Fire Safety Requirements for Automated Vehicle Parking Systems

PROCEDURAL

GUIDELINE

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Review period

This position should be reviewed by the doctrine owner come 1 November, 2020.

Contents

Acknowledgements

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Source of authority

Approved by AFAC Council on 22 November, 2010.

Purpose

The primary objectives of this guideline are to:

- describe the specific issues affecting occupant life safety and fire brigade intervention within buildings incorporating automated vehicle parking systems due to an alternative method of vehicle storage;
- identify the limitations of the relevant building regulations in relation to building solutions that specify the use of automated vehicle parking systems, specifically the deemed to satisfy (DTS) Clause E1.5 of the Building Code of Australia (BCA);
- identify Clause E1.10 as a relevant DTS clause when designing for automated vehicle parking systems, due to the special fire hazards produced; and
- provide guidance to practitioners who design and certify building solutions that specify the use of automated vehicle parking systems.

Scope

The scope of this guideline relates to all classes of buildings that incorporate automated vehicle parking systems (AVPS).

Statement of engagement

AFAC's Built Environment Technical Group participated in the creation and review of this document. The review process was led by Brian Talbot (ACT ESA).

Audience

The primary audience for this guideline is practitioners who design and certify building solutions that use or intend to use automated vehicle parking systems.

Definitions, acronyms and key terms

In this document the following terms have specific meanings.

Automatic Vehicle Parking System/s (AVPS): a mechanical device that is generally powered by electric motors or hydraulic pumps that move vehicles into storage positions. Systems can be fully-automated or semi-automated, and they commonly store cars but can also be designed to store motorcycles and trucks. They can range from a storage capacity of one vehicle and up to over 1000 vehicles. Vehicles may be stored in a horizontal configuration, vertical configuration or a combination of both.

BCA: refers to the Building Code of Australia 2016 (BCA) and includes any amendment or replacement of the BCA as incorporated in the National Construction Code (NCC) series.

Carpark: has the same meaning as Clause A1.1 of the BCA.

Compliant: the AVPS complies with the Australian Standard AS1524 or its European equivalent, EN 14010. Compliance is evidenced through certification from a recognised third party from the country of origin and would be required by a building certifier.

Enclosed carpark: a carpark, other than an open-deck carpark, as defined in Clause A1.1 of the BCA. Carpark has the same meaning as 'vehicle park' throughout this document.

Fully-automated VPS: an AVPS that requires the driver to drive the vehicle into an entry / transfer area. When the driver and passengers have exited the vehicle and left the transfer area, the mechanical system transports the vehicle to a pre-determined parking space within the storage area / building. These systems are also commonly referred to as automated car storage systems, fully-automated car storage systems or parking towers.

Fire compartment: has the same meaning as Clause A1.1 of the BCA.

Fire hazard: has the same meaning as Clause A1.1 of the BCA.

Fire resistance level (FRL): has the same meaning as Clause A1.1 of the BCA.

Heat release rate: the rate in which heat is released by a fire.

Open-deck carpark: has the same meaning as Clause A1.1 of the BCA.

Safe, well considered access: refers to the firefighter access provisions provided with regards to an AVPS. Detailed planning and design is required to ensure firefighters have safe access, various access options and a means of safe retreat.

Storage area: the area where the vehicles are transported to and stored until they are required again by the driver, at which point they are retrieved and subsequently removed from storage.

Semi-automated VPS: an AVPS that is typically less sophisticated than a fully-automated VPS. Semi-automated systems usually involve the driver having to drive the vehicle into or onto the storage system before exiting the vehicle. Once the driver has exited the vehicle, these systems typically require the driver to operate a control panel and monitor the system until the vehicle is secured or housed in the storage position. The following systems typically fall into these categories:

- shifting pallet / platform systems
- stackers
- shufflers
- lift and slide systems
- park and lift systems.

Transfer / entry area: the area where the driver and passengers exit their vehicle and remove their applicable belongings, prior to the vehicle being automatically moved into the storage area. This area may also be referred to the as the loading area or drop-off /pick-up area.

Traverser: a component of an AVPS that has the ability to move vehicles both horizontally and vertically within the storage area. These components are also commonly referred to as:

- storage and retrieval units (SRU)
- shuttles
- transfer carriers
- travelling towers
- robots
- sliding Lifts

Vehicle lift: a lift that transfers vehicles between carpark levels or storage areas / levels. In a traditional carpark, a lift may be provided in the absence of a vehicular ramp. In these circumstances the driver usually drives the vehicle into the lift and remains within the vehicle while the lift moves between levels. Alternatively, a vehicle lift may be incorporated into an AVPS to move vehicles between storage areas and transfer areas. In this case the driver is not permitted to travel within the vehicle.

Vehicle storage arrangement: the vehicle storage configuration in relation to vehicle fuel loading and access. For example, horizontal vehicle storage arrangements or vertical storage arrangements as is the case where multi-tiered vehicle parking systems are utilised.

Introduction

Traditionally, vehicles stored in carparks have typically been parked in a horizontal configuration, meaning that only one vehicle is stored in a single parking space. However, the majority of AVPSs allow for multiple vehicles to be stored in a vertical configuration within a traditional single vehicle storage space.

Australian fire incident statistics reveal that stationary vehicle fires are considered likely events. The probability of fire spreading to more than one vehicle is also considered likely when vehicles are stored in a vertical configuration. The presence of fire in these instances results in the generation of dense toxic smoke and reduced visibility. This has the potential to significantly impact on the safe evacuation of occupants and quickly reduce firefighter access as well as impacting on fire control and extinguishment effectiveness.

