONS TO BE VERIFIED ON SITE BEFORE MAKING ANY SHOP DRAWINGS OR COMMENCING ANY WORK.
DO NOT SCALE FROM THIS DRAWING.

FUSIONHVAC

BRISBANE OFFICE
281 MONTAGUE ROAD
WEST END QLD 4101
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PROJECT: MASTERS PENRITH

DRAWN DK SCALE 1:250 (A1)
APPROVED AC FILENAME ANX28-Roof.dwg

SHEET TITLE: MECHANICAL SERVICES ROOF BUILDERSWORK LAYOUT

JOB ANX028
SHEET MB-01
REVISION C5

ORIGINAL SHEET SIZE : A1

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

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STAND SURE
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Shaylie Walton
Masters Home Improvement
3 City View Road
PENNANT HILLS NSW 2120

3 July 2014

NCC ENERGY EFFICIENCY REPORT

Thank-you for the opportunity to perform the Building Energy Efficiency Assessment for the building at **Mulgoa Road, Penrith, NSW** Job No: 3166 Drawing No: DA01/A, DA02/A, DA04/A, DA05/A dated 25-10-13, DA06/A Date: 23.10.13, Drawing/Sketch No. 1, Amend D Date: 16/06/14

This building COMPLIES with NCC Performance Requirement JP1 (details below)

The DesignBuilder™ Version 3.4 thermal simulation was performed on plans as *modified* and for a Reference Building in strict accordance with National Construction Code Verification Method JV3. DesignBuilder™ meets the requirements of the ABCB Protocol for Building Energy Analysis Software as it uses EnergyPlus™ Version 8 for the Calculation Engine.

For the thermal simulation the Tenancy Building was separated into 5 zones and the Masters building was separated into 25 Zones, including all conditioned spaces and unconditioned Receiving Area and Timber & Building Area. The conditioned part of the Tenancy Building was modelled as Retail, the conditioned part of Masters building was modelled as Retail Warehouse with special occupancy and operation schedules for lighting, equipment and air-conditioning plant. Example assumptions included, **non-DTS elements are in Bold** [DTS-compliant Reference Building elements are in square brackets]:

Building Elevation:	Single storey, Ground floor adjacent to ground
Infiltration:	1.0 air changes per hour, fresh air rate min. 10 L/s per person, no additional natural ventilation
External walls:	Tenancy: Concrete panel ***added R1.5 fibre insulation***. Masters: North-West (between Main Floor and Garden): Insulated panel wall R3.6 insulation, North-East **Uninsulated hob**, Insulated panel wall R3.6 insulation, South-West: (Main Floor & Office-Amenities): Concrete panel no added insulation; α = 0.4, 0.5, 0.6, 0.7 [R1.4 or R2.8 total, α = 0.6]
Internal walls:	Insulated panel wall R3.6 insulation between main floor and Receiving -Timber & Building, Cavity panel **no added insulation** to internal walls of Office-Amenities [R1.0 total to envelope walls]
Floor:	Slab on ground, with vinyl, tiles, carpet or bare, no added insulation
Ceiling:	Plasterboard or Ceiling tiles to Office-Amenities, **no added insulation**, no ceiling to Retail
Glazing:	***Glass U-value = 3.6 W/m².K, Glass Solar Heat Gain Coefficient = 0.68***, Aluminium frames, sizes as per drawings, shade as specified [DTS-compliant SHGC, Option A & B]
Roof:	Metal, **R1.8 (~100 mm compressed at purlins, R2.5 uncompressed)** white-faced insulation, low pitch, α = 0.7 [R3.2 total roof+ceiling, α = 0.7] Skylight U-value = 1.4 W/m².K, Skylight Solar Heat Gain Coefficient = 0.18, ***9.7 % of Main floor area***, sizes as per drawings [DTS U-value & SHGC, 5% area]
Air Conditioning:	Simple Packaged Direct Expansion, average heating EER = 2.4, average cooling EER = 3.1, no outdoor air economy cycle, standard fan operation, 18°-26° temperature control per zone. Tenancy: Heating (DF=1) 129 kW, Cooling (DF=1) 179 kW, Masters: Heating (DF=1) 395 kW, Cooling (DF=1) 296 kW
Lighting:	As for BCA Part J6, e.g. 7W/m² for Office, 8W/m² for Corridor, 10W/m² for Retail Warehouse

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The results of the thermal simulation, presented in the Table below, show various splits of monthly and annual Energy Load (kWh) for the simulated year: Electricity Breakdown, Energy Pathways (Fabric and Ventilation), Internal Gains, and Total Electricity consumed.

DesignBuilder™ Simulation Output - Monthly and Annual Totals

Mulgoa Road, Penrith, NSW 3 July 2014

Tenancy

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
ELECTRICITY BREAKDOWN													
Room Electricity (kWh)	4685	4232	4685	4534	4685	4534	4685	4685	4534	4685	4534	4685	55166
Lighting (kWh)	45129	40761	45129	43673	45129	43673	45129	45129	43673	45129	43673	45129	531352
Heating (Electricity) (kWh)	3	0	1	57	253	889	901	712	240	70	27	0	3153
Cooling (Electricity) (kWh)	4140	7481	3423	660	143	0	0	0	278	1609	1144	2572	21450
FABRIC AND VENTILATION													
Glazing (kWh)	-4	389	-64	-773	-1596	-2294	-2565	-2292	-1839	-1212	-762	-439	-13250
Walls (kWh)	217	339	-86	-754	-1304	-1933	-2188	-1951	-1321	-814	-312	-105	-10302
Ceilings (int) (kWh)	34	37	21	-6	-33	-59	-65	-55	-27	-6	11	24	-125
Ground Floors (kWh)	-34079	-32499	-32014	-25650	-19696	-13361	-12583	-15098	-20306	-25147	-28102	-32059	-290504
Partitions (int) (kWh)	-43	-33	-62	-102	-141	-173	-187	-179	-139	-108	-77	-61	-1305
Roofs (kWh)	573	620	-1559	-4232	-7232	-8950	-9459	-8578	-5782	-3451	-1743	-584	-50378
External Infiltration (kWh)	-3643	-1272	-5385	-11772	-18016	-24137	-26043	-24871	-18982	-14351	-9781	-6666	-164919
INTERNAL GAINS													
General Lighting (kWh)	45129	40761	45129	43673	45129	43673	45129	45129	43673	45129	43673	45129	531352
Computer + Equip (kWh)	4685	4232	4685	4534	4685	4534	4685	4685	4534	4685	4534	4685	55166
Occupancy (kWh)	4814	4321	4814	4711	5007	5021	5348	5180	4820	4902	4709	4788	58434
Solar Gains Exterior Windows (kWh)	7872	7704	9064	8748	7635	8194	8648	9559	9753	9368	8188	7768	101491
Zone Sensible Heating (kWh)	8	2	3	131	581	2045	2070	1626	549	161	63	1	7240
Zone Sensible Cooling (kWh)	-24744	-23850	-22630	-17519	-13888	-11217	-11397	-11799	-13835	-18025	-19470	-21559	-209933
Sensible Cooling (kWh)	-10649	-16257	-7668	-1779	-356	0	0	0	-861	-4611	-3282	-5374	-50827
Total Cooling (kWh)	-12835	-23192	-10610	-2046	-444	0	0	0	-861	-4987	-3547	-7974	-66496
Zone Heating (kWh)	6	0	3	138	613	2152	2160	1723	580	169	85	0	7630
TOTAL ENERGY													
Electricity (kWh)	53957	52475	53237	48924	50210	49096	50715	50526	48724	51493	49378	52386	611121

Masters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
ELECTRICITY BREAKDOWN													
Room Electricity (kWh)	26120	23592	26120	25277	26120	25277	26120	26120	25277	26120	25277	26120	307538
Lighting (kWh)	31463	28418	31463	30448	31463	30448	31463	31463	30448	31463	30448	31463	370449
Heating (Electricity) (kWh)	44	0	34	764	2509	6364	6886	5484	2409	1067	413	45	26021
Cooling (Electricity) (kWh)	6459	9747	4651	794	155	22	15	21	306	2317	2080	4138	30704
FABRIC AND VENTILATION													
Glazing (kWh)	-10748	-8574	-11783	-15638	-18866	-22933	-24498	-24063	-20861	-18381	-14621	-12795	-203760
Walls (kWh)	-1250	1661	-940	-6888	-11393	-17562	-20325	-16580	-14754	-11880	-6742	-5469	-114135
Ceilings (int) (kWh)	65	176	-72	-451	-807	-1165	-1278	-1166	-805	-540	-284	-125	-6451
Floors (int) (kWh)	-185	-184	-91	46	179	281	307	258	130	22	-69	-131	563
Ground Floors (kWh)	-167929	-156879	-124098	-61705	-206	47997	57803	32851	-27682	-80600	-116550	-148128	-745137
Partitions (int) (kWh)	737	763	476	1	-403	-759	-873	-762	-343	31	320	538	-275
Roofs (kWh)	-13274	-9596	-18373	-31167	-43459	-53520	-57216	-54360	-43815	-34900	-25283	-21035	-405999
External Infiltration (kWh)	-31558	-16397	-32278	-58385	-81324	-111941	-121812	-118203	-94462	-77871	-58447	-44025	-846500
External Vent. (kWh)	-2379	-758	-3523	-6089	-8412	-9988	-11733	-11017	-9057	-6601	-6194	-4865	-80617
INTERNAL GAINS													
General Lighting (kWh)	31463	28418	31463	30448	31463	30448	31463	31463	30448	31463	30448	31463	370449
Computer + Equip (kWh)	26120	23592	26120	25277	26120	25277	26120	26120	25277	26120	25277	26120	307538
Occupancy (kWh)	22840	19880	24624	27201	31866	33320	35336	34099	29879	27798	24889	24347	336079
Solar Gains Interior Windows (kWh)	2201	1835	1589	1388	1117	1206	1227	1410	1745	2080	2080	2216	20095
Solar Gains Exterior Windows (kWh)	168358	140355	120656	100512	73399	71349	78194	96430	127104	155881	159133	170305	1459577
Zone Sensible Heating (kWh)	108	0	82	1849	6073	15400	16665	13272	5830	2583	1001	109	62971
Zone Sensible Cooling (kWh)	-15177	-18283	-8939	-1821	-357	-65	-45	-65	-914	-6655	-5343	-7878	-65523
Sensible Cooling (kWh)	-15166	-18280	-8936	-1821	-357	-65	-45	-65	-914	-6652	-5317	-7815	-65473
Total Cooling (kWh)	-20022	-30216	-14418	-2460	-481	-67	-45	-66	-946	-7183	-6449	-12828	-95183
Zone Heating (kWh)	108	0	82	1849	6073	15400	16665	13272	5830	2583	1001	109	62971
TOTAL ENERGY													
Electricity (kWh)	64086	61757	62267	57282	60247	62110	64483	63088	58440	60967	58219	61786	734712

Please note:

The results of the Thermal Simulation do not predict actual electricity consumption but are used for Regulatory Compliance Assessment only. The numbers represent cumulative energy transfer totals relative to the conditioned space (plus is in and minus is out) providing some indicators of the likely relative magnitudes of heat transfer to, or energy consumed by different building components.

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The Tenancy building simulated had a calculated Annual Energy Consumption of 611,121 kWh, compared to the Reference Building Annual Energy Consumption of 611,210 kWh. The The Masters building simulated had a calculated Annual Energy Consumption of 734,712 kWh, compared to the Reference Building Annual Energy Consumption of 735,735 kWh. The proposed air-conditioning is expected to have weighted average EERs more than the simulated values of 2.4 and 3.1. The proposed artificial lighting for the Tenancy building is expected to be less than the aggregate Allowances of NCC Part J6 (27.6 kW, including losses in ballasts and controls). The proposed artificial lighting for the Masters building is expected to be less than the aggregate Allowances of NCC Part J6 (119.0 kW, including losses in ballasts and controls).The proposed air-conditioning system and lighting are therefore more efficient than the Deemed-To-Satisfy values used in the Reference Building thermal simulation. Given the Building Annual Energy Consumption was less than the Reference Building, a range of technical solutions for air-conditioning and lighting is likely to retain Code compliance.

Therefore, provided the insulation installation complies with NCC Part J1.2, this building design **complies** with the National Construction Code Performance Requirement JP1 according to thermal calculation Verification Method JV3.

Regards,

Mr Juancho Bauyon, MIEAust No. 3411690
Certified Energy Efficiency Assessor, ABSA 61079
DesignBuilder™ Licence No. ZR1DB003657

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

Compliance Certificate for building Design or Specification

NOTE	
1. Property description This section need only be completed if details of street address and property description are applicable. EG. In the case of (standard/generic) pool design/shell manufacture and/or patio and carport systems this section may not be applicable. The description must identify all land the subject of the application. The lot & plan details (e.g. SP / RP) are shown on title documents or a rates notice. If the plan is not registered by title, provide previous lot and plan details	Street address *(include no., street, suburb / locality & postcode)* **Mulgoa Road, Penrith, NSW** Postcode 2750 Lot & plan details *(attach list if necessary)* In which local government area is the land situated? Penrith City Council
2. Description of component/s certified Clearly describe the extent of work covered by this certificate, e.g. all structural aspects of the steel roof beams.	Energy Efficiency of Building Design and Services Except Air-Conditioning (J5) and Artificial Lighting (J6)
3. Basis of certification Detail the basis for giving the certificate and the extent to which tests, specifications, rules, standards, codes of practice and other publications, were relied upon.	DesignBuilder™ Thermal Simulation for Energy Efficiency Verification Method JV3 Using Specific Conditions and Schedules and spreadsheet calculations for Part J6 for Compliance to NCC Volume 1 Performance Requirement JP1
4. Reference documentation Clearly identify any relevant documentation, e.g. numbered structural engineering plans.	Job No: 3166 Drawing No: DA01/A, DA02/A, DA04/A, DA05/A dated 25-10-13, DA06/A Date: 23.10.13, Drawing/Sketch No. 1, Amend D Date: 16/06/14 Energy Efficiency Check List Energy Efficiency Report dated 3 July 2014
5. Building certifier reference number	Building certifier reference number Walton 03/07/14
6. Competent person details A competent person for building work, means a person who is assessed by the building certifier for the work as competent to practise in an aspect of the building and specification design, of the building work because of the individual's skill, experience and qualifications in the aspect. The competent person must also be registered or licensed under a law applying in the State to practice the aspect. If no relevant law requires the individual to be licensed or registered to be able to give the help, the certifier must assess the individual as having appropriate experience, qualifications or skills to be able to give the help. If the chief executive issues any guidelines for assessing a competent person, the building certifier must use the guidelines when assessing the person.	Name *(in full)* Juancho Bauyon Company name *(if applicable)*: Anderson Energy Efficiency Contact person: Dr Clyde Anderson Phone no. *business hours*: 07 3394 2886 Mobile no.: 0414 396 422 Fax no.: Email address info@clydeanderson.com.au Postal address PO Box 12, COORPAROO QLD Postcode 4151 Licence or registration number *(if applicable)* MIEAust 3411690, DesignBuilder™ Licence No. ZR1DB003657, ABSA 61079
7. Signature of competent person This certificate must be signed by the individual assessed by the building certifier as competent.	Signature: [signature] Date: 3 July 2014

LOCAL GOVERNMENT USE ONLY

Date received		Reference Number/s	

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

EXISTING MECHANICAL SERVICES DRAWINGS

THE FOLLOWING DRAWINGS ARE PROVIDED FOR INFORMATION ONLY TO ASSIST THE BUILDER

IMPORTANT: MANY ELEMENTS OF THE FUSION SYSTEM INCLUDED PATENTED ITEMS, REGISTERED DESIGNS AND OUR IP.

THE BASE FRAME ARRANGEMENT IS ONLY TO BE USED WITH OUR FUSION UNITS INSTALLED BY FUSION.

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

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MASTERS PROJECT

PENRITH, NSW

HVAC Mechanical Drawing Set

CONSTRUCTION ISSUE

Drawing Index

Legend

SA	Supply air
EA	Extract air
RA	Return air
OA	Outside (fresh) air
FD	Fire damper
AP	Access panel
SM	Site measure
UCD 15	Undercut door 15mm
U/S	Underside
l/s	Litres per second
U.N.O.	Unless noted otherwise
FOB(T)	Flat on bottom (top)
TSU(D)	Top set up (down)
BSU(D)	Bottom set up (down)
TA(B)	To above (below)
FA(B)	From above (below)
UCD20	Door Undercut 20mm (By Builder)
	Airflow direction (in duct)
	Airflow direction (outside duct)

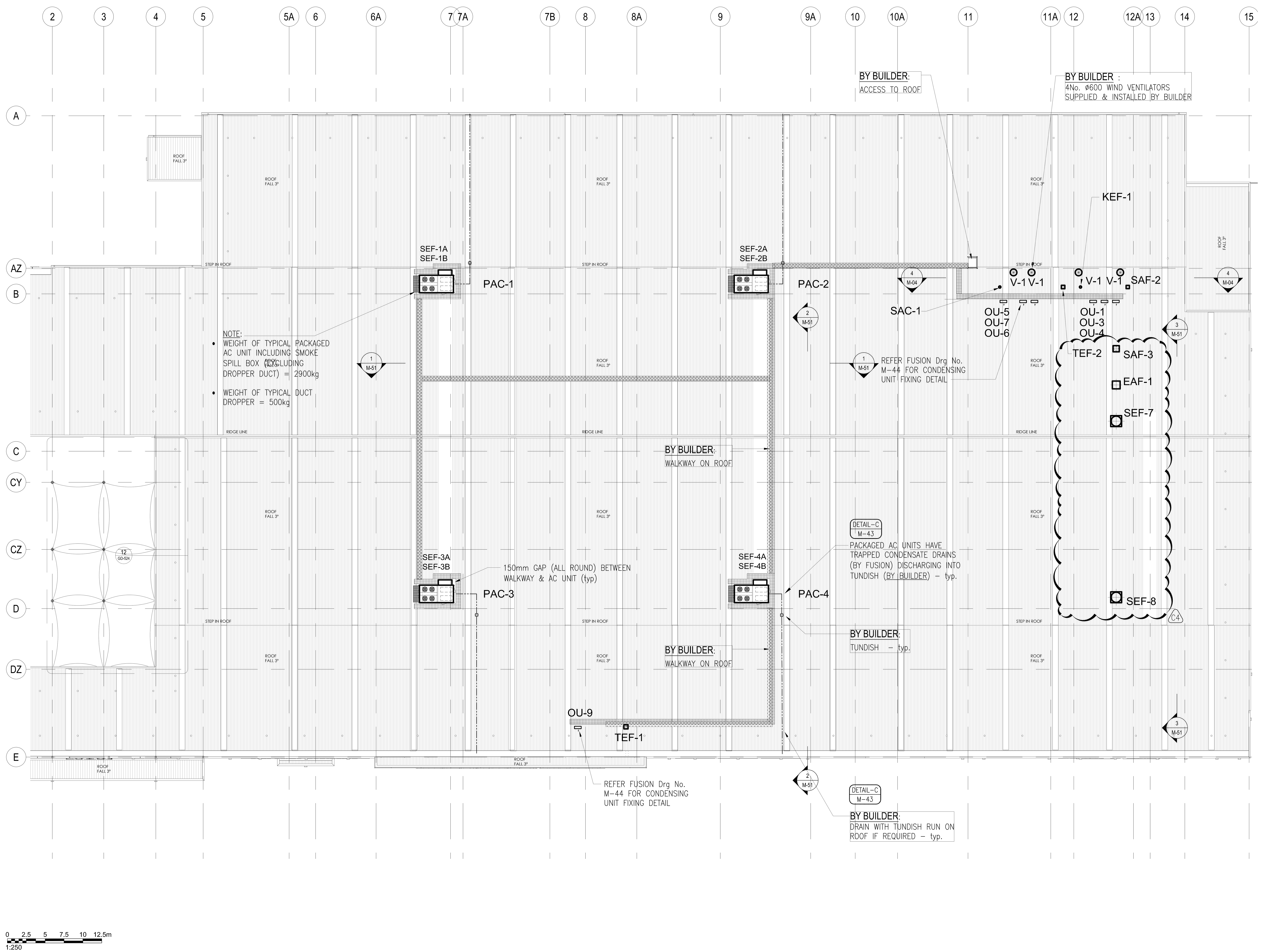
/1	Galvanised mild steel – no insulation
/2	Galvanised mild steel with 50mm internal perforated foil faced insulation
/3	Galvanised mild steel with 75mm (R2.0) internal perforated foil faced insulation
/4	Galvanised mild steel with 100mm internal perforated foil faced insulation
/5	Galvanised mild steel with 25mm external thermal insulation
/6	Galvanised mild steel with 25mm internal perforated foil faced insulation
	Fire rated
	Flexible Ductwork (Nude)
	Flexible Ductwork (c/w R2.0 75mm insulation)
	Refrigerant Pipework
	Condensate Drain Pipework

	Attenuator
	Supply grille
	Extract/return grille
	Door grille
S3	Grille reference
90	Airflow (l/s)
C	AC Controller
01	Duct part number
BL 100	Bottom level from floor
CL 100	Centre level from floor
C1	Revision cloud reference
	Damper
	Fire damper
	Tundish (by others)
BAP	Access panel in ceiling
Detail ref. DETAIL–A / Drg No. M–42	Detail drawing reference
Section ref. 1 / Drg No. M–51	Section drawing reference

REVISION C1

JOB AXN28

SHEET M-00



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5. All AC units & plenums to be mounted with rubber feet on brackets.
6. Typical Armaflex insulation to be used on all pipework is 25mm (internal) & 38mm Alu foil face (external).
7. Drawings produced in accordance with:

Architectural:	3116 GA200 Rev F 3116 GA201 Rev A 3116 GA310 Rev A 3116 GA311 Rev A 3116 GD600 Rev A Control Plan Rev Q
Structural:	S141039 S013 Rev B
Hydraulic:	NW140053_H1.03 Rev 2 NW140053_H1.04 Rev 2
Fire:	32349-FS02-FS04 Rev A
Electrical:	140149-MAS-A-304 Rev A

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C4	FAN UPSTANDS RELOCATED	BJH	18.06.15
C3	REVISED TO LATEST ARCH LAYOUTS	BJH	14.04.15
C2	REVISED TO LATEST ARCH LAYOUTS	DK	06.02.15
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

All dimensions to be verified on site before making any shop drawings or commencing any work. Do not scale from this drawing.

FUSIONHVAC

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PROJECT: MASTERS PENRITH

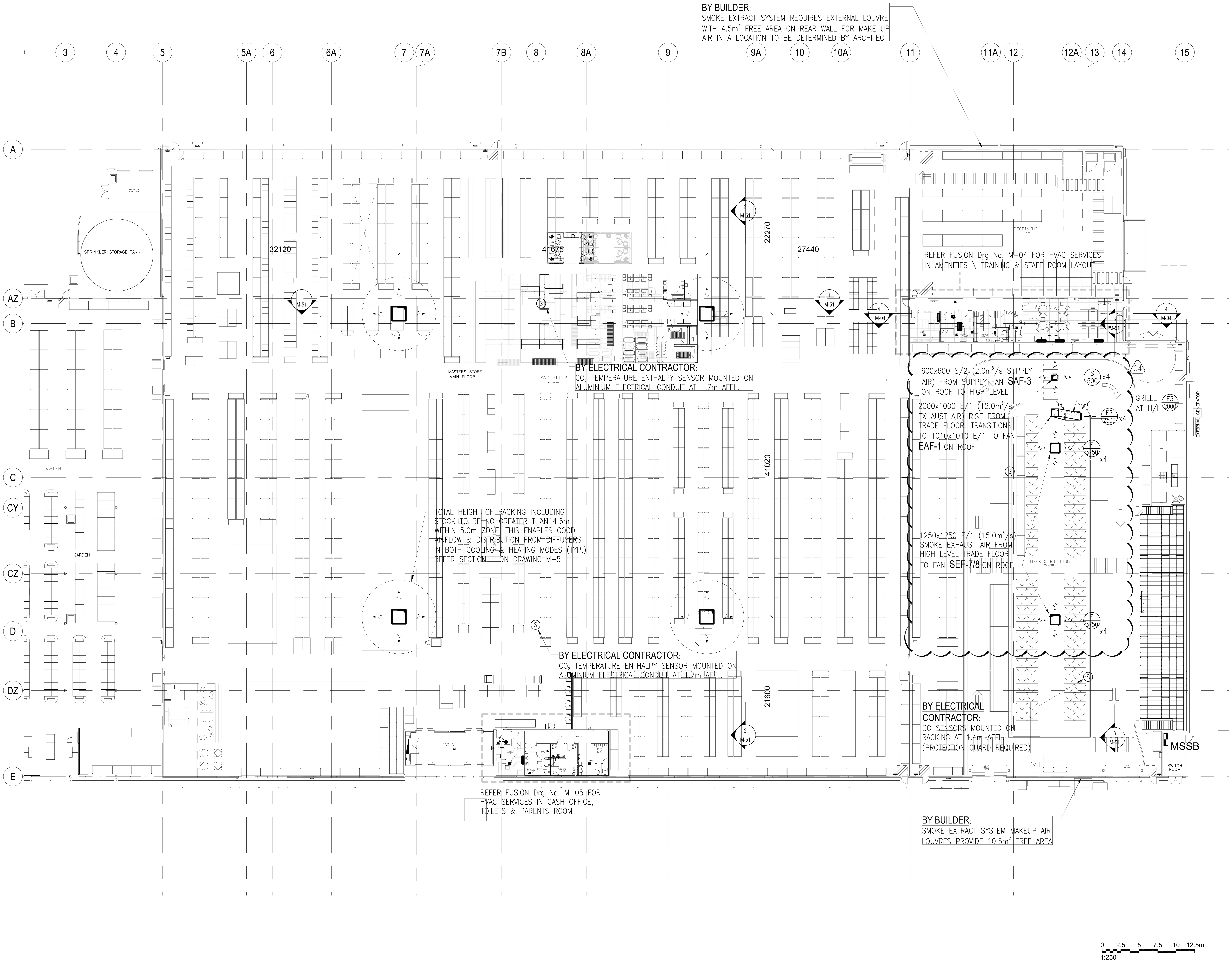
DRAWN	DK	SCALE	1:250 (A1)
APPROVED	AC	FILENAME	AXN28-Roof.dwg

SHEET TITLE: MECHANICAL SERVICES HVAC LAYOUT ROOF

JOB AXN28
SHEET M-01
REVISION C4

ORIGINAL SHEET SIZE : A1

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020



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Fire:	32349-FS02-FS04 Rev A
Electrical:	140149-MAS-A-304 Rev A

DUCTWORK TYPES

- /1 Galvanised mild steel – no insulation
- /2 Galvanised mild steel with 50mm internal perforated foil faced insulation
- /3 Galvanised mild steel with 75mm(R2.0) internal perforated foil faced insulation
- /4 Galvanised mild steel with 100mm internal perforated foil faced insulation
- /5 Galvanised mild steel with 25mm external thermal insulation
- /6 Galvanised mild steel with 50mm external thermal insulation
- Fire rated ductwork
- Flexible ductwork (nude)
- Flexible ductwork with 75mm insulation

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C4	ROOF FAN LOCATIONS UPDATED	BJH	18.06.15
C3	REVISED TO LATEST ARCH LAYOUTS	BJH	14.04.15
C2	REVISED TO LATEST ARCH LAYOUTS	DK	06.02.15
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

All dimensions to be verified on site before making any shop drawings or commencing any work. Do not scale from this drawing.

