Warehouse and Distribution Facilities
Lot 2B Oakdale Central
Horsley Park NSW

Goodman
Level 17, 60 Castlereagh Street
Sydney NSW 2000

26 March 2015 | Final Issue | Report No. s131415(2B)_FSS_02

Fire Safety Strategy

Warehouse and Distribution Facilities

Lot 2B Oakdale Central

RAWFIRE
Fire Safety Engineering

Sydney
Suite 401, Grafton Bond Building,
201 Kent Street, Sydney NSW 2000
Phone | +61 2 9299 6605
Fax | +61 2 9299 6615
Email | sydney@rawfire.com

Melbourne
Suite 123, 757 Bourke Street
Docklands VIC 3008
Phone | +61 3 8616 0686
Fax | +61 3 8616 0690
Email | melbourne@rawfire.com

London
Suite 105, 40 Bowling Green Lane,
Clerkenwell
London, EC1R 0NE
Phone | +44(0) 203 384 0050
Email | london@rawfire.com

www.rawfire.com

RAW Fire Safety Engineering
ABN 73 746 163 281

Report Details

Project: Warehouse and Distribution Facilities, Lot 2B Oakdale Central, Horsley Park

Document: Fire Safety Strategy

Report No.: s131415(2B)_FSS_02

Report Revision History

REV	DATE ISSUED	COMMENT	PREPARED BY	REVIEWED BY
01	17/03/2015	Draft Issue	**Jun Liu** *PhDEng (Chemical Eng.).*	**Thomas Newton** *Adv. Dip. Mechanical Engineering, Master Fire & Safety Engineering*
02	26/03/2015	Final Issue		

Table of Contents

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.

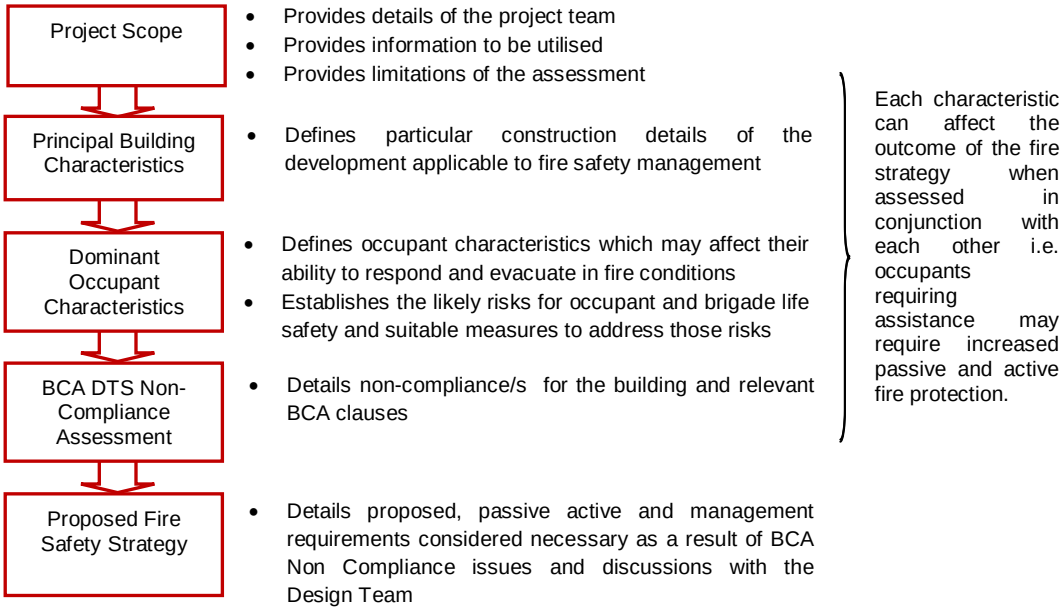


Figure 1-1: Fire Safety Strategy Process

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 assess 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

RAWFiRE Safety Engineering has been engaged to undertake a fire safety review of the new industrial development to be located on Lot 2B of the Oakdale Central Estate in Horsley Park.

The development is a storage and dispatch facility. The site shall constitute a single warehouse building with ancillary office, truck wash area and external onsite carparking.

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
Development Manager	Richard Seddon	Goodman
Principal Certifying Authority / BCA Consultant	Dean Goldsmith	Blackett Maguire + Goldsmith
Planning	Andrew Cowan	McKenzie Group
Architect	Greg Baird	SBA Architects
Fire Safety Consultant(s)	Jun Liu Thomas Newton	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:

- BCA Compliance Report for the S75W submission produced by Blackett Maguire + Goldsmith. Report No: 130335, dated 23 March 2015, Revision 02.
- Preliminary Hazard Analysis Report prepared by RAWRiSK Engineering. Report No. 20047_DHL_FinalPHA_26Mar15_Rev(0); dated 26 March 2015.
- Architectural plans provided by Greg Baird of SBA Architects, as indicated in Table 2-2.

Table 2-2: Drawings

REF	DESCRIPTION	REV
OAK DA-01	Cover Sheet & Title Page	G
OAK DA-02	Estate Masterplan	M
OAK DA-03	Staging Plan	C
OAK DA-04	Subdivision Plan	D
OAK DA-05	Estate Signage Plan	B
OAK DA-06	Land Use Plan	E
OAK 2B DA-20	Site Plan / Floor Plan	N
OAK 2B DA-21	Roof Plan	G
OAK 2B DA-22	Office Plans	E
OAK 2B DA-23	Dock Office Plans	D
OAK 2B DA-24	Elevations	E
OAK 2B DA-25	Sections	D
OAK 2B DA-26	DG Store	E

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 5.2. 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.
- 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

Principal Building Characteristics

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 DESCRIPTION

The development site is located in Horsley Park, approximately 40km west of Sydney's central business district. The site is located on Milner Avenue which is accessed from Old Wallgrove Road.

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 estate respectively. The estate layout illustrating the location of Lot 2B is detailed below.

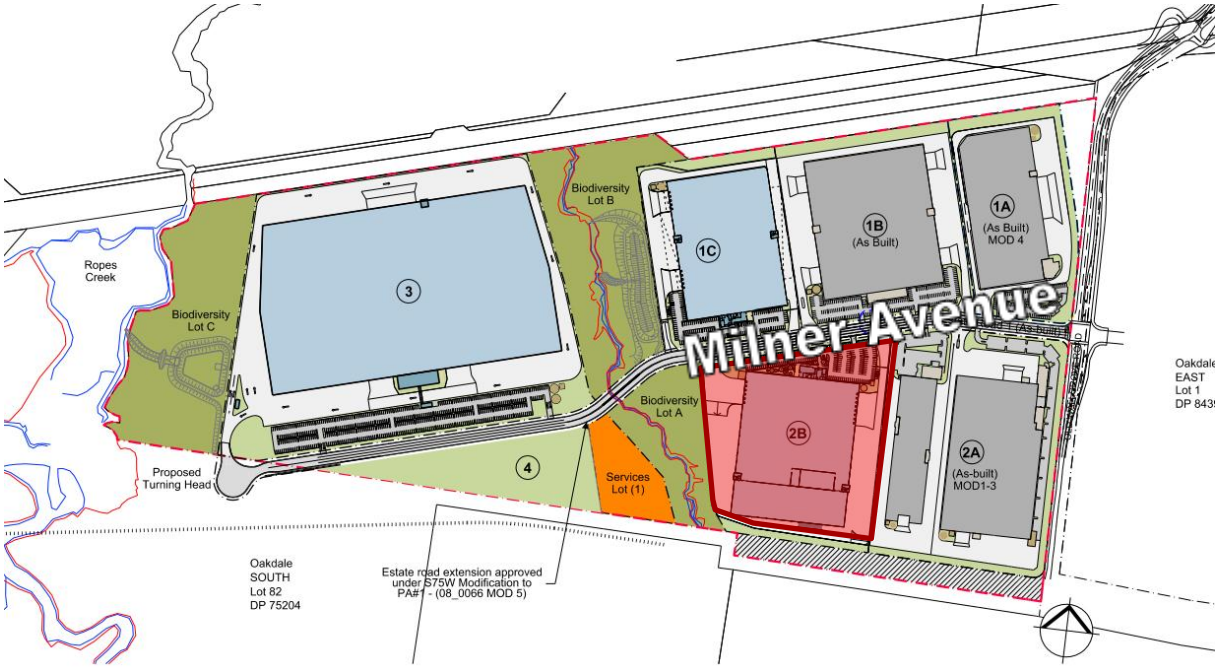


Figure 3-1: Site location

The Lot 2B building consists of a single warehouse with ancillary office, truck wash and external onsite carparking. It is considered a large isolated building for certification purposes and as such is provided with a sprinkler system throughout, smoke exhaust provisions and vehicular perimeter access around the building; of which the smoke exhaust and perimeter access is proposed to be rationalised through fire engineering.