In recent decades a number of factors have led to the increasing use of AVPSs. These reasons include, but are not limited to:

- scarcity of land available for developing has resulted in developers / designers having to look at alternative solutions in regards to how vehicles are stored;
- maximising the use of the physical space / land area available within a designated vehicle parking area;
- satisfying off-street parking requirements that may be imposed by local government planning permits;
- satisfying local or state government planning policies / initiatives;
- AVPSs are more cost effective to construct per vehicle space than it would be to construct in a traditional carpark;
- developers are able to offer more than a single vehicle parking space as part of a property sale / lease, or offer additional parking spaces for sale; and
- in some areas, increased traffic congestion and social trends have seen an increase in public transport use and a decrease in owner vehicle use. In these instances, the off street security and vehicle storage convenience of AVPSs may be appealing to those wanting to live close to public transport or inner city areas.

AFAC's guideline

Carpark fire safety research initiatives

In 1998, BHP Steel published its first edition of Economical Carparks – A Design Guide. In developing the guide, BHP Steel conducted a series of full scale fire tests. The purpose of the tests was to gain a better understanding of the effects of fire associated within carpark buildings. The document indicated that the series of fire tests BHP Steel had conducted, consistently demonstrated that when fire spread between vehicles occurred, large quantities of dense toxic smoke was generated and that occupants within a building would experience a significant degree of reduced visibility.

As a result of these tests, regulations in Australia began to prescribe that closed carparks are to be afforded sprinkler protection where more than 40 cars are proposed to be accommodated.

One of the most significant aspects of the BHP Steel publication is that the research itself was based on full scale fire tests where vehicles stored within a horizontal configuration only (e.g. cars parked next to one another). Cars stored in a vertical arrangement however, were not considered in the BHP Steel test.

In October 2009, BRE Research published a research project – Fires in Enclosed Car Parks – on behalf of the UK Department of Communities and Local Government. The aim of the research project was to gather information on the nature of fires involving recent model cars for inclusion into existing guidance on fire safety strategies for closed carparks. The project involved eleven full scale tests, including tests on single cars, multiple cars (horizontal configuration) and two cars stored in a vertical configuration, as found in most carpark storage systems (Test 11).

The following is an extract from BRE's findings as stated in their document titled BD2552 - Fire Spread in Car Parks (December 2010):

'The additional test that was carried out on a stacker with two cars showed that, in the absence of any fire suppression, fire would spread very quickly from the lower car to the upper car, developing into a very extensive and severe fire which might be expected to readily spread laterally to nearby cars.

The test deliberately did not allow for any collapse of the stacker structure due to failure of the hydraulics or due to steel weakening but this might happen in practice. The potential risks from car stackers are clearly a concern. Such innovations also have implications for fire fighters due to the very rapid development of fire in the second

car. The complexity of stacker structures may also cause difficulties in the application of firefighting water.'

The results of BRE Test 11 confirmed the suspected fire behavior and spread characteristics associated with this vehicle storage configuration. Accelerated fire spread and development were recorded along with the associated effects.

The current DTS fire safety solution does not consider the fire behavior demonstrated in Test 11. Therefore, occupant life safety and fire brigade intervention is potentially compromised, with respect to adequate time for safe egress in an emergency and time for search, rescue, control and extinguishment activities.

Occupational health and safety legislation

Each state or territory has obligations to ensure compliance with work health and safety / occupational health and safety acts, regulations and codes of practice. Designers of buildings and structures must ensure hazards and risks that may exist in workplaces are eliminated or controlled at design stage, so far as reasonably practicable. It is therefore important that designers recognise that in the context of a fire incident at a building or structure, the building or structure becomes the fire fighters workplace.

Planning compliance with the BCA

BCA performance requirements

The relevant performance requirements applicable to carparks incorporating AVPS have generally have been determined in accordance with the principles of Clause A0.7 of the BCA.

Relevant deemed-to-satisfy provision

The following deemed-to-satisfy provisions are generally considered to be applicable:

- E1.5 – Sprinklers (inter-alia Table E1.5 and Specification E1.5);
- E1.10 – Provision for special hazards; and
- E2.3 – Provision for special hazards.

Directly related performance requirement

Performance Requirement EP1.4 is considered to be directly relevant to the deemed-to-satisfy provisions identified above.

Indirectly related performance requirement

Performance requirements CP1, CP2, EP1.1, EP1.2, EP1.3, EP1.5, EP1.6 and EP2.2 are considered to be relevant to any aspects of a performance based design applying to the construction of closed carparks / vehicular storage areas.

Fire engineering analysis considerations

The current DTS provisions pertaining to carpark buildings do not correctly distinguish between the risk of vehicles stored in both a vertical and horizontal storage arrangement. In this context, an AVPS that stores vehicles in a vertical array is firmly outside the scope of Clause E1.5 of the BCA and must therefore be considered as a performance solution that is supported by suitably justified fire engineering analysis.

Vehicle fires in buildings, where vehicles are stored in a vertical arrangement, are likely to generate a larger heat release rate, potentially promoting untenable conditions in a shorter period of time (e.g. reduced time for occupant evacuation and fire brigade access and setup).

A multiple vehicle design fire scenario should be considered (fire development and spread), as the potential exists for fire spread to occur both horizontally and vertically. Therefore, a deterministic or probabilistic analysis should be utilised in the fire engineering analysis that is consistent with the principles of the International Fire Engineering Guidelines.

In addition to the above considerations, suitable factors of safety should be adopted to satisfy the relevant acceptance criteria for occupant life safety and firefighter tenability.

From a structural perspective, consideration should be given to the following issues when quantifying an appropriate duration for fire brigade intervention:

- local collapse of the building;
- structural failure of the AVPS structure;
- spalling of concrete elements; and
- the applied fire resistance levels (FRL) to structural members.

Operational firefighting concerns

The following section highlights some of the hazards involved with fighting vehicle fires within an AVPS so that designers can better understand the importance of providing safe, well considered access in addition to enhanced fire safety systems.