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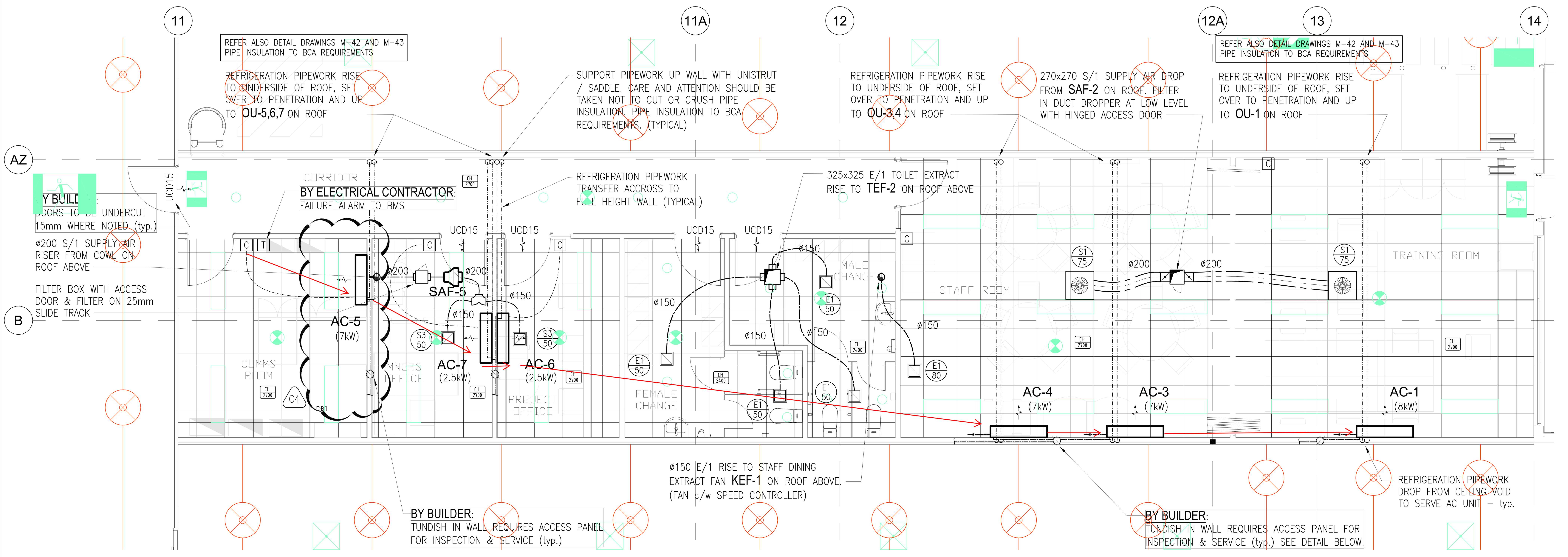
PROJECT: MASTERS PENRITH

DRAWN	DK	SCALE	1:250 (A1)
APPROVED	AC	FILENAME	AXN28-Ground.dwg

SHEET TITLE: MECHANICAL SERVICES HVAC LAYOUT STORE

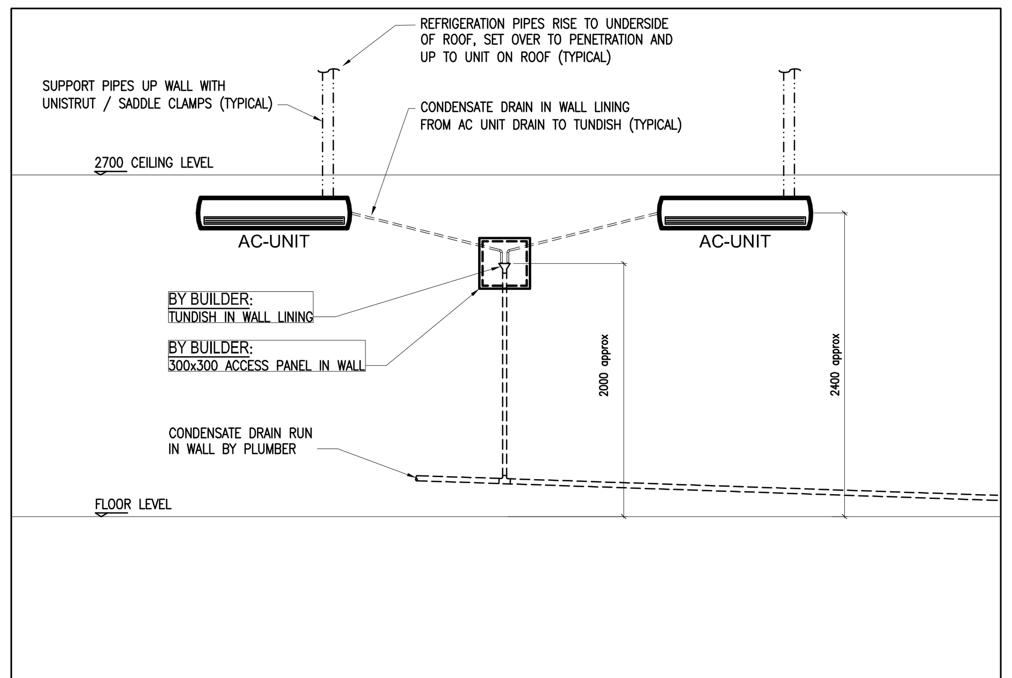
JOB: AXN28
SHEET: M-02
REVISION: C4

ORIGINAL SHEET SIZE : A1



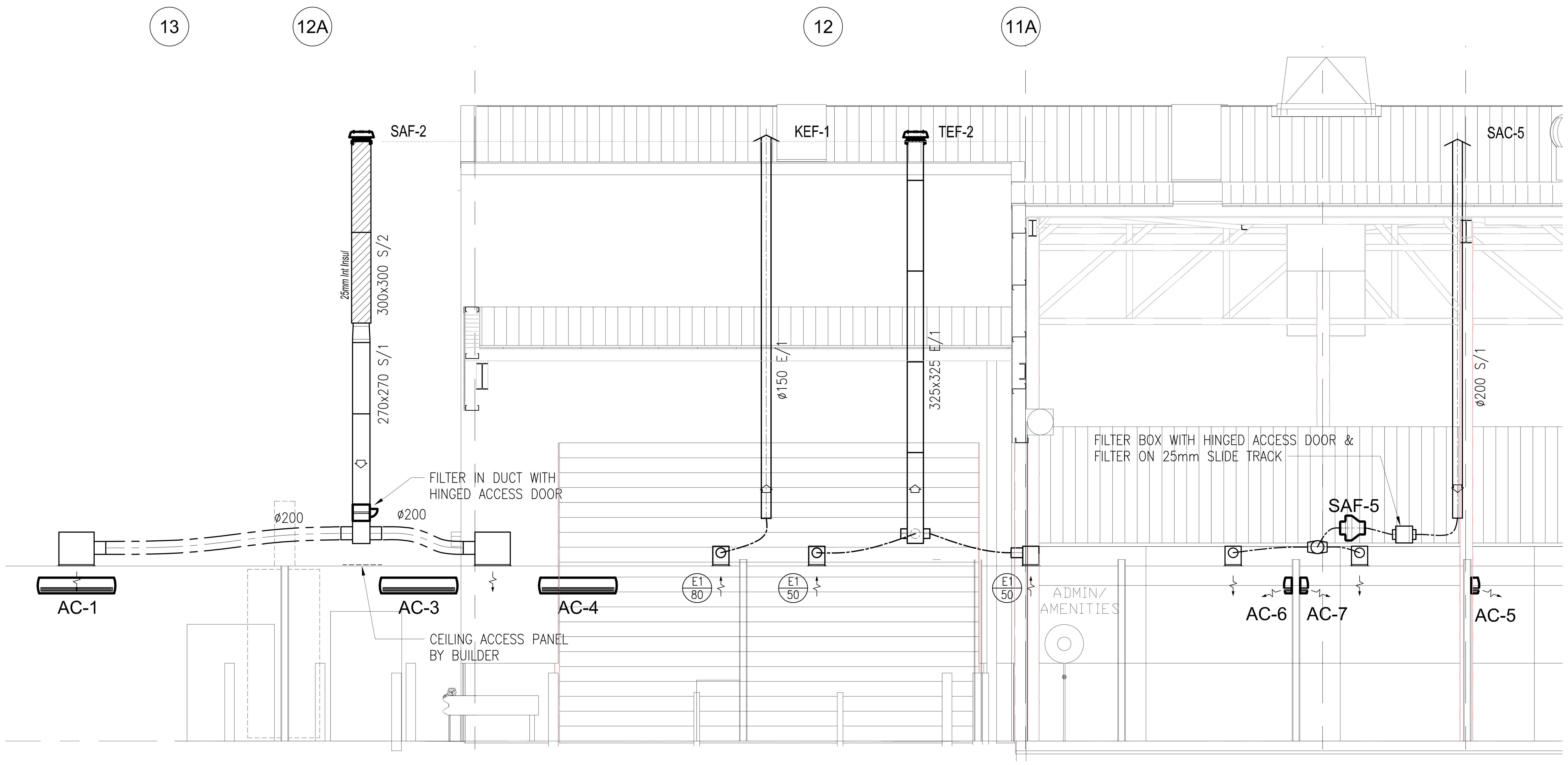
AMENITIES \ TRAINING & STAFF ROOM LAYOUT

SCALE 1:50



TYPICAL STAFF / TRAINING ROOM TUNDISH DETAIL

SCALE 1:50



SECTION 4 M-02 STAFF AMENITIES

Scale 1:50

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NOTES

1. For sensor references and cabling refer to Fusion electrical (for mechanical) drawings.
2. Distribution Board locations to be confirmed by Electrical Consultant.
3. Flex duct to be correctly supported along it's length & cut to length.
4. The contractor is to ensure an air tight seal between eggcrate, supply grilles & their diffuser boxes.
5. All AC units & plenums to be mounted with rubber feet on brackets.
6. Typical Armaflex insulation to be used on all pipework is 25mm (internal) & 38mm Alu foil face (external).
7. Drawings produced in accordance with:

Architectural: 3116 GA200 Rev F, 3116 GA201 Rev A, 3116 GA310 Rev A, 3116 GA311 Rev A, 3116 GD600 Rev A

Structural: S141039 S013 Rev B

Hydraulic: NW140053_H1.03 Rev 2, NW140053_H1.04 Rev 2

Fire: 32349-FS02-FS04 Rev A

Electrical: 140149-MAS-A-304 Rev A

DUCTWORK TYPES

/1 Galvanised mild steel – no insulation
/2 Galvanised mild steel with 50mm internal perforated foil faced insulation
/3 Galvanised mild steel with 75mm(R2.0) internal perforated foil faced insulation
/4 Galvanised mild steel with 100mm internal perforated foil faced insulation
/5 Galvanised mild steel with 25mm external thermal insulation
/6 Galvanised mild steel with 50mm external thermal insulation
Fire rated ductwork
Flexible ductwork (nude)
Flexible ductwork with 75mm insulation

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C4	AC-5 RELOCATED	BJH	14.04.15
C3	REVISED TO LATEST ARCH LAYOUTS	DK	06.02.15
C2	REFRIGERATION PIPEWORK AMENDED	BJH	10.12.14
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

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PROJECT: MASTERS PENRITH

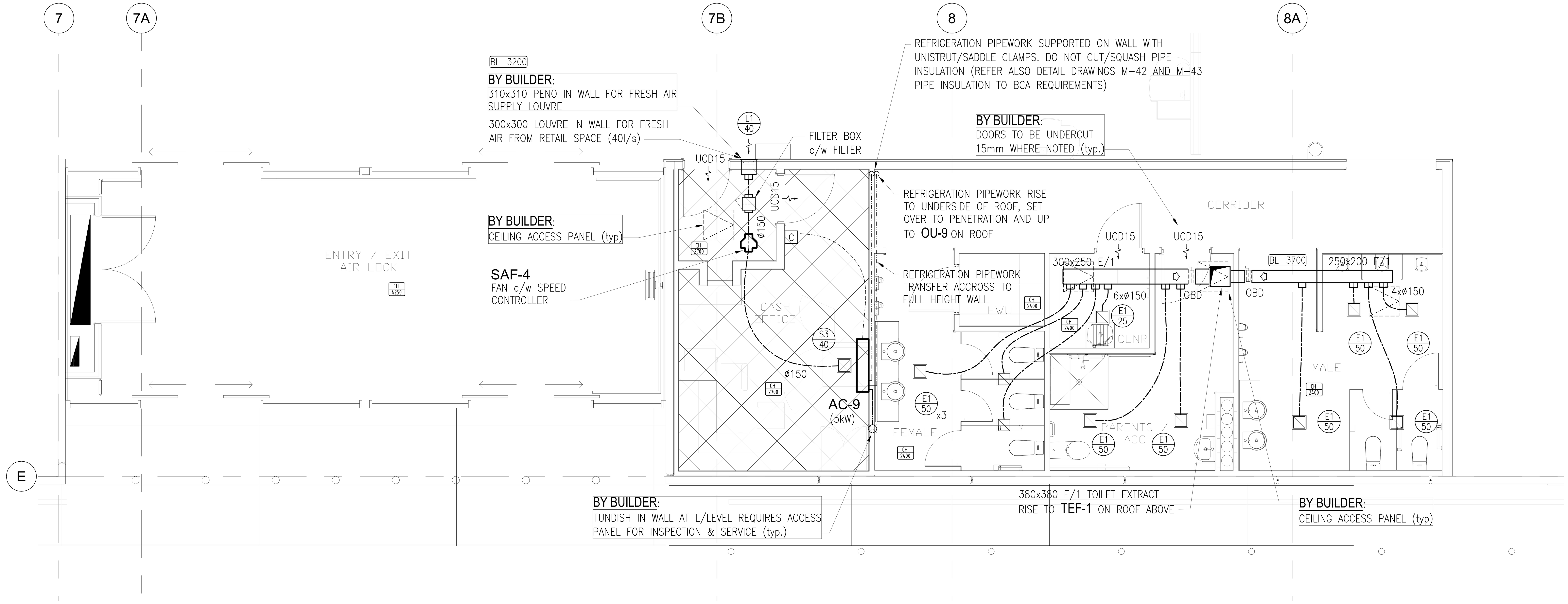
DRAWN DK SCALE AS SHOWN (A1)
APPROVED AC FILENAME AXN28-Ground.dwg

SHEET TITLE: MECHANICAL SERVICES AMENITIES & OFFICES LAYOUT SHEET 1

JOB AXN28
SHEET M-04
REVISION C4

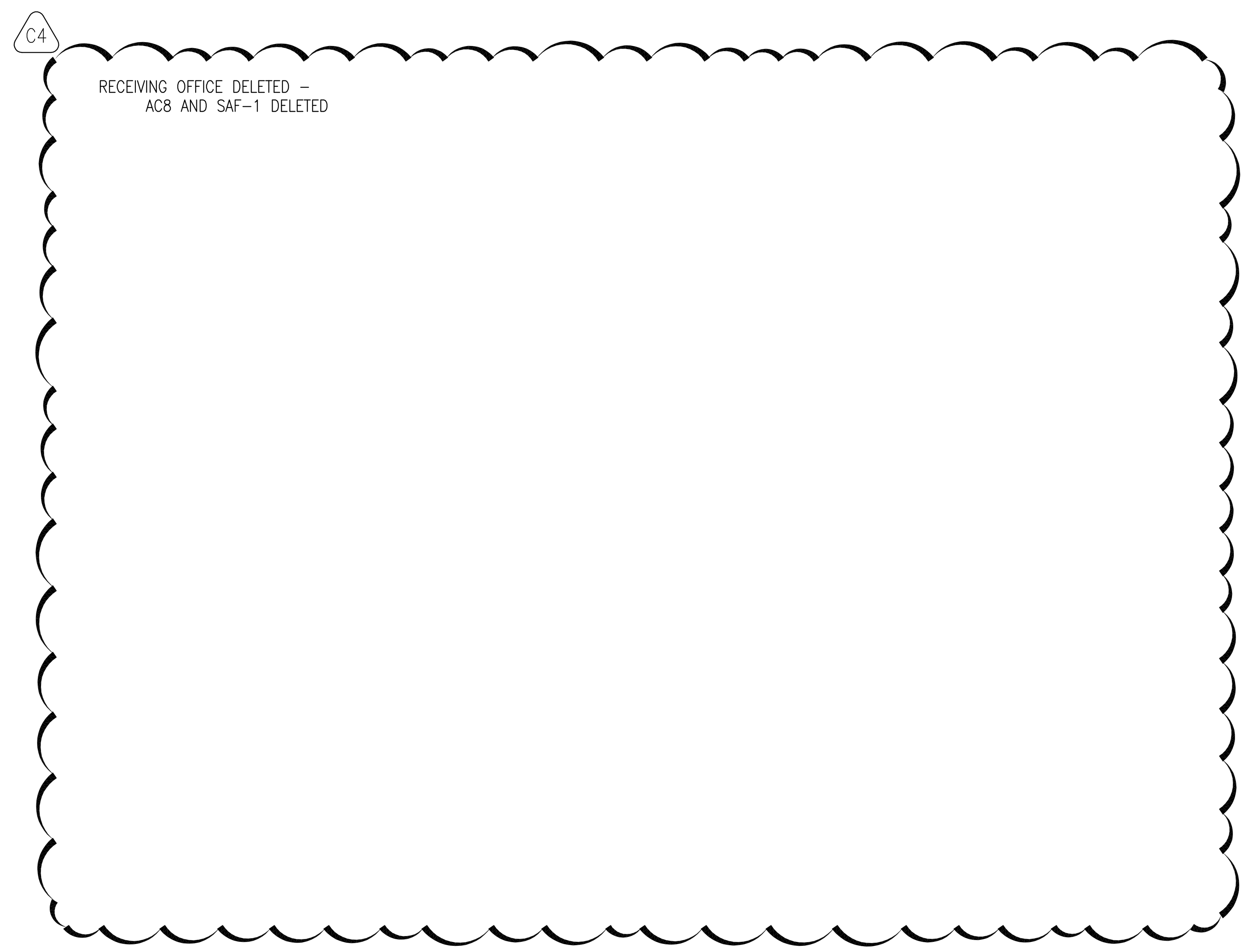
ORIGINAL SHEET SIZE : A1

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020



CASH OFFICE, TOILETS & PARENTS ROOM LAYOUT

SCALE 1:50



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NOTES

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2. Distribution Board locations to be confirmed by Electrical Consultant.
3. Flex duct to be correctly supported along it's length & cut to length.
4. The contractor is to ensure an air tight seal between eggcrate, supply grilles & their diffuser boxes.
5. All AC units & plenums to be mounted with rubber feet on brackets.
6. Typical Armaflex insulation to be used on all pipework is 25mm (internal) & 38mm Alu foil face (external).
7. Drawings produced in accordance with:

Architectural: 3116 GA200 Rev F
3116 GA201 Rev A
3116 GA310 Rev A
3116 GA311 Rev A
3116 GD600 Rev A

Structural: S141039 S013 Rev B

Hydraulic: NW140053_H1.03 Rev 2
NW140053_H1.04 Rev 2

Fire: 32349-FS02-FS04 Rev A

Electrical: 140149-MAS-A-304 Rev A

DUCTWORK TYPES

- /1 Galvanised mild steel – no insulation
- /2 Galvanised mild steel with 50mm internal perforated foil faced insulation
- /3 Galvanised mild steel with 75mm(R2.0) internal perforated foil faced insulation
- /4 Galvanised mild steel with 100mm internal perforated foil faced insulation
- /5 Galvanised mild steel with 25mm external thermal insulation
- /6 Galvanised mild steel with 50mm external thermal insulation
- Fire rated ductwork
- Flexible ductwork (nude)
- Flexible ductwork with 75mm insulation

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C4	RECEIVING OFFICE DELETED	BJH	14.04.15
C3	REVISED TO LATEST ARCH LAYOUTS	DK	06.02.15
C2	REFRIGERATION PIPEWORK AMENDED	BJH	10.12.14
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

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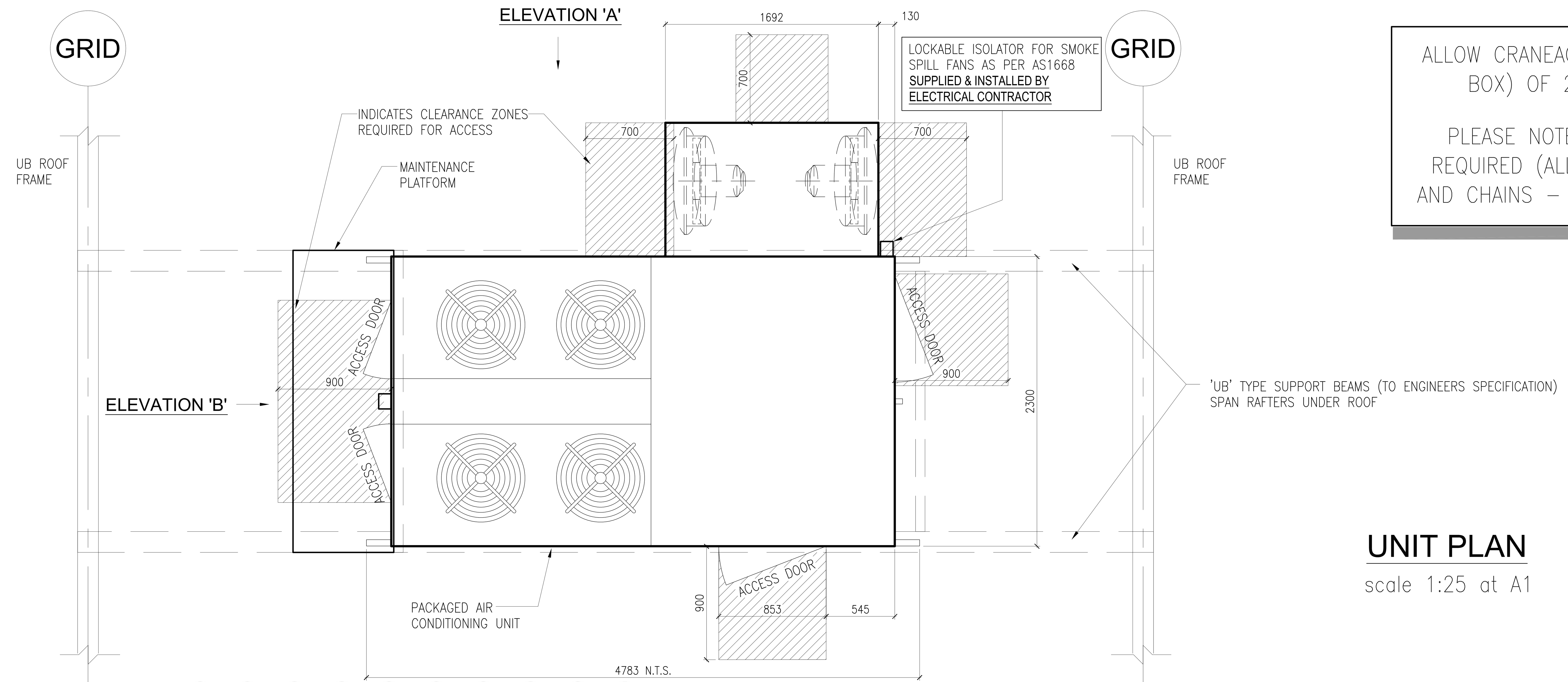
DRAWN DK SCALE 1:50 (A1)
APPROVED AC FILENAME AXN28-Ground.dwg

SHEET TITLE
MECHANICAL SERVICES
AMENITIES & OFFICES LAYOUT
SHEET 2

JOB AXN28
SHEET M-05
REVISION C4

ORIGINAL SHEET SIZE : A1

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020



ALLOW CRANEAGE WEIGHT (PAC UNIT c/w SMOKE SPILL BOX) OF 2900kg FOR FPA 180 (180kW UNIT)

