DHL Canon Facility
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Horsley Park NSW

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Fire Safety Strategy

DHL Canon Facility
Old Wallgrove Rd, Horsley Park

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Report Details

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Report Revision History

REV	DATE ISSUED	COMMENT	PREPARED BY	REVIEWED BY
01	10 August 2012	Draft Issue for Comment	**Thomas Newton**	**Trent De Maria**
02	16 August 2012	Final Issue	**Thomas Newton** *Adv. Dip. Mech Engineering*	**Trent De Maria** *Grad Cert Performance Based Bdg & Fire Codes, Grad Dip Building Fire Safety & Risk Engineering*

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1 INTRODUCTION

1.1 OVERVIEW

This Fire Safety Strategy has been undertaken to nominate proposed Alternative Solutions for assessing compliance with the nominated performance requirements of the BCA [1] in accordance with the methodologies defined in the IFEG [3].

In order to develop and assess the nominated non-compliances the following flowchart process is to be adopted.

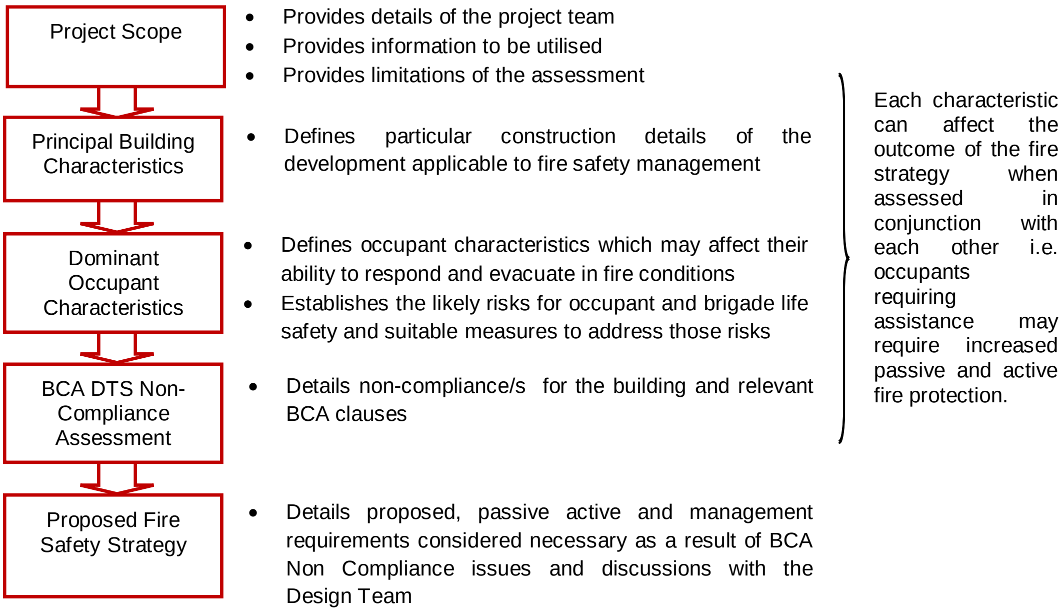


Figure 1-1: Fire Safety Strategy Process

The scope of the Fire Safety Strategy is to detail the nominated non-complying BCA DTS provisions with the performance requirements of the BCA and provide methodologies for establishing a workable and safe Fire Safety Strategy through a trial design.

1.2 FIRE SAFETY OBJECTIVES

The objective of a Fire Engineering Assessment is to develop a Fire Safety System, which satisfies the performance requirements of the BCA whilst maintaining an acceptable level of life safety, protection of adjacent property and adequate provisions for Fire Brigade intervention. At a community level, fire safety objectives are met if the relevant legislation and regulations are complied with. As stated in the BCA, "A Building Solution will comply with the BCA if it satisfies the Performance Requirements". In addition to this certain non-regulatory objectives exist as detailed below.

1.2.1 Building regulatory objectives

The following items are a summary of the fire and life safety objectives of the BCA:

- **Life safety of occupants -** the occupants must be able to leave the building (or remain in a safe refuge) without being subject to hazardous or untenable conditions. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would minimise the risk of exposing building occupants to hazardous or untenable conditions in an event of a fire.
- **Life safety of fire fighters -** fire fighters must be given a reasonable time to rescue any remaining occupants before hazardous conditions or building collapse occurs. The objective of

the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would facilitate fire brigade intervention and minimise the risk of exposing fire fighters to hazardous or untenable conditions in an event of a fire.

- **Protection of adjoining buildings** - structures must not collapse onto adjacent property and fire spread by radiation should not occur. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would minimise the risk of fire spreading from one building to another.

1.2.2 Fire Brigade objectives

The overall philosophical Fire Brigade objectives throughout Australia are to protect life, property and the environment from fire according to the Fire Brigade Intervention Model (FBIM) [5] as per the Fire Services State and Territory Acts and Regulations.

Over and above the requirements of the BCA, the Fire Brigade has functions with regard to property and environmental protection and considerations regarding occupational health and safety for its employees.

1.2.3 Non-prescribed objectives

Fire Engineering has an overarching benefit to many facets of the built environment where non-prescribed objectives can have an influence on the Fire Safety Strategy adopted. Although not assessed within, the following can be considered if requested.

- **Business continuity -** will the loss of a particular facility due to fire / smoke damage result in excessive financial impact on the client? For example, is the facility critical to business continuity?
- **Public perception -** should a fire occur within the facility is there likely to be questionable public perception about the safety and operation of the facility?
- **Environmental protection –** fires of excessive sizes can have significant effects on the environment which may require a detailed risk assessment to minimise such outcomes.
- **Risk mitigation / insurance limitations -** are there specific limitations on insurance with respect to risk mitigation and fire safety design? i.e. Does the relevant insurer have concerns with respect to open atriums through the building?
- **Future proofing (isolation of systems) -** what flexibility is required in the overall design to allow for future development or changes in building layout?
- **OHS requirements -** buildings may have specific fire safety requirements pertaining to OHS requirements.

1.3 REGULATORY FRAMEWORK OF THE FIRE ENGINEERING ASSESSMENT

1.3.1 Building Code of Australia

One of the goals of the BCA is the achievement and maintenance of acceptable standards of safety from fire for the benefit of the community. This goal extends no further than is necessary in the public interest and is considered to be cost effective and not needlessly onerous in its application.

Section A0.5 of the BCA [1] outlines how compliance with the Performance Requirements can be achieved. These are as follows:

(a) complying with the Deemed-to-Satisfy Provisions; or

(b) formulating an Alternative Solution which –

  (i) complies with the Performance Requirements; or

  (ii) is shown to be at least equivalent to the Deemed-to-Satisfy Provisions or

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

Section A0.9 of the BCA provides several different methods for assessing that an Alternate Solution complies with the Performance Requirements. These methods are summarised as follows:

(d) Evidence to support that the use of a material, form of construction or design meets a Performance Requirement or a Deemed-to-Satisfy Provision.

(e) Verification Methods such as:

(i) the Verifications Methods in the BCA; or

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

(f) Comparison with the Deemed-to-Satisfy Provisions.

(g) Expert Judgment.

Section A0.10 of the BCA provides methods for complying with provisions A1.5 (to comply with Sections A to J of the BCA inclusive). The following method must be used to determine the Performance Requirements relevant to the Alternative Solution: These methods are summarised as follows:

(i) Identify the relevant Deemed-to-Satisfy Provision of each Section or Part that is to be the subject of the Alternative Solution.

(ii) Identify the Performance Requirements from the same Section or Part that are relevant to the identified Deemed-to-Satisfy Provisions.

(iii) Identify Performance Requirements from the other Sections and Parts that are relevant to any aspects of the Alternative Solution proposed or that are affected by the application of the Deemed-to-Satisfy Provisions that are the subject of the Alternative Solution.

1.3.2 International Fire Engineering Guidelines

The IFEG [3] document has been developed for use in fire safety design and assessment of buildings and reflects world's best practice. The document is intended to provide guidance for fire engineers as they work to develop and access strategies that provide acceptable levels of safety.

The document is particularly useful in providing guidance in the design and assessment of Alternative Solutions against the Performance Requirements of the BCA. The prescribed methodology set out in the IFEG has been generally adopted in the Fire Safety Strategy.

2 PROJECT SCOPE

2.1 PROJECT SCOPE

Project Scope

RAWFire Safety Engineering has been engaged to undertake a fire safety review of the new industrial development located on Old Wallgrove Road, Horsley Park in NSW.

The completed development shall form a storage and dispatch facility for use by logistics company DHL. The facility constitutes a single storey warehouse with two ancillary office areas.

The purpose of this fire safety review is to outline the fire engineering principles that will be utilised in ensuring that the non-compliances with the DTS provisions of the BCA are resolved in order to conform to the building regulations. The complete fire engineered analysis will be completed in the Fire Engineering Report, and as such is not documented herein. This Fire Safety Strategy outlines the construction and management requirements considered necessary to achieve an acceptable level of life safety within the building and satisfy the Performance Requirements of the BCA.

2.2 RELEVANT STAKEHOLDERS

This Alternative Solution has been developed collaboratively with the relevant stakeholders as identified below:

Table 2-1: Relevant Stakeholders

ROLE	NAME	ORGANISATION
Project Manager	Adrian Tesoriero Michael Ossitt	Goodman
Principal Certifying Authority	Dean Goldsmith	Blackett Maguire + Goldsmith
Architect	Greg Baird	SBA Architects
Fire Safety Consultant(s)	Thomas Newton Trent De Maria	RAWFire Safety Engineering
Fire Safety Engineers	Sandro Razzi	

It should be noted that at times some parties may have a vested interest in the outcome of the Fire Engineering assessment. Such parties can include local fire brigades, insurers, project control groups, end users and community representatives. Although not always a legislative requirement, the design team should give due consideration to their inclusion in the Fire Engineering process. Where not required by legislation it is the clients' decision to involve such parties, especially local fire brigade, to ensure a transparent and adequate fire safety solution for all. Where we are not notified of the inclusion of such parties it is assumed the client / representative has given due consideration to the above.

2.3 SOURCES OF INFORMATION

The following sources of information have been provided by the design team:

- Building BCA compliance assessment provided by Tony Heaslip of Blackett Maguire + Goldsmith. Report No: 120336, dated 13 August 2012, Revision 0.
- Architectural plans provided by Greg Baird of SBA Architects, as indicated in Table 2-2.