The main entry to the building shall be via the administration office on the northern side of the building. The office shall contain two storeys and occupy a level of approximately 1,200m^2.

The warehouse has a floor area of approximately 29,480m^2 consisting of two portions; a temperature controlled area occupying 22,365m^2 that will maintain a temperature below 25°C and an ambient temperature area to the south occupying 6,885m^2.

Dispatch loading docks shall be located on the eastern and western sides of the warehouse with high level awnings extending up to 15m over the hardstand on each side of the warehouse.

Within the temperature controlled area are two receiving and dispatch dock offices. Each dock office consists of two levels and occupies a floor area of approximately 190m^2.

The building shall store a variety of stock that will change throughout the building's life. This development application has made allowance for the storage of the following Dangerous Goods items:-

- Class 2.1 (aerosols)
- Class 3 (flammable liquids)
- Class 5.1 (oxidising agents)
- Class 8 (corrosives)
- Class 9 (miscellaneous materials)

Storage of the dangerous goods shall be in high bay racking and located within a dedicated Dangerous Goods (DG) store. The DG store will be fire rated from the remainder of the warehouse and provided with an internal and in-rack fire sprinkler system, ventilation provisions, manual fire suppression measures with foam capabilities and other requirements as specified under Australian Standards 1940.

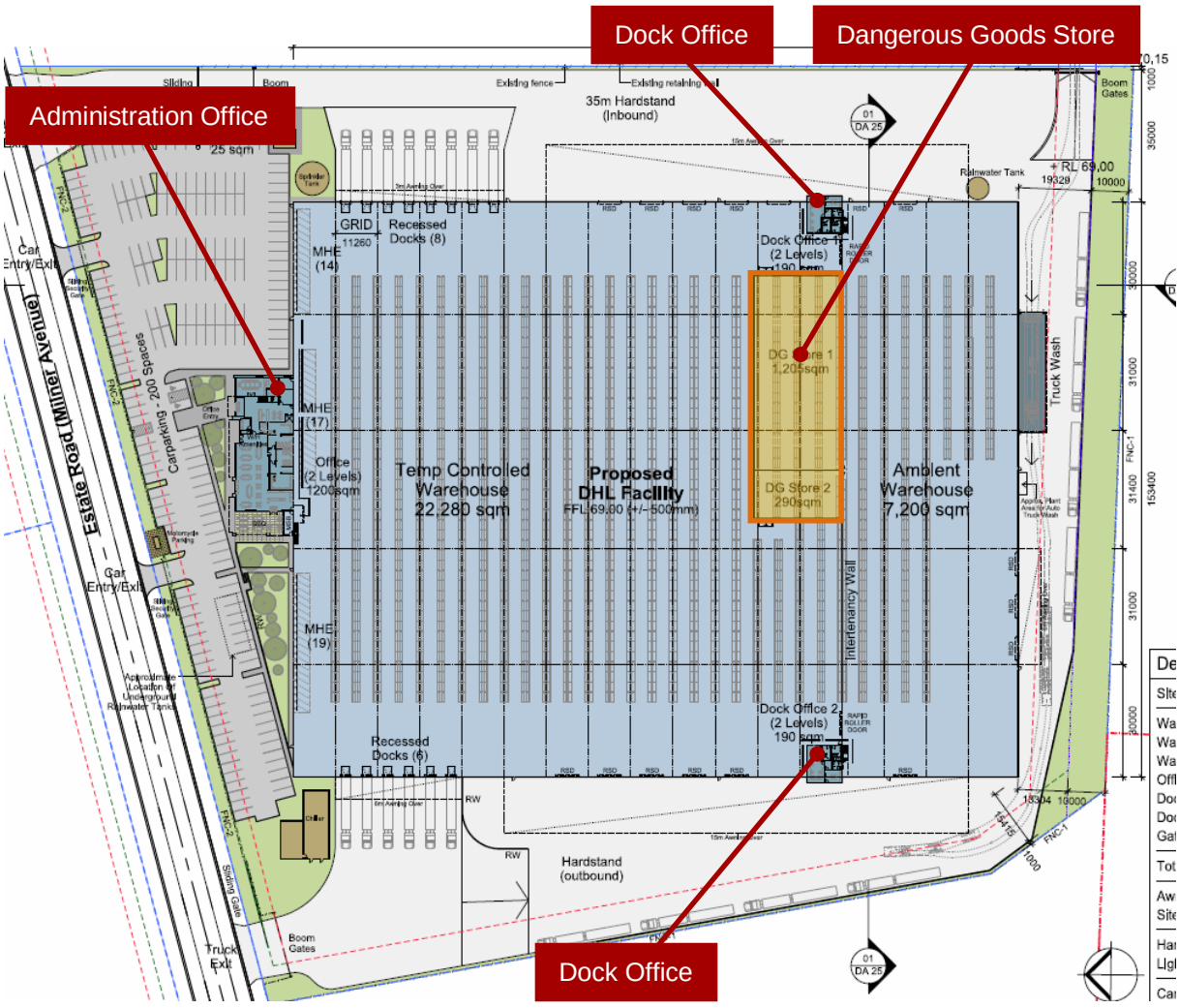


Figure 3-2: Site Plan

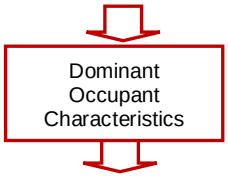
3.3 BUILDING CHARACTERISTIC ASSESSMENT

Table 3-1: Building Characteristics

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 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 building shall be constructed as a single fire compartment and is intended to be utilised for the temporary storage of stock prior to final dispatch. The warehouse shall have high-bay racking running in a single direction 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 opposite directions creating a barrier in determining the safest path of egress in a fire emergency. Exit doors are generally situated around the building perimeter providing occupants with multiple egress opportunities in the event of a fire emergency.	
Structure	Materials and finishes shall be in accordance with the DTS requirements for Type C construction. Construction materials will include masonry/concrete 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 Site occupies a floor area of 60,010m^2 and the building structures shall consist of a total floor area of 31,085m^2 with the following break-up:- ■ Warehouse: 29,480m^2 ■ Main office: 1,200m^2 ■ Dock office 1: 190m^2 ■ Dock office 2: 190m^2 ■ Gate house: 20m^2	
BCA Assessment	Classifications	Class 5 - Offices Class 7b - Storage facility
	Construction Type	Type C Construction *(Large Isolated Building)*
	Rise in Storeys	Rise in storeys of two (2) applicable to the office areas. **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	Less than 12m.

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

CHARACTERISTIC	DESCRIPTION
Population numbers	The number of occupants expected within the building is considered to be generally less than that assumed in the BCA Table D1.13 [1] due to the type of function and use. 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. ■ 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 building 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 and implementing decisions independently however may require assistance in locating the nearest and safest egress path in an emergency;

CHARACTERISTIC	DESCRIPTION
	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 buildings 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 within the building they are located 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 of the building they are located and the means of exits from these parts. General familiarity of their building as a whole and the location of main exits; and ■ ***Clients / visitors*** – may or may not be familiar with the building layout 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 within which they are located 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 HAZARDS AND PROTECTIVE MEASURES

5.1 OVERVIEW

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.

5.2 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 5-1: 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.