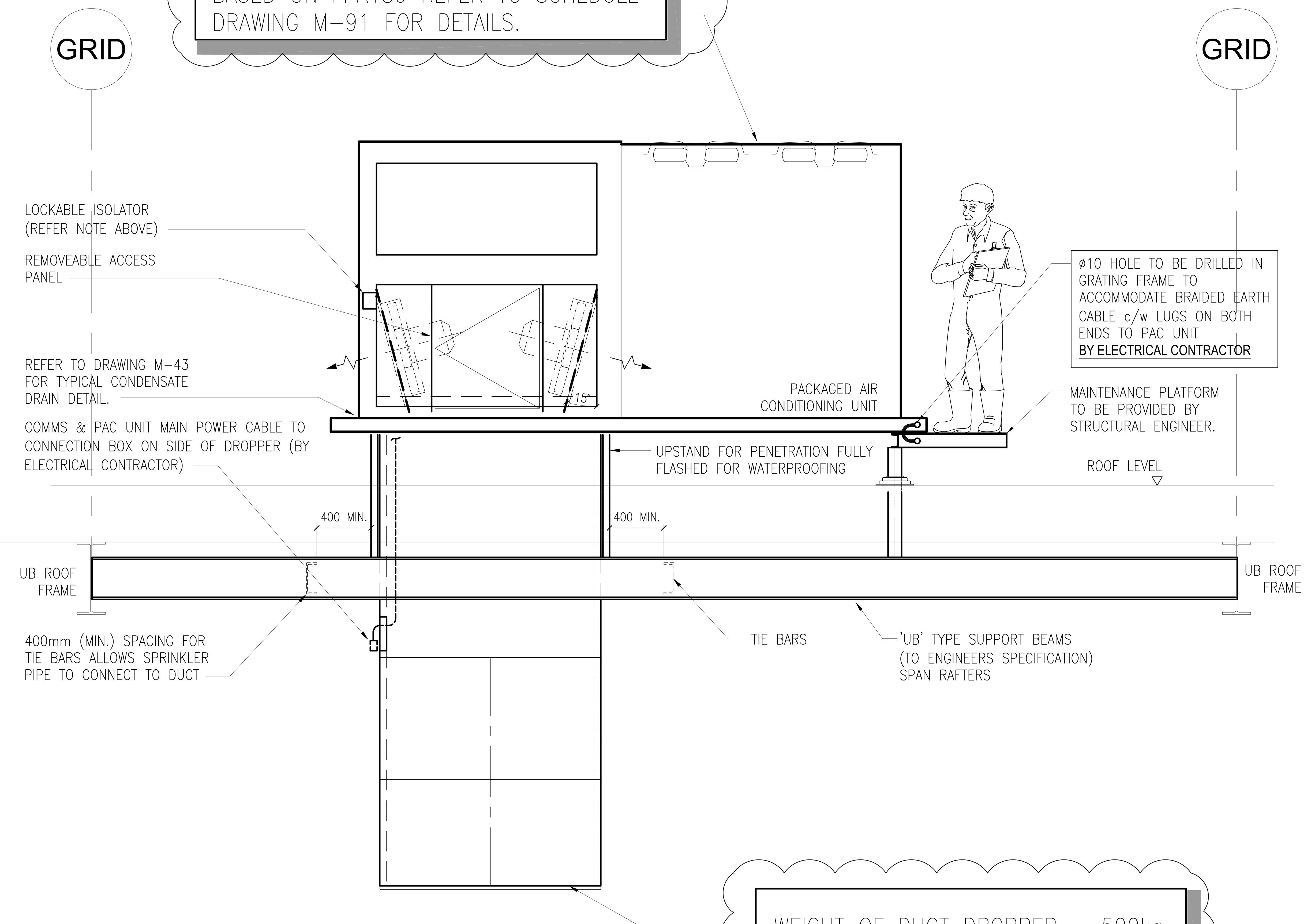
PLEASE NOTE THAT 5.0m LONG SPREADER BAR IS REQUIRED (ALLOW EXTRA WEIGHT FOR SPREADER BAR AND CHAINS – TO BE ADVISED BY CRANEAGE COMPANY)

UNIT PLAN

scale 1:25 at A1

WEIGHT OF PACKAGED AC UNIT = 2900kg BASED ON FPA180 REFER TO SCHEDULE DRAWING M-91 FOR DETAILS. (C2)

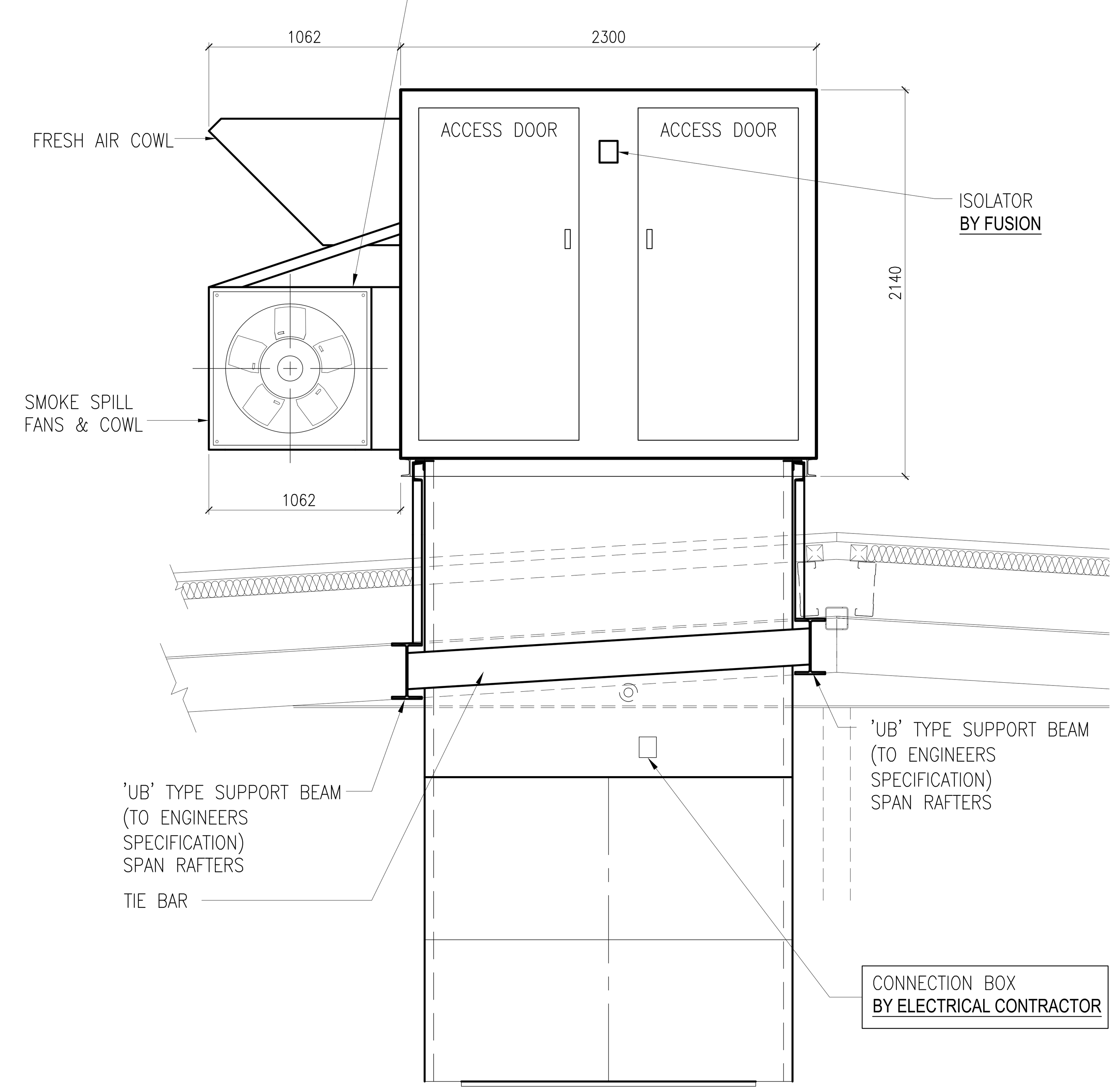
WEIGHT OF SMOKE SPILL BOX & FANS = 200kg



WEIGHT OF DUCT DROPPER = 500kg (C2)

ELEVATION 'A'

scale 1:25 at A1



ELEVATION 'B'

scale 1:25 at A1

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CONSTRUCTION

REV	AMENDMENT	BY	DATE
C2	Revised as clouded	DK	05.02.15
C1	Issued for Construction	BJH	30.07.14

All dimensions to be verified on site before making any shop drawings or commencing any work. Do not scale from this drawing.

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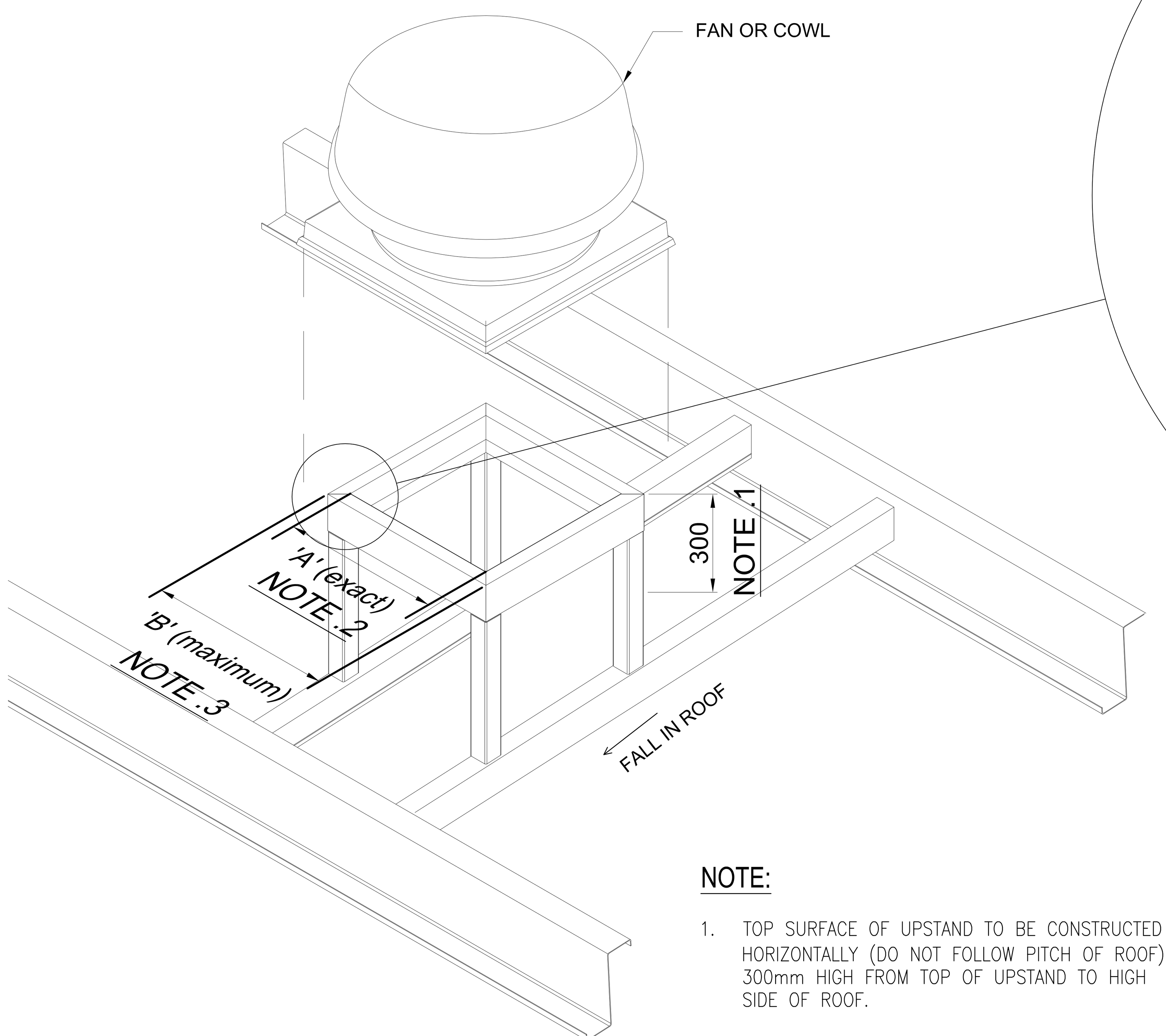
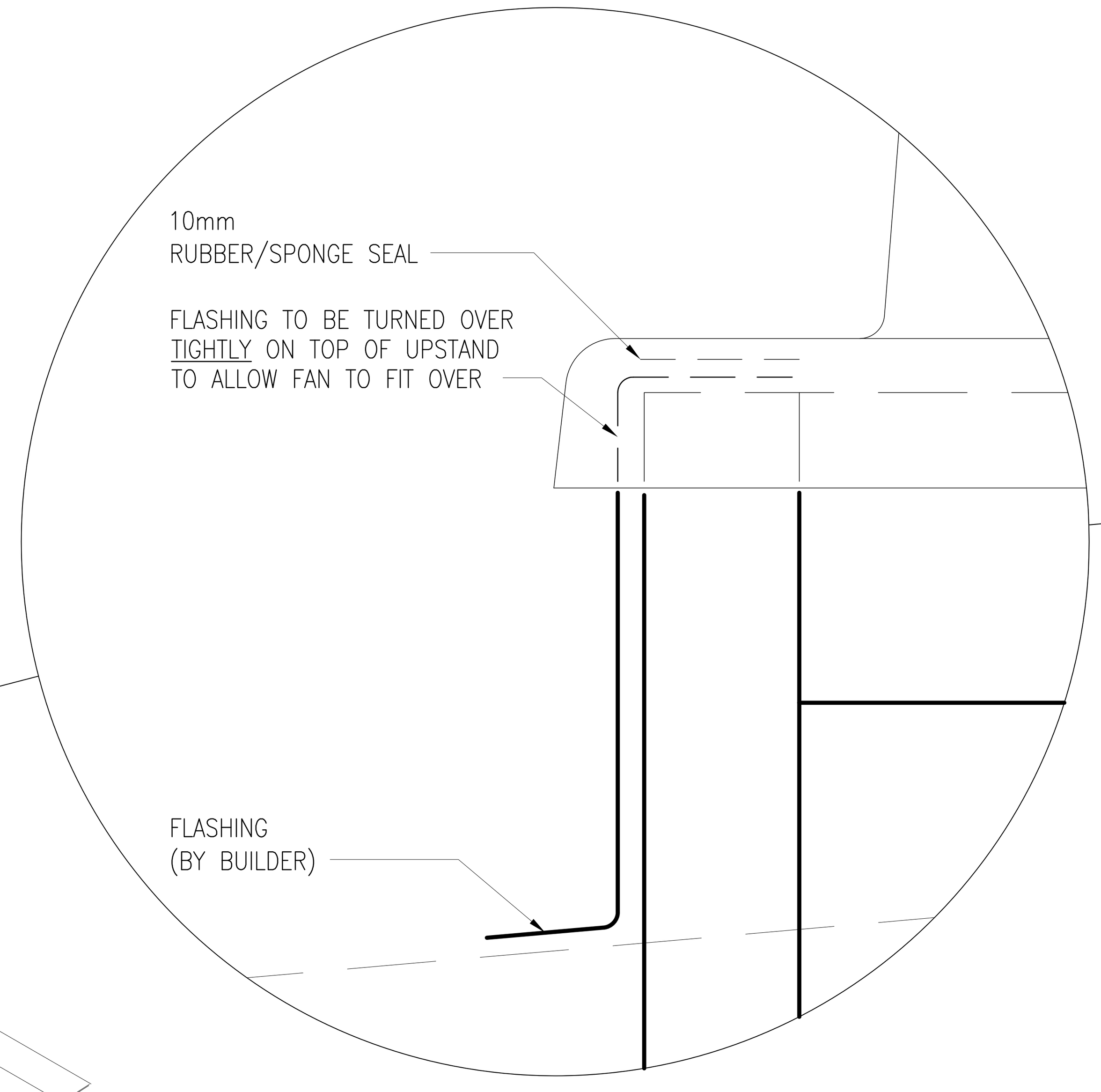
DRAWN: DK | SCALE: 1:25 (A1)
APPROVED: MB | FILENAME: AXN28-details.dwg

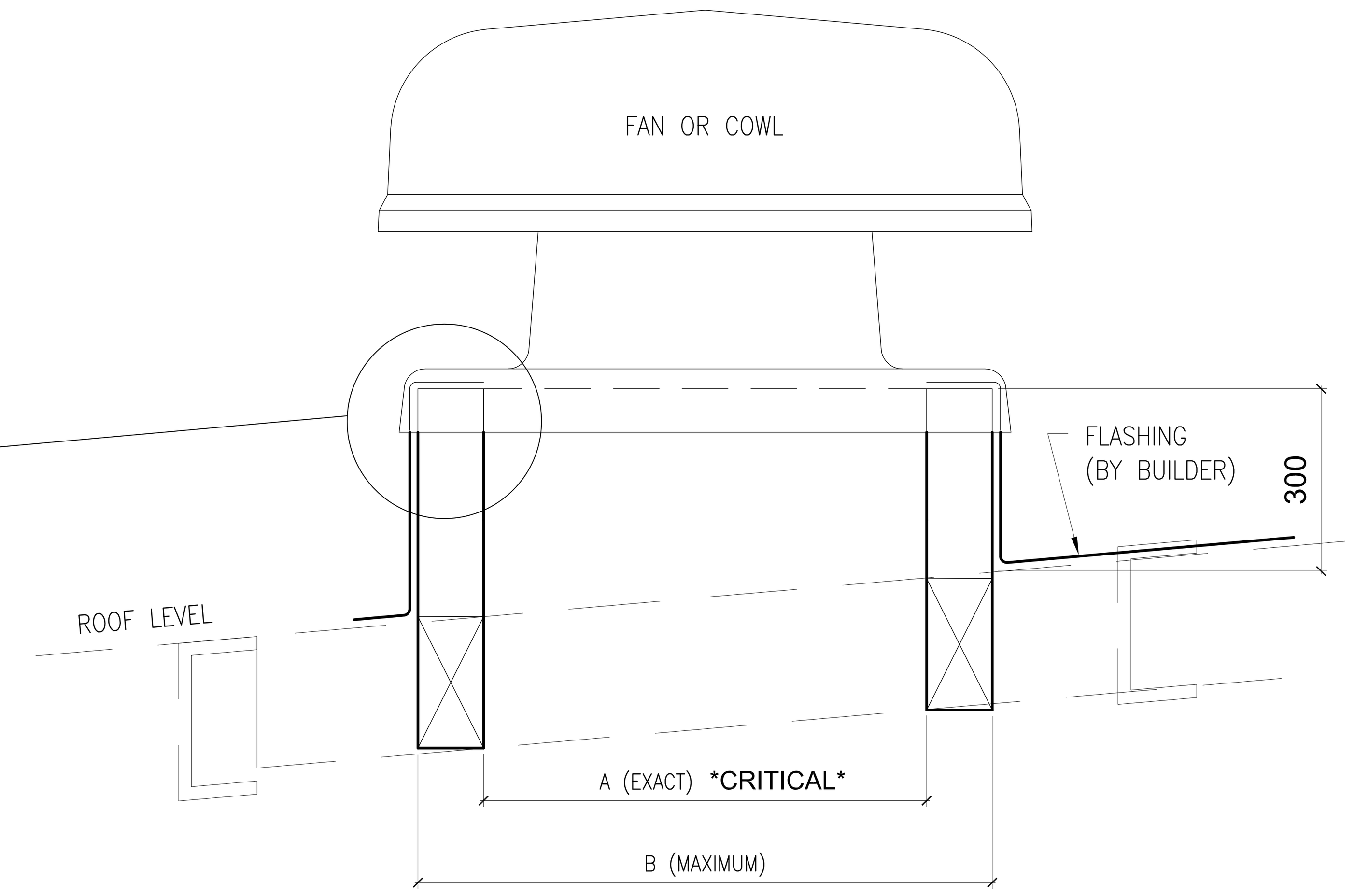
SHEET TITLE: HVAC SERVICES ROOFTOP PACKAGED AC PLANT SYSTEM DETAILS

JOB: AXN28
SHEET: M-41
REVISION: C2

ORIGINAL SHEET SIZE : A1







UPSTAND ELEVATION

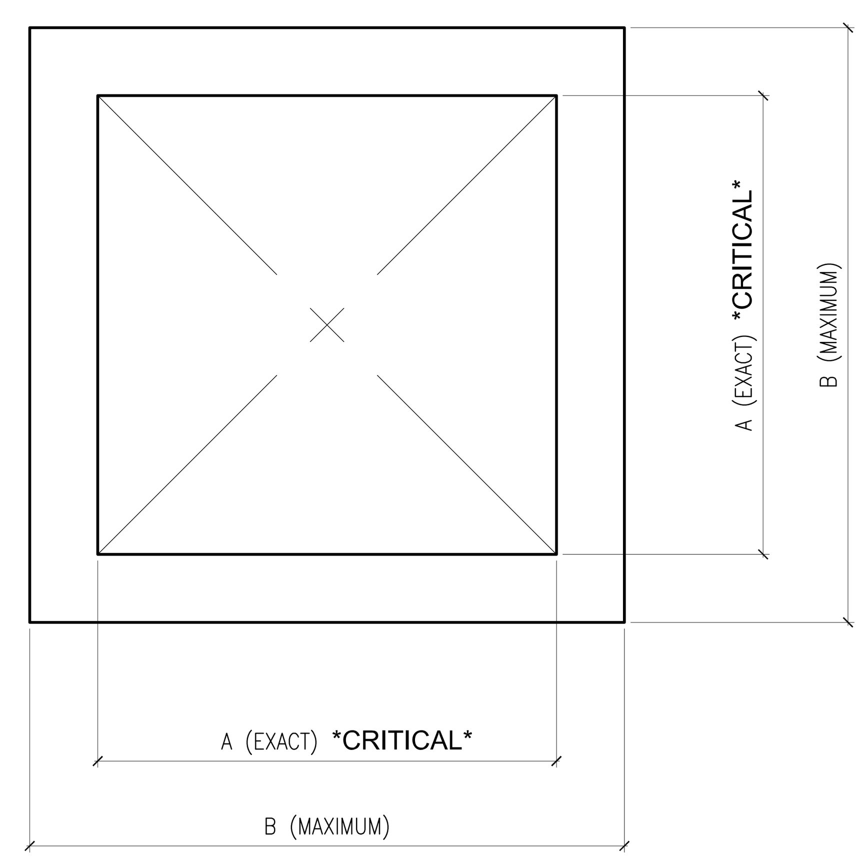
NOTE:

1. TOP SURFACE OF UPSTAND TO BE CONSTRUCTED HORIZONTALLY (DO NOT FOLLOW PITCH OF ROOF). 300mm HIGH FROM TOP OF UPSTAND TO HIGH SIDE OF ROOF.
2. DIMENSION 'A' (EXACT) IS CLEAR OPENING DIMENSION (NO BOLT HEADS etc. ON INSIDE OF UPSTAND AS DUCT HAS TO BE INSTALLED FROM THE TOP OF THE UPSTAND)
3. 'B' MAX. DIMENSION INDICATES MAXIMUM EXTERNAL SIZE OF UPSTAND (INCLUDING ROOF FLASHING) TO ALLOW FAN TO FIT OVER UPSTAND.