- Accelerated horizontal and vertical fire spread within the carpark / storage area potentially compromises fire brigade intervention times for search, rescue, control and extinguishment activities.
- More rapid development of heat and dense toxic smoke, subsequently limiting firefighting operations prior to the onset of fire-fighter tenability limits.
- Difficulties in applying effective firefighting medium to the seat of a fire that may be shielded by other vehicles, the AVPSs structural / mechanical components and building structural elements such as columns. At least two access points to the storage area should be considered, allowing firefighters an alternate means of attack when combating a shielded fire in a dense load storage configuration.
- Due to the nature of vehicle design and construction, a fire in a vehicle is typically very well shielded by body panels. During a fire, boot, bonnet and door release mechanisms are commonly damaged or unable to be accessed. This results in firefighters having to manually force boots, bonnets and doors and panels open with hand tools and hydraulic spreaders. Even in open areas such as a roadway where access is excellent these actions can easily result in injury due to the forces being applied. These risks are greatly exacerbated in an AVPS where vehicles are stored extremely close to one another, blocked by structural elements and stored at heights above or below the pedestrian level of egress.
- It is common for firefighting hoses to get caught under the tires of the vehicle that is being extinguished and other surrounding vehicles. This can result in sprains, strains and trips. These risks are compounded in an AVPS, as firefighters have to drag hoses and negotiate their way around other stored vehicles, through doors, around pillars, corners and the structure / components of the AVPS itself.
- Components containing liquid or gas under pressure such as shock absorbers, air conditioning systems and gas struts can explode or rupture violently when exposed to fire.
- A fire can result in the failure of park brake systems. In these instances a vehicle may become mobile.
- A vehicles fuel source is often the greatest risk to responding firefighters. In modern petrol fuelled vehicles, fuel tanks are most commonly made from high-density polyethylene (HDPE) plastic. These tanks can be quickly compromised under fire conditions resulting in free flowing liquid fuel fires, thus not only increasing the fire intensity but also spreading the fire to other areas.
- A fire involving a LPG (liquid petroleum gas) fuelled vehicle or a liquid hydrogen (fuel cell) fuelled vehicle can result in a boiling liquid expanding vapour explosion (BLEVE). This is a violent explosion caused by the rupture of a vessel containing a pressurized flammable liquid. A failure of either of these fuel systems can also result in a highly flammable gas leak.
- Electric / hybrid vehicles have the ability to significantly increase the fire intensity due to their large storage batteries. They require significantly more water to extinguish and are capable of reigniting hours later. There is also a real risk of electrocution to firefighters.

In addition to the above items, AFAC is concerned that the AVPS structures supporting the vehicles may fail and a vehicle may move or fall from its storage position.

Design considerations

Compliant with AS 5124 in the safety of machinery

A broad range of AVPSs are available from local and international suppliers. Along with such variation in suppliers and products comes differing levels of safety considered in the design, manufacture and erection of these systems. Compliance with Australian Standard AS 5124 is prerequisite for this guideline. This standard covers a list of hazards such as mechanical, electrical, thermal and noise and should be read alongside this guideline. Evidence of compliance with AS 5124 or its European equivalent must be provided for consideration of firefighter safety.

Appendix ZX5 of AS 5124 is an informative appendix to the standard. This appendix should be normative and applied as a requirement, it should be considered with equal regard to the body of the standard.

Fire sprinkler system design

All buildings incorporating an AVPS should be provided with an automatic fire sprinkler system, complying with AS 2118.1 (Part 1: General Systems) to serve the entire carpark / storage area.

An Ordinary Hazard 2 category sprinkler system as prescribed by AS 2118.1 has not necessarily been tested in association with the vertical storage of vehicles. The increased fire load may reduce the performance of the Ordinary Hazard 2 category sprinkler system (e.g. 5 mm/m over 144 m2). Therefore, the appropriateness of the sprinkler system, in terms of the schematic design, sprinkler spacing and locations, sprinkler spray technology and hydraulic requirements must be designed for the specific vehicle storage arrangement.

Important note: sprinkler systems are designed to control a fire, they may extinguish it but this is not the intent of the AS 2118.1. It is expected that firefighters extinguish the fire after sprinklers have controlled the fire and the heat release rate. The reason for this is that typically, a vehicle fire involves significant shielding from sprinklers. For example, a fire in the engine compartment of a vehicle will be shielded by the bonnet, guards and radiator.

The following design requirements should be implemented as an absolute minimum.

1. Sprinklers heads should be provided at the ceiling level and be designed as per OH2.
2. In addition to the sprinkles provided in Item 1 above, additional sprinkler heads should be incorporated within the vehicle storage bays (including pits). The design of these additional sprinklers should be based on a minimum of eight sprinkler heads operating. Hydraulic calculations should to be based on these eight sprinkler heads discharging simultaneously with the OH2 ceiling sprinklers. Thus, a minimum total of 20 heads discharging simultaneously is suggested.
3. Sprinklers incorporated within the storage bays should be positioned so that every corner of each vehicle space / bay is covered. These sprinkler heads should also be positioned at a height that is not heavily shielded or obstructed by the vehicle itself. Refer to Figures 1 and 2 for suggested placement positions and spray directions. The intent of these sprinkler heads is to contain the heat and flame from a burning vehicle and prevent fire spread sideways and upwards, this should be considered when designing head placement and direction.
4. Sprinklers should include fast response heads.

Consideration should also be given to zoning the sprinkler system in conjunction with firefighter access points. With the use of strategically placed flow switch, the system should be able to identify a certain point within the vehicle storage area where the sprinkler has activated. This should then in turn identify what level or area of the building firefighters should gain access to. For example, an activated sprinkler flow switch may indicate at the FIP that firefighters should respond to the 'Southern Vehicle Storage Access Point on Building Level 4'.