Table 2-2: Drawings

DRAWING NO.	DESCRIPTION	ISSUE	DATE
OAK PA1 05	DHL 1A Ground Floor Plan	F	10 August 2012
OAK PA1 06	DHL 1A Roof Plan	F	10 August 2012
OAK PA1 07	DHL 1A Elevations / Sections	F	10 August 2012

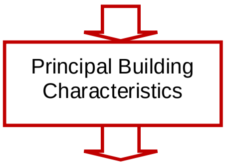
2.4 LIMITATIONS AND ASSUMPTIONS

In this instance the Fire Engineering Strategy is developed based on applicable limitations and assumptions for the development which are listed as follows:

- The report is specifically limited to the project described in Section 2.1.
- The report is based on the information provided by the team as listed above in Section 2.3.
- Building and occupant characteristics are as per Section 3 and 4 respectively of this report. Variations to these assumptions may affect the Fire Engineering Strategy and therefore they should be reviewed by a suitably qualified Fire Engineer should they differ.
- As per any building design, DTS or otherwise, the report is limited to the fire hazards and fuel loads as prescribed in Section 6.2. The report does not provide guidance in respect of areas, which are used for bulk storage, processing of flammable liquids, explosive materials, multiple fire ignitions or sabotage of fire safety systems.
- The development complies with the DTS provisions of the BCA [1] with all aspects unless otherwise specifically stated in this report. Where not specifically mentioned, the design is expected to meet the BCA DTS requirements of all relevant codes and legislation at the time of construction and / or at the time of issue of this report.
- The assessment is limited to the objectives of the BCA and does not consider property damage such as building and contents damage caused by fire, potential increased insurance liability and loss of business continuity.
- Malicious acts or arson with respect to fire ignition and safety systems are limited in nature and are outside the objectives of the BCA. Such acts can potentially overwhelm fire safety systems and therefore further strategies such as security, housekeeping and management procedures may better mitigate such risks.
- This report is prepared in good faith and with due care for information purposes only, and should not be relied upon as providing any warranty or guarantee that ignition or a fire will not occur.
- The Fire Engineering Strategy is only applicable to the completed building. This report is not suitable, unless approved otherwise, to the building in a staged handover.
- Where parties not nominated in Table 2-1 have not been consulted or legislatively are not required to be, this report does not take into account, nor warrant, that fire safety requirements specific to their needs have been complied with.

3 PRINCIPAL BUILDING CHARACTERISTICS

3.1 OVERVIEW



Building characteristics are assessed as part of the Fire Engineering Review due the following:

1. The location can affect the time for fire brigade intervention and potential external fire exposure issues.
2. The structure will impact on the ability to resist a developing fire and support condition to allow occupants to escape the building and the fire brigade to undertake fire fighting to the degree necessary.
3. The floor area determines the potential fire size and area required to be evacuated in the event of a fire.
4. BCA details such as Type of Construction, Class and Height will dictate passive and active fire safety systems.

3.2 SITE & DEVELOPMENT DESCRIPTION

The site of the new development is located in Horsley Park approximately 40km west of Sydney City. The site is bound by Old Wallgrove Road to the east and Milner Avenue to the South. The two nearest fire brigade stations that are provided with permanent staff are located in Huntingwood and Mount Druitt approximately 8km and 11km from the site respectively.

Figure 3-1: Site location

The main portion of the development is occupied by a large warehouse running north/south with a length and breadth of 206m and 97m respectively. The warehouse is provided with a high level awning extending 15m over the loading bays on the eastern side of the warehouse, with the central loading bays provided with a recessed dock. Further to this a ground floor office is provided at the building's entry encompassing approximately 500m^2, with a smaller 2-storey (150m^2) dock office adjacent to the loading docks in the warehouse.

Figure 3-2: Development layout

The new development shall have a rise in storeys of two and an effective height of approximately 4m *(applicable to the dock office)*. The structure is considered for building certification compliance to be a Large Isolated Building requiring Type C construction and perimeter access for emergency vehicles.

Subsequently the building is constructed as a single fire compartment with the bounding structure consisting of steel columns, beams and purlins supporting sheet metal roofing.

3.3 BUILDING CHARACTERISTIC ASSESSMENT

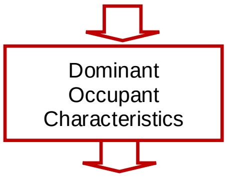
Table 3-1: Building Characteristics Assessment

CHARACTERISTIC	DESCRIPTION
Location	The site is located within the industrial area of Horsley Park. The two nearest fire brigade stations are located within 11km of the site. The building site influences the likely fire brigade intervention times, and given the close proximity to the nearest fire station is expected to facilitate a relatively convenient and expedient fire brigade response. Furthermore being located within a major city outer suburb the development is provided with the services and facilities expected in an urban setting.
Layout	The development shall be constructed as a single fire compartment and is intended to be utilised for the temporary storage of stock prior to final dispatch by the logistic company DHL. The warehouse parts shall have high-bay racking running east to west permitting a clear line of sight along the racking aisles that will assist in occupant evacuation in a fire emergency. Conversely occupant's line of sight will be highly obstructed in the north south direction creating a barrier in determining the safest path of egress in a fire emergency. Exit doors are situated around the building perimeter providing occupants with multiple egress opportunities in the event of a fire emergency.

CHARACTERISTIC	DESCRIPTION	
Structure	Materials and finishes shall be in accordance with the DTS requirements for Type C construction. Construction materials will include masonry and steel construction, with external steel sheeting. Materials used in construction will conform with the testing methodology outlined in the DTS provisions so as to avoid the spread of smoke and fire and minimise the risk to occupants and fire fighters.	
Total Floor area	The total floor area and volume of the building is approximately 20,170m^2 and 190,000m^3 respectively; with the following floor area breakdown:- ■ Warehouse: 19,520m^2 ■ Main office: 500m^2 ■ Dock office: 150m^2	
BCA Assessment	Classification	Class 5 - Offices Class 7b - Storage facility
	Construction Type	Type C Construction *(Large Isolated Building)*
	Rise in Storeys	The building has a rise in storeys of two (2) *(as applied to the dock office)*. **NB:** Increasing the number of floors in a building increases the building population, placing more occupants at risk in the event of a fire, and allowing for overcrowding in stairways and other pinch points in the path of egress to a final exit.
	Effective Height	The building has an effective height of less than 12m *(as applied to the dock office)*.

4 DOMINANT OCCUPANT CHARACTERISTICS

4.1 OVERVIEW



The occupant characteristics are assessed within the Fire Safety Strategy due to the following:

1. Population numbers can dictate the time required to evacuate the building and the required life safety systems to be provided due to evacuation times.
2. Physical and mental attributes affects the occupants capacity to respond to various fire cues and react accordingly.
3. Familiarity of occupants can affect the time taken to evacuate the building and subsequent active / passive requirements.

4.2 OCCUPANT CHARACTERISTIC ASSESSMENT

Table 4-1: Occupant Characteristics Assessment

CHARACTERISTIC	DESCRIPTION
Population numbers	The number of occupants expected within the subject building is considered to be generally less than that assumed in the BCA Table D1.13 [1] due to the type of works being undertaken. However the BCA values shall be used on a preliminary basis to provide an estimated value in the absence of accurate numbers being provided by the building tenant. The BCA assumes the following occupant densities per an area's use: ■ 1 person per 30 square metres in the plant room and warehouse. ■ 1 person per 10 square metres in the office areas.
Population location	The population is expected to be distributed throughout the building. The office is considered to 'on average' be more densely populated than the warehouse and plant areas, however the building's function and use may dictate an overall lower occupant number in the office areas.
Physical and mental attributes	Occupants in the proposed buildings may be of mixed age, although the elderly and children are generally not expected to be present. The population is therefore expected to be that of the general working public and be adults between the ages of 16 to 70. Due to the nature of the work conducted the majority of occupants are assumed to be able bodied people with a small number of less mobile occupants requiring assistance during an evacuation. All occupants are expected to be awake and alert adults or in the direct company of an adult, capable of entering the leaving the building under their own volition. Occupants in all of these areas are not expected to be adversely impaired by drugs, alcohol, fatigue or other adverse conditions to degrees greater than in other warehouse and office buildings. ■ ***Staff and Security*** – are expected to be mobile with normal hearing and visual abilities, and occupants in this group are considered to take and implement decisions independently, and require minimal assistance during evacuation in a fire emergency. This occupant group is expected to be awake and fully conscious at all times when inside the building; and ■ ***Clients / Visitors*** – are expected to be mobile with normal hearing and visual abilities, this occupant group are expected to be capable of making

CHARACTERISTIC	DESCRIPTION
	and implementing decisions independently however may require assistance in locating the nearest and safest egress path in an emergency; and ■ ***External Maintenance Contractors*** – are expected to be mobile with normal hearing and visual abilities and occupants in this group are considered to take and implement decisions independently and require minimal assistance during evacuation in a fire emergency. The contractors are expected to be awake and aware of their surroundings at all times when inside the building; and ■ ***Fire & Rescue NSW*** – are expected to be equipped with safety equipment and will be educated in fire fighting activities and the dangers associated with fire incidents. This occupant group would be expected to be in a position to assist other occupants requiring assistance to evacuate. It is not expected that this occupant group would be present in the building at the time of fire ignition; however, they are expected to enter the building at a later stage to assist with the evacuation of occupants, if required, and to undertake fire suppression activities.
Familiarity with the building	■ ***Warehouse Staff and Security*** – can be expected to have a good familiarity with the building and the fire safety systems provided and may be trained in emergency procedures; and ■ ***Office Staff*** – can be expected to have a good familiarity with the administration areas and the means of exits from these parts. General familiarity of the building as a whole and the location of main exits; and ■ ***Clients / visitors*** – may or may not be familiar with the layout of the building and may require assistance in locating the exits; and ■ ***External Maintenance Contractors*** – this occupant group is expected to have a reasonable familiarity with the building as they would have to undergo site specific induction prior to commencement of work on site; and ■ ***Fire & Rescue NSW*** – are not expected to have any familiarity of the building layout, however are assumed to obtain the required information from the site block plans and tactical fire plans available prior to entering the building. Notwithstanding this they will be equipped with breathing apparatus and specialist equipment to prevent them from being adversely affected by fire hazards.

5 FIRE BRIGADE CHARACTERISTICS

5.1 OVERVIEW

The fire brigade characteristics are assessed within the Fire Safety Strategy due to the following:

1. Fire Brigade characteristics can dictate the time required for fire brigade intervention including search and rescue and fire attack.

5.2 FIRE BRIGADE ASSESSMENT

In order to assess the likely fire brigade response times and likely requirements additional to those normally presented within a DTS design an indicative assessment of fire brigade intervention has been undertaken based on the methods defined in the Fire Brigade Intervention Model (FBIM) [5].

Figure 5-1 illustrates the building layout with the entry points to the building and the allotment, with the perimeter access outlined.