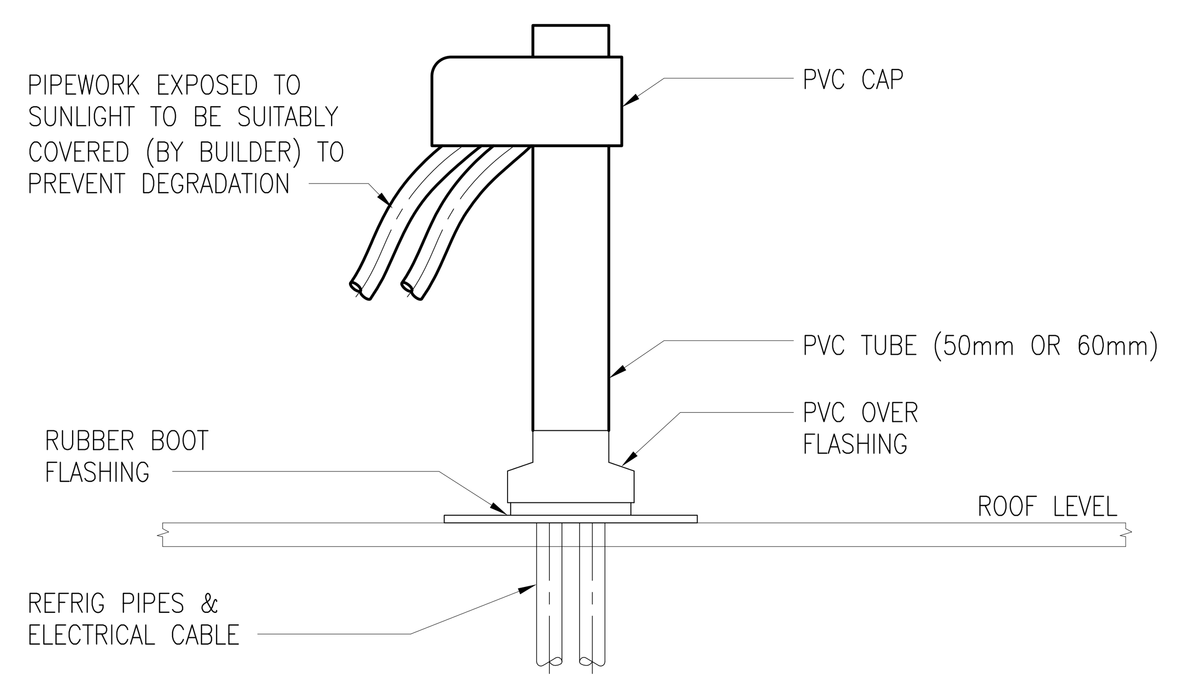
FAN OR COWL REF.	FAN /COWL WEIGHT	UPSTAND DIMENSIONS (mm)	
	(kg)	A (exact) *CRITICAL*	B (max)
TEF–1	40	400	515
TEF–2	5	345	400
EAF–1	157	1020	1160
SAF–2	4	325	380
SAF–3	54	615	715
SEF–7	277	1280	1420
SEF–8	277	1280	1420
KEF–1	3.2	ø150 DECKTITE	
SAC–1	2	ø200 DECKTITE	

DETAIL A
Scale: NTS

TYPICAL UPSTAND (BY BUILDER) FOR FANS AND COWLS



UPSTAND PLAN
(FAN NOT SHOWN FOR CLARITY)



DETAIL B
Not to scale

REFRIGERATION PIPEWORK ROOF PENETRATION DETAIL (SINGLE INVERTER SPLIT SYSTEMS)

MODEL REF. "TOP HAT RF-PN-50" SHOWN ABOVE

SYSTEM SUPPLIED BY MECHANICAL SUBCONTRACTOR
(REFER www.tophatroofkits.com FOR SUPPLIERS & INSTALLATION DETAILS)

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NOTES

1. Typical armaflex insulation to be used on all pipework is 25mm (internal) & 38mm alu foil face (external)

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C3	"Timber upstand" note removed	DK	30.04.15
C2	Revised as clouded	DK	05.02.15
C1	Issued for Construction	BJH	30.07.14

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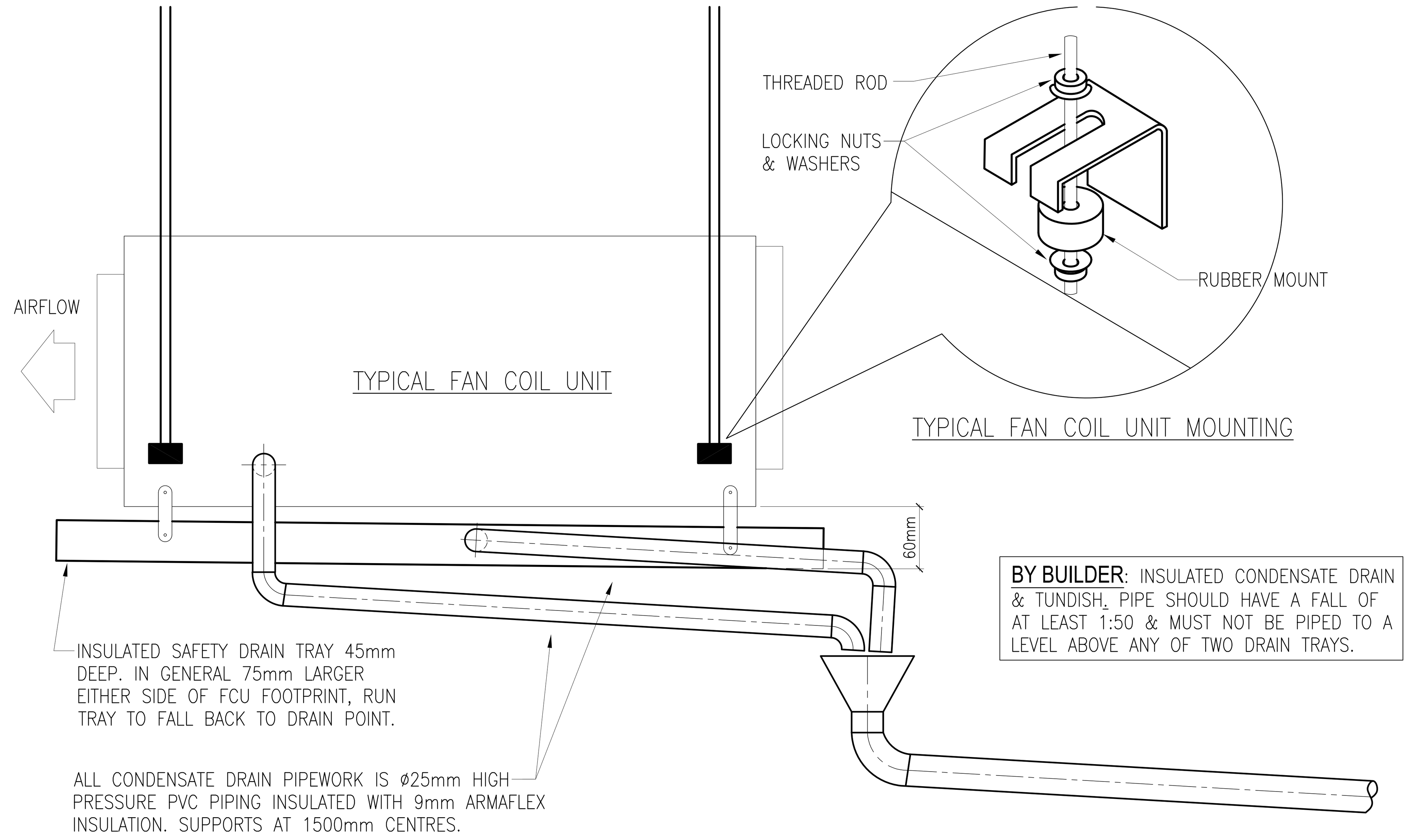
DRAWN: DK | SCALE: AS SHOWN (A1)
APPROVED: MB | FILENAME: AXN28-details.dwg

SHEET TITLE: HVAC SERVICES DETAILS Sheet 1

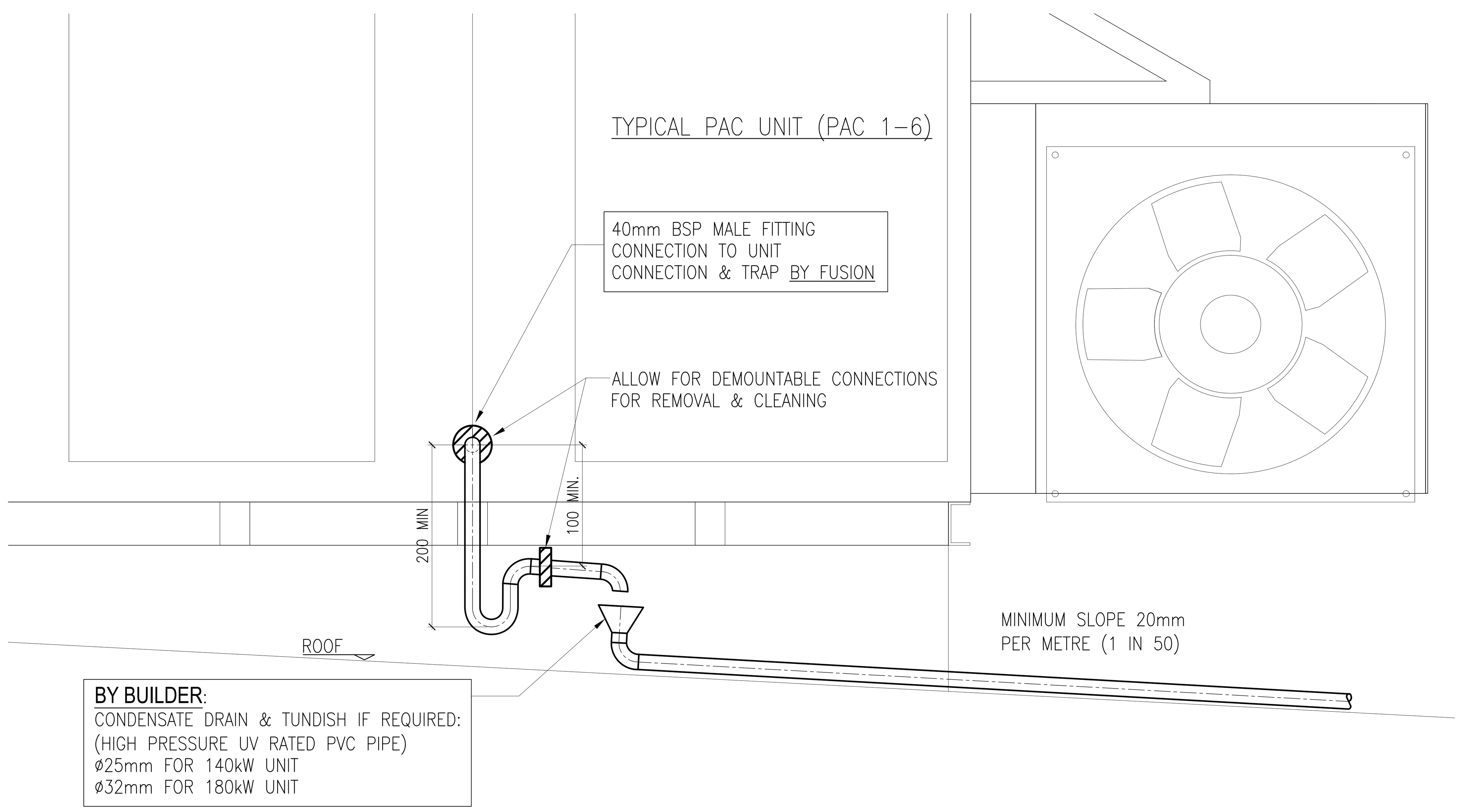
JOB: AXN28 | REVISION: C3
SHEET: M-42

ORIGINAL SHEET SIZE : A1



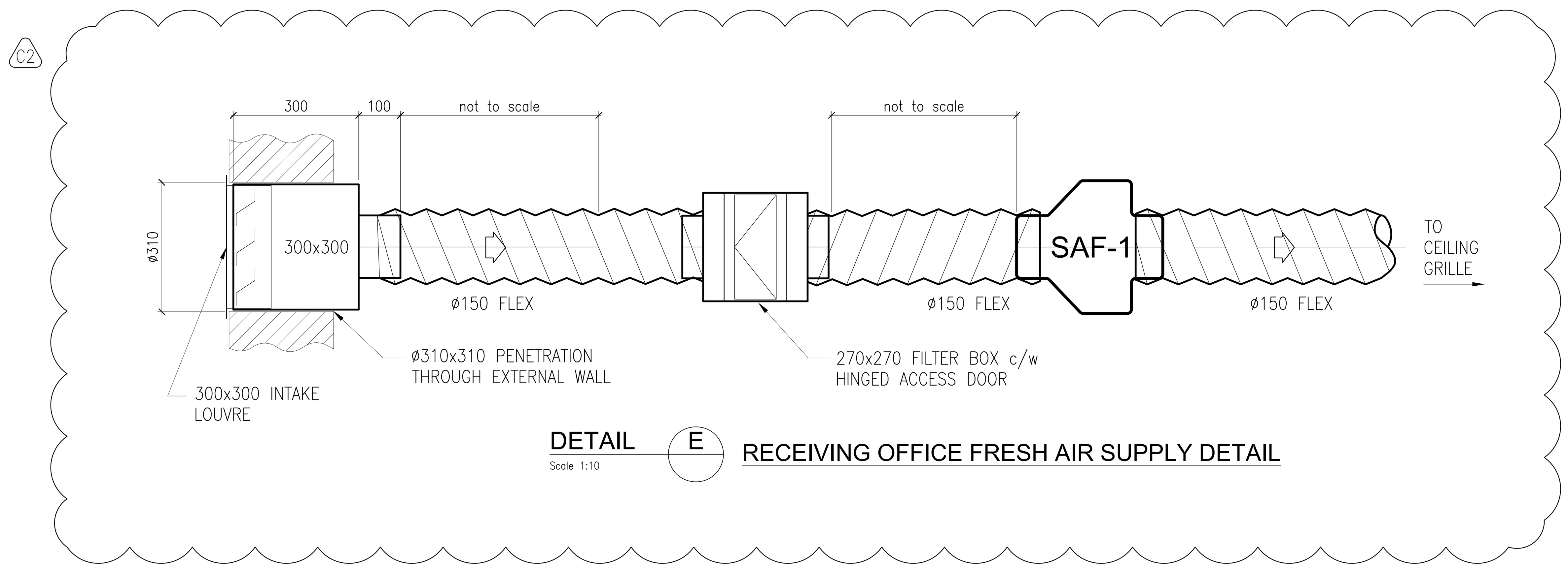
DETAIL D
Scale: NOT TO SCALE

TYPICAL CONDENSATE DRAIN CONNECTION
TO DAIKIN FAN COIL UNIT



DETAIL C
Scale: NOT TO SCALE

TYPICAL CONDENSATE DRAIN CONNECTION
TO PACKAGED AIR CONDITIONING UNIT



DETAIL E
Scale 1:10

RECEIVING OFFICE FRESH AIR SUPPLY DETAIL

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CONSTRUCTION

REV	AMENDMENT	BY	DATE
C2	Revised as clouded	DK	05.02.15
C1	Issued for Construction	BJH	30.07.14

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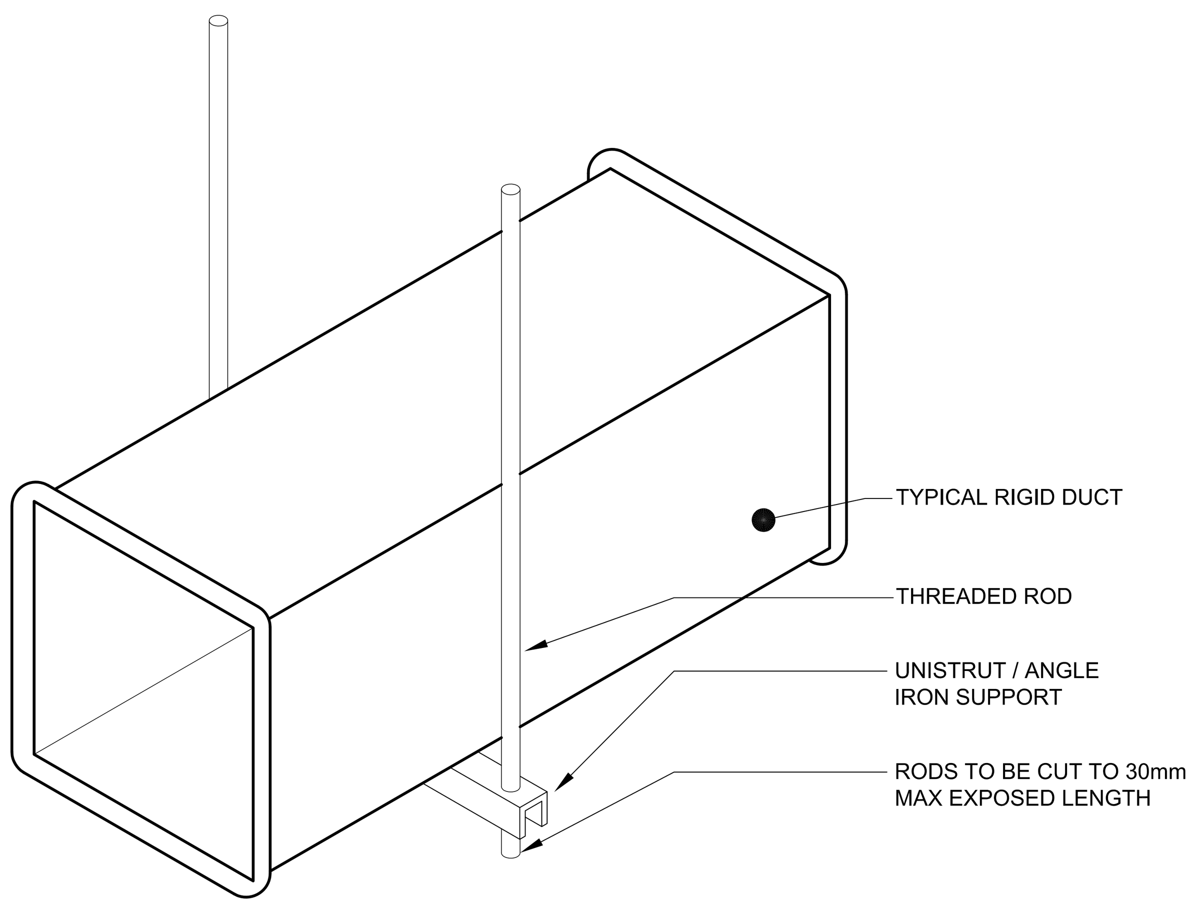
APPROVED MB | FILENAME AXN28-details.dwg

SHEET TITLE: HVAC SERVICES DETAILS Sheet 2

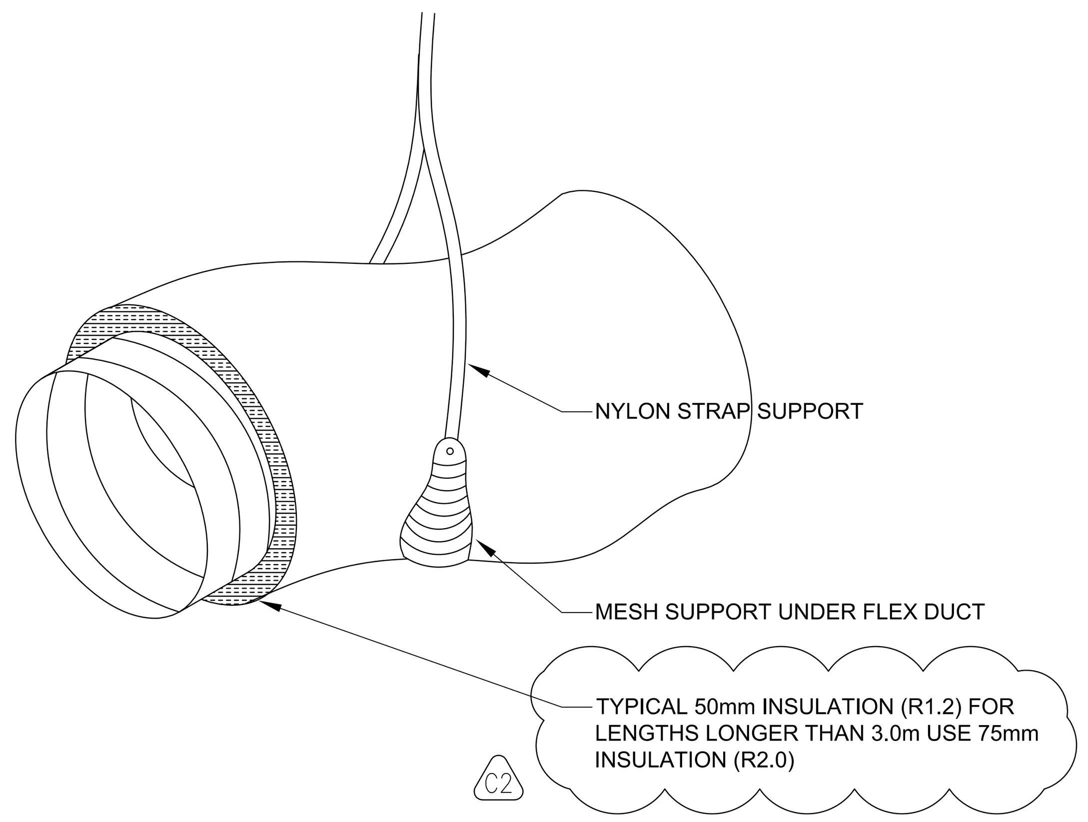
JOB AXN28
SHEET M-43
REVISION C2

ORIGINAL SHEET SIZE : A1



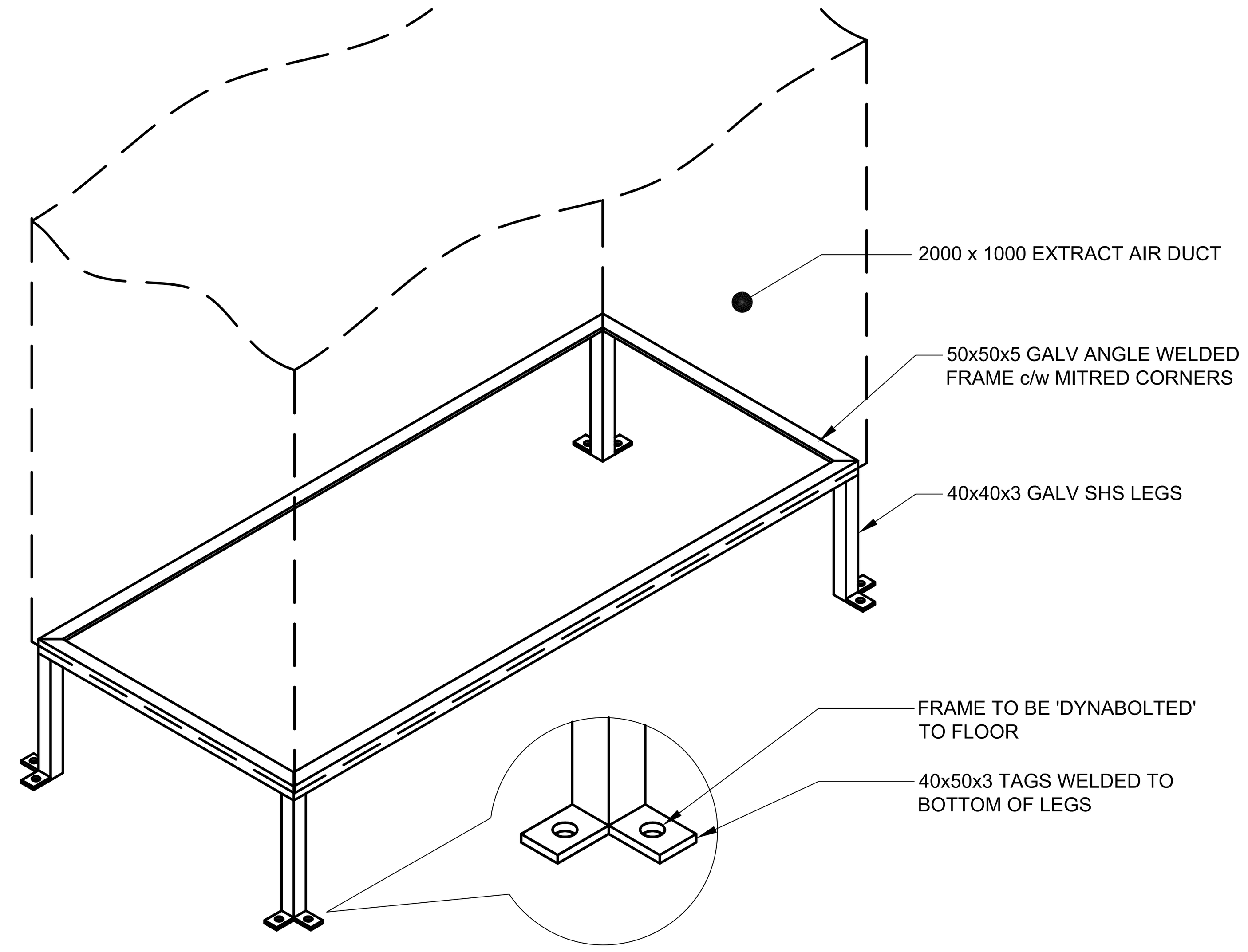
TYPICAL RIGID DUCT INSTALLATION DETAIL

SCALE: 1:10

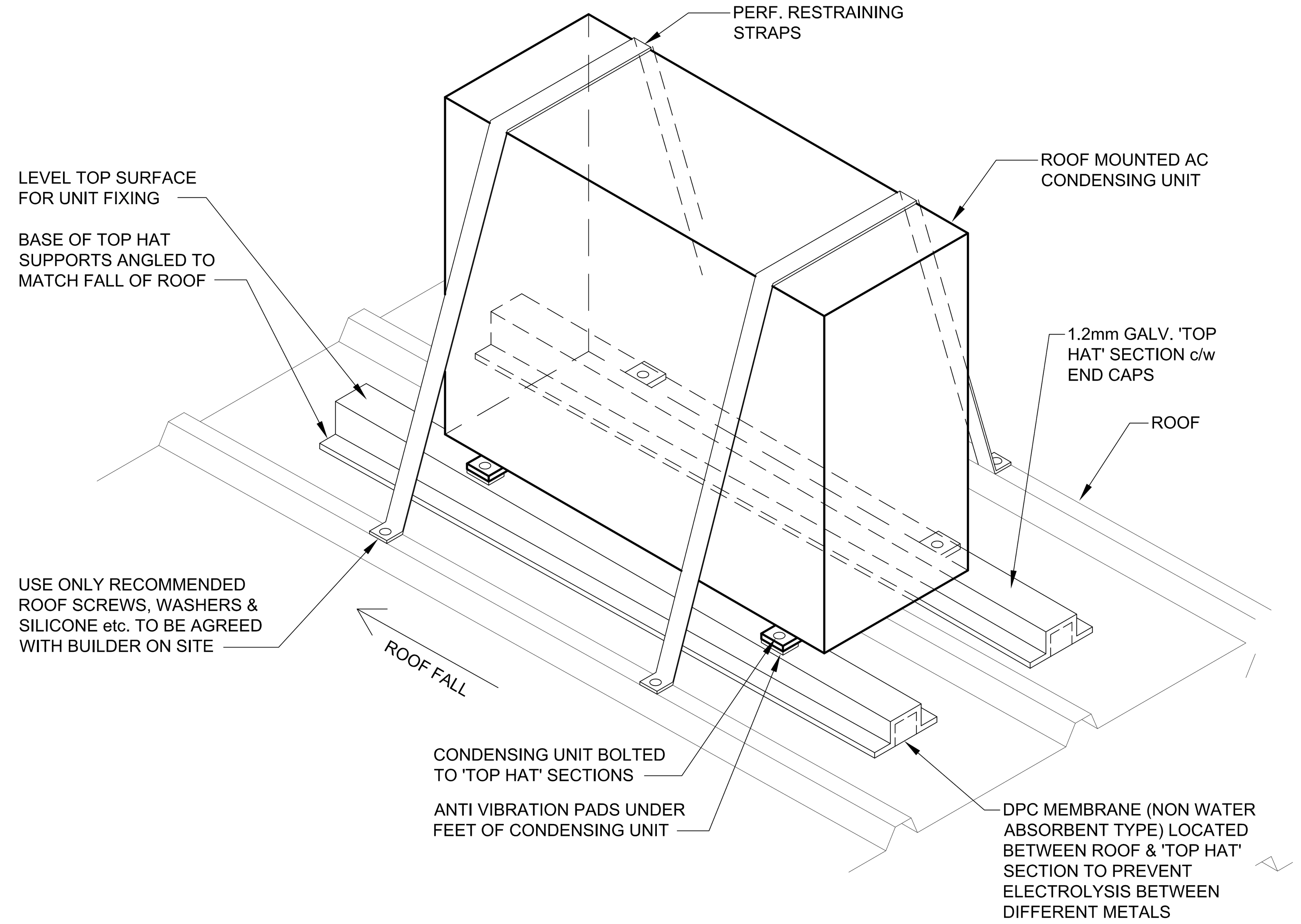


TYPICAL (INSULATED) FLEX DUCT INSTALLATION DETAIL

SCALE: 1:10



EAF-1 DUCT DROPPER GROUND FIXING DETAIL



ROOF MOUNTED AC CONDENSING UNIT FIXING DETAIL

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NOTES

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C2	Revised as clouded	DK	05.02.15
C1	Issued for Construction	BJH	30.07.14