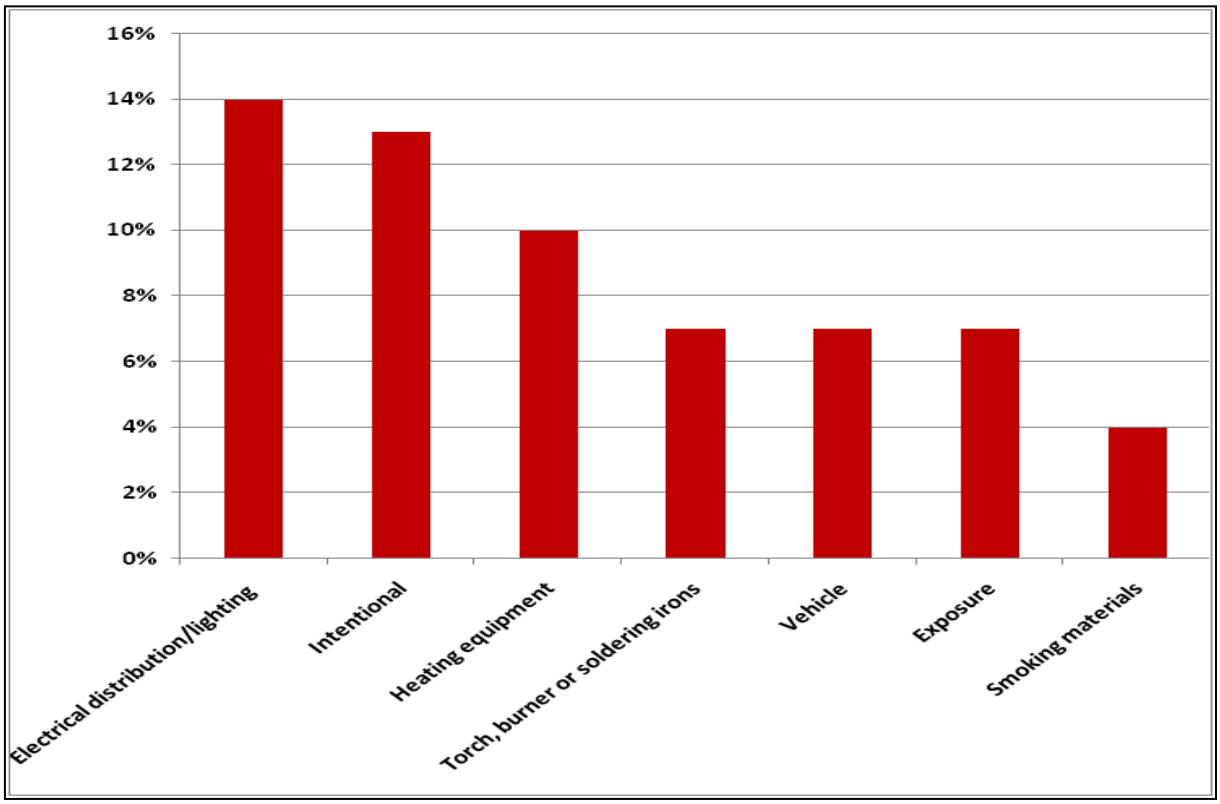


Figure 5-1 Leading causes of fires in warehouse (excluding cold storage) structures

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).

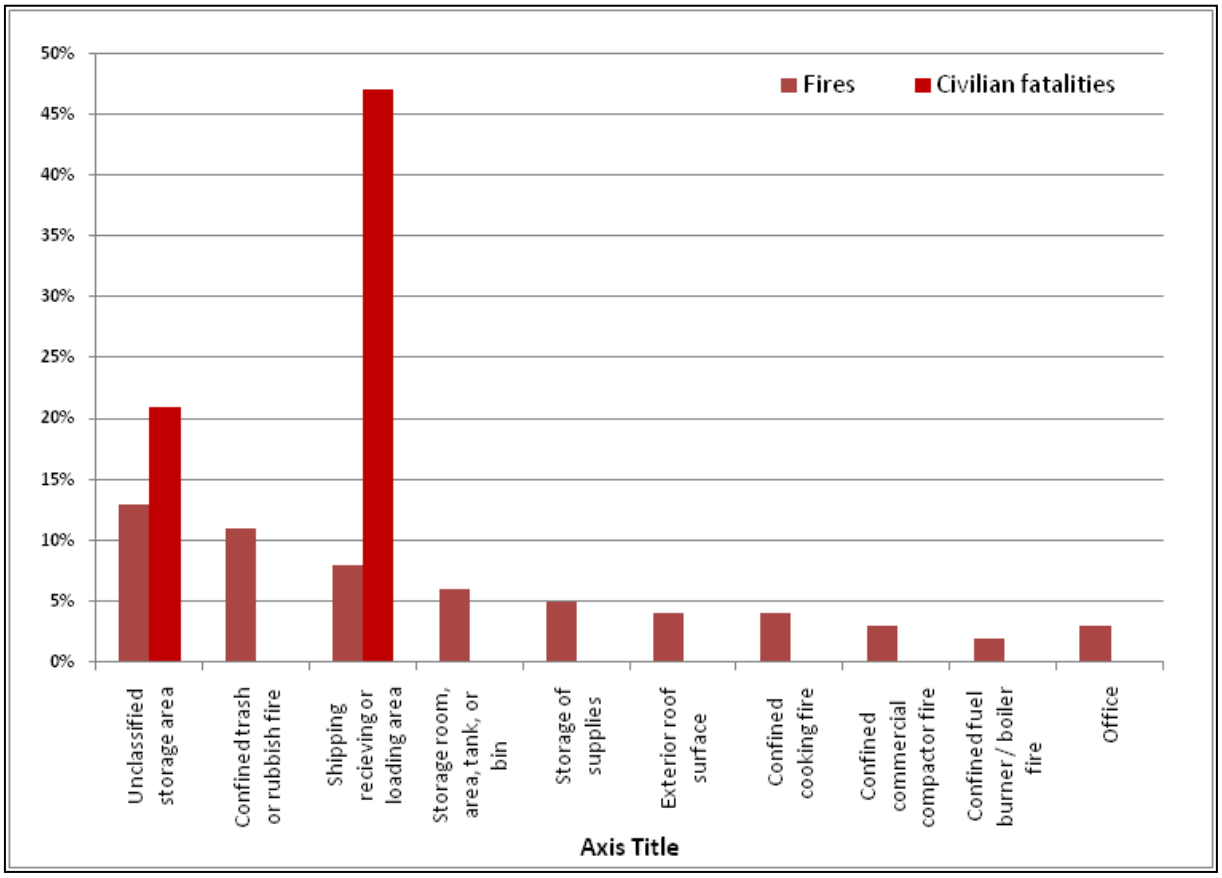


Figure 5-2 Structure fires in warehouse (excluding cold storage) structures by area of origin

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 5-2: 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 5-3: 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**

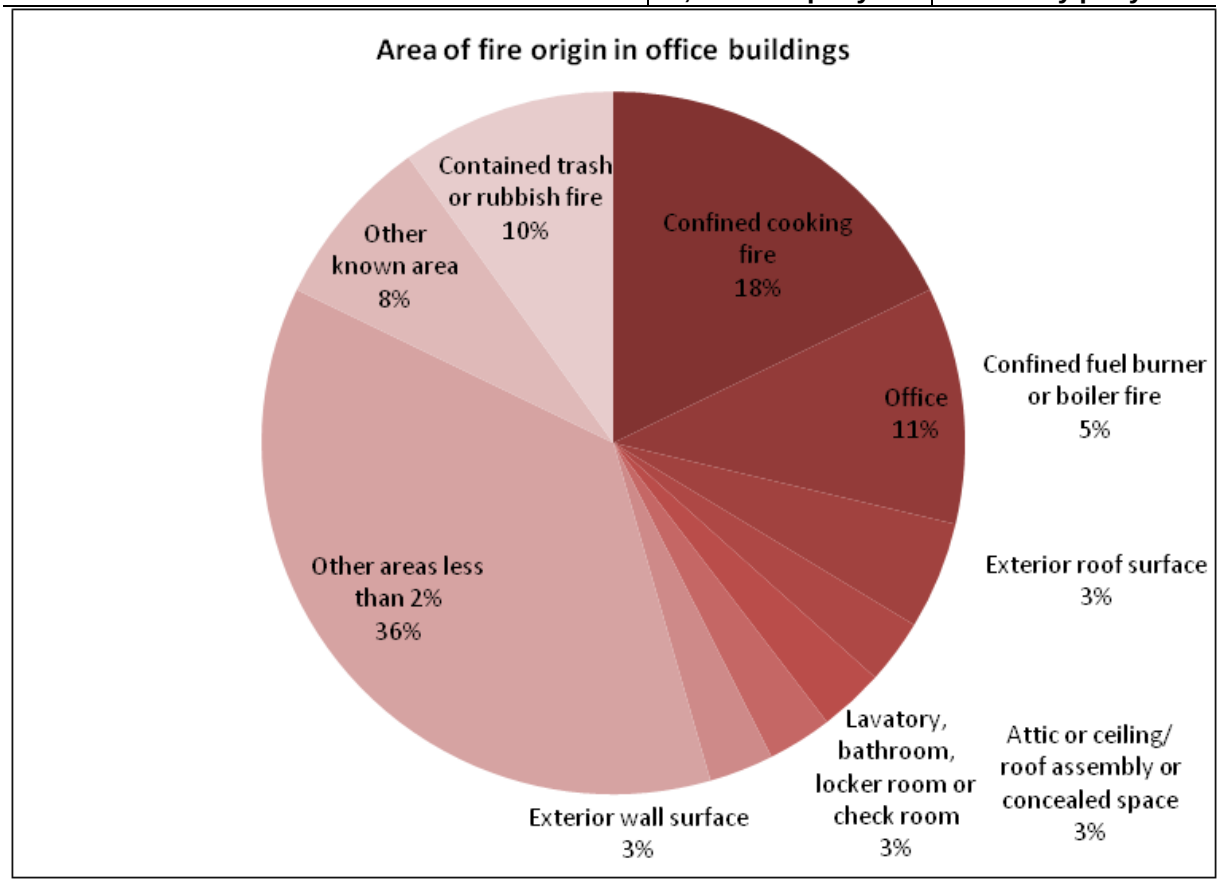


Figure 5-3: Area of fire origin in office buildings

Statistics shown in Figure 5-3 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.