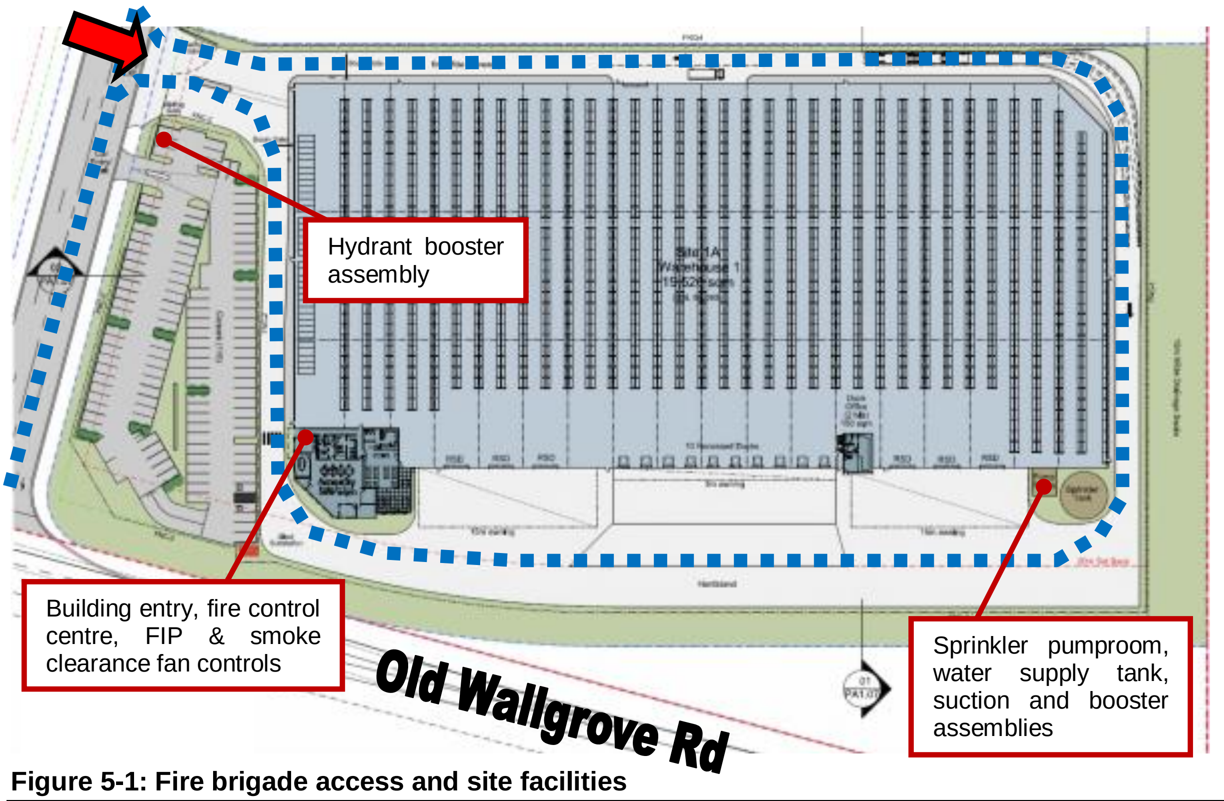


Figure 5-1: Fire brigade access and site facilities

The two nearest fire brigade stations that are provided with permanent staff are located in Huntingwood and Mount Druitt approximately 8km and 11km from the site respectively. Figure 5-2 illustrates the expected route to be taken in the event of a fire.

Figure 5-2: Route from the two nearest fire stations

Due to the nature of the FBIM, it is necessary to justify the results through the inclusion of assumptions. The accuracy of results weighs heavily upon the measure of which assumptions are made and the sources from which they are derived.

The model produced details the time it will take for brigade personnel within the aforementioned location to receive notification of a fire, time to respond and dispatch resources, time for resources to reach the fire scene, time for the initial determination of the fire location, time to assess the fire, time for fire fighter travel to location of fire, and time for water setup such that suppression of the fire can commence. The following are details of the assumptions utilised in this FBIM:

<u>Location of Fire</u>

- This FBIM will only be an indicative model of one fire scenario within the building. For conservative purposes, the FBIM considers a fire in the furthest habitable room from the point of entry. In this case entry is through the office areas and the fire located in the north-western corner of the warehouse.

<u>Time between Ignition and Detection</u>

- Based on calculations using the Alpert's Correlations (Figure 5-3) the initial brigade notification is via the activation of the warehouse sprinkler system.

  The alarm time calculated has considered a fire with an Ultra-Fast t-squared fire growth rate, which is expected to be indicative of the type of fire in the high bay racking area. The alarm time following fire ignition was calculated to occur at 191 seconds.

Input data required			**Fire Type:**	α =
The ambient temperature of the room, T_∞ =	20	(°C)	Ultrafast	0.178
Fire Category =	Ultrafast		Fast	0.044
Output time step =	20	(s)	Medium	0.011
The distance of the detector from the fire, r =	2.12	(m)	Slow	0.003
The height of the ceiling above the fire, H =	12	(m)	Custom	0.011
The Response Time Index of the detector, RTI =	50	($m^{1/2}s^{1/2}$)		
Sprinkler density of discharge =	5	mm / min		
Detector activation temperature =	101	(°C)		
Calculated quantities at detector activation				
The gas temperature at sprinkler activation, T =	112.79	(°C)		
HRR at sprinkler activation =	6417.78	(kW)		
The gas velocity, U =	6.71	(m/s)		
Time at detector activation =	191	(s)		
Time to reach 10% of peak HRR =	877	(s)		
Ratio, r / H =	0.18			

Figure 5-3: Sprinkler activation

<u>Time for Initial Brigade Notification</u>

- Fire brigade notification is expected to occur via a direct monitored alarm.
- A time for alarms/fire verification and any notification delay is 20 seconds based on Table B of the Fire Brigade Intervention Model. Therefore the time after ignition at which the fire brigade receive the alarm is (191+20) = 211 seconds.

<u>Time to Dispatch Resources</u>

- The two fire stations are assumed to be manned at the time of the fire as they are permanently staffed stations.

Time for fire fighters to respond to dispatch call and leave fire station is included in the travel time for fire brigade in NSW (Fire Brigade Intervention Model [5]).

<u>Time to Travel to Scene</u>

Table 5-1: FBIM data for the FRNSW (Table F2 FBIM)

GRAPH	REGION CLASSIFICATION	SPEED (KM/H)	
		μ	σ
F2.1	Major city central business district	26.6	11.3
F2.2	Major city inner suburb	26.3	11.9
F2.3	**Major city outer suburb**	**29.5**	**12.2**
F2.4	Rural town centre	21.6	11.0
F2.5	Rural country	40.5	15.6
	Travel speed through site	8	-

Based on speed data provided by the Fire Brigade Intervention Model (FBIM) [5], this travel speed assumes the brigade is travelling at a mean speed of 29.5km/h (major city outer suburb) with a standard deviation of 12.2km/h. Since the mean speed would result in this particular travel speed occurring 50% of the time, there is an equal likelihood that the travel speed would take longer. Hence, it is desirable to introduce a margin of safety of using a greater percentile of 90%.

In order for the speed to be within the 90% percentile value, a safety factor of 1.28 is applied to the standard deviation as noted in Table 4.3 of Fire Brigade Intervention Model V2.2 [5].

Hence, a mean travel speed will be taken at a much slower travel speed at 29.5 – (12.2 x 1.28) = 13.9km/h which is conservative.

- Appliance travel speeds of 13.9km/h have been adopted for the purposes of modelling, and as such the following travel times are expected:-

Table 5-2: Fire Brigade Arrival Times

STATION	TRAVEL SPEED (km/h)	DISTANCE (km)	TRAVEL TIME (sec)
Huntingwood	13.9 km/h	8 km	2072
Mount Druitt	13.9 km/h	11 km	2849

<u>Time for Initial Determination of Fire Location</u>

- On arrival, the fire location is not visible to the approaching brigade personnel, thus requiring information to be obtained from the Fire Indicator Panel (FIP) and evacuating occupants.
- Fire brigade personnel assemble at the FIP in the office building's main entry.
- Fire brigade tactical fire plans will be provided.
- Security procedures are expected to be minimal as brigade personnel will be issued with a key for the site. As such, forced entry into the building is not required.

<u>Time for Water Setup</u>

- The first appliance would be expected to commence the initial attack on the fire.
- Time taken to connect and charge hoses from on site hydrants to the fire area is based on V3 on Table V of the Fire Brigade Intervention Model Guidelines, which indicates an average time of 18.4 seconds, and a standard deviation of 10.2 seconds. Therefore allowing for 5 connections, the time utilised in this FBIM is 5*[18.4+(1.28x10.2)]* = 155 seconds.

<u>Time for Fire Fighters to Travel to Fire Location</u>

- Time for fire fighters to travel from the FIP to the fire affected area; in this case conservatively assumed to be the furthest point from the FIP in the eastern end of the warehouse.

Table 5-3: FBIM data for horizontal travel speeds (Table Q FBIM)

GRAPH	TRAVEL CONDITIONS	SPEED (KM/H)	
		μ	σ
Q1	Dressed in turnout uniform	2.3	1.4
Q2	Dressed in turnout uniform with equipment	1.9	1.3
Q3	**Dressed in turnout uniform in BA with or without equipment**	**1.4**	**0.6**
Q4	Dressed in full hazardous incident suit in BA	0.8	0.5

Horizontal egress speeds have been based on fire brigade personnel dressed in turnout uniform in BA. An average travel speed of 1.4m/s with a standard deviation of 0.6m/s are utilised. As such, for the purposes of the calculations, a horizontal travel speed of 1.40-(1.28x0.6) = 0.63m/s is utilised.

- Horizontal travel distances (not including travel via lifts or stairs) will include the following:
  - Travel from the curb to the Main FIP in the office foyer and finally to the north-western corner of the warehouse is approximately 300m.
  - Based on the above, the total <u>horizontal</u> travel distance of 300m coupled with an egress speed of 0.63m/s results in a horizontal travel time of up to 476 seconds.

<u>Search and Rescue</u>

- Search and rescue will consist of a perimeter search of the warehouse; due to the size of the warehouse in comparison to the office it is assumed that a second team will conduct a search of the office in the time required to cover the warehouse. Thus, this will provide fire fighting personnel with an additional 600m of travel. At a speed of 0.63m/s, this will take fire fighting personnel approximately 953 seconds.

Table 5-4 Summary of the Fire Brigade Intervention Model (FBIM)

FIRE STATION	TIME OF ALARM	TRAVEL TIME TO SCENE	ASSUMED SET UP TIME	TIME TO REACH THE FIRE BASE	TIME OF ATTACK	PERIMETER SEARCH & RESCUE
Huntingwood	211	2072	155	476	2914 (49 min)	3867 sec
Mount Druitt		2849			3691 (62 min)	4644 sec

The FBIM indicates that the arrival time of the brigade from the nearest two fire stations is approximately 38 and 51 minutes respectively after fire ignition. It is estimated that it takes another 11 minutes for the fire brigade to carry out activities including determination of fire location, preparation of fire fighting equipment and travel on foot to the fire base. As such, fire fighting activities are expected to commence between approximately 49 and 62 minutes, with preliminary search and rescue completed at 65-78 minutes.