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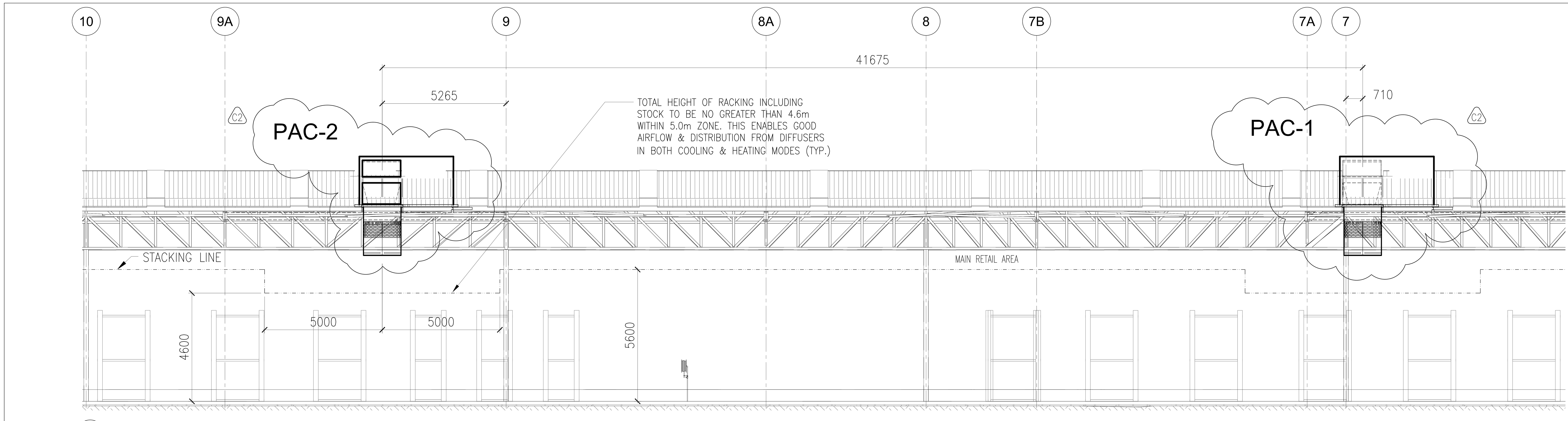
APPROVED MB FILENAME AXN28-details.dwg

SHEET TITLE
HVAC SERVICES
DETAILS
Sheet 3

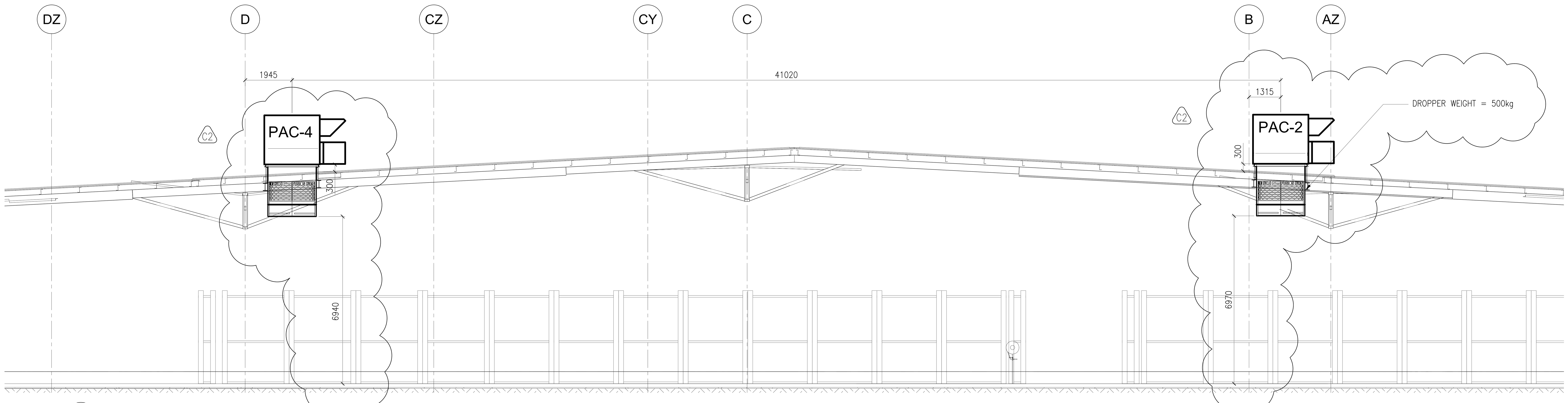
JOB AXN28
SHEET M-44
REVISION C2

ORIGINAL SHEET SIZE : A1

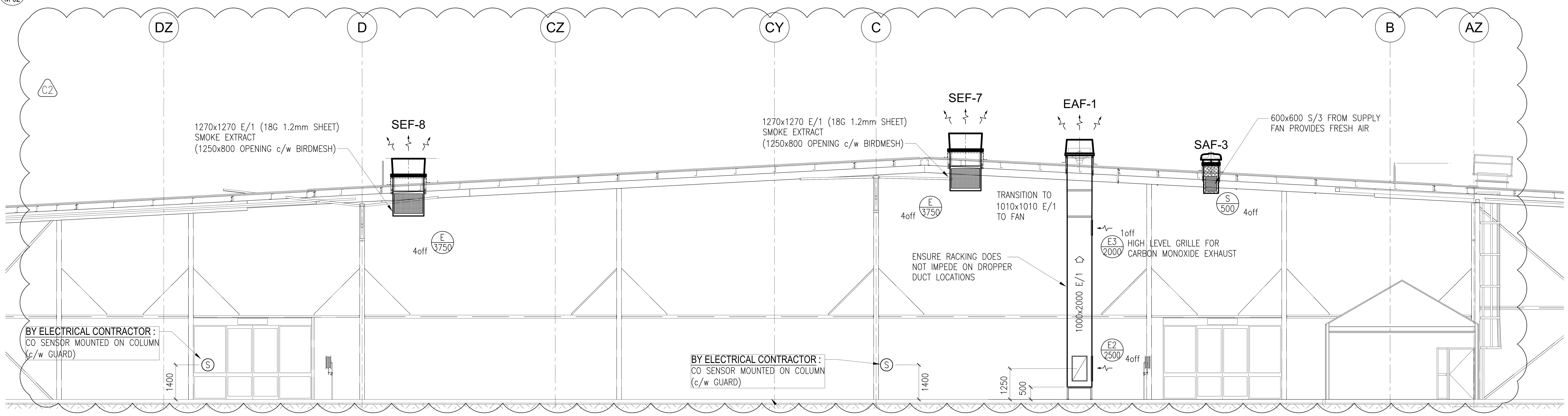
Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020



SECTION 1 MAIN FLOOR
Scale 1:100 M-02



SECTION 2 MAIN FLOOR
Scale 1:100 M-02



SECTION 3 TRADE CENTRE
Scale 1:100 M-02

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NOTES

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3. Flex duct to be correctly supported along it's length & cut to length.
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5. All AC units & plenums to be mounted with rubber feet on brackets.
6. Typical Armaflex insulation to be used on all pipework is 25mm (internal) & 38mm Alu foil face (external).
7. Drawings produced in accordance with:

   Architectural: 3116 GA200 Rev P7
   3116 GA201 Rev P5
   3116 GA310 Rev P3
   3116 GA311 Rev P3
   3116 GD600 Rev P2
   140149-MAS-A-304 Rev A

   Structural: S141039 S013 Rev B

   Hydraulic: NW140053_H1.03 Rev 2
   NW140053_H1.04 Rev 2

   Fire: 32349-FS02[A]-FS04[A]

   Electrical: 140149-MAS-A-304 Rev A

DUCTWORK TYPES

/1	Galvanised mild steel – no insulation
/2	Galvanised mild steel with 50mm internal perforated foil faced insulation
/3	Galvanised mild steel with 75mm(R2.0) internal perforated foil faced insulation
/4	Galvanised mild steel with 100mm internal perforated foil faced insulation
/5	Galvanised mild steel with 25mm external thermal insulation
/6	Galvanised mild steel with 50mm external thermal insulation
	Fire rated ductwork
	Flexible ductwork (nude)
	Flexible ductwork with 75mm insulation

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C2	REVISED TO LATEST ARCH LAYOUTS	DK	06.02.15
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

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PROJECT: MASTERS PENRITH

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APPROVED AC FILENAME AXN28-Ground.dwg

SHEET TITLE: HVAC SERVICES SECTIONS

JOB AXN28
SHEET M-51
REVISION C2

ORIGINAL SHEET SIZE : A1

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

C4

AC UNITS

REF	QTY	LOCATION	MAKE	MODEL	COOLING CAPACITY (kW)	TOTAL SUPPLY AIR FLOW (L/s)	TOTAL FRESH AIR (L/s)	POWER SUPPLY PHASE	RUNNING AMPS (A)	WEIGHT (kg)	CONNECTED TO	NOTES
AC-1	1	Training Room	Mitsubishi	SRK80ZMA-S	8	350	75	1	–	16	OU-1	Wall Mounted Inverter indoor unit
OU-1	1	Roof Above Staff Room	Mitsubishi	SRC80ZMA-S	–	–	–	–	11	63	AC-1	Outdoor Condenser Inverter Unit
AC-3	1	Staff Room	Mitsubishi	SRK71ZMA-S	7	325	–	1	–	16	OU-3	Wall Mounted Inverter indoor unit
OU-3	1	Roof Above Staff Room	Mitsubishi	SRC71ZMA-S	–	–	–	–	9.3	57	AC-3	Outdoor Condenser Inverter Unit
AC-4	1	Staff Room	Mitsubishi	SRK71ZMA-S	7	325	75	1	–	16	OU-4	Wall Mounted Inverter indoor unit
OU-4	1	Roof Above Staff Room	Mitsubishi	SRC71ZMA-S	–	–	–	–	9.3	57	AC-4	Outdoor Condenser Inverter Unit
AC-5	1	Comms Room	Mitsubishi	SRK24YMA-S	7	200	–	1	–	16	OU-5	Wall Mounted Inverter indoor unit
OU-5	1	Roof Above Comms Room	Mitsubishi	SRC24YMA-S	–	–	–	–	9.3	56	AC-5	Outdoor Condenser Inverter Unit
AC-6	1	Project Office	Mitsubishi	SRK25ZMA-S	2.5	132	50	1	–	9.5	OU-6	Wall Mounted Inverter indoor unit
OU-6	1	Roof Above Project Office	Mitsubishi	SRC25ZMA-S	–	–	–	–	3.2	35	AC-6	Outdoor Condenser Inverter Unit
AC-7	1	Manager's Office	Mitsubishi	SRK25ZMA-S	2.5	132	50	1	–	9.5	OU-7	Wall Mounted Inverter indoor unit
OU-7	1	Roof over Manager's Office	Mitsubishi	SRC25ZMA-S	–	–	–	–	3.2	35	AC-7	Outdoor Condenser Inverter Unit
AC-8	0	Receiving Office Deleted	–	–	–	–	–	–	–	–	–	–
OU-8	0	Deleted	–	–	–	–	–	–	–	–	–	–
AC-9	1	Cash Office	Mitsubishi	SRK50ZMA-S	5	188	40	1	.	9.5	OU-9	Wall Mounted Inverter indoor unit
OU-9	1	Roof Above Cash Office	Mitsubishi	SRC50ZMA-S	–	–	–	–	6.7	41	AC-9	Outdoor Condenser Inverter Unit

FAN SCHEDULE

REF	QTY	LOCATION	MAKE	MODEL	NOMINAL AIR FLOW (l/s)	STATIC PRESSURE (Pa)	POWER (kW)	POWER SUPPLY PHASE	RUNNING AMPS (A)	WEIGHT (kg)	NOTES
EAF-1	1	Timber Trade Floor Extract Fan	Fans Direct	VD10WY17A-6JSF	12000	100	5.5	3	11.4/11.4/11.4	157	
SEF-7 & 8	2	Timber Trade Floor Smoke Extract Fan	Fans Direct	LE11DD30A-6KFF	15000	125	7.5	3	15/15/15	277	F class motor, rated for 200?C for 2 hours, connected to essential power. Fire rated wiring is required.
SEF-1A, 1B to 4A, 4B	8	Retail Area Smoke Extract Fan located inside Rooftop Packaged AC unit (2No. per unit)	Fans Direct	SP63DB30A-4FFL	5500	125	3.0	3	4.4/4.4/4.4	55	F class motor, rated for 200°C for 2 hrs, connected to essential power. Fire rated wiring required.
TEF-1	1	Public Toilet Extract Fan	Fans Direct	RCD355-4E	475	160	0.3	1	1.12	40	
TEF-2	1	Staff Toilet Extract Fan	Fans Direct	RCD280-4E	200	115	0.08	1	0.35	5	
SAF-1	0	Receiving Office Deleted	–	–	–	–	–	–	–	–	–
SAF-2	1	Staff / Training Room Fresh Air Supply Fan	Fans Direct	CS225-2E	150	140	0.1	1	0.46	4	c/w Speed Controller and Filter.
SAF-3	1	Timber Trade Fresh Air Supply Fan	Fans Direct	DS56DB25P-1KSF	2000	130	1.1	1	8	54	c/w Speed Controller and Filter.
SAF-4	1	Cash Office Fresh Air Supply Fan	Fans Direct	SBD-150	40	180	0.06	1	0.2	3	c/w Speed Controller and Filter
SAF-5	1	Open/Manager's Office Fresh Air Supply Fan	Fans Direct	SBD-200	100	180	0.08	1	0.34	3.5	c/w Speed Controller and Filter. Duct to Roof Cowl SAC-1
KEF-1	1	Staff Dining Extract	Fans Direct	RCR-150A	80	100	0.08	1	0.35	5	c/w Speed Controller
V-1	4	Roof Mounted Wind Ventilator	Hurricane	H600	–	–	–	–	–	–	By Builder
SAC-1	1	Manager's Office Supply Air Cowl	Fans Direct	MAD200	–	–	–	–	–	2	–

GRILLE SCHEDULE

REF	QTY	MAKE	MODEL	SIZE	NOTES
S1	2	Krantz	RA-N3Q-DN350	350 dia	595sq. face for 1200x600 ceiling grid
S2	4	Custom Made	Wire Mesh Grille	600x400	by Duct Manufacturer
S3	4	Air Grilles	RCEG5-OBD	250x250	c/w OBD Std white
E1	15	Air Grilles	RCEG5-OBD	250x250	c/w OBD Std white
E2	4	Custom Made	Wire Mesh Grille	1000x600	by Duct Manufacturer
E3	1	Custom Made	Wire Mesh Grille	800x600	by Duct Manufacturer
L1	2	Air Grilles	OAL 50	300x300	Nat anodised ALU. finish c/w vermin mesh

FILTER SCHEDULE

REF	QTY	MAKE	MODEL	NOM. SIZE	ACTUAL SIZE
SAF-1	1	Airpure	80011010	254x254x25	241x241x22
SAF-2	1	Airpure	80011010	254x254x25	241x241x22
SAF-4	1	Airpure	80011010	254x254x25	241x241x22
SAF-5	1	Airpure	80011010	254x254x25	241x241x22

PACKAGED ROOFTOP AC UNITS

REF	QTY	LOCATION	MAKE	MODEL	NOMINAL AIR FLOW (L/s)	COOLING CAPACITY (kW)	POWER SUPPLY PHASE	RUNNING AMPS (A)	WEIGHT (kg)	DIMENSIONS H x L x D (mm)	NOTES
PAC-1 to 4	4	ROOF	TEMPERZONE	FPA180	9000	180.0	3	130	3400 *	2140x4500x2300	c/w 100mm EU5 disposable filters, EC fans, EEV's, Digital scroll lead compressor & factory fitted controls

* 2900 kg OUTDOOR MODULE + 500 kg INDOOR MODULE = 3400 kg TOTAL WEIGHT SUPPORTED BY FRAME

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CONSTRUCTION

REV	AMENDMENT	BY	DATE
C4	AC UNITS MAKE/MODEL REVISED	DK	10.06.15
C3	AC-8 & SAF-1 DELETED	BJH	14.04.15
C2	REVISED AS CLOUDED	DK	06.02.15
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

All dimensions to be verified on site before making any shop drawings or commencing any work.
Do not scale from this drawing.

FUSIONHVAC
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West End QLD 4101 + 61 (0)7 3118 5546

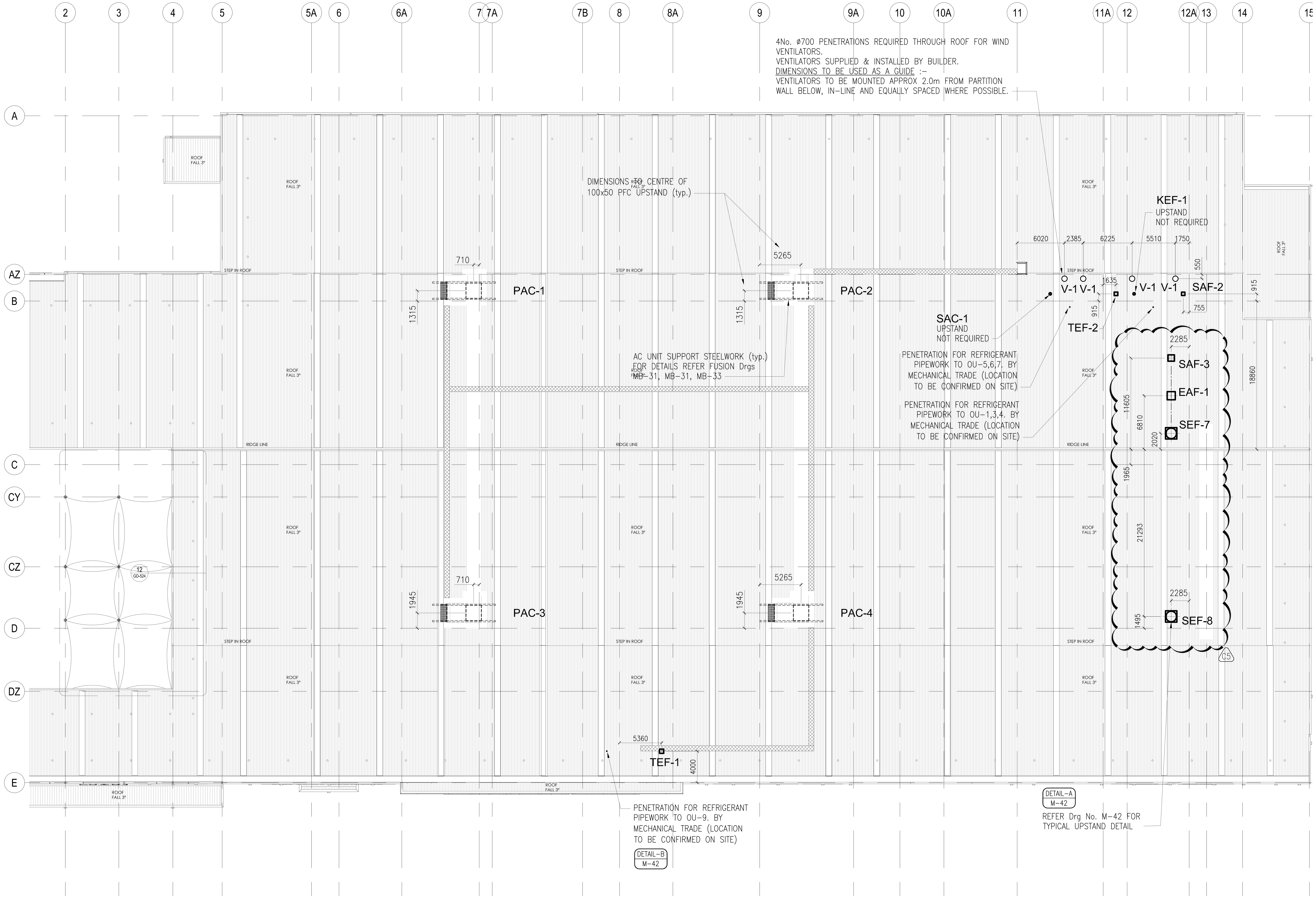
PROJECT: MASTERS PENRITH

DRAWN DK SCALE - (A1)
APPROVED AC FILENAME AXN28-Sched.dwg

SHEET TITLE
HVAC SERVICES
EQUIPMENT SCHEDULES

JOB AXN28
SHEET M-91
REVISION C4

ORIGINAL SHEET SIZE : A1



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NOTES

1. For sensor references and cabling refer to Fusion electrical (for mechanical) drawings.
2. Distribution Board locations to be confirmed by Electrical Consultant.
3. Flex duct to be correctly supported along it's length & cut to length.
4. The contractor is to ensure an air tight seal between eggcrate, supply grilles & their diffuser boxes.
5. All AC units & plenums to be mounted with rubber feet on brackets.
6. Typical Armaflex insulation to be used on all pipework is 25mm (internal) & 38mm Alu foil face (external).
7. Drawings produced in accordance with:

Architectural:	3116 GA200 Rev F 3116 GA201 Rev A 3116 GA310 Rev A 3116 GA311 Rev A 3116 GD600 Rev A Control Plan Rev Q
Structural:	S141039 S013 Rev B
Hydraulic:	NW140053_H1.03 Rev 2 NW140053_H1.04 Rev 2
Fire:	32349-FS02-FS04 Rev A
Electrical:	140149-MAS-A-304 Rev A

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C5	FAN UPSTANDS RELOCATED	BJH	18.06.15
C4	RECEIVING OFFICE NOTE REMOVED	BJH	14.04.15
C3	REVISED TO LATEST ARCH LAYOUTS	DK	05.02.15
C2	DIMENSIONS ADJUSTED TO SUIT M-51	BJH	03.12.14
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

ALL DIMENSIONS TO BE VERIFIED ON SITE BEFORE MAKING ANY SHOP DRAWINGS OR COMMENCING ANY WORK. DO NOT SCALE FROM THIS DRAWING.

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PROJECT: MASTERS PENRITH

DRAWN DK SCALE 1:250 (A1)
APPROVED AC FILENAME ANX28-Roof.dwg

SHEET TITLE: MECHANICAL SERVICES ROOF BUILDERSWORK LAYOUT

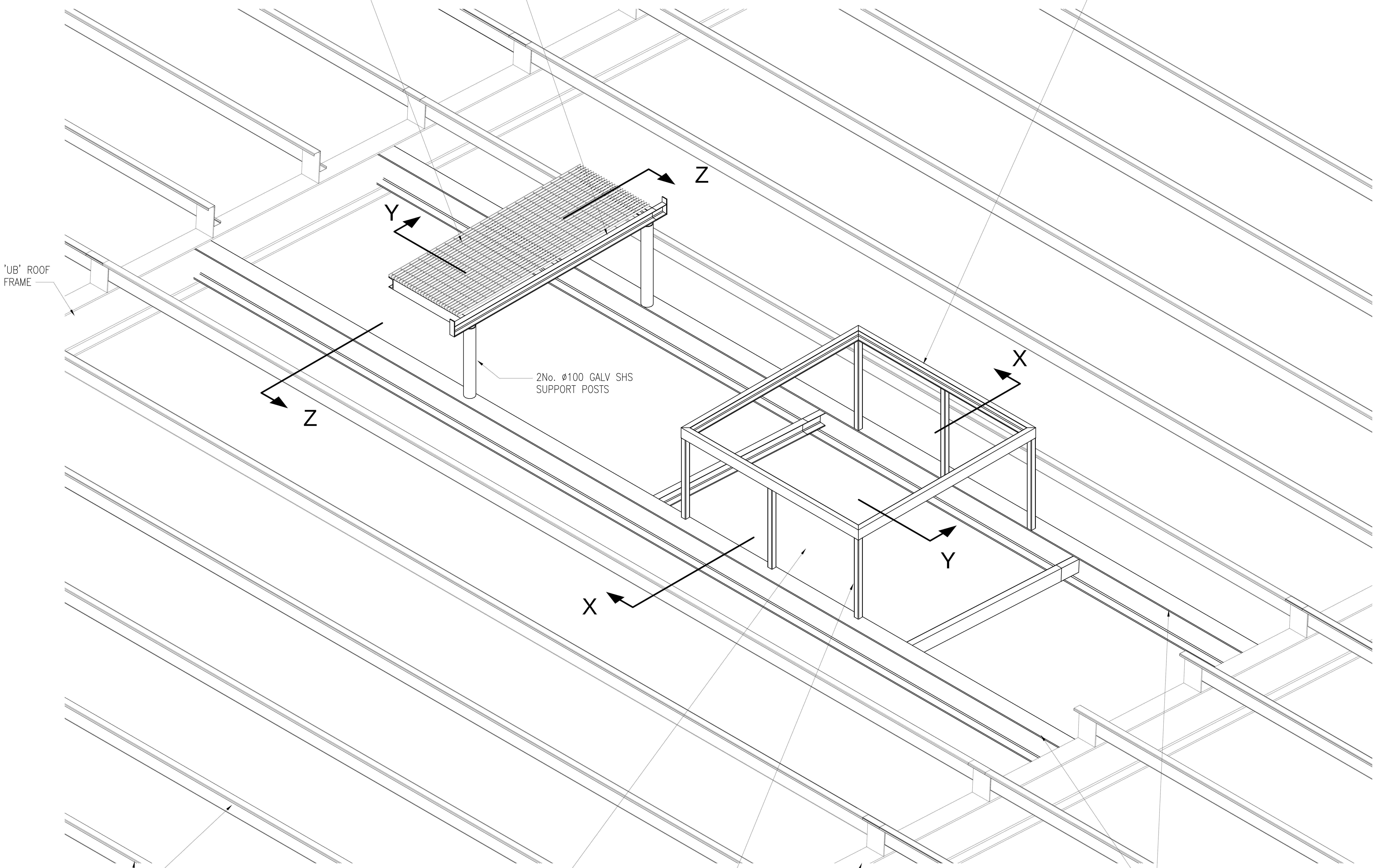
JOB ANX028 REVISION C5
SHEET MB-01

0 2.5 5 7.5 10 12.5m
1:250

ORIGINAL SHEET SIZE : A1

Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

STRUCTURAL ENGINEER'S FINAL SUPPORT STEELWORK DRAWINGS TO BE REVIEWED AND APPROVED BY FUSION PRIOR TO MANUFACTURE



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NOTES

1. This drawing is part of a set and is to be read in conjunction with all FUSION roof plant builderswork drawings: MB-31 to MB-33.
2. Penetration must be clear vertically above and below roof line.
3. Penetration upstand must be level on top and 300mm above the roof on the high side.
4. Unit support goalposts must be parallel to upstand.
5. 100x50 pfc must have open throats facing inwards as shown.
6. All steel hot dip galvanised.
7. All welds continuous above roofline.
8. All beams and posts to be sized by structural engineer.
9. All structural details to be confirmed by structural engineer.