5.3 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, *"loss history over the past twenty years indicates 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 5-4 lists the effectiveness of sprinkler systems in the event of a fire growing to a size that facilitates sprinkler head activation [10].

Table 5-4: 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 5-5: 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

5.4 FIRE LOAD

The fire load within a room or compartment will influence the duration and severity of a fire and resultant hazard to occupants.

5.4.1 General Storage Commodities

The expected fire load of the general storage commodities in the building have been estimated by consideration of the typical materials in that space.

The general storage commodities throughout the warehouse is 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. The fire loads listed in Table 5-6 have been extracted from Chapter 3.4 of the International Fire Engineering Guidelines [3]. This data is derived from Switzerland, however is also deemed applicable to buildings in Australia of similar use.

Table 5-6: 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 per metre stored height
Storage of paper	1000 MJ/m^2 per metre stored height

The IFEG indicates that average values should be multiplied by a factor of 1.35 to 1.65 to reach the 90% fractile value and for isolated peak values a factor of 2 should be used.

5.4.2 Storage of Dangerous Goods

Additional to the general storage commodity that will vary throughout the life of the building, the stock includes the storage and handling of several commodities that are classified as Dangerous Goods under the 'Australian Transportation of Dangerous Goods Code'. Additional items that are combustible but not deemed 'hazardous' such as household cleaning agents, dishwashing detergents, laundry powder, and disinfectants may also be stored within the building.

A Preliminary Fire Safety Study prepared by RAWRiSK Safety Engineering defines the maximum quantities of Dangerous Goods expected to be stored within the facility at any one time; these quantities are reiterated below in Table 5-7.

The storage of the Dangerous Goods shall be within the high bay racking and entirely contained inside a dedicated fire rated enclosure.

Table 5-7: Quantities of Dangerous Goods to be stored within the warehouse

CLASS	PACKING GROUP	QUANTITY (L OR KG)
2.1	N/A	30,000 kg
3	II	50,000 L
3	III	250,000 L
5.1	II & III	15,000 kg
8	II & III	20,000 kg
9	III	10,000 kg

It should be noted that many of the items classified as *Dangerous Goods* are not necessarily flammable and do not present a significant threat to increased fire ignition, fire intensity, or accelerated fire spread. For instance general Class 8 and 9 items are defined as being dangerous goods due to the impact they would have to the environment if released in high quantities into the air or water systems.

Table 5-8 provides summary of the Dangerous Goods expected in the building and the impact those specific Classifications would have in regards to fire ignition and fire spread.

Table 5-8: Generic Description of the Dangerous Goods Classifications that shall be present

ITEM	CHARACTERISTICS
Class 2.1 materials *(aerosols)*	This Class encompasses compressed gases, liquefied gases, dissolved gases, refrigerated liquefied gases, mixtures of one or more gases with one or more vapours of substances of other classes, articles charged with a gas and aerosols. Class 2 flammable gases are defined by dangerous goods regulations as substances which have a vapour pressure of 300 kPa or greater at 50°C, or which are completely gaseous at 20°C at standard atmospheric pressure. In this instance Class 2.1 aerosols shall be present in the building. Generally the base products have a high water content are alone are not highly flammable however those products are projected from a nozzle of the can using compressed liquefied petroleum gas (LPG). LPG is a flammable gas that is heavier than air. In the event of a can rupturing, the LPG could ignite resulting in a fire or explosion. The quantity of LPG in each aerosol can is generally relatively small (a maximum of approximately 80 grams) and as a result a fire from a single can would be localised and short in duration. The heat generated from a single can explosion could however also cause a chain reaction rupturing adjacent cans and facilitating in a series of small explosions.
Class 3 materials *(flammable liquids)*	Paint, paint related materials (e.g. thinners), lacquers, ethanol, perfume products, etc., are classified as Class 3 flammable liquids. Gels and foams may also be classified as flammable liquids, but are predominantly non-dangerous goods. Flammable liquids are defined by dangerous goods regulations as liquids, mixtures of liquids or liquids containing solids in solution or suspension which give off a flammable vapour (have a flash point) at temperatures of not more than 60-65°C. Flammable liquids contain component chemicals that vaporise when exposed to air. The vaporisation rate is a function of the ambient temperature at the time of the release, the temperature of the flammable liquid released and the flash point of the liquid. When released flammable vapours could form clouds that mix with ambient air that may ignite and burn forming a flash fire, explosion or pool fire over the liquid released. When a container is ruptured, the liquid will spill onto the stock below before forming a pool on the ground. This potentially flaming pool may then spread to the adjoining materials and facilitate in fire spread.

ITEM	CHARACTERISTICS
Class 5.1 materials *(oxidising agents)*	Oxidizers are defined by dangerous goods regulations as substances which may cause or contribute to combustion, generally by yielding oxygen as a result of a redox chemical reaction. Oxidising agents are manufactured in solid form (such as powders, granules or tablets) and liquid form (such as sprays, gels or foams). By themselves oxidising agents are not flammable or combustible and as a result pose no fire risk. However when introduced to a flammable or combustible material fire such as (e.g. pallets, packaging, etc.) the oxidising agent will act as a catalyst by providing additional oxygen to enhance the fire intensity.
Class 8 materials *(corrosives)*	Class 8 corrosive materials incorporate both acidic and alkaline substances. A corrosive material is a liquid or solid that causes destruction of a material when coming in contact for a specified period of time. Corrosives cause severe damage when in contact with living tissue or, in the case of leakage, damage or destroy surrounding materials. These materials do not pose a risk to fire ignition, however when released they may pose a threat to occupants in the building or the surrounding area, and the environment.
Class 9 materials *(miscellaneous)*	Miscellaneous dangerous goods are substances and articles which during transport present a danger or hazard not covered by other classes. This class encompasses, but is not limited to, environmentally hazardous substances, substances that are transported at elevated temperatures, miscellaneous articles and substances, genetically modified organisms and micro-organisms and (depending on the method of transport) magnetized materials and aviation regulated substances

The Preliminary Hazard Analysis prepared by RAWRiSK concluded that any potential fire risk presented by the Dangerous Goods items on site shall be adequately mitigated through the fire safety measures required under AS1940:2004 - *The storage and handling of flammable and combustible liquids*. This includes provisions for –

- The DGs store shall be bound by fire-resisting construction to prevent fire spread both too and from the store room.
- The enclosure shall be provided with mechanical ventilation to extract flammable vapours and maintaining the vapour concentration well below the lower explosive limit (LEL).
- Ceiling level storage mode sprinkler protection throughout the warehouse and the DGs store.
- In-rack (scheme A) sprinkler protection with solid shelving to the DGs store.

5.5 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.