6 FIRE HAZARDS AND PROTECTIVE MEASURES

6.1 OVERVIEW

Fire Hazards and Protective Measures

The fire hazard analysis forms the basis for the review of non-compliances within the building. In assessing expected and statistically validated hazards, preventative and protective measures are developed commensurate with those expected risks. The following section reviews applicable hazards and recommends possible measures to address those risks. Furthermore, hazards identified can form a justified basis for selected scenarios.

6.2 FIRE STATISTICS

In order to assess the most likely fire hazards within the building, and subsequently the risk presented by these hazards it is necessary to develop an understanding of the factors that have an influence on the fire safety of building occupants. The best method in doing so is to review existing statistical data.

Existing data is an invaluable tool in providing an overview of the situations in which occupant deaths have, and are likely to occur, and factors that contribute to more severe fires. This aids in understanding, and helps evaluate the effectiveness of, and the need for various fire safety systems. Reference is made to the American database as it is significantly larger than Australian data sets, but is generally considered to be representative of the Australian situation.

Table 6-1: Fire Statistics in all building types

STRUCTURE TYPE	FIRES PER YEAR	CIVILIAN FATALITIES PER YEAR	CIVILIAN FATALITIES PER 1000 FIRES
Offices	**5,800**	**1**	**0.17**
Storage facilities	**22,900**	**15**	**0.66**
Retail shopping complexes*	NA	NA	0.74
Public assembly, excluding eating/drinking	6,000	5	0.83
Facilities that care for the sick	2,600	5	1.92
Hotels & Motels	4,900	28	5.7
Apartments	96,200	632	6.57
Homes	406,400	3,498	8.61

*From the FCRC 'Fire Safety in Shopping Centres' Project 6 all other data from the NFPA 'U.S. Fire Problem Overview Report' [11]

Based on the National Fire Protection Association, the statistics are based upon recorded fire events occurring between:

- 2003 – 2007 Structure fires in Warehouses (excluding cold storage)

Note that the statistics below have been compiled from U.S. fires reported to U.S. municipal fire departments between 2003 and 2007, and do not include fires where private or government fire brigades responded or fires that were not reported. Further, it should be noted that cold storage, residential storage and self-storage are excluded. Despite the fact that cold storage is not reported within the statistics it is considered that they still provide a reasonable basis for the general understanding of the risk presented by a high storage warehouse, cold storage or otherwise.

It is a common misconception that fires do not occur in cold store. However, factors such as an ultra dry atmosphere and the highly combustible nature of polyurethane or polystyrene foam insulation, wooden pallets and plastic wrapping present a high fire risk in these environments. Electrical faults from conveyor/transport equipment, lighting, or hot spots caused by maintenance operation can also contribute to this risk. Additionally the holding capacity of a cold store demands specialized high volume storage racking which can affect the airflow and impede the detection and response to a fire event.

These statistics represent a much greater number of events than Australian statistics and therefore have a greater statistical reliability. Building construction types and fire hazards are estimated to be sufficiently similar between Australia and the U.S. for the following results to be applicable.

Warehouse (excluding cold storage) Fire Statistics

A total of 1,350 structure fires occurred in warehouses. The fires recorded resulted in 5 occupant fatalities, and 21 occupant injuries and $124 million in direct property damage per year. The leading cause of fires in Warehouses (excluding cold storage) is from electrical distribution or lighting resulting in 17% civilian injuries. The leading area of fire origin in warehouses comes from an unclassified storage area resulting in 21% civilian injuries.

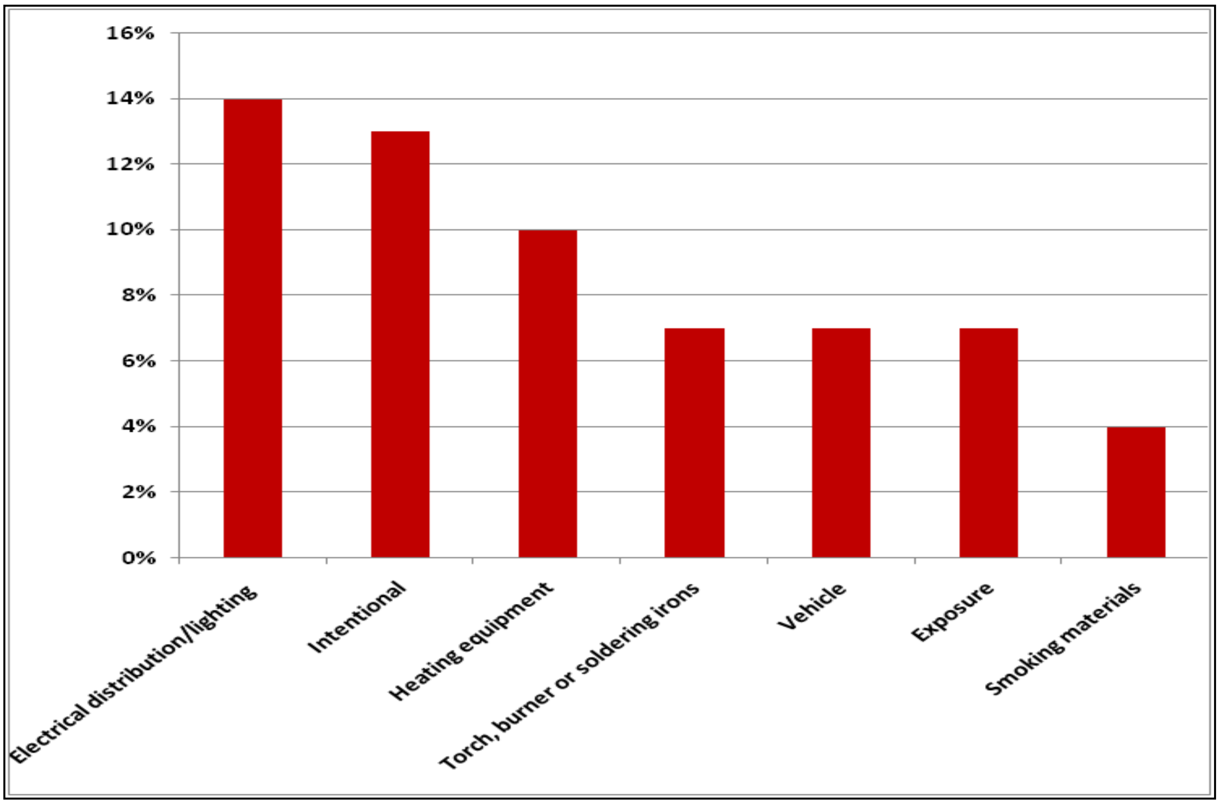


Figure 6-1 Leading causes of fires in warehouse (excluding cold storage) structures

The potential fire hazards (inclusive of the leading causes, as well as area of origin of a fire) identified throughout the development are illustrated in the graphs below. The statistics as illustrated in the figures below have been obtained from the National Fire Protection Association (NFPA) website (www.nfpa.com).

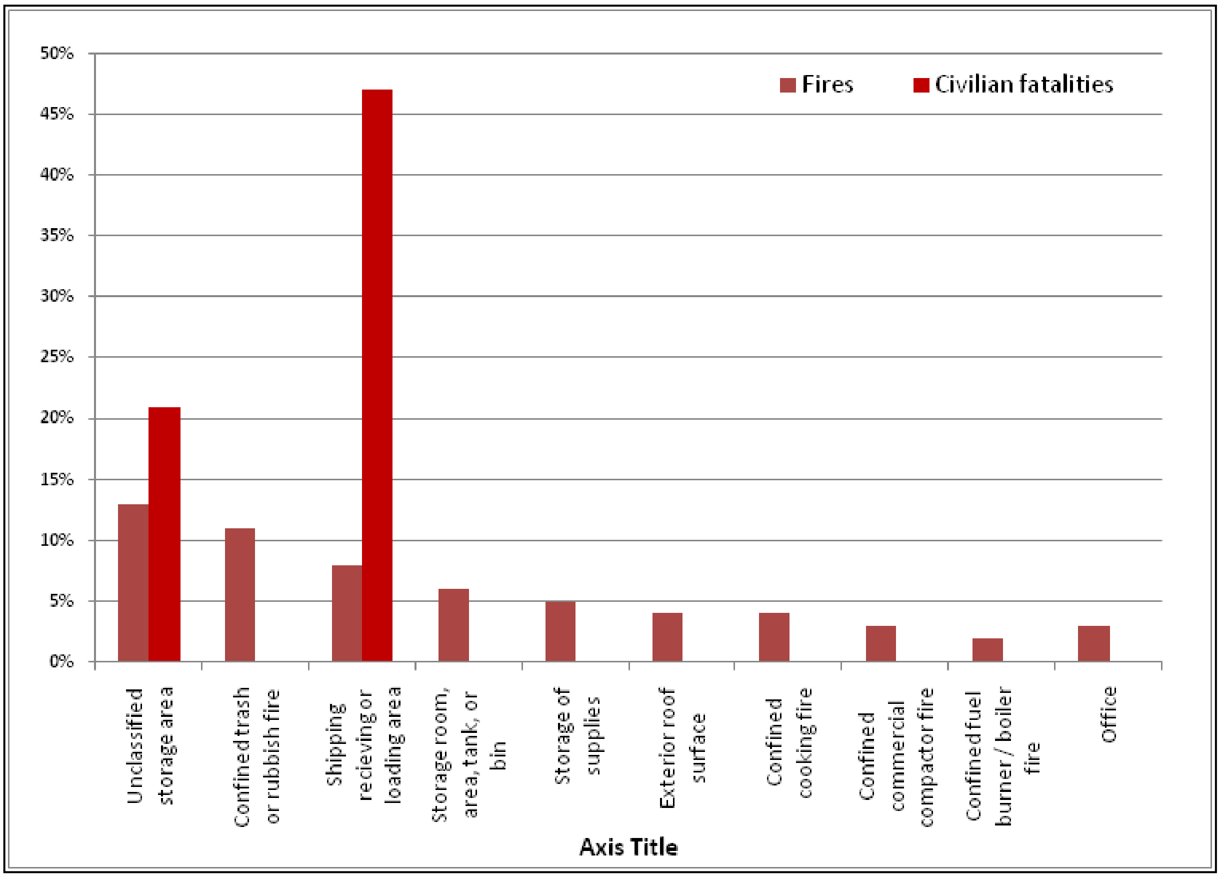


Figure 6-2 Structure fires in warehouse (excluding cold storage) structures by area of origin

Office Facilities

Fire statistics for offices in Australia as reported in Technical Report 96-02 [14] show that the most common cause of fires in these types of buildings are attributed to faults in electrical equipment, with lighting fixtures being the equipment most often cited. Ahrens (2001) [16] reports that fire statistics from the U.S. confirm the same key ignition sources. It should be noted that with so few fire fatalities in office fires, the data for fatalities should be considered holistically, representing a low likelihood of fatalities overall in offices. The identification of the comparative risk of fatality within different areas or by different ignition sources is lacking in accuracy by virtue of a limited data set of 1 fatality per year.