Alternative methods of fire suppression and detection

The use of alternative suppression mediums such as foam, mist and gas may be supported. However, support will be dependent upon research and design.

Designers are encourages to investigate alternative methods of detection that increases detection times and assists in pinpointing the area within an AVPS where the detection has occurred.

Fire compartmentation and building structural stability

In instances where a fully-automated VPS is proposed – due to the potential fire loads and intervention issues involved – the compartment containing the fully-automated VPS / storage area should be separated from the remainder of the building by barriers to fire such as walls and / or floors that achieve a minimum 240 minute resistance to the spread of fire. Any openings must be adequately protected.

All penetrations through building elements required by the BCA to achieve a specific FRL should be protected with fire collars and assemblies that have been tested in accordance with AS 4072.1 and AS 1530.4. Additionally, any ductwork and associated system componentry that is required to function in fire mode should not reduce the fire resistance of the construction element through which the duct(s) may pass.

The effects of fire loads on the structural adequacy of the building must also be considered (structural stability of the building).

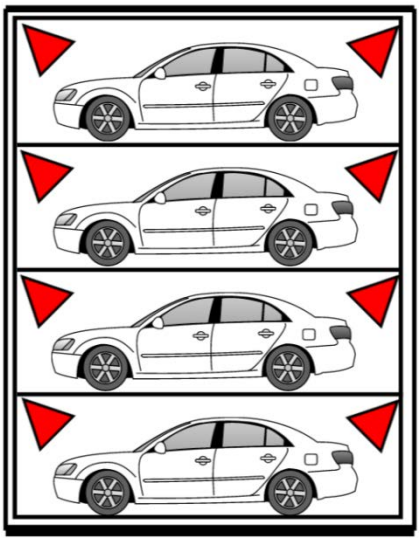


Figure 1: Sprinkler placement example

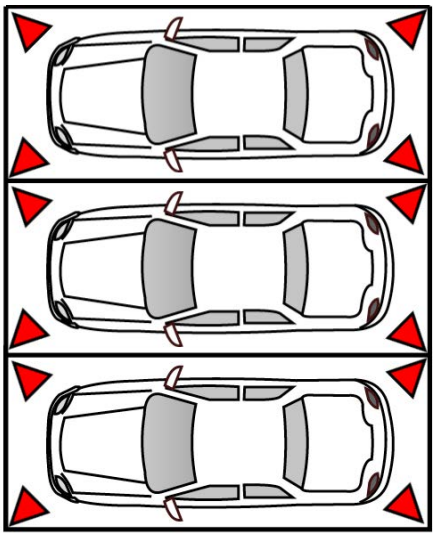


Figure 2: Sprinkler placement example

AVPS structural stability

With limited structural / thermal protection afforded to an AVPS under fire conditions, the likely fire intensity may cause structural failure of an AVPS or its supporting frame. In this instance the vehicle may roll or drop into other areas promoting further fire spread.

Calculations indicating the structural adequacy of the steel structure are required and need to be compared to Fire Brigade Intervention Model (FBIM) and the relevant fire brigade requirements.

Linings within the vehicle storage area

Any internal linings and the like, fitted to walls and the underside of ceilings within the vehicle storage area must be successfully tested to AS 9705 in accordance with AS 5637.1. The lining material must be fixed in accordance with the tested prototype. An example of an internal lining would be a product fitted to the underside of the vehicle storage area ceiling for the purpose of insulation.

Controlled automatic shutdown of an AVPS

Upon activation of a GFA, it is expected that the control and indicating equipment (or the FIP) will automatically initiate a controlled shutdown of an AVPS. This will assist with firefighter investigation and intervention, as well as reducing the potential for the system to move a vehicle that may be on fire.

In this context, building designers and the technicians who program the FIP and an AVPS are to implement the following system controls and enhancements.

1. Visual signals should be provided at the designated firefighter access points to the carpark / storage area and the fire indicator panel (FIP). These visual signals should indicate the status of the system, e.g. 'vehicle parking system operating' or 'vehicle parking system isolated'.
2. An AVPS should not automatically start back up when the fire panel has been reset. AFAC's concern is that a firefighter may be in the storage area when the fire panel is reset and that firefighter faces the risk of being crushed when an AVPS reactivates. Designers should consider a separate process for the reactivation of an AVPS that is undertaken by a trained authorised person.

In regards to a fully-automated VPS, it is recommended that designers incorporate the following additional functions upon activation of a GFA.

1. If the system is moving a vehicle at the time of a GFA then the vehicle should be automatically moved as a priority to an enhanced sprinkler protected area prior to the system shutting down.
2. Vehicle lifts should return to predetermined levels to act as void fall protection for firefighters potentially entering the area. For example, in buildings where a vehicle lift passed through a number of levels then the lift should return to the fire level where firefighters will be responding to protect / cover the lift void. See further discussion on this issue in section 10.12.10.
3. Consideration must still be given to accessibility and safety.

Power isolation to an AVPS (and identification / status)

Signage indicating the power isolation procedure and isolation locations should be provided at the FIP and designated firefighter access points to the carpark / storage area. Isolation points / breakers should also be clearly identified.

Considerations should be given to providing signals at the designated firefighter access points to the carpark / storage area and the fire indicator panel (FIP). These visual signals should indicate the status of the electrical systems within an AVPS area / storage area, e.g. 'electrical systems live' or 'electrical systems isolated'.

Fire hydrant design

Compliant fire hydrant coverage should be achieved within an AVPS and storage areas in accordance with the BCA and AS 2419.

If compliant coverage is not achieved, then depending on the final design and fire-fighter accessibility, additional fire hydrants may be required to be installed within the vehicle storage area. This may require significant consultation with the relevant fire service to determine the site specific 'operational requirements'.

Furthermore, as per AS 2419, the fire hydrant system performance should also be validated given the potential for a multiple vehicle fire.