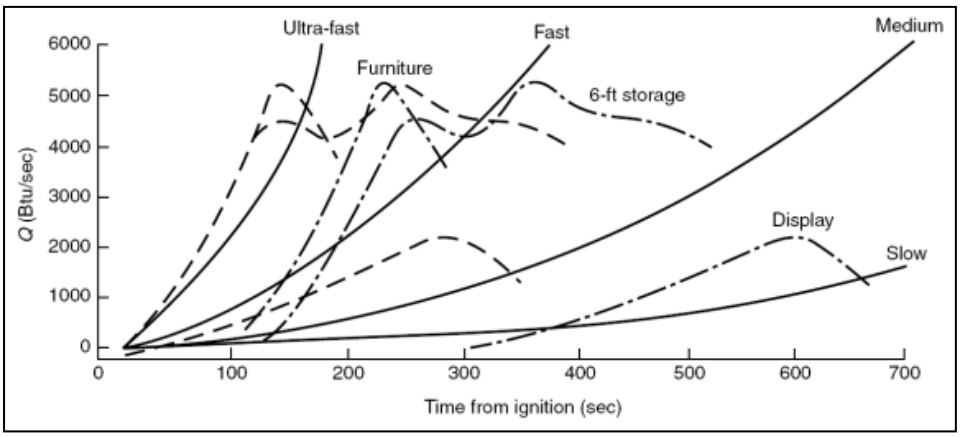


Figure 5-4: NFPA 92B: T-squared fire, rates of energy release

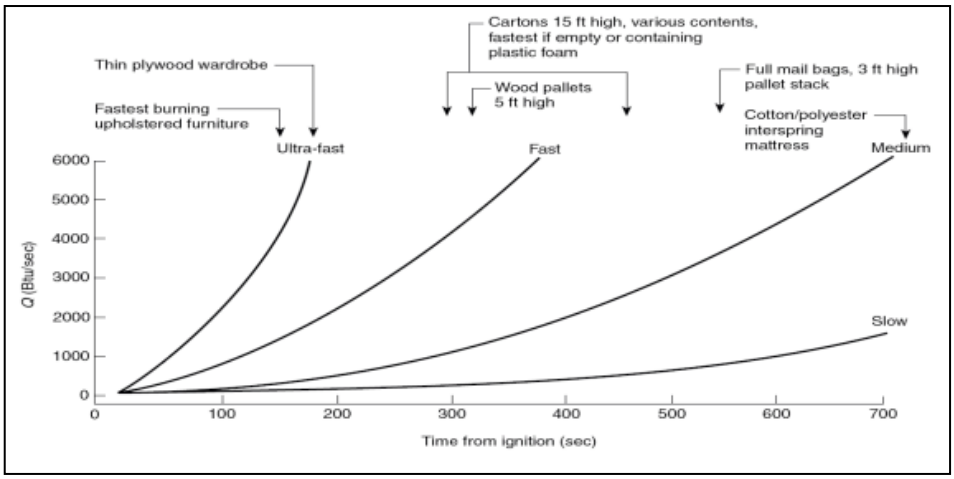


Figure 5-5: NFPA 92B: Relation of t-squared fires to some fire tests

The rate of fire growth can also be estimated from data published in British Standard (BS) 9999:2008 [5] as shown below in Table 5-9, and Table 5-10.

Table 5-9: 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 – 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 5-10: 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.

In regards to the Dangerous Goods items, it is expected that a fire would likely commence with the combustion of the cardboard or plastic packaging/wrapping and then spread to the flammable items within once the fire had reached an adequate size to compromise the storage container. It is assumed that a packaging fire would grow at an ultra-fast growth rate in a vertical manner up the high-bay racking. This is expected to be controlled upon activation of the sprinkler system. A similar conclusion was drawn from the Preliminary Hazard analysis, where it was stated that should the fie penetrate one of the Dangerous Goods storage containers, the in-rack and ceiling level sprinklers would resist further fire spread to adjoining racks.

Therefore any fire scenario should consider rapid fire growth until sprinkler activation; at which point further fire spread and growth can be assumed to be stagnate.

5.6 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.

5.7 FIRE HAZARD SUMMARY

Subsequent to a review of the relevant fire statistics and hazards presented in Section 0 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;

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

Table 5-11: Building Hazard Assessment

POTENTIAL HAZARDS DUE TO:	DESCRIPTION / DETAILS		PREVENTATIVE & PROTECTIVE MEASURES TO ADDRESS HAZARDS
Building layout	Egress provisions	Exits are generally provided around the building perimeter to allow for multiple alternative egress opportunities. However, due to the building size extended travel distances to the nearest of the alternative exits, and between alternative exits exist. Areas within the building have limited dead end travel routes to exits.	*Fire Safety Systems* ■ Type C Construction ■ Fire Hydrants ■ Fire Hose Reels ■ Fire Extinguishers ■ Fire Suppression System ■ Occupant Warning System ■ Smoke Exhaust System ■ Mechanical Ventilation System ■ Smoke Detection System ■ Fire Brigade Monitoring ■ Emergency Lighting ■ Exit Signage ■ Storage restrictions and separation requirements for the Dangerous Goods
	Fire exposure hazards	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 buildings have 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.	
Activities	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 buildings. The development is a storage facility likely to contain a large number of high piled and racking containing combustibles and dangerous goods and hazardous substances. With the storage of those goods it is likely that a range of hazards will be identified, the applicable and credible hazards relate to: ■ Spillage of goods and liquids; ■ Development potential of a flammable atmosphere; ■ Fire associated with the development of a flammable atmosphere. Risks associated with these hazards shall be identified and addressed in accordance with HIPAP and the site's Fire Safety Analysis. The fire protection equipment shall be designed so the equipment is appropriate to the type and class of dangerous goods stored. The fire protection measures implemented must be able to quickly control or extinguish a fire and prevent a fire nearby from affecting the store. In that respect the provision of a ceiling level storage mode sprinkler system with the provision of in-rack sprinkler in the DGs areas is deemed to be suitable for the particular commodity being stored (as tested by FM Global).		

POTENTIAL HAZARDS DUE TO:	DESCRIPTION / DETAILS		PREVENTATIVE & PROTECTIVE MEASURES TO ADDRESS HAZARDS
Ignition sources	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 ■ Forklift and picking machinery		
Fuel sources	Quantity of materials	The items stored in the facility shall include a variety of general cellulosic and food content as well as some flammable materials. Where aerosol cans are heated, they pose the risk of forming flammable projectiles accelerating fire spread to multiple areas in the warehouse. Flammable liquids pose a threat to spreading a fire on the stock below as the alight liquids spills from their containers. Flaming liquid pools also pose a threat, although minor due to size of the containers. There shall also be plastic containers (household/retail size) containing alkaline and acidic produce that when spilt may cause low levels of irritation to occupants and the surrounding environment.	
	Location of materials	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. The high risk DG items are stored within the dedicated DGs store.	
	Fire behaviour	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.	

POTENTIAL HAZARDS DUE TO:	DESCRIPTION / DETAILS	PREVENTATIVE & PROTECTIVE MEASURES TO ADDRESS HAZARDS
Fire origins	Refer to previous charts whereby fires are likely to occur in the following origins: ■ High storage racking areas. ■ Waste and rubbish containers. ■ Store room.	

6 BCA DTS NON-COMPLIANCE ASSESSMENT

6.1 OVERVIEW

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 6-1: Summary of Alternative Solutions

BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT	PERFORMANCE BASED SOLUTION
BCA DTS Provisions C2.4: Requirements for open spaces and vehicular access ***Performance Requirement(s)*** CP9	***BCA DTS Provision*** Clause C2.4: The building must be provided with continuous perimeter vehicular access with no part of the roadway less than 6m in width and no more than 18m from the building. The pathway must also permit the passage and operations of fire brigade appliances. ***DTS Non-conformance*** Access along Milner Avenue on the northern side of the site (adjacent the office/carpark) is greater than 18m from the building. ***Alternative Solution*** The acceptance of the above non-conformances is based on the following fire safety systems/measures provided. ■ Access is provided around the whole of the site and although not entirely within the allotment, continuous forward travel is available. ■ The areas greater than 18m from the building are accessible for pedestrians and smaller vehicles via the carpark hardstand and dedicated pathways. ***Assessment Methodology*** The assessment methodology adheres to BCA clauses A0.5(b)(i), A0.9(b)(ii) and A0.10 of the BCA based on an absolute approach, where a qualitative fire safety engineering assessment has been conducted using a system similar to the Delphi Technique to establish that the design matches the Performance Requirements. The assessment will, in consultation with Fire & Rescue NSW and project stakeholders, demonstrate that the configuration of perimeter access combined with the fire safety systems installed within the building ensure that fire fighting capabilities are not adversely disadvantaged.