CONSTRUCTION

REV	AMENDMENT	BY	DATE
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

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DRAWN DK SCALE N.T.S.
APPROVED KH FILENAME AXN28-Platform Basket.dwg

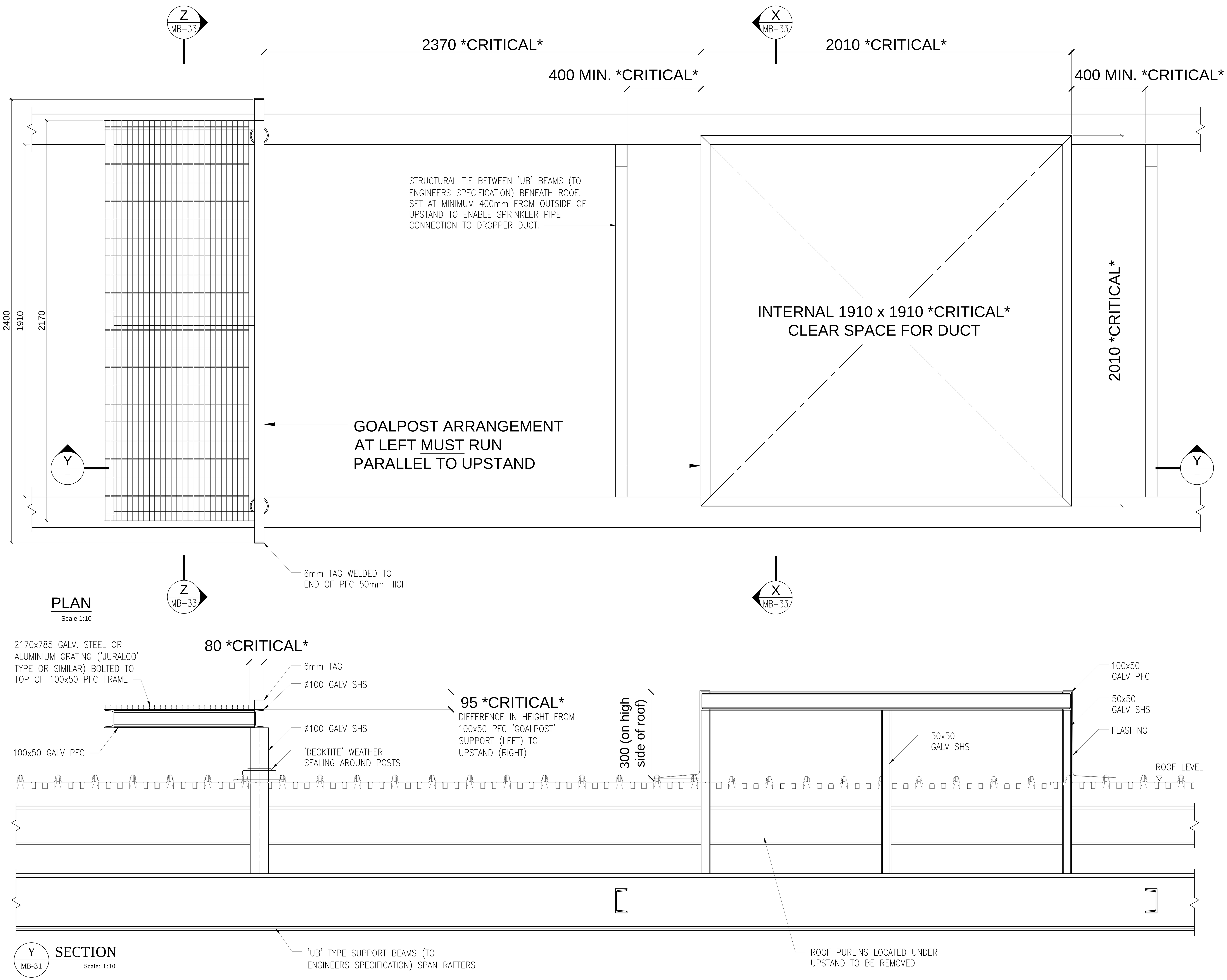
SHEET TITLE
MECHANICAL SERVICES
HVAC ROOF PLANT BUILDERSWORK
3D VIEW (FPA180)

JOB AXN28
SHEET MB-31
REVISION C1

ID - F:\PROJECTS\MASTERS\AXN28 PENRITH\DRAWINGS\AXN28-Platform Basket.dwg

ORIGINAL SHEET SIZE : A1

STRUCTURAL ENGINEER'S FINAL SUPPORT STEELWORK DRAWINGS TO BE REVIEWED AND APPROVED BY FUSION PRIOR TO MANUFACTURE



ID - F:\PROJECTS\MASTERS\AXN28 PENRITH\DRAWINGS\AXN28-Platform Basket.dwg

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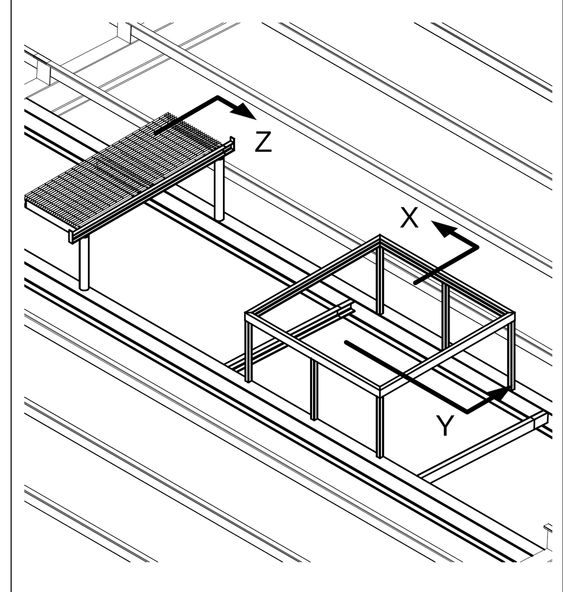
KEYPLAN



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CONSTRUCTION

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C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

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PROJECT: MASTERS PENRITH

DRAWN: DK | SCALE: 1:10 (A1)
APPROVED: KH | FILENAME: AXN28-Platform Basket.dwg

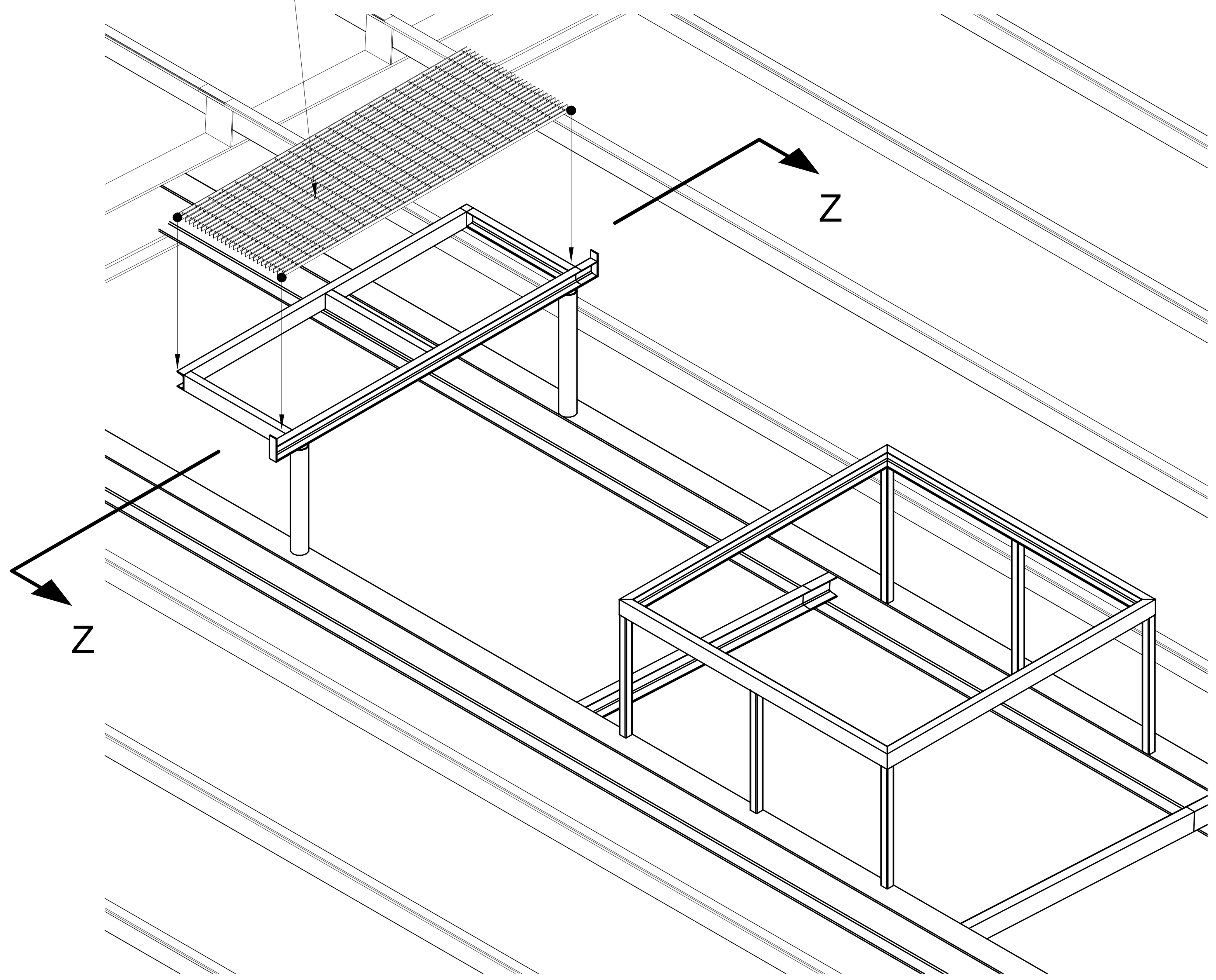
SHEET TITLE:
MECHANICAL SERVICES
HVAC ROOF PLANT BUILDERSWORK
MAIN PLAN & SECTION (FPA180)

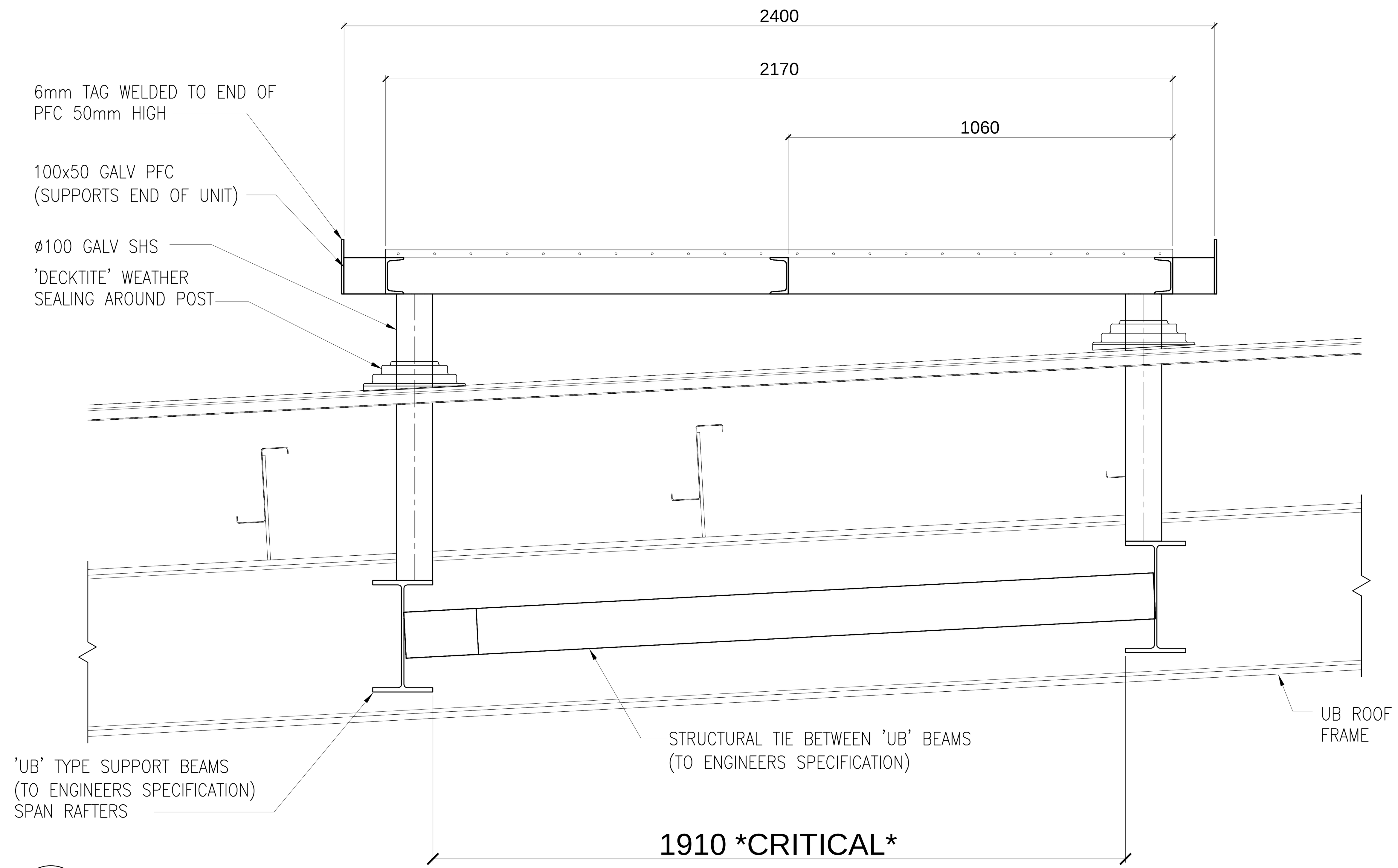
JOB: AXN28
SHEET: MB-32
REVISION: C1

ORIGINAL SHEET SIZE : A1

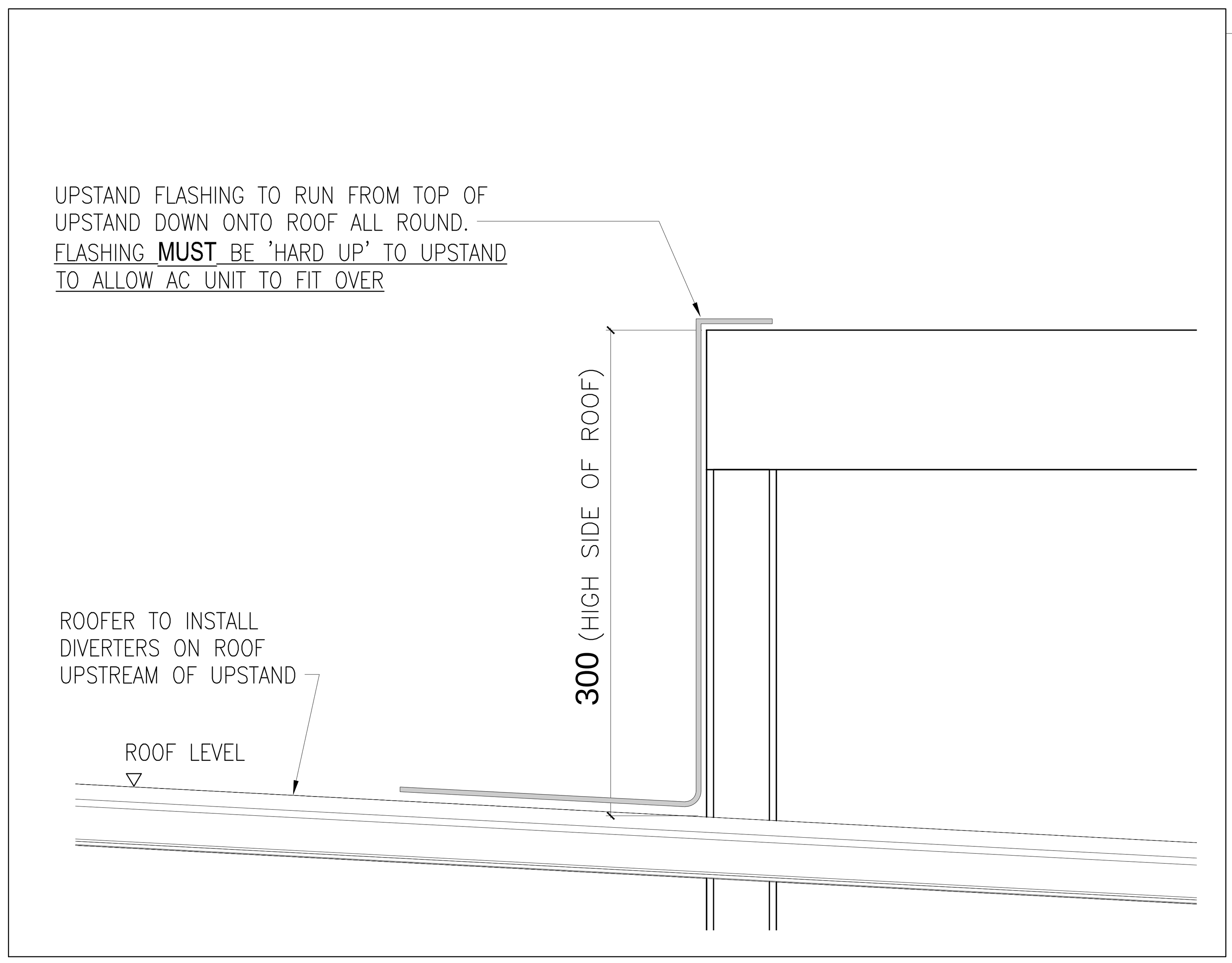
Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

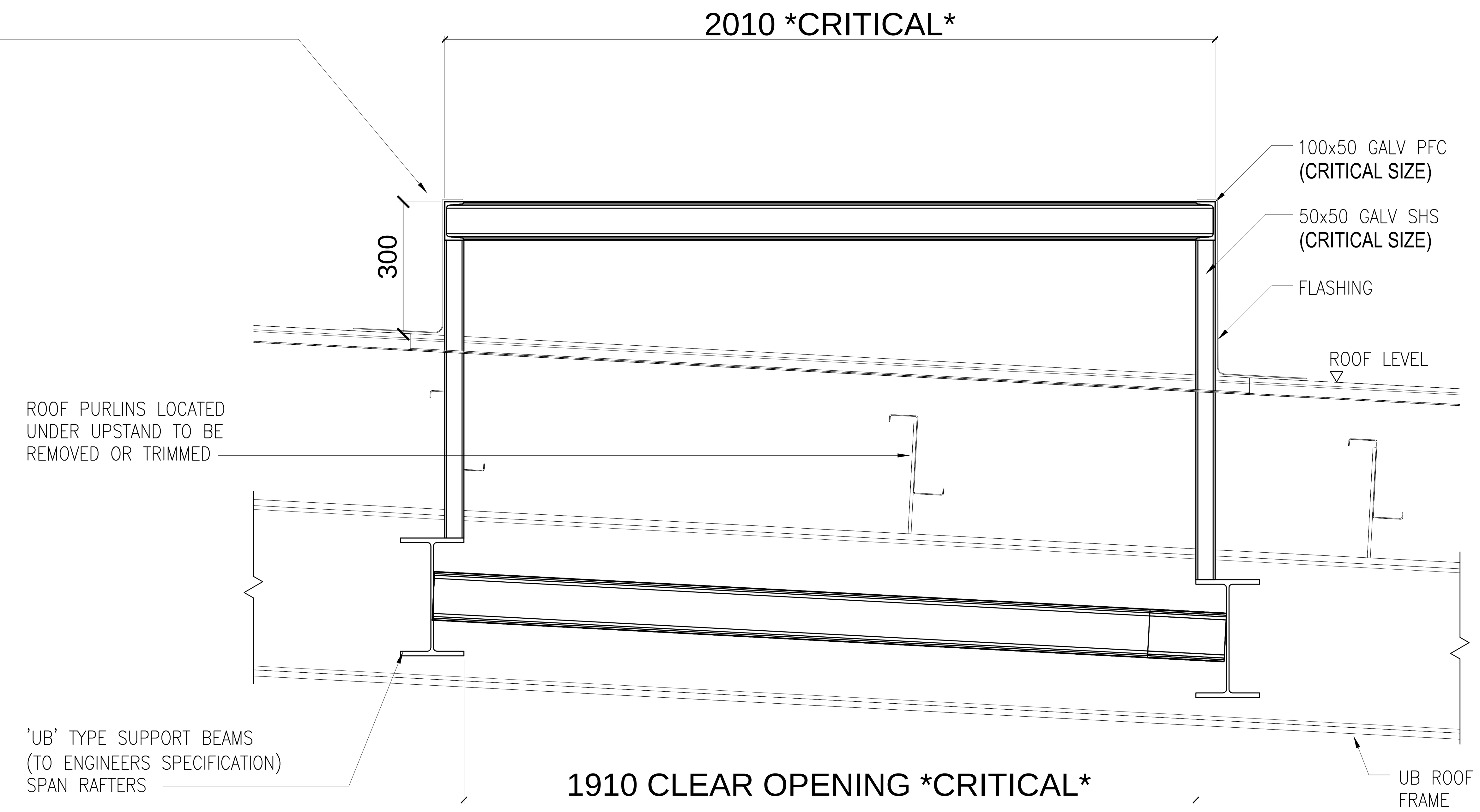
STRUCTURAL ENGINEER'S FINAL SUPPORT STEELWORK DRAWINGS TO BE REVIEWED AND APPROVED BY FUSION PRIOR TO MANUFACTURE





Z SECTION MB-31 Scale: 1:10 (TYPICAL–ROOF MAY SLOPE IN OPPOSITE DIRECTION)





X SECTION MB-31 Scale: 1:10 (TYPICAL–ROOF MAY SLOPE IN OPPOSITE DIRECTION)

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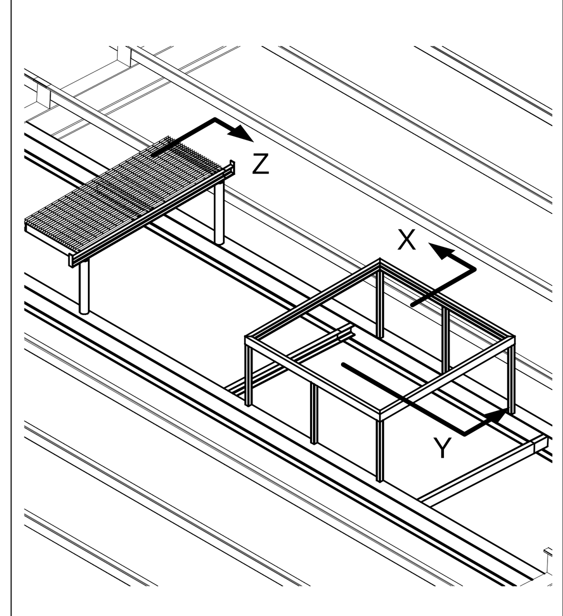
KEYPLAN



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CONSTRUCTION

REV	AMENDMENT	BY	DATE
C1	ISSUED FOR CONSTRUCTION	BJH	30.07.14

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PROJECT: MASTERS PENRITH

DRAWN DK | SCALE 1:10 (A1)
APPROVED KH | FILENAME AXN28-Platform Basket.dwg

SHEET TITLE: MECHANICAL SERVICES HVAC ROOF PLANT BUILDERSWORK SECTIONS (FPA180)

JOB AXN28 | REVISION C1
SHEET MB-33

ID – F:\PROJECTS\MASTERS\AXN28 PENRITH\DRAWINGS\AXN28-Platform Basket.dwg

ORIGINAL SHEET SIZE : A1

THE FOLLOWING DRAWINGS ARE PROVIDED FOR INFORMATION ONLY TO ASSIST THE BUILDER

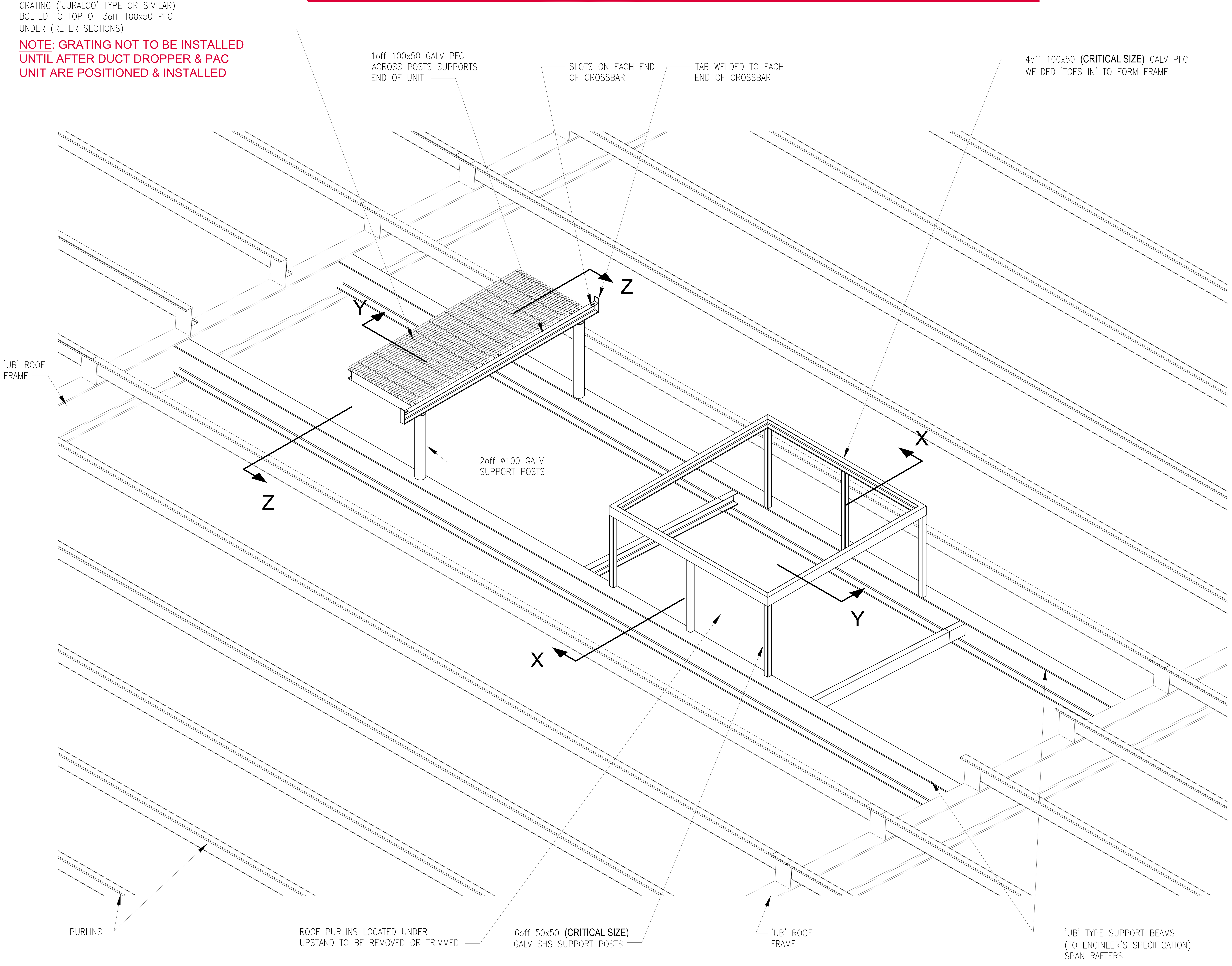
IMPORTANT: MANY ELEMENTS OF THE FUSION SYSTEM INCLUDED PATENTED ITEMS, REGISTERED DESIGNS AND OUR IP.