Occupant warning system

As per specification E1.5 of the BCA, the sprinkler system must be interfaced to initiate the operation of an occupant warning throughout all areas of the building or SSISEP, where it is installed.

Ventilation design

Smoke exhaust / natural venting will also need to be provided at the highest level and / or along the façade of the vehicle storage system. Ventilation is required to ensure visibility is maintained in the event of fire. Preference would be for natural venting as it may also be utilised for fighting a fire from the outside of the building depending on the site access.

The performance criteria and fan selection of any mechanical system should meet the smoke exhaust system requirements under specification E2.2b of the BCA and adhere to relevant standard AS 1668.1, with consideration of the system having fire rated fans, cabling and controls that do not hinder sprinkler activation. With respect to any metal ductwork, and the likelihood of that ductwork deforming, suitable passive protection should be provided (e.g. fire rated board material) to encase the entire metal ductwork. Additional protection of the ductwork will increase the reliability and robustness of the overall smoke exhaust system.

Natural ventilation should encourage designs that have cross flow on opposite walls of the vehicle storage compartment, with at least 50% openings. Mechanical ventilation should be encouraged to adhere to the relevant AS 1668.1 standard with consideration of the system having fire rated or fire separated fans, cabling and controls that do not hinder sprinkler activation.

The design must demonstrate that;

- conditions within the carpark / storage area permit fire-fighters to undertake search and rescue;
- fire-fighters must be able to locate the seat of a fire and commence primary containment and extinguishment operations; and
- fire-fighters must be provided with appropriate controls to operate a mechanical exhaust or ventilation system.

Access and egress requirements for firefighters

Section 5.12 and its subsequent sub sections relate to the provision of access and egress requirements for firefighters.

Scenarios requiring the response of emergency services personnel and potential access into an AVPS / storage area may include:

- rescue of persons or animals trapped within a transferred vehicle;
- rescue of staff members or maintenance workers trapped or suffering a medical emergency within the AVPS / storage area;
- emergency situation (fire/fuel leak/chemical leak/ structural collapse/etc.);
- investigation of activation of FIP (accidental false alarms);
- fire Investigation Analysis (post fire); and
- emergency lift shall be provided for effective height exceeding 25 m.

Accessing the storage area

Two separate firefighter access points into the vehicle storage area should be provided at each pedestrian access level (refer to Figures 3 and 4). This provides an egress contingency and assists in firefighter access and intervention.

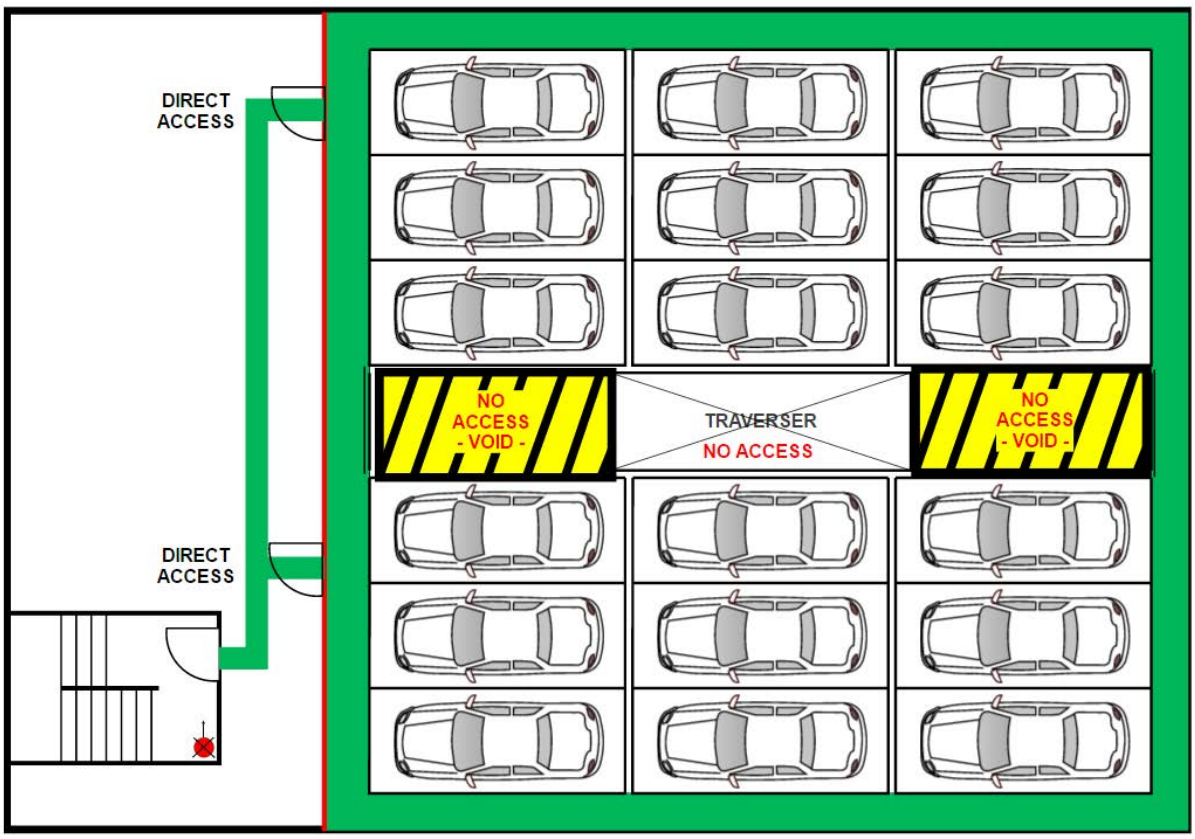


Figure 3: Vehicles stored no greater than 3 vehicles deep from the safe pedestrian access area.

Any door leading into the vehicle storage area should achieve a fire rating of -/240/30 and be provided with smoke seals.