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. Clause E2.2: Smoke hazard management ***Performance Requirement(s)*** DP4 & EP2.2	***BCA DTS Provision*** Clause D1.4: travel distance to the nearest exit must not exceed 40-metres. Clause D1.5: travel distance between alternative exits must not exceed 60-metres. Clause E2.2 *(Table E2.2a):* requires a large isolated building be provided with a smoke exhaust system with extraction rates as detailed in BCA Spec E2.2b and smoke zones no greater than 2000m^2. ***DTS Non-conformances*** The following non-conformances have been identified:- ■ Travel distances of up to 95m to the nearest exit and 190m between alternative exits exist in the warehouse in lieu of 40m and 60m respectively. ■ A rationalised smoke exhaust system shall be provided with reduced exhaust rates (one enclosure air change per hour) and consist of a single smoke reservoir in each of the two warehouse parts. ***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. An AS1670.1 smoke detection system shall be installed to the office levels with non-conformant travel distances to provide an earlier warning to occupants. ***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 warehouses with these results utilised in an ASET/RSET time-line analysis.
BC DTS Provisions Clause E1.3: Fire hydrants ***Performance Requirement(s)*** EP1.3	***BCA DTS Provision*** Clause E1.3 requires that a fire hydrant system is provided and installed in accordance with AS2419.1, which in turn requires internal hydrants to have the following measures:- ■ Be installed within 4m of an exit (additional hydrants permitted thereafter); and ■ Coverage achieved from a single hose length. ***DTS Non-Conformance*** Internal hydrants located beneath the warehouse awnings shall be treated as external hydrants, thereby allowing two hose lengths for coverage. ***Alternative Solution*** The hydrants located beneath the awnings are to have all the requirements of external hydrants per AS2419.1:2005 except in that they are located within the building footprint. That is:- ■ Provided with 90/90/90 protection ■ Use two hose lengths to achieve coverage ■ Located in (an area equivalent to) open space ■ Double connection points ■ Have hardstand adjacent to stage fire fighting equipment Additionally, fall back hydrants shall be provided to achieve DTS compliant coverage under the awning. ***Approaches and Method of Analysis*** The assessment methodology will adhere to Clauses A0.5(b)(ii), A0.9(c), and

BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT	PERFORMANCE BASED SOLUTION
	A0.10 of the BCA. The analysis will be comparative and quantitative in demonstrating that the fire hydrant system facilitates the needs of the fire brigade to an equivalent degree to a DtS compliant design.
BCA DTS Provisions Clause E4.6: Direction exit signs **Performance Requirement(s)** 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. ***DTS Non-conformance*** The exit lighting design shall incorporate signage in the warehouse that is positioned above a height of 2.7m to permit the passage of picking machinery below. ***Alternative Solution*** The Alternative Solution relies upon the volume of the warehouse enclosure 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 staff presence within the building shall provide for a rapid evacuation along obvious egress routes. ***Assessment Methodology*** The assessment methodology will adhere to Clauses A0.5(b)(ii), A0.9(b)(ii) and A0.9(c), and A0.10 of the BCA. The analysis will consist of a semi quantitative and qualitative comparative discussion to demonstrate compliance with the relevant Performance Requirements. The assessment will demonstrate that the risk associated with obscuration of the exit signs is equivalent to the risk in a DTS Solution.

7 PROPOSED FIRE SAFETY STRATEGY

The 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 building, 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 expected that those items are to meet the Deemed-to-Satisfy (DTS) provisions.

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:-

7.1 EGRESS PROVISIONS

7.1.1 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.

7.1.2 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 on mechanism used to open sliding doors.

7.1.3 Signage and Lighting

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

Exit signage is to be provided throughout the building in accordance with the DTS Provisions E4.5, E4.6, E4.8 of the BCA and AS2293.1:2005 with the directional signage at the end of the racking aisles and above block storage areas permitted to be installed at a height greater than 2.7m (up to approximately 4.5m above FFL).

- All directional exit signs above 2.7m from FFL must be ‘jumbo size’, with a minimum pictorial element size of 200 mm.

7.1.4 Egress Provisions

The travel distances to a point of choice, to the nearest exit, and between alternative exits must comply with the prescriptive BCA DTS provisions with the following exceptions identified and illustrated in Figure 7-1:-

- Travel distances of up to 95m to the nearest exit and 190m between alternative exits exist in the warehouse in lieu of 40m and 60m respectively.

Additional doors and racking walkthroughs shall be provided as necessary to ensured that occupant travel distances do not exceed the following limitation defined by Fire & Rescue NSW,

- *No point in a fire compartment is to be more than 100 m from a hydrant external to that compartment*.

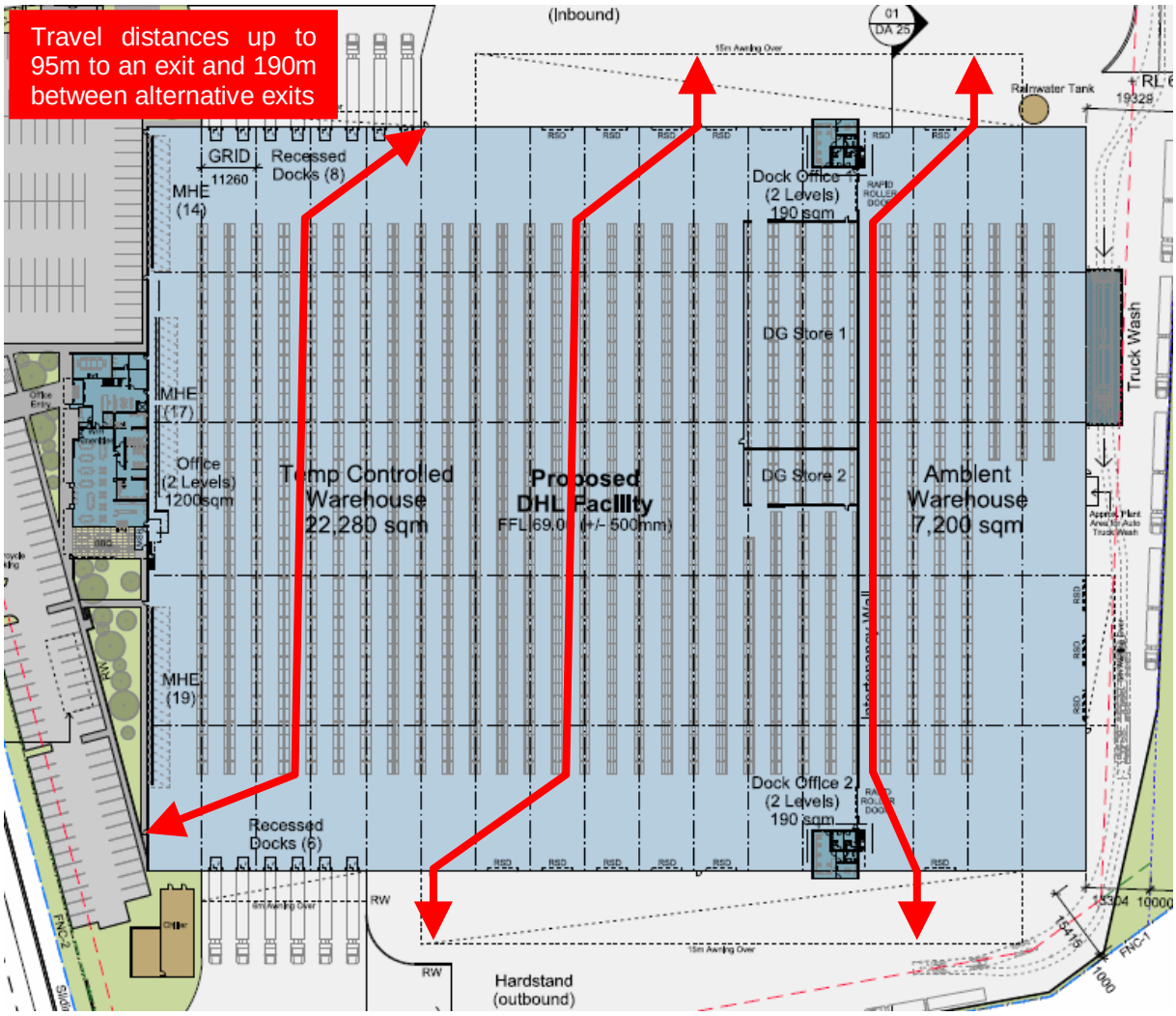


Figure 7-1: Approximate location of Non-Compliant Travel Distances within the Warehouse

7.2 PASSIVE FIRE PROTECTION

7.2.1 Type of Construction Required

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

7.3 ACTIVE FIRE PROTECTION SYSTEMS

7.3.1 Fire Indicator Panels

The building shall be provided with a Main Fire Indicator Panel (FIP) within a compliant Fire Control Centre in the main entry to the administration office.

The Main FIP must be installed in accordance with BCA Specification E2.2a and AS1670.1:2004 and have the following capabilities.