Table 6-2: Office fire statistics by cause of ignition

CAUSE OF FIRE	FIRES	CIVILIAN FATALITIES
Electrical Distribution	21.1%	51.6%
Other Equipment; motors, generator, elevators, office equipment etc.	17.0%	21.4%
Incendiary or suspicious	15.7%	26.9%
Smoking Materials	8.6%	0.0%
Heating equipment	8.1%	0.0%
Appliance, tool or air conditioning	7.5%	0.0%
Open flame or torch	7.3%	0.0%
Cooking equipment	5.7%	0.0%
Other, less than 6% of fires per area	9.0%	0.0%
Total:	**100%** **5,800 fires per year**	**100.0%** **1 fatality per year**

Ahrens also indicates that 17.7% of all recorded office fires occur within the specific office area. This figure is likely to be highest by virtue of the proportion of the buildings which the general office space occupies and as such may not actually represent the high ignition risk of the office space but the risk of fire resulting from the application of a minor risk over the majority of the floor space. The next four most frequent areas of ignition are grouped around 5% each and include kitchens, exterior walls, concealed spaces and heating equipment rooms. Any correlation between the area of ignition and the likelihood of fatalities is likely to be misrepresentative due to the low number of fatalities relied upon to draw such conclusions.

Table 6-3: Office fire statistics by area of fire origin

AREA OF FIRE ORIGIN	FIRES	CIVILIAN FATALITIES
Office	17.7%	40.7%
Kitchen	6.0%	0.0%
Exterior wall surface	5.6%	0.0%
Attic or ceiling/roof assembly or concealed space	5.2%	0.0%
Heating equipment room	5.1%	0.0%
Hallway, Corridor or Mall	3.5%	21.2%
Crawl space or substructure space	1.6%	21.2%
Other, less than 5% of fires per area	55.3%	16.9%
Total:	**100%** **5,800 fires per year**	**100.0%** **1 fatality per year**

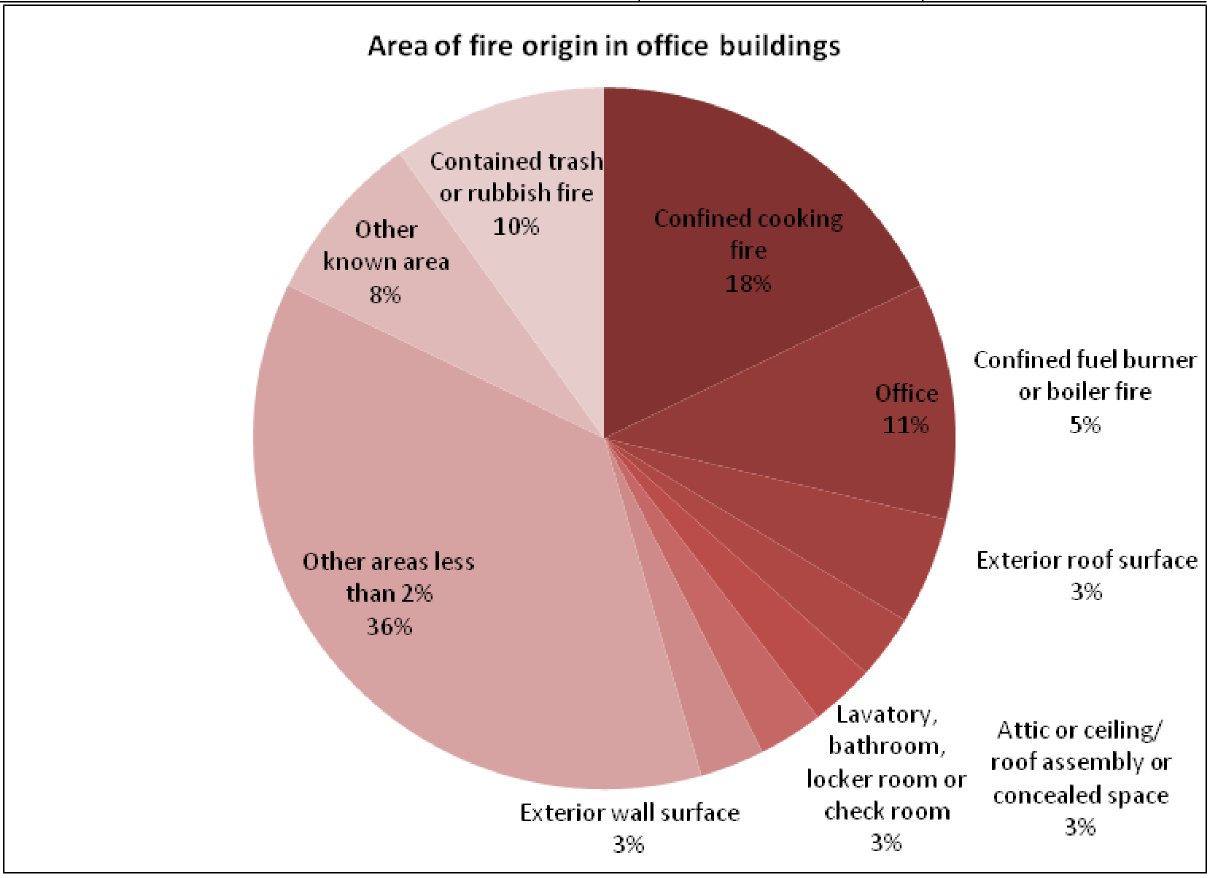


Figure 6-3: Area of fire origin in office buildings

Statistics shown in Figure 6-3 are published in the document ‘U.S Structure fires in office properties’ by Flynn (2007) [15], and is the most recent available statistics from the National Fire Protection Association in the U.S.A, relating to office buildings. A total of 3,810 fires were considered in the statistical data and had recorded one civilian fatality in these fires. It can be seen from the above figure that office, cooking and rubbish areas are the most common areas for fire origins within office buildings, which is consistent with the findings of Ahrens.

6.3 SPRINKLER EFFECTIVENESS & RELIABILITY

The effectiveness of automatic fire sprinklers in general in limiting fire spread and growth is supported by statistics and studies undertaken into the effects of automatic fire sprinklers within buildings. These studies show that fire sprinkler systems operate and control fires in 81% to 99.5% of fire occurrences [3]. The lower reliability estimates of 81.3% [8] as well as some of the higher values of 87.6% [10] appear to reflect significant bias in data in terms of the small number of fire incidents and the lack of differentiation between fire sprinklers and other fire suppression systems. A number of the lower figures are results of dated studies.

It must be noted that the higher reliability of fire sprinklers reported by Marryatt [12] of 99.5% reflect fire sprinkler systems where inspections, testing and maintenance exceeded normal expectations and applies to installations specifically in Australia and New Zealand. The statistical data indicate that sprinklers with appropriate maintenance are highly effective in reducing the loss of life and limiting fire spread and in particular the storage (ESFR) system has an exemplary record.

With reference to FM Global data sheet (2-2) as of 2002 [5] there had been six known fires involving suppression mode sprinkler protection.

In all of these incidents, the sprinkler system was successful in suppressing the fire and no more than four sprinkler heads operated. Therefore for the purposes of this assessment, on the activation of the ESFR fire sprinkler system, the fire growth is considered to be suppressed within the area of activation.

FM Global Data Sheet 2-0 states that, FM Global loss history over the past twenty years indicates that approximately 25% of the time, the operation of a single sprinkler will control or suppress a fire if the sprinkler system has been properly designed and installed. This percentage increases to approximately 50% of the time with the operation of 3 or fewer sprinklers, and 75% of the time with the operation of nine or fewer sprinklers.

In addition analysis of the likelihood of sprinkler failure shows that most sprinkler system failures are due to impaired water supplies such as closed valves, blocked pipes, impaired sources, etc., which tend to affect sections of or the entire system [10]. As such, system reliability can be increased by active monitoring of water supplies and controls. The general consensus within the fire protection industry is that problems with individual sprinkler heads are rare. This information combined with sprinkler reliability data is favourable when compared with the reliability of fire compartmentation [3].

Moinuddin and Thomas [10] have found that masonry fire rated construction had a reliability of 81-95%, and gypsum 69-95%, with the upper level in both instances having been reported within the IFEG [3]. Both reported ranges are considered to be less than that offered by automatic sprinkler systems. Table 6-4 lists the effectiveness of sprinkler systems in the event of a fire growing to a size that facilitates sprinkler head activation [10].

Table 6-4: Effectiveness of Sprinkler systems

PROPERTY TYPE	EFFECTIVENESS OF SPRINKLERS IN EVENTS WHERE SPRINKLERS OPERATE
Public Assembly	90%
Educational	93%
Health care / Correctional Centre	95%
Residential (average)	97%
Office / Retail	91%
Manufacturing	93%
Storage	86%
Cold Storage	89%
All properties	7%

Statistics for general sprinkler effectiveness in storage properties is provided in the table below which is drawn from the research of Rohr [13]. The data indicates over 77% of storage fires and 84% of manufacturing facility fires are confined to the area of fire origin where sprinklers are fitted.

Table 6-5: The Effectiveness of Sprinkler in Storage Facilities

EXTENT OF FLAME DAMAGE	FIRES WITH SPRINKLER PROTECTION	FIRES WITHOUT SPRINKLER PROTECTION
Confined to object of origin	50.0%	19.9%
Confined to area of origin	27.8%	14.1%
Confined to room of origin	6.7%	4.9%
Confined to fire-rated compartment of origin	1.1%	0.6%
Confined to floor of origin	2.4%	1.1%
Confined to structure of origin	10.0%	45.0%
Extended beyond structure of fire origin	2.2%	14.3%
Total:	900 fires	29,330 fires

According to the tests undertaken by FM Global Property Loss Prevention Data Sheets [5], automatic smoke exhaust systems would operate prior to an installed sprinkler system. This would result in the removal of hot smoke from the ceiling causing a critical delay in sprinkler operation. As such, FM Global recommends that a sprinkler system should not be installed in conjunction with automatic smoke exhaust systems.

It is considered likely that the BCA DTS smoke management would hinder and prevent the activation of the sprinkler system as discussed in the FM Global Property Loss Prevention Data Sheets. The failure of the sprinkler system would allow fire development and cause uncontrolled spread throughout the building leading to a more rapid onset of untenable conditions, significant property loss, and restriction of fire fighter access into the building.

Furthermore, rapid fire development and spread could eventually overrun the sprinkler system by resulting in the activation of several fast response sprinkler heads, over and above the system design requirement, potentially depleting the water supply. In this instance, the system may be rendered ineffective and unable to hydraulically perform as intended. As such, it is recommended that the removal of the BCA DTS smoke management system would allow hot smoke to build up in the ceiling leading to the activation of the sprinkler system as intended by design parameters which are based on tested systems and therefore improving the likelihood of fire control and/or suppression.