Each doorway must permit entry by a firefighter wearing a breathing apparatus and carrying a telescopic 'jumbo' ladder or other firefighting equipment.

In regards to fully-automated VPS, any doors leading into vehicle storage areas should be locked and be only accessible by attending fire brigade and maintenance personnel.

Storage depth restrictions

Vehicles should be stored no deeper (horizontally) than three vehicles deep from the safe pedestrian access area (refer to Figure 3 where no part of any vehicle storage bay shall exceed 30 m from an internal hydrant. And where no pedestrian access level is provided to every vehicle storage bay, the maximum distance measured from the staircase door / pedestrian access path to the most remote part of the vehicle storage bay shall not exceed 10 m.).

This restriction relates to the following:

- the limitations of a standard water spray from a fire hose;
- the amount that a vehicle shields/blocks a water spray from the safe pedestrian access area to the furthest most vehicle; and
- the amount of manoeuvring required by a firefighter to physically access the furthest most vehicles and the associated evacuation from this confined area.

Storage level restrictions

Safe pedestrian access should be provided to every vehicle storage level. However, at an absolute minimum, safe pedestrian access must be provided to every 3rd vehicle level (vertically) of the vehicle storage area. In designs which incorporate higher vehicles, such as SUVs being stored on top of each other, then pedestrian access should be provided to every 2nd vehicle level in these areas (Refer to Figure 4).

A concrete slab floor should be provided at this pedestrian access level. However, if this is unachievable then access must be provided by way of a compliant gantry system. Gantry system shall include balustrade / handrails on both sides (where necessary) to prevent fall.

Note: When used, gantries should be galvanised for reliability and longevity. ChemSet style anchoring systems should not be used due to the tendency for these products to fail under fire conditions (AS 1735 should be used when specifying anchoring requirements).

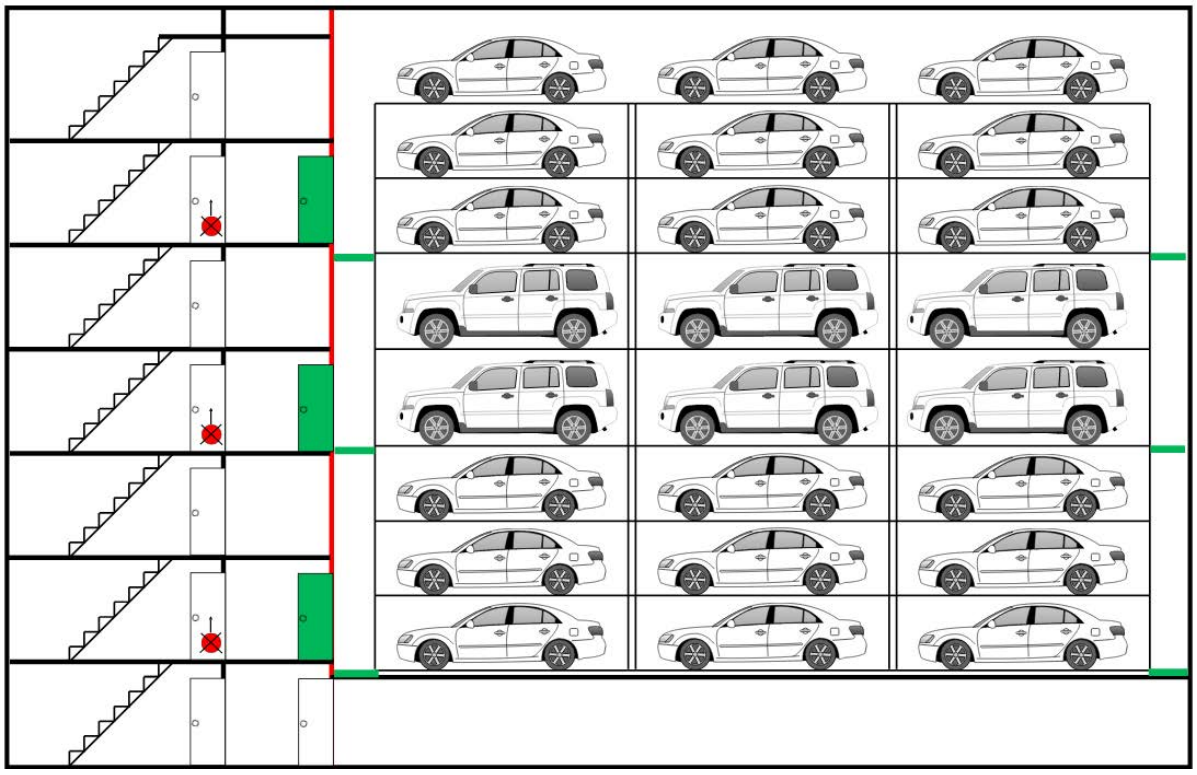


Figure 4: Pedestrian access at minimum every 3rd vehicle level for sedan levels and at least every 2nd vehicle level for SUV levels.

Accessing a gantry level

Where a design includes an internal gantry system, the gantry level should be accessed directly off an adjacent building floor level.

If it is not achievable to provide access to a gantry level off an adjacent building floor level, and all design options have been exhausted, then access between the access level and the internal gantry level may be provided by way of a permanent safety ladder, compliant to AS 1657 (refer to additional clearance requirements in the following section). Depending on the length of these ladders they may be caged or uncaged, as detailed in AS 1657.

This type of design restricts intervention and does not offer an evacuation contingency, as such this design should only be considered as a last resort.

Pedestrian access must be provided from the entry door to the permanent ladder. Pedestrian access is to be interpreted as the ability to walk up to the ladder without obstruction.

Note 1: A permanent ladder can only be used in an access design to ascend from a direct pedestrian access level to a gantry level above. It cannot be used to descend to a lower level.