- The FIP must be capable of isolating, resetting, and determining the fire location within the building.
- A red strobe shall be installed externally at the main entry to the Fire Control Centre alert arriving fire brigade of the fire alarm origin and FIP location.
- Smoke exhaust fan controls shall be provided at the Main 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 any smoke exhaust and supply fans.

7.3.2 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 and AS1670.1:2004.

- The occupant warning alarm shall be sounded throughout all areas of the building upon fire detection by the smoke detection or sprinkler systems.

7.3.3 Fire Sprinkler System

A fire sprinkler system shall be provided throughout the building in accordance with the relevant regulatory requirements. The site shall have an independent system with dedicated fire pump, water supply tanks and booster assemblies.

- In the offices, beneath the warehouse awnings and within the truck wash the sprinkler 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 (or NFPA regulations). 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).
- The Dangerous Goods shall be provided with in-rack scheme A sprinklers in accordance with the Factory Mutual Guidelines 7-31.

Upon detection of a fire by any sprinkler system, the building occupant warning alarm shall be initiated throughout that building and the direct brigade notification signal activated.

7.3.4 Smoke Detection System

A smoke detection system shall be provided throughout the warehouse in accordance with Clause 5 of BCA Specification E2.2a and AS/NZS1668.1:1998. This system shall be programmed to operate the automatic smoke exhaust system, building occupant warning alarm and brigade notification alarm.

7.3.5 Automatic Smoke Exhaust System

An automatic smoke exhaust system shall be provided in accordance with the prescriptive requirements of BCA Specification E2.2b and AS/NZS1668.1:1998 with the following exceptions addressed through a fire engineered Alternative Solution:-

- The system shall have a rationalised smoke extraction rate of one (1) enclosure air change per hour.
- The exhaust system shall consist of two (2) smoke zones. Zone ‘A’ in the temperature controlled warehouse and Zone ‘B’ in the ambient controlled warehouse. Each system shall consist of a single smoke reservoir that exceeds $2000m^2$ (approximately $22,000m^2$ and $7,000m^2$ respectively).

The smoke exhaust system shall be designed to achieve the following minimum performance requirements.

- Initiation switches shall be located on the Main FIP, or an adjacent panel, at the office’s main entry.
- Signs alerting the Fire Brigade to the operation of the smoke exhaust fans must be provided.
- Fire rated fans and fire rated cabling shall be designed to operate at 200°C for a period no less than 60-minutes.
- If used for general ventilation, the air flow rate at any sprinkler head must be less than 1.5m/s.
- The system shall be connected to an essential power supply.
- 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 smoke exhaust system’s 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 to automatic louvers, vents or supply fans must be fire rated to operate at 200°C for a period of 60-minutes.

***Note** that manual opening of the dispatch rollers doors is not considered an acceptable method of achieving the required makeup air supply.*

7.4 FIRST AID FIRE FIGHTING

7.4.1 Fire Hose Reels

Fire hose reel shall be provided throughout the building in accordance with Clause E1.4 of the BCA 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).

7.4.2 Portable Fire Fighting Equipment

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

General office areas	Dry Powder (ABE type)	2.5 Kg
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

7.5 FIRE BRIGADE INTERVENTION

7.5.1 Fire Brigade Rendezvous

The site shall have a dedicated fire brigade rendezvous point at the fire control centre where the Main FIP and a set of tactical fire plans shall be located.

7.5.2 Fire Hydrants

A dedicated hydrant system, with independent booster assembly, must be provided to serve the site. The fire hydrant system shall be in accordance with BCA Clause E1.3 and AS2419.1:2005 with the exception of the following:-

- Hydrants located beneath the warehouse dispatch awnings are not required to be located within 4m of an exit and may be considered external hydrants in regards to system coverage.

The above shall be addressed through an Alternative Solution based on the following minimum design requirements.

- Hydrants located beneath the warehouse awnings are to have all the requirements of external hydrants except in that they are located within the building footprint. That is:-
  - Provided with 90/90/90 protection
  - Use two hose lengths to achieve coverage
  - Located in (an area equivalent to) open space
  - Double connection points
  - Have hardstand adjacent to stage fire fighting equipment
- Fall back hydrants shall be provided to achieve DTS compliant coverage of a fire under the awning. The proposed fall-back hydrant locations are illustrated in Figure 7-2.
- The systems must be capable of providing coverage to all parts of the building based on a 30m (internal hydrant connections) and a 60m (external hydrants and those under the warehouse awnings) hose length with an additional 10m water stream.
- As far as possible the hydrant system should consist of external hydrant points, with internal hydrants only provided to achieve coverage to those areas not able to achieve coverage from external hydrant points.

- Each system shall incorporate a ring main with isolation valves that are external to the building and numbered with the corresponding numbers indicated on the blockplan at the booster assembly.
- 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 hydrant connection points and the booster assembly 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.
- The hydrant booster assembly shall be located within sight of the office entry and adjacent one of the site's main vehicular entrances.

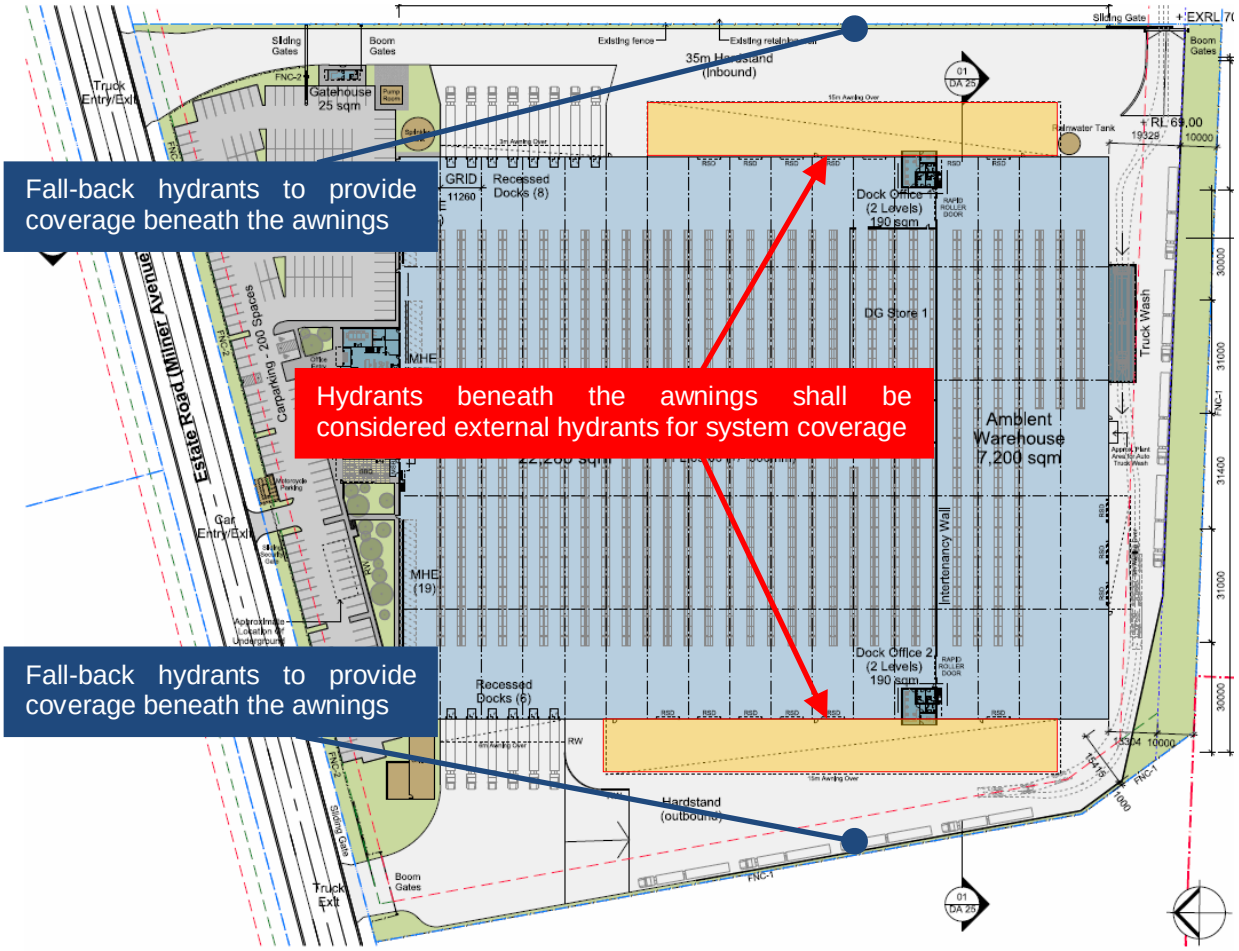


Figure 7-2: Hydrants under the awnings and fall-back hydrant requirements

7.5.3 Vehicular Perimeter Access

The vehicular perimeter access pathway shall be provided around the whole of the building. These 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 with the following exception permitted:-

- Access along Milner Avenue along the northern side of the site (adjacent the office/carpark) is greater than 18m from the building.