6.4 FIRE LOAD

The fire load within a room or compartment will influence the duration and severity of a fire and resultant hazard to occupants. The effective fire load for the building has been estimated by consideration of the typical spaces within the building.

The following fire loads have been extracted from Chapter 3.4 of the International Fire Engineering Guidelines [3] and are listed in Table 6-6. This data is derived from Switzerland, however is also deemed applicable to buildings in Australia of similar use.

The warehouses are considered to generally contain mixed types of commodities, where in some cases cellulosic materials are mixed with plastics and non-combustible materials on the same racks. There is a large amount of data concerning the burning rates of items and materials; however, this information is not often presented such that it is sufficiently generic to be universally adopted.

Also, while the current occupants within the buildings may be known during the design stages of the development the length of their occupancy can not be definitively identified. Therefore while what can be representative of the current fuel loadings for the enclosure, these may not be the case in the future use of the building. Therefore, it would be a rare assessment in which the specific items forming the fuel load had been tested to provide the fire heat release data. As such it is considered that the application of generic burning rates, translated through simplified mathematical expression (time squared growth rates) is a suitable means of estimating fire development.

Table 6-6: Fire Load Densities

TYPE OF OCCUPANCY	AVERAGE FIRE LOAD
Office, Business	300 MJ/m^2
Forwarding facility dealing in; Beverages, food, furniture, glassware, plastic product, printed goods, varnish/polish.	Range from; 200 MJ/m^2 - 1700 MJ/m^2
Storage of rubber products	5000 $MJ/m^2/m$
Storage of paper	1000 $MJ/m^2/m$

6.5 FIRE GROWTH RATE AND INTENSITY

As the fire increases in size, the rate of fire growth accelerates. The growth rate of a fire can result in various hazards for occupants due to the following:

- Protective and preventative measures may not be adequate.
- Occupants may have insufficient time to evacuate.
- Occupants may perceive a reduced threat from slow growing fires.

The rate of fire growth is generally expressed in terms of an energy release rate. The most commonly used relationship is what is commonly referred to as a quadratic time-squared fire. The basis of the time squared fire arises from the fact that the growth during the flaming stage can be approximated by a smooth curve that can be expressed mathematically. The rate of heat release is given by the expression:

$$Q = ({}^{t}/_{k})^{2}$$

Where: t = time from after ignition of the fire (seconds)

K = the growth time (seconds)

Q = a heat release output of 1.055 MW.

Studies of actual fires have led to the adoption of five (5) standard fire growth rates covering a wide range of potential fire scenarios and fuel loads. It should be noted, the times of fire incubation are not included in the time-squared growth fire models. National Fire Protection Association Standard NFPA 92B [10] provides information on the relevance of time-squared approximation to real fire as depicted in the figure below.

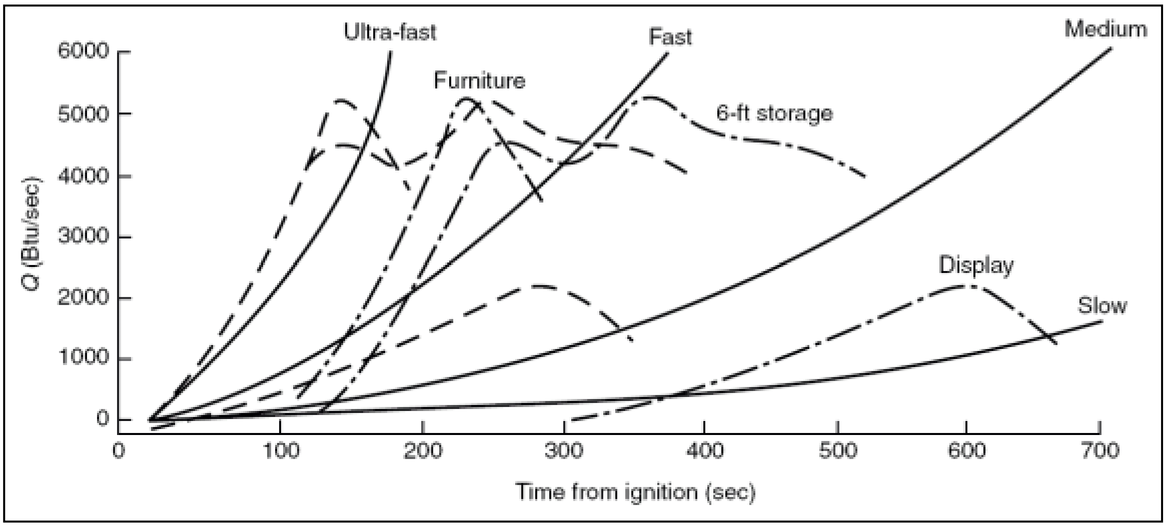


Figure 6-4: NFPA 92B: T-squared fire, rates of energy release

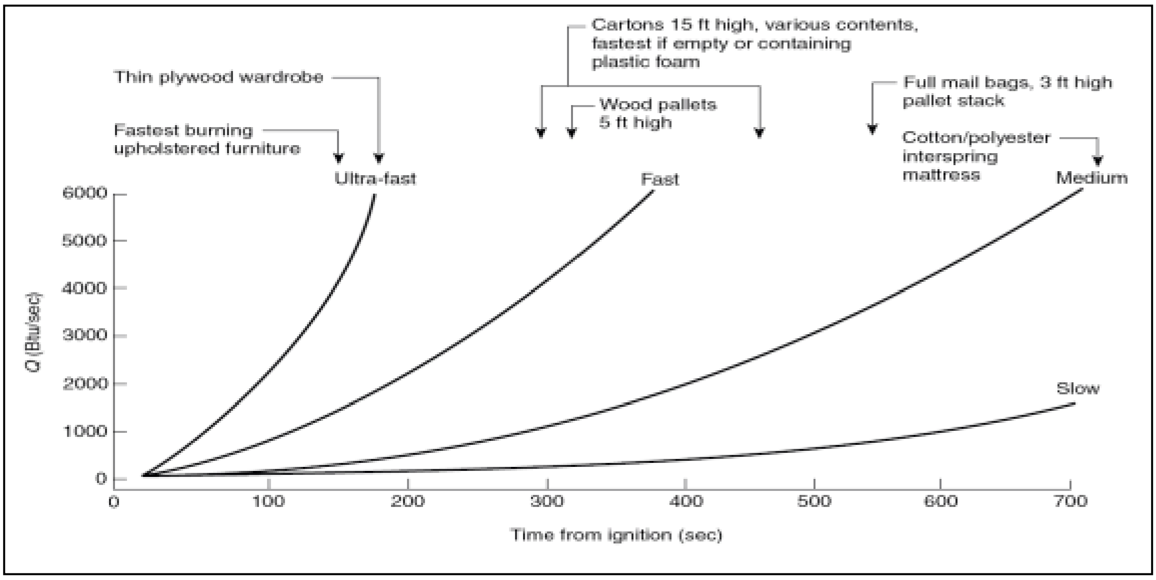


Figure 6-5: NFPA 92B: Relation of t-squared fires to some fire tests

The rate of fire growth can also be estimated from data published in British Standard (BS) 9999:2008 [5] as shown below in Table 6-7, and Table 6-8.

Table 6-7: Summary of Fire Growth Rates per Building Type

BUILDING AREA PROVIDING FUEL	GROWTH RATE	BUILDING AREA PROVIDING FUEL	GROWTH RATE
Reception area	Slow	Restaurant/Canteen	Medium
Office	**Medium**	Teaching Laboratories	Fast
Shop	Fast	Meeting Room	Medium
Warehouse	**Medium/Fast/Ultra-Fast**	Waiting Room	slow

The variation in warehouse growth rates can be understood from the following table illustrating the types of stored items.

Table 6-8: Fire Growth Rates as described in BS 9999:2008

FIRE GROWTH RATE	STORED MATERIALS
Slow t^2	Banking hall, limited combustible materials.
Medium t^2	Stacked cardboard boxes, wooden pallets.
Fast t^2	**Baled thermoplastic chips, stacked plastic products, and baled clothing.**
Ultra-Fast t^2	**Flammable liquids, expanded cellular plastics and foam.**

From the above tables (and figures) it is concluded that the likely fire scenarios in the high bay racking may be approximated by an Ultra-Fast standard time-squared fire growth rate curve, while the office areas can be approximated with a Medium time-squared fire growth rate.

6.6 FIRE SOOT YIELD

The materials that make up the fuel load will determine the soot yield of a fire. The fire soot yield should be assessed with respect to hazard due to the following:

- Soot yield can affect visibility for occupants trying to escape a fire.
- Soot yield can be directly related to other products of combustion which may cause untenable conditions.

The fire load materials within an office is likely to involve plastics in the form of computer equipment and telephones etc. and large quantities of cellulosic materials in the form of chip board desks, paper and general office stationary. Generally cellulosic materials have far lower smoke yields than plastics. A common plastic is polyurethane which has a soot yield of 0.1 kg/kg as referenced from Babrauskas in the NFPA Handbook. As a conservative input to the computer modelling all material involved in the fire has therefore assumed to be plastic.

6.7 FIRE HAZARD SUMMARY

Subsequent to a review of the relevant fire statistics and hazards presented in Section 1 the fire hazards for the building are listed in the following table.

Hazards due to functions or characteristics are reviewed based on the building in question and relevant statistics; and

1. A description is provided on the nominated hazards; and
2. Relevant preventative / protective measures are provided to address the nominated hazards.

Table 6-9: Building Hazard Assessment

<table>
<tr><th>POTENTIAL HAZARDS DUE TO:</th><th colspan="2">DESCRIPTION / DETAILS</th><th>PREVENTATIVE & PROTECTIVE MEASURES TO ADDRESS HAZARDS</th></tr>
<tr><td>Building layout</td><td>Egress provisions</td><td>Exits are provided around the building perimeter to allow for multiple alternative egress opportunities.
Areas within the warehouse have limited dead end travel routes to exits.
Due to the size of the building extended travel distances to the nearest of the alternative exits and between alternative exits exist.
Within the subject building it is not expected that there will be any greater exposure to fire as a result of the alternative solution.
No hazards to adjoining building shave been identified, hazards generally relate to any internal exposures.
Occupants in the area of fire origin are expected to be aware of fire and commence evacuation – apart from those intimately involved in ignition are expected to be aware of the fire.
The first floors of the two offices are provided with single paths of egress which requires traversing a non fire-isolated stairway through the ground floor office.</td><td rowspan="2">Type C construction, BCA Spec C1.1 (Table 5).

Fire Hydrants, BCA Clause E1.3, AS 2419.1: 2005.

Booster set, BCA Clause E1.3, and AS2419.1:2005.

Fire Hose Reels, BCA Clause E1.4, and AS 24441:2005.