Note 2: Ladders should be galvanised for reliability and longevity. ChemSet style anchoring systems should not be used due to the tendency for these products to fail under fire conditions (AS 1735 should be used when specifying anchoring requirements).

Note 3: The provision of on-site portable ladders is not considered as an acceptable means of fire fighter access.

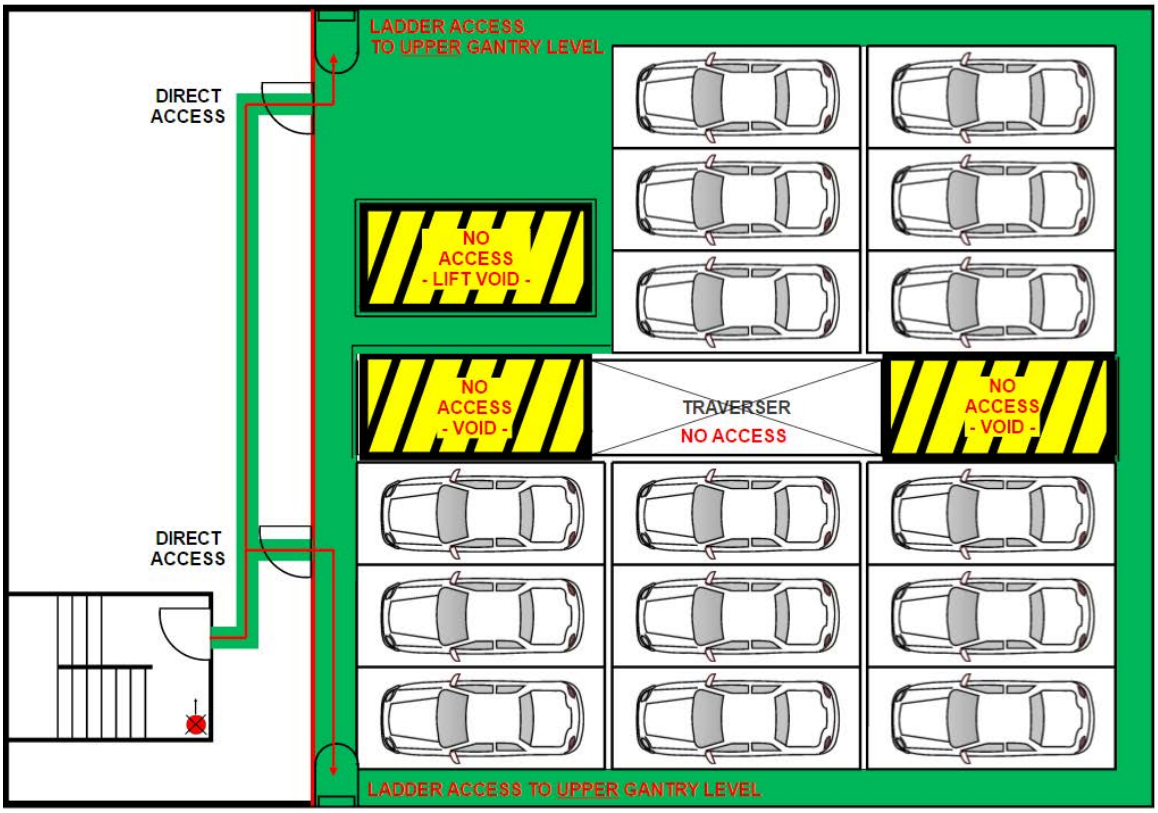


Figure 5A: AVPS level with direct pedestrian access, showing access to higher levels by permanently attached ladder.