THE BASE FRAME ARRANGEMENT IS ONLY TO BE USED WITH OUR FUSION UNITS INSTALLED BY FUSION.

BASE DETAILS FOR NEW 180 UNIT

STRUCTURAL DESIGN AND CERTIFICATION BY YOUR STRUCTURAL ENGINEER

STRUCTURAL ENGINEER'S FINAL SUPPORT STEELWORK DRAWINGS TO BE REVIEWED AND APPROVED BY FUSION PRIOR TO MANUFACTURE



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NOTES

1. THIS DRAWING IS PART OF A SET AND IS TO BE READ IN CONJUNCTION WITH ALL FUSION ROOF PLANT BUILDERSWORK DRAWINGS: MB-180-31 to MB-180-33
2. ALL PENETRATIONS **MUST** BE CLEAR VERTICALLY ABOVE AND BELOW ROOF
3. PENETRATION UPSTANDS **MUST** BE LEVEL ON TOP AND 300mm ABOVE THE ROOF ON THE HIGH SIDE
4. UNIT SUPPORT GOALPOST **MUST** BE PARALLEL TO THE UPSTAND
5. 100x50 PFC **MUST** HAVE OPEN THROATS FACING INWARDS AS SHOWN
6. ALL STEEL HOT DIP GALVANISED
7. ALL WELDS CONTINUOUS ABOVE ROOFLINE
8. ALL BEAMS AND POSTS TO BE SIZED BY STRUCTURAL ENGINEER
9. ALL STRUCTURAL DETAILS TO BE CONFIRMED BY STRUCTURAL ENGINEER

PRELIMINARY

REV	AMENDMENT	BY	DATE
ST5	TITLEBLOCK LOGO UPDATED	DK	06.07.16
ST4	HOLES, Z BRACKET DELETED	DK	23.06.16
ST3	SLOTS/HOLES ADDED	DK	10.03.16
ST1	PRELIMINARY ISSUE	BJH	18.03.15

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PROJECT: FPA180
-

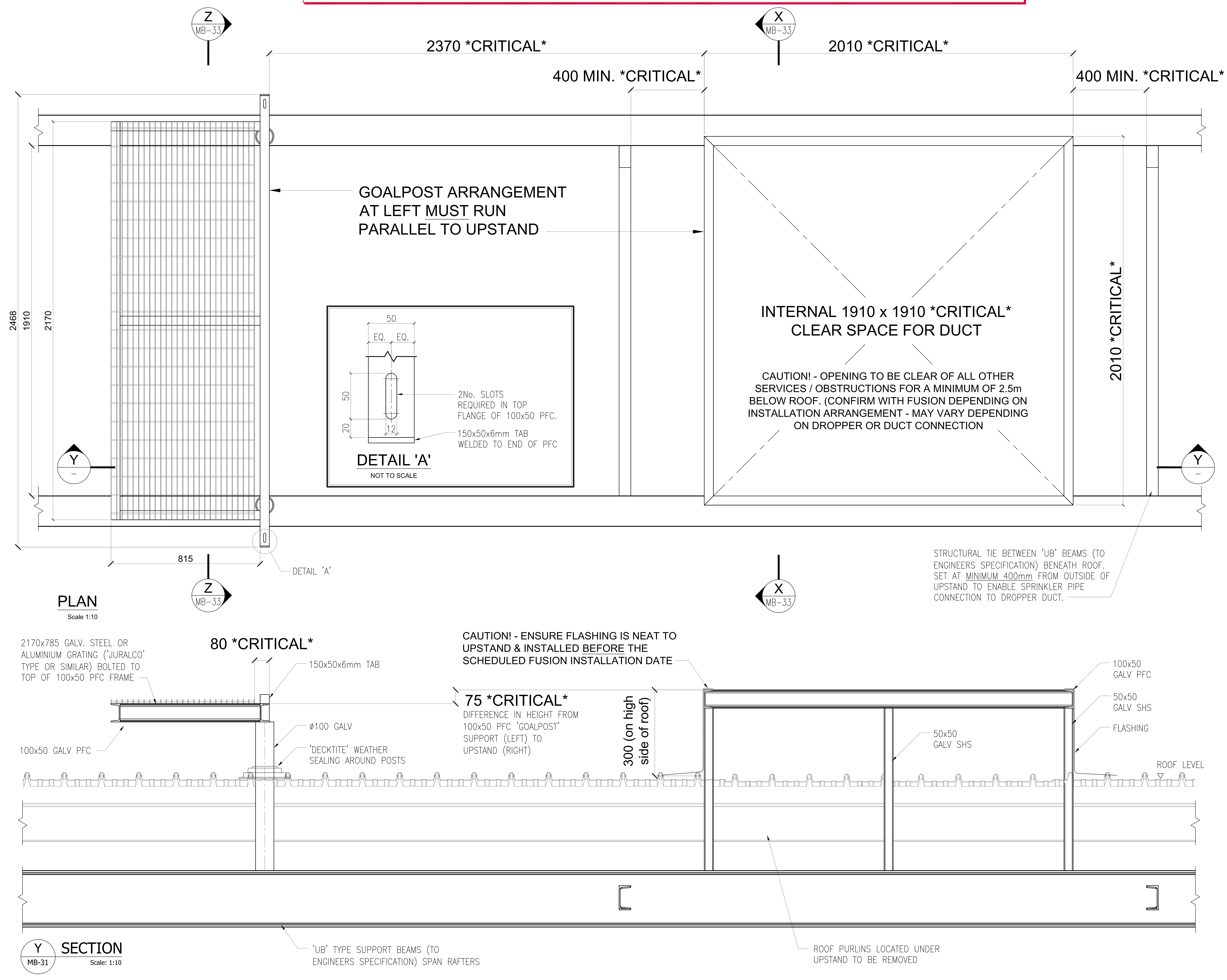
DRAWN	DK	SCALE	N.T.S.
APPROVED	MCP	FILENAME	AX-FPA180-1910.dwg

SHEET TITLE
MECHANICAL SERVICES
HVAC ROOF PLANT BUILDERSWORK
3D VIEW (FPA180)

JOB -
SHEET MB-180-31
REVISION ST5

ORIGINAL SHEET SIZE : A1

STRUCTURAL ENGINEER'S FINAL SUPPORT STEELWORK DRAWINGS TO BE REVIEWED AND APPROVED BY FUSION PRIOR TO MANUFACTURE



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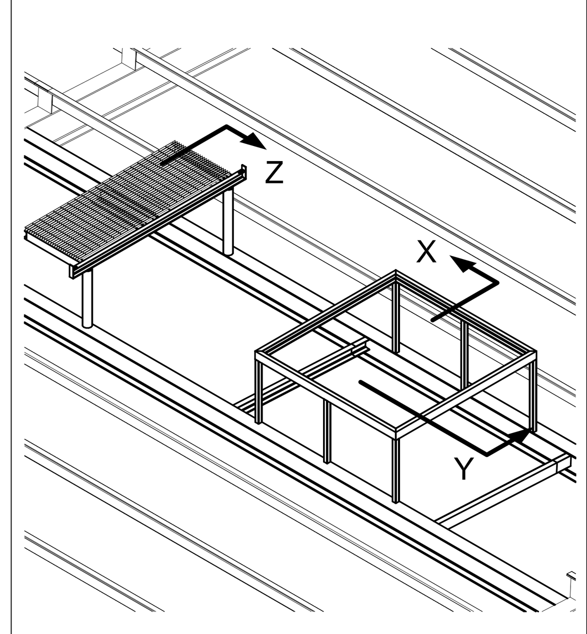
KEYPLAN



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4. UNIT SUPPORT GOALPOST MUST BE PARALLEL TO THE UPSTAND
5. 100x50 PFC MUST HAVE OPEN THROATS FACING INWARDS AS SHOWN
6. ALL STEEL HOT DIP GALVANISED
7. ALL WELDS CONTINUOUS ABOVE ROOFLINE
8. ALL BEAMS AND POSTS TO BE SIZED BY STRUCTURAL ENGINEER
9. ALL STRUCTURAL DETAILS TO BE CONFIRMED BY STRUCTURAL ENGINEER

PRELIMINARY

REV	AMENDMENT	BY	DATE
ST5	TITLEBLOCK LOGO UPDATED	DK	06.07.16
ST4	HOLES, Z BRACKET DELETED	DK	23.06.15
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ST1	PRELIMINARY ISSUE	BJH	18.03.15

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PROJECT: FPA180
-

DRAWN: DK SCALE: 1:10 (A1)
APPROVED: MCP FILENAME: AX-FPA180-1910.dwg

SHEET TITLE
MECHANICAL SERVICES
HVAC ROOF PLANT BUILDERSWORK
MAIN PLAN & SECTION (FPA180)

JOB: -
SHEET: MB-180-32
REVISION: ST5

ORIGINAL SHEET SIZE : A1

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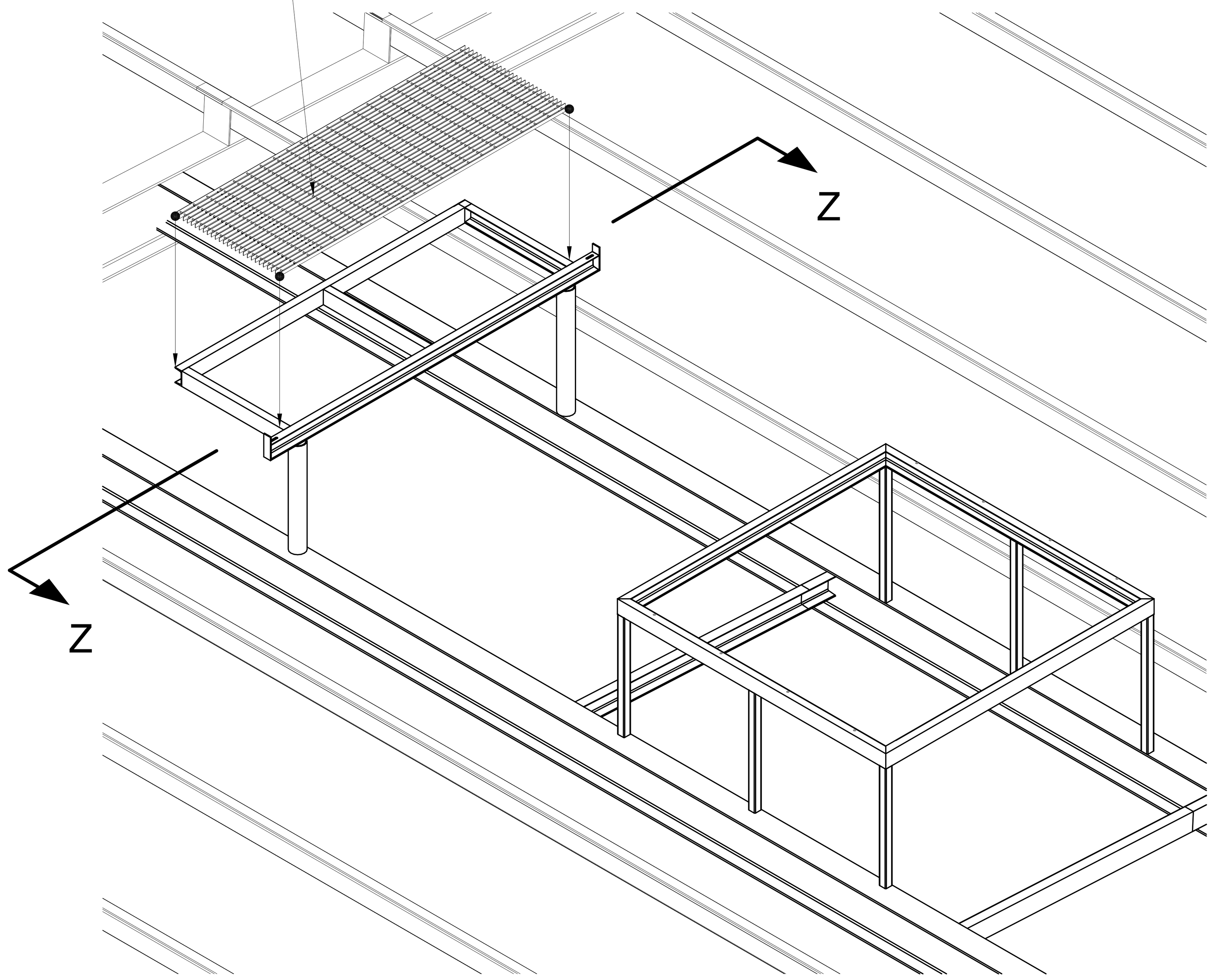
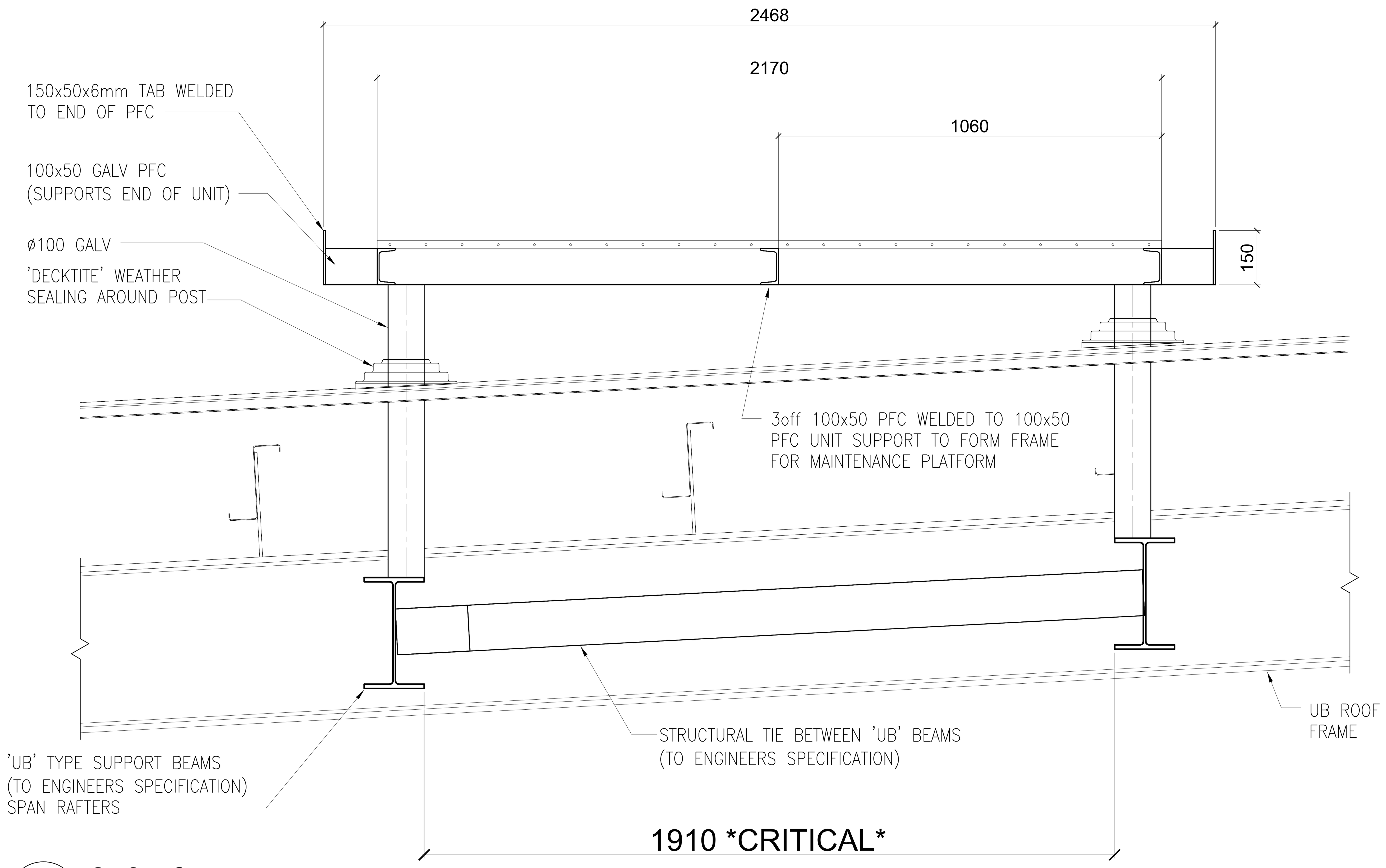
6/07/2016 7:46:35 PM

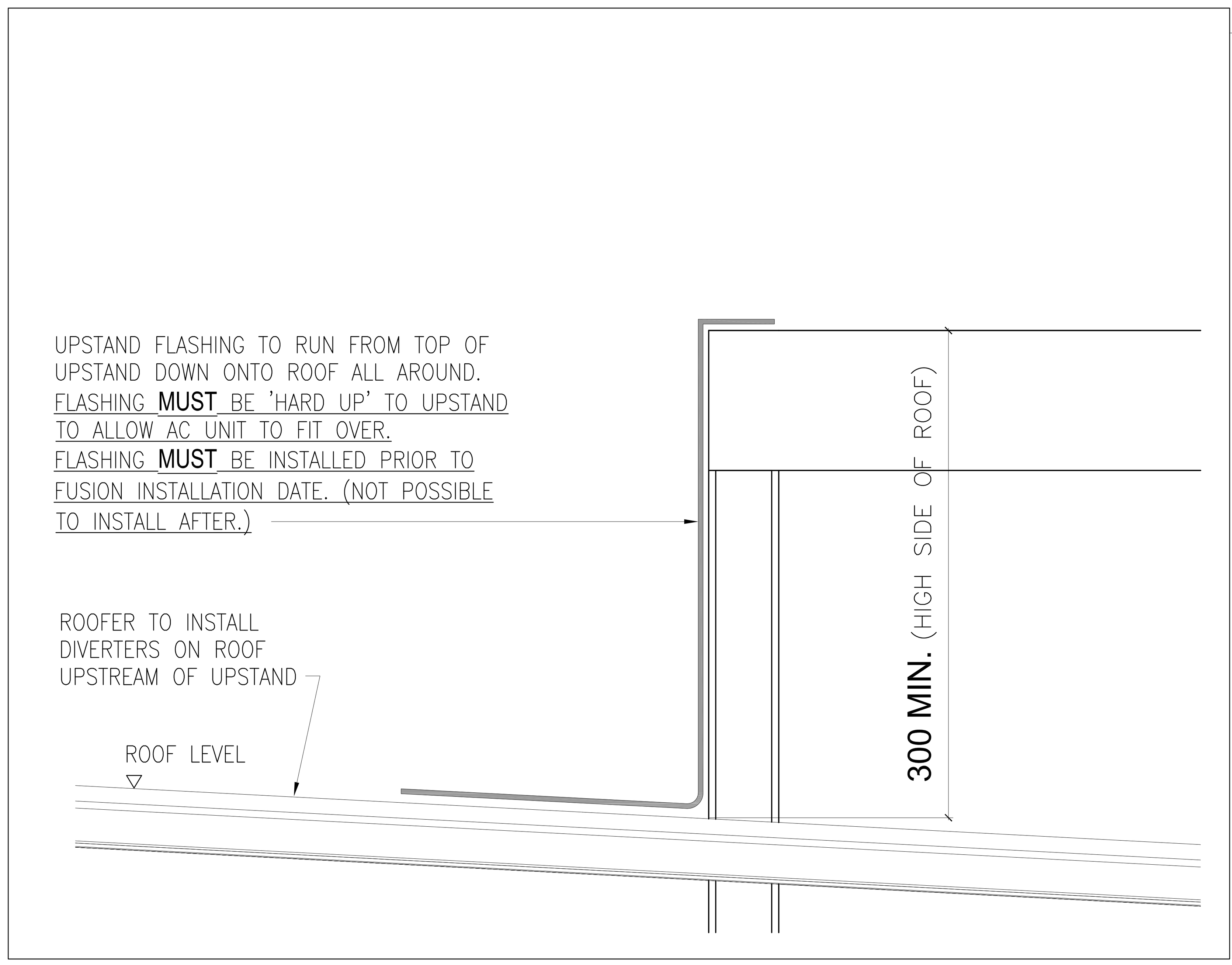
Document Set ID: 9184217
Version: 1, Version Date: 22/06/2020

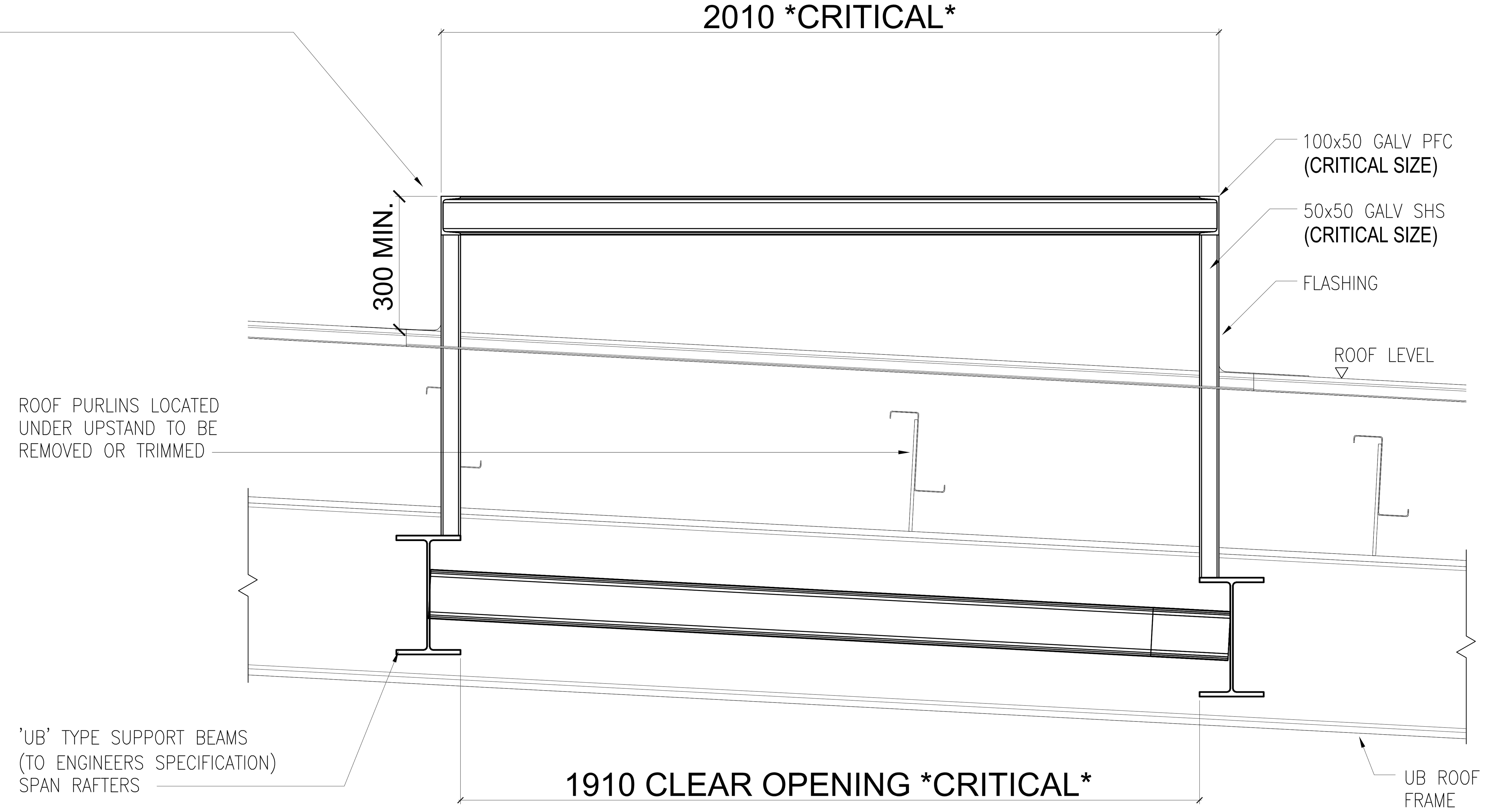
STRUCTURAL ENGINEER'S FINAL SUPPORT STEELWORK DRAWINGS TO BE REVIEWED AND APPROVED BY FUSION PRIOR TO MANUFACTURE