Fire Extinguishers, BCA Clause E1.6, and AS2444:2004.

Automatic Suppression System, BCA E1.5, and AS2118.1:199, and FM2-0 & FM8-9.

Occupant Warning System, AS1670.1:2004 Clause 3.22.</td></tr>
<tr><td>Activities</td><td colspan="2">With regard to activities it is not expected that regular hot work processes, use of highly flammable materials, manufacturing processes or operation of high friction or high temperature machinery will be performed within the building.
The development is a storage and dispatch facility containing a large number of high piled and racking containing combustibles. These items are only stored temporarily before being dispatched onward, thus there is no degradation of old stock. Notwithstanding the assumed turnover, the storage is assumed to be constantly filled to capacity due to the constant rolling stock.
▪ Corridors, stairs and lobbies will generally be used only for transient purposes, occupants travelling to and from the various parts of the building.</td></tr>
</table>

<table>
<tr><th>POTENTIAL HAZARDS DUE TO:</th><th colspan="2">DESCRIPTION / DETAILS</th><th>PREVENTATIVE & PROTECTIVE MEASURES TO ADDRESS HAZARDS</th></tr>
<tr><td>Ignition sources</td><td colspan="2">Based on the statistical review contained above the ignition sources relevant to this site, in order of occurrence and likelihood
▪ Electrical Equipment / lighting
▪ Intentional fire starts
▪ Stored waste or rubbish
▪ Heating equipment</td><td rowspan="5">Smoke Clearance System, Alternative Solution in lieu of BCA Spec E2.2b.

Minimum of Extended Grid Spaced Automatic Smoke Detection System, BCA E2.2a Clause 5(b) and Alternative Solution

Automatic Link to Fire Brigade, BCA Spec E1.5.

Emergency Lighting, BCA Clause E4.2/E4.4, and AS2293.1:2005.

Exit Signage, BCA Clause E4.5, NSW E4.6, NSW E4.8, and AS2293.1:2005 & Alternative Solution</td></tr>
<tr><td rowspan="3">Fuel sources</td><td>Quantity of materials</td><td>Dangerous goods cannot be discounted from being present in the building. However the quantity will be limited by the space available and relevant workplace health and safety regulations will apply governing storage allowances (quantity) and requirements.</td></tr>
<tr><td>Location of materials</td><td>Products in high storage racking, store room, waste and rubbish containers.
The lobbies, stairways and corridors are to be maintained clear of furniture, stored items and the like and constructed with materials and assemblies in accordance with C1.10 to reduce fire spread and smoke production in the event of fire in common areas. Significant fuel loads will therefore be generally limited to the warehouse and offices.</td></tr>
<tr><td>Fire behaviour</td><td>Fire growth rates will vary with fuel type and conditions of ventilation and compartmentation. The most likely outcome of any fire outbreak within the building is expected to be sprinkler controlled fire. This would be expected to grow at an Ultra-Fast time squared fire growth rate
An office fire would likely be smaller in size due to the limited fuel density and would be expected to grow at a Medium time squared fire growth rate.</td></tr>
<tr><td>Fire origins</td><td colspan="2">Refer to previous charts whereby fires are likely to occur in the following origins:
▪ High storage racking areas.
▪ Waste and rubbish containers.
▪ Store room.</td></tr>
</table>

7 BCA DTS NON-COMPLIANCE ASSESSMENT

7.1 OVERVIEW

BCA DTS Non-Compliance Assessment

In this instance the BCA DTS non-compliances have been formulated based on the regulatory review as provided by the project building surveyor and / or design team. Where not listed herein the building is required to achieve compliance with relevant DTS clauses or if existing, comply with relevant codes, reports and / or Standards approved at the time of consideration.

The following table lists the departures from the DTS provisions of the BCA for the proposed building and the analysis methodology proposed for the Fire Engineering assessment, which is to be generally in accordance with the IFEG [3].

Table 7-1: Summary of Alternative Solutions

BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT	PERFORMANCE BASED SOLUTION
BCA DTS Provisions Clause D1.4: Distance to the nearest exit. Clause D1.5: Distance between alternative exits. **Performance Requirement** DP4 & EP2.2	***BCA DTS Provision*** Clause D1.4 states that the travel distance to the nearest exit must not exceed 40-metres. Clause D1.5 states that the travel distance between alternative exits must not exceed 60-metres. Clause E2.2 (inter alia Table E2.2a) requires large isolated buildings with a ceiling height above 12-metres and a floor area or volume more than 18,000m^2 or 108,000m^3 respectively to be equipped with an automatic smoke exhaust system. ***Non-Compliance*** The following DTS non-compliances have been identified in the warehouse. ▪ Travel distances of up to 73m to the nearest exit and 145m between alternative exits have been identified in the central parts of the warehouse; and ▪ A manually operated smoke clearance system shall be provided in lieu of the DTS required automatic smoke exhaust system. ***Alternative Solution*** The Alternative Solution will rely upon the volume of the warehouse enclosure to act as a smoke reservoir for hot combustion products with significant reserve so as to provide the population with adequate time to safely evacuate the building prior to the onset of untenable conditions. ***Assessment Methodology*** The assessment methodology will adhere to Clauses A0.5(b)(i), A0.9(b)(ii), and A0.10 of the BCA. The analysis will be absolute and quantitative where the results of the deterministic assessment are measured directly against the agreed acceptance criteria, with a supporting qualitative argument. Computational Fluid Dynamic (CFD) programs will be used to simulate the fire development and smoke spread in the warehouse with these results utilised in an ASET/RSET time-line analysis.

BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT	PERFORMANCE BASED SOLUTION
BCA DTS Provisions Clause E4.6 – Direction signs (inter alia AS2293.1: 2005) **Performance Requirement** EP4.2	***BCA DTS Provision*** BCA DTS Clause E4.6 (NSW) states that if an exit is not readily apparent to persons occupying or visiting the building, then exit signs must be appropriately provided in accordance with AS2293.1. AS2293.1 Clause 6.8.1 requires exit signs be mounted not less than 2m and not more than 2.7 above floor level. ***Non-Compliance*** The exit lighting design shall incorporate signage in the warehouse parts that are positioned above a height of 2.7m to permit the passage of picking machinery below. ***Alternative Solution*** The Alternative Solution shall rely upon the volume of the warehouse enclosures to provide for adequate time for building population to evacuate prior to the directional exit signs becoming compromised by the hot smoke layer. Further to this, the simplicity of the racking layouts and the familiarity of the occupants within the building shall provide for a rapid evacuation along familiar egress routes. ***Assessment Methodology*** The assessment methodology will adhere to Clauses A0.5(b)(i), A0.9(b)(ii), and A0.10 of the BCA. The analysis will consist of a qualitative discussion to demonstrate compliance with the relevant Performance Requirements. Further to the above the deterministic results of the CFD modelling shall demonstrate that the directional exit signage will not be obscured by the descending smoke layer prior to the completion of occupant evacuation, thereby permitting adequate and sufficient way-finding provisions to complete an evacuation.

8 PROPOSED FIRE SAFETY STRATEGY

The fire safety strategy outlined below has been proposed to satisfy the fire and life safety objectives specified for this project by the relevant stakeholders. In addition, the fire safety strategy is required to adequately address the specific fire and life safety hazards identified for the proposed development, and as such have been generally derived from the preventative and protective measures outlined within the BCA, and fire engineering literature and research. Where items of non-compliance have not been identified by the design team in the concept design it is considered that those items are expected to be Deemed-to-Satisfy (DTS) solutions.

The specified Fire Safety Strategy will undergo analysis as part of the Fire Engineering Report to ascertain whether the relevant Performance Requirements of the BCA are satisfied. The fire safety strategy will incorporate the following elements:-

8.1 EGRESS PROVISIONS

8.1.1 Evacuation Strategy

Activation of any sprinkler head or detector shall initiate the evacuation of all areas of the building. Dedicated fire wardens from the warehouse and office areas shall ensure that all clients, visitors, and staff are promptly evacuated.

8.1.2 Egress Provisions

The travel distances to a point of choice, to the nearest exit, and between alternative exits must be compliant with the BCA DTS requirements with the following exceptions listed hereunder and illustrated in:-

- Travel distances of up to 73-metres to the nearest exit in the warehouse; and
- Travel distances of up to 145-metres between alternative exits in the warehouse.

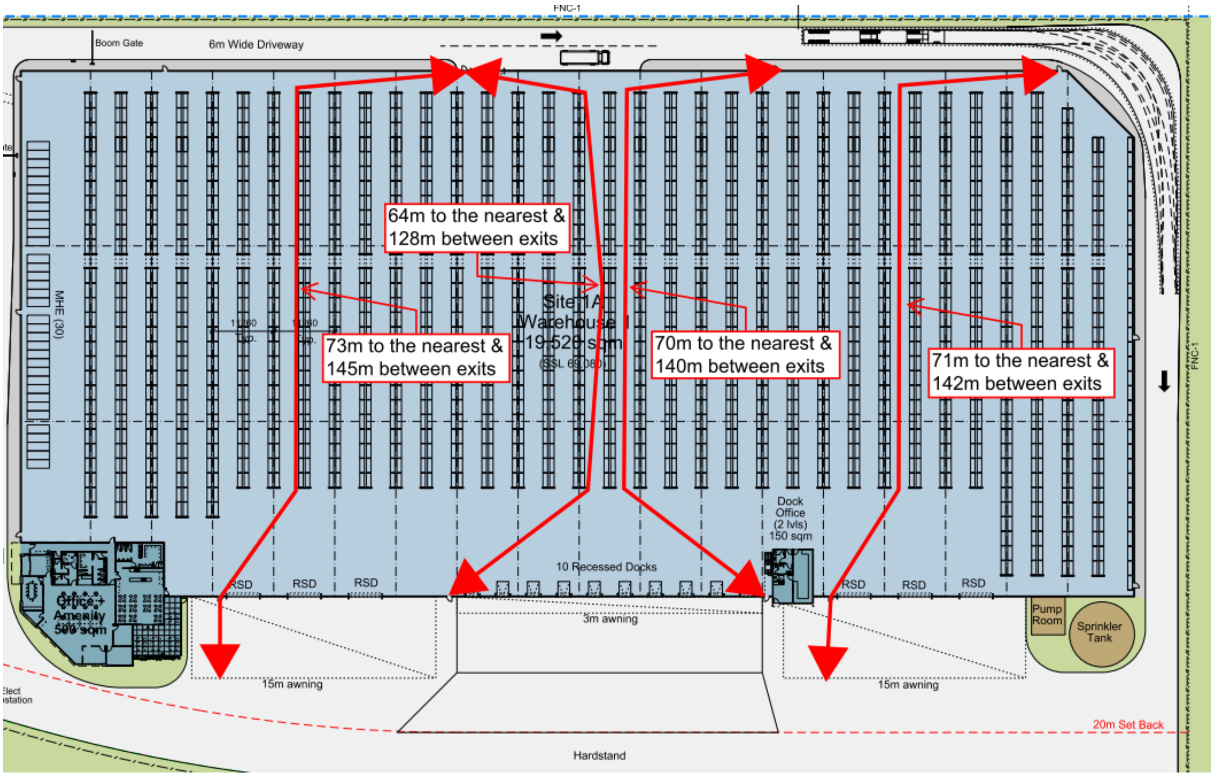


Figure 8-1: Warehouse travel distances

8.1.3 Door Hardware, Operation and Mechanisms

All exit doors and doors in a path of travel to an exit are required to be DTS compliant throughout. This includes the swing of doors, the applied latching and locking mechanisms and the force required mechanism used to open sliding doors.