To facilitate the perimeter access non-conformances the following measures shall be provided as part of the Alternative Solution:-

- All gates, security fencing and boom gates shall be readily openable by the fire authorities. This can be achieved through one, or a combination of, the following –
  - Fitted with locks that are openable with a 003 key; and/or
  - Fitted with locks / latches that are openable with a master key, swipe or badge with copies of these keys/swipes/badges provided to the two local fire brigade stations; and/or
  - Mechanical gates and boom gates shall open on fire trip and power failure.

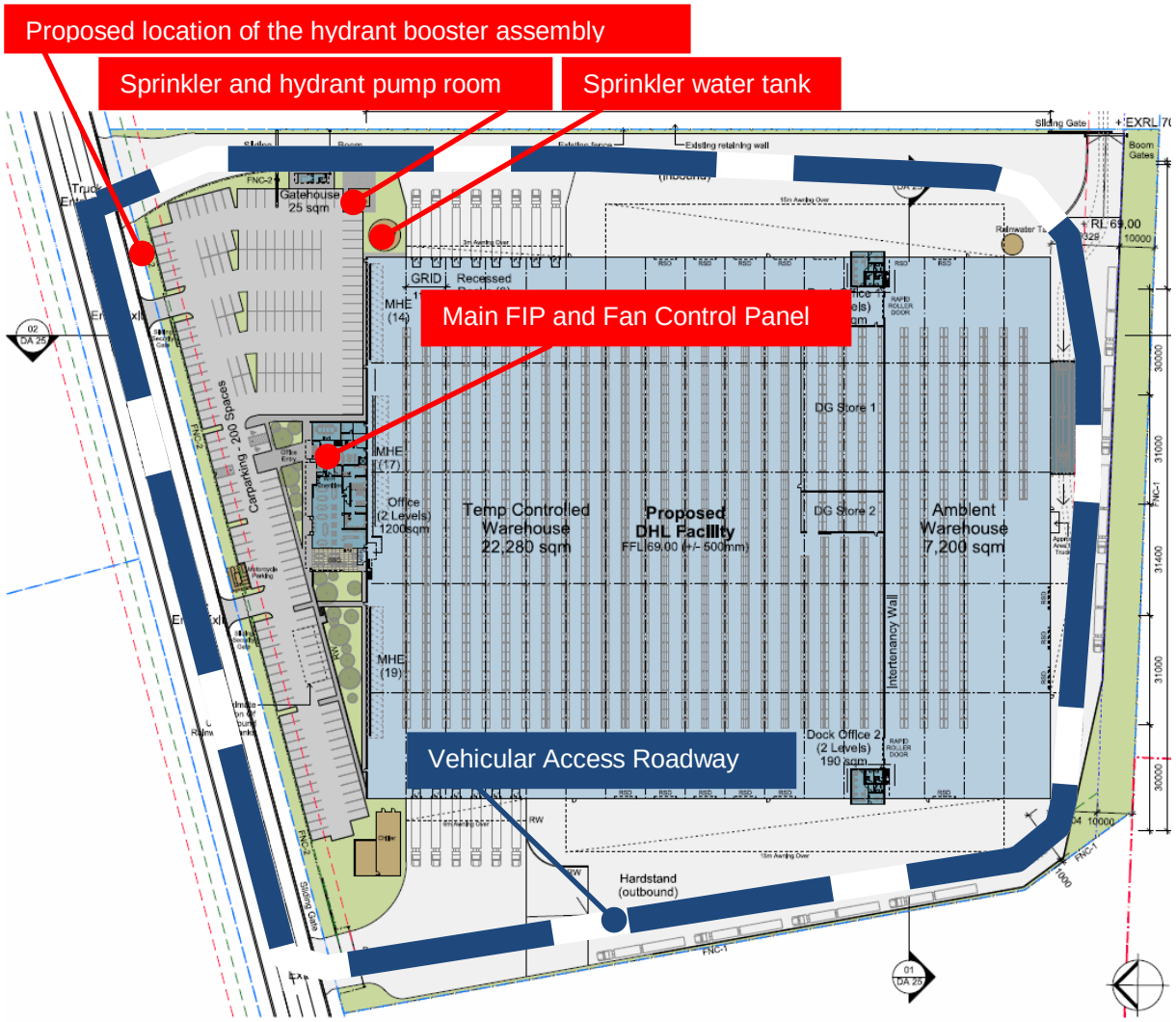


Figure 7-3: Site plan illustrating the location of fire services and fire brigade access roadway

7.6 PROTECTION OF THE DANGEROUS GOODS COMMODITY

7.6.1 Fire safety measures

Due to the storage of Dangerous Goods in the warehouse a Fire Hazard Analysis (FHA) shall be prepared to determine what, if any, additional fire safety measures are required for the development. Based on previous experience it is likely that the FHA will request the following –

- Fire hose reels with foam capabilities to combat the flammable liquid commodity.
- Additional dry chemical powder portable fire extinguishers.
- In-rack Scheme A sprinkler protection to the areas dedicated to Dangerous Goods.
- Fire rated storage enclosures to accommodate the DG stock.
- Mechanical ventilation to the DGs store rooms.

- Management in use provisions such as staff evacuation and fire suppression training and restriction on forklift speeds etc.
- Bunding requirements for the flammable liquids and aerosol storage areas.
- Flame proof forklifts.

7.7 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.

7.7.1 Maintenance of Fire Safety Equipment

The fire detection systems, fire sprinkler systems, emergency warning systems, 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.

7.7.2 No Smoking Policy

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

7.7.3 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.

7.7.4 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.

7.7.5 Evacuation Plan

An evacuation plan should be developed for the site in accordance with AS3745:2010.

Standard fire orders should be displayed throughout the building.

7.7.6 Fire Safety Manual

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

7.7.7 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.

7.7.8 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.

8 REFERENCES

1. ABCB, “Building Code of Australia, Volume One”, CanPrint Communications, Canberra 2014.
2. ABCB, “Guide to the BCA 2014”, CanPrint Communications, Canberra 2014.
3. ABCB, “International Fire Engineering Guidelines”, ABCB, Canberra, 2005.
4. The Chartered Institute of Building Services Engineers, ‘CIBSE Guide E, “Fire engineering’, 3rd Edition, May 2010.
5. Australasian Fire Authorities Council “Fire Brigade Intervention Model V2.2”, Australasian Fire Authorities Council, October 2004.
6. FM Global Data Sheet 2-0, Installation Guidelines for Automatic Sprinklers, March 2010.
7. FM Global Data Sheet 8-9, Storage of Class 1, 2, 3, 4 and Plastic Commodities, September 2010.
8. McGrattan, Kevin. “Sprinkler, Smoke & Heat Vent, Draft Curtain Interaction – Large Scale Experiments and Model Development” NISTIR 6196-1, National Institute of Standards and Technology, United States Department of Commerce, Gaithersburg Maryland, September 1998.
9. BS 9999: Code of practice for fire safety in the design, management and use of buildings, October 2008.
10. Technical Standard, “NFPA 92B: Standard for Smoke Management Systems in Malls, Atria and Large Spaces”, National Fire Protection Association (NFPA), 2009.
11. Technical Report FCRC-TR 96-02: Building Fire Scenarios – An analysis of Fire Incident Statistics, Fire Code Reform Research Program, March 1996
12. Marryatt, H.W., “Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886-1986”, Australian Fire Protection Association, Melbourne, Australia, 1988.
13. Rohr, KD 2003, “US Experience with Sprinklers”, National Fire Protection Association, Quincy, MA.
14. Technical Report FCRC-TR 96-02: Building Fire Scenarios – An analysis of Fire Incident Statistics, Fire Code Reform Research Program, March 1996
15. Flynn, Jennifer, “U.S. Structure Fires in Eating and Drinking Properties”, National Fire Protection Association, Quincy Massachusetts, February 2007.
16. Marty Ahrens, (2001) “U.S. Fire Problem Overview Report”, NFPA, Quincy, MA.