Z SECTION
MB-31
Scale: 1:10
(TYPICAL–ROOF MAY SLOPE IN OPPOSITE DIRECTION)





X SECTION
MB-31
Scale: 1:10
(TYPICAL–ROOF MAY SLOPE IN OPPOSITE DIRECTION)

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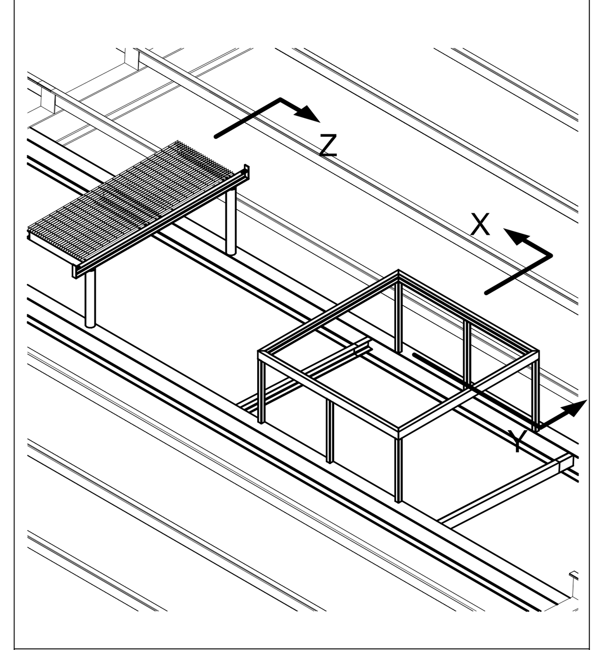
KEYPLAN



NOTES

1. THIS DRAWING IS PART OF A SET AND IS TO BE READ IN CONJUNCTION WITH ALL FUSION ROOF PLANT BUILDERSWORK DRAWINGS: MB-180-31 to MB-180-33
2. ALL PENETRATIONS MUST BE CLEAR VERTICALLY ABOVE AND BELOW ROOF
3. PENETRATION UPSTANDS MUST BE LEVEL ON TOP AND 300mm ABOVE THE ROOF ON THE HIGH SIDE
4. UNIT SUPPORT GOALPOST MUST BE PARALLEL TO THE UPSTAND
5. 100x50 PFC MUST HAVE OPEN THROATS FACING INWARDS AS SHOWN
6. ALL STEEL HOT DIP GALVANISED
7. ALL WELDS CONTINUOUS ABOVE ROOFLINE
8. ALL BEAMS AND POSTS TO BE SIZED BY STRUCTURAL ENGINEER
9. ALL STRUCTURAL DETAILS TO BE CONFIRMED BY STRUCTURAL ENGINEER

PRELIMINARY

REV	AMENDMENT	BY	DATE
ST5	TITLEBLOCK LOGO UPDATED	DK	06.07.16
ST4	HOLES, Z BRACKET DELETED	DK	23.06.16
ST3	SLOTS/HOLES ADDED	DK	10.03.16
ST1	PRELIMINARY ISSUE	BJH	18.03.15

ALL DIMENSIONS TO BE VERIFIED ON SITE BEFORE MAKING ANY SHOP DRAWINGS OR COMMENCING ANY WORK. DO NOT SCALE FROM THIS DRAWING.

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PROJECT: FPA180 -

DRAWN	DK	SCALE	1:10 (A1)
APPROVED	MCP	FILENAME	AX-FPA180-1910.dwg

SHEET TITLE
MECHANICAL SERVICES
HVAC ROOF PLANT BUILDERSWORK
SECTIONS (FPA180)

JOB -
SHEET MB-180-33
REVISION ST5

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ORIGINAL SHEET SIZE : A1

Appendix E Peak Heat Release Rates

Appendix E.1 Summary

Figure E.1.1 summarises the expected heat release rates for each of the Fire Scenarios detailed in Section 5.3.

Sprinkler Activation

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Consulting Fire Engineers

Theory

References:

[1] Alpert, R L. Calculation Of Response Time Of Ceiling–Mounted Fire Detectors. Fire Technology. August 1972, Vol. Vol. 8, No. 3, pp 181–195

[2] Heskestad G and Bill R G, Conduction heat-loss effect on thermal response of automatic sprinklers, Fire Safety Journal, v.14, pages 113-125, 1988

[3] Society of Fire Protection Engineers. The SFPE Handbook of Fire Protection Engineering. Fourth Edition. s.l. : National Fire Protection Association, 2008.

[4] Australian Building Codes Board. International Fire Engineering Guidelines. s.l. : Australian Building Codes Board, Edition 2005

Assumptions:

* Flat smooth ceilings
* Unconfined gas flow
* Strong plume (flaming) fires
* Axisymmetric plumes (not near walls or corners)
* The heat sensitive element is located in the peak velocity and peak temperature region of the ceiling jet.

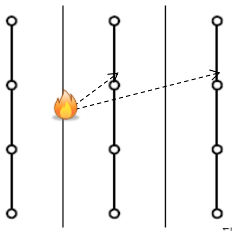
$$T_g - T_a = \frac{5.38\,(Q/r)^{2/3}}{H} \quad \circ C \qquad \text{where } \frac{r}{H} > 0.18$$

$$T_g - T_a = \frac{16.9\,Q^{2/3}}{H^{5/3}} \quad \circ C \qquad \text{where } \frac{r}{H} \le 0.18$$

$$u = \frac{0.20\,Q^{1/3} H^{1/2}}{r^{5/6}} \quad m/s \qquad \text{where } \frac{r}{H} > 0.15$$

$$u = 0.95\left(\frac{Q}{H}\right)^{1/3} \quad m/s \qquad \text{where } \frac{r}{H} \le 0.15$$

$$\frac{dT_d}{dt} = \frac{\sqrt{u}}{RTI}\left[(T_g - T_{room}) - \left(1 + \frac{C}{\sqrt{u}}\right)(T_d - T_{room})\right]$$



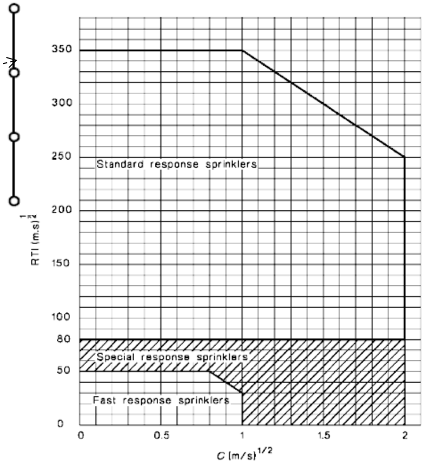


FIGURE 3.1 STANDARD ORIENTATION RTI AND *C* LIMITS

T_g = maximum, near ceiling, fire-gas
Ta = ambient temperature (°C)
Q = total heat release rate of fire (kW)
r = radial distance from the axis of the fire
H = height above the origin of the fire (m)
u = maximum, near ceiling, fire-gas velocity
Td = detector temperature (°C)
RTI = response time index (m1/2s1/2)
C = conduction factor (m1/2s-1/2)

Calculation

Ambient temperature, T∞ 24 °C

Scenario / Fire Location	Fire Growth Rate	Height Above Fire (m)	Radial Distance (m)	Sprinkler Efficacy Delay (s)	Sprinkler Activation Temp (°C)	Response time Index ($m^{1/2}s^{1/2}$)	Conduction Factor ($m^{1/2}s^{-1/2}$)	Sprinkler Activation Time (s)	Maxium Fire HRR (MW)
FS01	t2 (Fast)	9.5	2.21	30	141	50	0.8	**473**	**11.79**
FS02	t2 (Ultrafast)	9.5	2.21	30	141	50	0.8	**243**	**13.97**
FS03	t2 (Fast)	9.5	2.21	30	141	50	0.8	**473**	**11.79**
FS04	t2 (Ultrafast)	9.5	2.21	30	141	50	0.8	**243**	**13.97**

Figure E.1.1 – Fire Sprinkler Activation Times

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Appendix F Fire Sprinkler System Reliability

The building is to be fitted with a fire sprinkler system installed throughout to AS 2118.1 'Automatic fire sprinkler systems – Part 1: General requirements'.

It is generally acknowledged (as supported by statistics) that a fire will generally be controlled or extinguished by automatic fire sprinkler operation [8]. This rationale is supported by research conducted by CIBSE [14] and Warrington [15] which showed that the upper layer temperatures are not likely to exceed 100°C during a controlled Fire and 200°C for a shielded fire respectively.

Marryatt [23], provides recorded statistics on buildings fitted with automatic Fire sprinkler systems between the years 1886–1986 in Australia and New Zealand. The statistical data shows that for a total of 9,022 recorded fires in 231 occupancies types, 99.46% were controlled or extinguished by activation of the sprinkler system. It is further stated that the "fire controlled" percentage of 99.46% is remarkable, and it is difficult to imagine any electrical, mechanical or hydraulic device in common use which would have attained a higher standard of reliability.

Marryatt also provides life safety statistics for the total of 9,022 recorded fires in buildings fitted with automatic sprinkler systems over the 100 year period and states that, it is remarkable that only 11 deaths occurred in 9,022 fires in 100 years – an average of just over one fatality every nine years. However, in seven of these deaths, the victims were caught in a flash fire or explosion. Therefore, it is likely only 4 deaths are applicable for occupancies typical to the use of these premises.

It is also worth noting that in all of the 9,022 recorded fires, standard sprinklers were used. Also, the current Australian Standard AS 2118.1 (1999) Automatic fire sprinkler systems – Part 1: General requirements has modern design requirements, which increases the reliability beyond previous standards/design practices. As such, the current sprinkler design standard and design of the fire sprinkler system in the building is expected to achieve a higher reliability than from the period where much of the statistical data was sourced.

As supported by the statistical data listed above, sprinkler reliability is considered to be excellent within Australia and as per Regulatory Legislation; the sprinkler system is required to be maintained as part of the Building's Essential Safety Measures (i.e. to AS 1851). The scenario of sprinkler failure is, therefore, considered extremely unlikely and is therefore excluded from this report except where specifically noted herein.

The NFPA Handbook [24] also summarises statistics from 2,860 fire incidents where fire sprinklers were provided (refer Table 6–10A). Of these fires, 74% of them were controlled by the action of six (6) or less sprinkler heads. Only six (6) fires occurred where more than 26 sprinkler heads activated. Note that no details are given regarding the occupancies that comprise the 2,860 fire incidents.

The International Fire Engineering Guidelines [2] suggests that successful control of fires is achieved in 99% of fires in sprinklered buildings.

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Appendix G Modelled System Delays

Where systems initiate or actuate upon detection of smoke or fire it is proposed to include time delays into the models to simulate verification delays, efficacy delays and system ramp up times.

<u>Multi-point Aspirating Smoked Detection Systems</u>

Multi-point Aspirating Smoked Detection Systems (MASDS) actively samples the surrounding environment by drawing in air for analysis. Detection of smoke by a MASDS requires smoke to be drawn into the sampling tubes at a sampling point and travel along the sampling tubes to the sampling device. When modelling a MASDS, point-type smoke detectors, which are a passive system (i.e. does not actively sample the surrounding environment), are used and located at the sampling points. It is considered that the time for the smoke to travel down the sampling tubes is offset by the fact that the MASDS is an active system where the modelled device is a passive system. Therefore, the considered delay for the purposes of modelling will be in accordance with AS 1670.1-2004 Section 7.1 item 'p' (i.e. 10 seconds)

Therefore, for the purposes of modelling, the delay between activation of a Multi-point Aspirating Smoked Detector and the actuation of the associated systems will be **10 seconds**.

<u>Fire Sprinkler Systems</u>

Activation of the occupant warning system by the fire sprinkler system is via the control valve.

The pressure applied to the control valve to keep it in the closed position is provided by the head within the fire sprinkler system (i.e. the height of water above the control valve). Under normal operation of the building (i.e. no fire), the control valve is keep in the closed (i.e. inactivated) position by the pressure provided by the head within the fire sprinkler system (i.e. the height of water above the control valve).

Activation of a fire sprinkler head causes a drop in pressure within the system. The control valve is a mechanical component and operates (i.e. opens) when this drop in system pressure results in the pressure in the mains being greater than the pressure in the system, allowing the flow of water from the mains to the fire sprinkler system through the control valve. This also, actuates the fire sprinkler pumps.

With regards to the delay between the activation of the fire sprinkler system and actuation of the Occupant Warning System, AS 2118.1-1999 Section 8.13.1 states that:

> "…*the installed alarm devices shall respond within 3 min of opening the test valve with a 15mm bore…and within 6 minutes of opening the remote test valve…*"

Therefore, for the purposes of modelling, the delay between activation of a fire sprinkler head and the actuation of the associated systems will be **30 seconds**.

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Appendix H Fire Dynamics Simulator (FDS)

Appendix H.1 General

Appendix H.1.1 Name and Version of the Model

The name of the program is the NIST Fire Dynamics Simulator or FDS. FDS is a Fortran 90 computer program that solves the governing equations of fluid dynamics. Smokeview is a companion program written in C/OpenGL programming language that produces images and animations of the results. The present version of FDS is 6.1.2.

Appendix H.1.2 Type of Model

FDS is a Computational Fluid Dynamics (CFD) model of fire-driven fluid flow. The model solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow with an emphasis on smoke and heat transport from fires.

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 a three-dimensional, rectilinear grid. Thermal radiation is computed using a finite volume technique on the same grid as the flow solver. Lagrangian particles are used to simulate smoke movement and sprinkler discharge.

Appendix H.1.3 Model Developers

The Fire Dynamics Simulator (FDS) was developed and is currently maintained by the Fire Research Division in the Building and Fire Research Laboratory (BFRL) at the National Institute of Standards and Technology (NIST). A substantial contribution to the development of the model was made by VTT Building and Transport in Finland. Additional contributors are cited in the Acknowledgments.

Appendix H.1.4 Model Uses

Throughout its development, FDS has been aimed at solving practical fire problems in fire protection engineering, whilst at the same time providing a tool to study fundamental fire dynamics and combustion. FDS can be used to model the following phenomena:

- Low speed transport of heat and combustion products from fire
- Radiative and convective heat transfer between the gas and solid surfaces
- Pyrolysis
- Flame spread and fire growth
- Sprinkler, heat detector and smoke detector activation
- Sprinkler sprays and suppression by water

Although FDS was designed specifically for fire simulations, it can be used for other low-speed fluid flow simulations that do not necessarily include fire or thermal effects. To date, about half of the applications of the model have been for design of smoke control systems and sprinkler/detector activation studies. The other half consists of residential and industrial fire reconstructions.

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Appendix H.1.5 Model Results

FDS computes the temperature, density, pressure, velocity and chemical composition within each numerical grid cell at each discrete time step. There are typically hundreds of thousands to several million grid cells and thousands to hundreds of thousands of time steps. In addition, FDS computes at solid surfaces the temperature, heat flux, mass loss rate, and various other quantities. The user must carefully select what data to save, much like one would do in designing an actual experiment. Even though only a small fraction of the computed information can be saved, the output typically consists of fairly large data files. Typical output quantities for the gas phase include:

- Gas temperature
- Gas velocity
- Gas species concentration (water vapour, CO_2, CO, N_2)
- Smoke concentration and visibility estimates
- Pressure
- Heat release rate per unit volume
- Mixture fraction (or air/fuel ratio)
- Gas density
- Water droplet mass per unit volume

On solid surfaces, FDS predicts additional quantities associated with the energy balance between gas and solid phase, including:

- Total Heat Release Rate (HRR)
- Sprinkler and detector activation times
- Mass and energy fluxes through openings or solids

Time histories of various quantities at a single point in space or global quantities like the fire's Heat Release Rate (HRR) are saved in simple, comma-delimited text files that can be plotted using a spreadsheet program. However, most field or surface data are visualised with a program called Smokeview, a tool specifically designed to analyse data generated by FDS. FDS and Smokeview are used in concert to model and visualise fire phenomena. Smokeview performs this visualisation by presenting animated tracer particle flow, animated contour slices of computed gas variables and animated surface data. Smokeview also presents contours and vector plots of static data anywhere within a scene at a fixed time.

The FDS software, Users Guide and Technical Reference Guides are freely available for download from the National Institute of Standards and Technology's website http://www.fire.nist.gov.

Appendix H.2 Grid and Fire Size Assessment

An assessment of the FDS cell sizes used in the fire modelling has been carried out. The following formula, as detailed in the NIST Fire Dynamics Simulator (Version 5) User's Guide [19], can be used to measure how well the flow field within the FDS model.

$D^* / \delta x$

where: δx is the nominal size of a mesh (m)

D^* is a characteristic fire diameter

$D^* = (Q / \rho_\infty c_p T_\infty \sqrt{g})^{2/5}$

where: Q is the fire size (kW)

ρ_∞ is the ambient density: 1.205kg/m³

c_p is the specific heat: 1.005kJ/kg.K

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T_∞ is the ambient temperature (20°C): 293K

g is the Gravity: 9.81m/s

Furthermore, if the physical area of a fire utilising a prescribed heat release rate is too small, the resulting fire characteristics may not be representative of a naturally occurring, buoyancy driven fire.

The physical fire area of the design fires in FDS will therefore be calculated using the methodology recommended by Cox and Kumar in the SFPE Handbook [18], where the Froude number (Q*) should be less than or equal to 1 [25].

$Q^* = Q / (\rho_\infty c_p T_\infty D^2 \sqrt{gD})$

where: Q* is the Froude number

Q is the fire size (kW)

ρ_∞ is the ambient density: 1.205kg/m³

c_p is the specific heat: 1.005kJ/kg.K

T_∞ is the ambient temperature (20°C): 293K

g is the Gravity: 9.81m/s

D is the fire diameter (m): $\sqrt{(4 \times Area / \pi)}$

The results of the assessment of the fire mesh grid size and fire size for the Fire Scenarios that will be modelled in FDS are summarised in Figure H.2.1.

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FDS Mesh and Fire Sizes

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Theory

References:

[1] K.B. McGrattan, S. Hostikka, and J.E. Floyd. Fire Dynamics Simulator (Version 5), User's Guide. NIST Special Publication 1019-5, National Institute of Standards and Technology, Gaithersburg, Maryland, October 2007

[2] K. Hill, J. Dreisbach, F. Joglar, B. Najafi, K. McGrattan, R. Peacock, and A. Hamins. Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications. NUREG 1824, United States Nuclear Regulatory Commission, Washington, DC, 2007

[3] National Institute of Standards and Technology, Gaithersburg, Maryland, USA, and VTT Technical Research Centre of Finland, Espoo, Finland. Fire Dynamics Simulator, Technical Reference Guide, 5th edition, October 2007. NIST Special Publication 1018-5 (Four volume set)

[4] Drysdale, D. An Introduction to Fire Dynamics. Second Edition, Section 4.3.2 p134. s.l. : John Wiley & Sons Ltd, 1998.

Optimal Mesh Size [1]

$D^*/\delta x$

Where:

δ_x = Nominal size of a mesh cell (m)
D^* = Characteristic fire diameter
= $(Q / \rho_\infty c_p T_\infty \sqrt{g})^{2/5}$

Where:

ρ_∞ = Ambient Density of Air (kg/m^3)
c_p = Specific Heat of Air (J/kg.K)
T_∞ = Ambient Temperature (K)
g = Gravitational Constant (m/s^2)

Fire Diameter [4]

$Q^* = Q / (\rho_\infty c_p T_\infty D^2 \sqrt{gD})$

Where:

Q^* = Froude number < 1.0
Q = Fire size (kW)
D = Fire diameter (m): $\sqrt{(4 \times \text{Area} / \pi)}$

Calculation

Ambient Density of Air, ρ_∞	1.205	kg/m^3
Specific Heat of Air, c_p	1.005	J/kg.K
Ambient Temperature, T_∞	24	°C
Gravitational Constant, g	9.81	m/s^2

Scenario / Fire Location	Maximum Heat Release Rate (KW)	Fire Mesh Cell Size (δ_x) (m)	Characteristic Fire Diameter (D*)	δx - Mesh Size Limits (m) [3]			Fire Diameter					
				Minimum	Maximum	Acceptable	Length	Width	Area	Diameter (D)	Q*	Acceptable
1	12000	**0.25**	2.58	0.16	0.64	**Yes**	3	3	9.00	3.39	0.51	**Yes**
2	14000	**0.25**	2.74	0.17	0.69	**Yes**	3	3	9.00	3.39	0.59	**Yes**
3	12000	**0.25**	2.58	0.16	0.64	**Yes**	3	3	9.00	3.39	0.51	**Yes**
4	14000	**0.25**	2.74	0.17	0.69	**Yes**	3	3	9.00	3.39	0.59	**Yes**

Figure H.2.1 – Grid and Fire Size Assessment Summary

The results determined that the fire mesh grid, δx, is within the acceptable range for the Fire Scenarios, indicating the flow domain is sufficiently well resolved.

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Appendix I CVs

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About

Graham is an Associate in Omnii's Brisbane office and has over 40 years' experience in the field of fire safety and fire engineering. Graham's wide-ranging experience has allowed him to develop innovative and cost-effective fire engineered Performance Solutions for both building and infrastructure projects.

Graham has undertaken testing and applied research into the performance of fire detection and suppression systems. This has given Graham a fundamental understanding of how these various systems operate, as well their suitability to different building applications.

Project experience is wide and varied, having developed fire engineered solutions for high rise commercial and residential buildings, major shopping centres, domestic and international airport terminal buildings, public entertainment including cinemas, theatres and sports complexes, hospital and aged care buildings. In addition, Graham has provided fire engineering for infrastructure projects such as road and bus tunnels, power stations and industrial complexes.

Graham has also contributed to the development of fire engineering in Australia participating in the Warren Centre project (1989-91) and Fire Code Reform Centre (1992-96), and education of practitioners via lecturing at Queensland University of Technology, Victoria University, University of Western Sydney and University of Technology Sydney.

Qualifications & Registrations

- **Graduate Diploma in Building Fire Safety and Risk Engineering**
  Victoria University of Technology
- **Graduate Diploma of Risk Management in Australia**
  (Distance Education) Swinburne University of Technology
- **Bachelor of Applied Science (Physics & Applied Mathematics)**
  Caulfield Institute of Technology

Projects

- Panorama Apartments, Bowen Hills Qld
- 80-88 Victoria Street, West End Qld
- Quest Apartments, Robina Qld
- 12 Creek Street Annex, Brisbane Qld
- 30 Albert Street, Brisbane Qld
- Precinct 3, Everton Park Shopping Centre Qld
- DFO Jindalee Qld
- Brisbane Girls Grammar School, Brisbane Qld
- Brigidine College Technical Building Qld
- Chung Tian Temple, Pilgrim Lodge, Underwood Qld
- Toowoomba Christian Fellowship, Toowoomba Qld
- Maryborough Hospital, Maryborough Qld
- Energex Geebung Qld
- 200 Holt Street, Pinkenba Qld
- Mylan Warehouse, Bundamba Qld
- Yandina Railway Depot, Yandina Qld
- Central Station, Brisbane Qld
- Brisbane Square, Brisbane Qld
- QUT Education Precinct Building, Kelvin Grove Qld
- Queensland Performing Arts Centre, Brisbane Qld

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About

David Fox is a Fire Consultant with Omnii's Brisbane office. He holds a Master's degree in Civil Engineering and a PhD in Structural Fire Engineering. His technical skills and five (5) years of industry practice across the UK, Australia and New Zealand have given him wide-ranging experience across many market sectors.

He is experienced in the development of performance-based fire engineered solutions, and in producing Fire Engineering Briefs (FEB) and Fire Engineering Reports (FER) for clients. His fire engineering experience covers residential buildings, combined office and retail developments, storage facilities and public buildings. He has covered infrastructure upgrades and specialised industrial and energy generation projects.

His technical skills include finite element analysis of structures exposed to fire, modelling of fire and smoke development and egress simulation of large buildings.

Qualifications & Registrations

- **Masters of Engineering in Civil Engineering**
  University of Edinburgh, Scotland
- **PhD Structural Fire Engineering**
  University of Edinburgh, Scotland

Projects

- Warehouse and Office Building Construction, Iraq
- Shari Jwan Five-Star Hotel, Iraq
- Faruk Medical City (FMC), Iraq
- Residential Properties Redevelopment, Iraq
- Private Properties Design and Construction, Iraq

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