8.1.4 Signage and Lighting

Emergency lighting is to be provided throughout in accordance with DTS Provisions E4.2 and E4.4 of the BCA 2012 and AS2293.1:2005.

Exit signage is to be provided throughout in accordance with the DTS Provisions E4.5, E4.6, E4.8 of the BCA 2012 and AS2293.1:2005, with the following exceptions listed hereunder:-

- Directional exit signs located at the eastern end of the racking are permitted to be situated in excess of 2.7m above finished floor level. Final exit heights are to be determined through CFD modelling.

8.2 PASSIVE FIRE PROTECTION

8.2.1 Type of Construction Required

The development shall be built in accordance with the BCA DTS provisions for Type C fire-resisting construction.

8.3 ACTIVE FIRE PROTECTION SYSTEMS

8.3.1 Fire Indicator Panels

The development shall be provided with a Main Fire Indicator Panel (FIP) at the entry lobby to the ground floor office, this shall also form the location of the fire control centre. The FIP shall be installed in accordance with BCA Specification E2.2a and AS1670.1:2004. The panel must be capable of isolating, resetting, and determining the fire location within the development.

- A red strobe shall be installed at the entry door to the FIP to alert arriving fire brigade personnel.
- The FIP must be connected to a direct brigade notification alarm and building occupant warning systems that shall both initiate upon fire detection by the sprinkler and/or smoke detection systems.
- Smoke clearance fan controls shall be provided at the FIP, if a separate fire fan control panel is provided it shall include a display to indicate the operation or otherwise of the fans.
    - The panel shall include clear signalling of the operational status of the fans. A local fire fan control panel shall include override controls of smoke clearance and supply fans.

8.3.2 Building Occupant Warning System

A building occupant warning system shall be provided throughout all parts of the building. The system shall be in accordance with the prescriptive requirements of Specification E1.5 and Clause 6 of Specification E2.2a of the BCA 2012 and AS1670.1:2004.

- The occupant warning system shall be connected to the FIP such that the alarm tone is sounded throughout all areas upon fire detection by the smoke detection or sprinkler systems.

8.3.3 Fire Sprinkler System

An automatic sprinkler system shall be provided throughout all areas of the building. The system shall be connected to the FIP such that upon detection of a fire the building occupant warning and the direct brigade alarm are initiated.

- In the office and beneath the warehouse awnings the system shall comply with BCA Specification E1.5 and AS2118.1:1999.
- In the warehouse a storage mode system shall be provided in accordance with BCA Specification E1.5 and AS2118.1:1999, with the sprinkler head location, spacing and design capacity in accordance with Factory Mutual Guidelines 2-0 and 8-9. Sprinkler activation temperature must be

no greater than 101°C and have a Response Time Index (RTI) of less than $50m^{1/2}s^{1/2}$ (i.e. fast response type).

8.3.4 Smoke Detection System

A smoke detection system shall be installed throughout the warehouse parts of the building in accordance with AS1670.1:2004 and spaced in accordance with BCA Specification E2.2a clause 5 (i.e. extended spacing 20m x 20m).

- The system shall be connected to the FIP such that upon detection of a fire the building occupant warning and the direct brigade alarm are initiated.

8.4 FIRST AID FIRE FIGHTING

8.4.1 Fire Hose Reels

Fire hose reel shall be provided throughout the building in accordance with Clause E1.4 of the BCA 2012 and AS2441:2005.

- Locations should be signposted and readily accessible to occupants. Use of facilities should be monitored for abuse, mistreatment and servicing. The fire hose reels shall be located within 4m of an exit and provide coverage to all areas of the building based on a 36m hose length with a 4m water stream (i.e. maximum 40m coverage from the hose location).

8.4.2 Portable Fire Fighting Equipment

Portable fire extinguishers are to be provided throughout in accordance with Table E1.6 of the BCA 2012 and selected, located, and distributed in accordance with AS2444:2001.

■ General office areas	Dry Powder (ABE type)	2.5Kg
■ Computer/server rooms	CO_2	3.5 Kg
■ Plant rooms	Dry Powder (ABE)	2.5 Kg
■ Designated exits	Dry Powder (ABE)	4.5 Kg
■ Adjacent each fire hose reel cabinet	Dry Powder (ABE)	4.5 Kg

8.5 FIRE BRIGADE INTERVENTION

8.5.1 Fire Brigade Rendezvous

The fire brigade rendezvous point shall be at the FIP in the fire control centre at the south-western corner of the building where all required tactical fire plans shall be provided.

8.5.2 Fire Hydrants

A fire hydrant system shall be provided in accordance with Clause E1.3 of BCA Part E1 and AS2419.1:2005. The system must be capable of providing coverage to all parts of the building based on a 30m (internal hydrant connections) and a 60m (external hydrant connections) hose length with an additional 10m water stream.

- Hydrant booster assembly is to be located at the main entrance to the site in a compliant location unless approved otherwise by the local fire authority.
- Flows and pressures are required to be achieved as per the current regulatory requirements.
- The site hydrant system is to be provided with a ring main. It is recommended that ring main isolation valves are external to the building and numbered with the corresponding numbers indicated on the blockplan at the booster assembly.
- Clear block plans (not less than A3 in size) shall be provided at the booster assembly. Further at the entries to the warehouse where an internal hydrant is to be used, a basic block plan is to be placed adjacent to each of the doors indicating the internal and intermediate hydrant locations (where provided).
- External hydrant connections shall be provided with the heat shields per the requirements of AS2419.1 (i.e. FRL 90/90/90 2m either side, and 3m above the hydrant connection point) or be setback more than 10m from the building.

- All connection points must be fitted with Storz hose couplings which comply with Clause 7.1 and 8.5.11 AS2419.1:2005. Further information is available from the FRNSW Guide Sheet No.4 '*Hydrant system connectors*' available at www.fire.nsw.gov.au.

8.5.3 Manual Smoke Clearance System

A manually operated smoke clearance system shall be installed to the warehouse areas in lieu of a DTS required automatic smoke exhaust system. The smoke clearance system shall be designed to achieve the following minimum performance requirements.

- Initiation switches shall be located on the FIP, or an adjacent panel, at the building entry.
- Signs alerting the Fire Brigade to the operation of the smoke clearance system must be provided.
- Fire rated fans and fire rated cabling shall be used and designed in accordance with NSW Fire Brigade Policy No.7 *'Guideline on Streamlined 144 Applications for Large Isolated Buildings'* (i.e. to operate at 200°C for a period of 60 minutes). This policy is available at http://www.fire.nsw.gov.au/gallery/files/pdf/guidelines/guidelines_large_isolated_buildings.pdf.
- System capacity must be capable of one enclosure air change per hour.
- It is recommended that multiple fans be provided and be evenly distributed to otherwise comply with the requirements of Specification E2.2b Clause 5 of the BCA.
- Adequate make-up air shall be provided at low level to facilitate the clearance systems designed operational capacity. The make-up air shall be provided at low level by:-
  - Permanently open natural ventilation louvers; and/or
  - Mechanically operated louvers that open upon activation of the fans. All motors and cables must be fire rated in accordance with NSW Fire Brigade Policy No.7 (i.e. to operate at 200°C for a period of 60 minutes).
  - If used for general ventilation, the air flow rate at any sprinkler head must be less than 1.5m/s and the system must shut down automatically upon any fire alarm, with manual override available to fire fighters.

8.5.4 Vehicular Perimeter Access

Vehicular perimeter access pathway shall be provided around the whole of the building. This shall be designed and constructed in all weather surface capable of supporting all FRNSW appliances in accordance with BCA Clause C2.4 and NSW Fire Brigade Policy No. 4 '*Guidelines for emergency vehicle access*', available at http://www.fire.nsw.gov.au/gallery/files/pdf/guidelines/vehicle_access.pdf.

- The egress pathway shall form a continuous access in a forward direction with a minimum unobstructed width of 6m and no part of its furthest boundary more than 18m from the building.

8.6 BUILDING MANAGEMENT PROCEDURES

The ongoing management of the building is as important in maintaining a high level of life safety as the provisions recommended during the design phase of the building.

8.6.1 Maintenance of Fire Safety Equipment

The fire detection system, fire sprinkler system, emergency warning, fire hydrants, hose reels, portable fire extinguishers, emergency lighting and any other fire safety equipment shall be tested and maintained in accordance with Australian Standard AS1851 or other relevant testing regulatory.

8.6.2 No Smoking Policy

A no-smoking policy shall be implemented and enforced through all internal areas of the building.

8.6.3 Housekeeping

A Fire Risk Assessment (FRA) or similar method should be adopted upon occupation to determine high risk areas, processes and fuel loads and instigate appropriate control measures. The FRA should be undertaken periodically or upon major alterations to the building layout or to the occupancy demographic or distribution.

8.6.4 Fire Drills and General Fire Safety Training

All fire wardens are to be trained in first-aid fire fighting and emergency response. All staff shall be inducted with a fire safety brief including the actions necessary on the activation of the building emergency warning system and the location of all emergency egress paths and fire exits.

In addition periodic fire drills should be undertaken and any lessons learned included in future fire safety procedures.

8.6.5 Evacuation Plan

An evacuation plan shall be developed in accordance with AS3745:2002. Standard fire orders should be displayed throughout the building.

8.6.6 Assembly Area

An assembly area is to be designated in a suitably safe and open location.

8.6.7 Fire Safety Manual

A fire safety manual shall be developed to provide an overview of all fire safety procedures and systems within the building. The manual will also record false alarms, outcomes from fire drills and provide details of the ongoing maintenance and inspection procedures. The manual should be reviewed annually and a lessons learned exercise undertaken. Any conclusions drawn from this exercise should be implemented into the fire safety procedures.

8.6.8 Premises Security

Arson is a major cause of industrial fires and malicious arson attacks may be well planned to overcome specific fire safety systems. The provision of adequate levels of security is a key parameter in reducing the number or effects of malicious arson attacks in any premises.

8.6.9 Hot Works Policy

A hot works policy should be put in place and rigorously enforced to ensure that all hot works, including grinding and welding, are managed to avoid the accidental ignition of fires.

9 REFERENCES

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APPENDIX A SITE LAYOUT