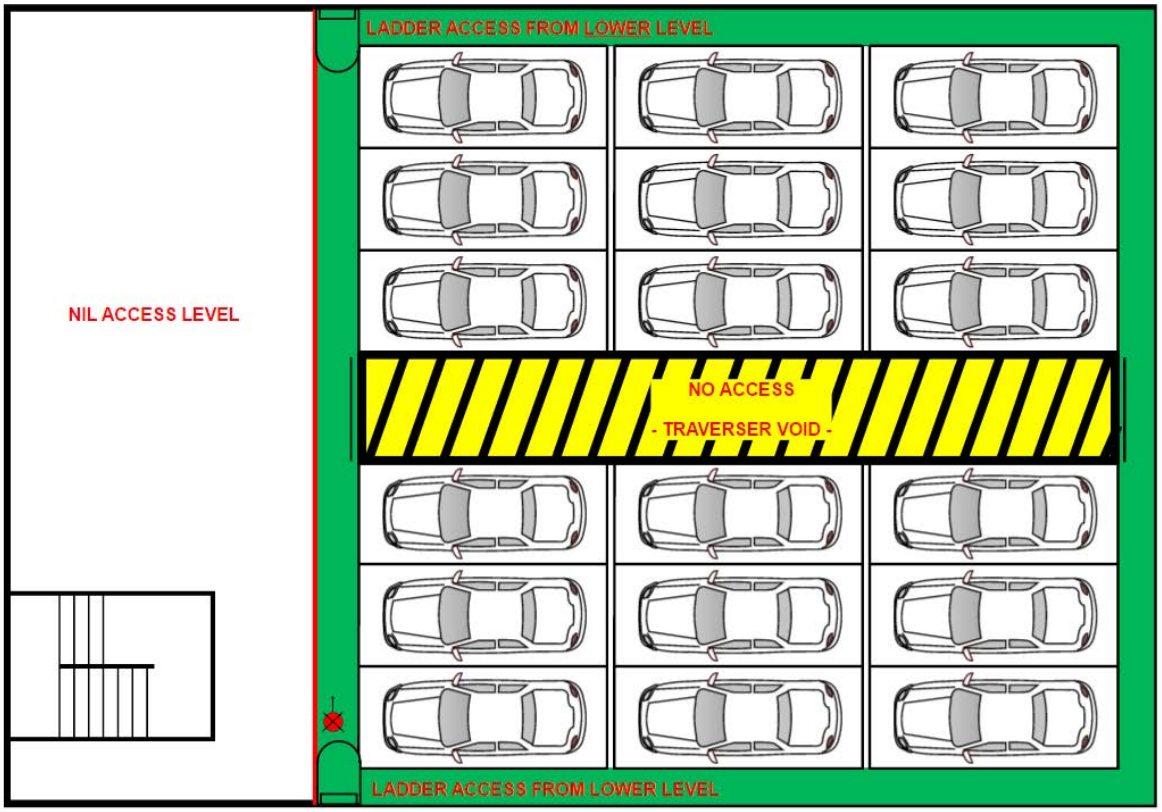


Figure 5B: AVPS level inaccessible by stairs or other external means, access via permanently attached ladder from access level below.

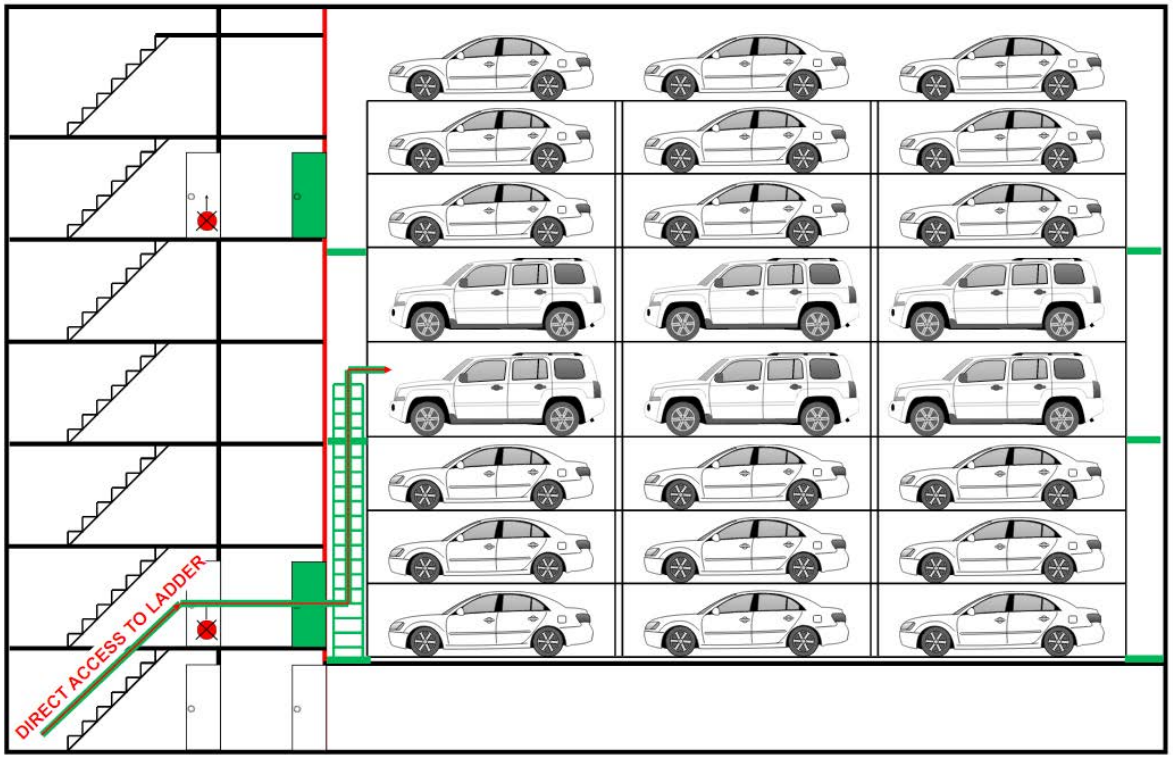


Figure 5C: Elevation view of figures 5A and 5B.

Accessing areas/levels below pedestrian access level

When it is proposed to build an AVPS that extends more than one car level below the main pedestrian access level or ground level, safe access to the lowest level within the storage area must be provided. This access must be provided via a compliant fire isolated stair, extending to the lowest most point of the storage area (refer to Figures 7A, B and C).

Note 1: All other access provisions detailed above must also be provided.

Note 2: The use of permanent ladders for access below ground level is not supported.

Note 3: Compliant fire hydrant coverage must be provided to these levels in accordance with AS 2419, as in many instances a fire hydrant will need to be located within this fire isolated access stair.

Firefighter pedestrian access clearances

When designing firefighter pedestrian access paths, it should always be considered that firefighters will be wearing a breathing apparatus kit and carrying firefighting equipment. Therefore, pinch points and ladders accessing gantry systems must accommodate the additional size of an air cylinder worn on the back of a firefighter, as well as the equipment they are carrying.

Firefighter pedestrian access paths should not require stepping over pipework, ducking below pipework or needing to manoeuver through spaces having a clear width of less than 800 mm wide. Pinch points should be no narrower than 700 mm wide and for a length no more than 400 mm (refer to Figure 6). An example of a pinch point would be passing a duct, pipe or other structural element. Note: the minimum 'effective' width of a pedestrian access path must not include the parking space / platform as part of calculation for the access path.

Permanent safety ladders must have an increased clearance to that detailed in AS 1657. The minimum clearance in front of the ladder between the ladder and all permanent objects that are not part of the ladder installation shall be as follows; from the nosing of the tread measured perpendicular to the slope of the ladder, 1200 mm when the ladder is inclined at 70 degrees to the horizontal, increasing proportionally to 1300 mm when the ladder is inclined at 60 degrees to the horizontal.

A minimum lateral clearance of permanently unobstructed space having a height above floor level of not less than 2000 mm should be maintained. Where this figure cannot be achieved due to a beam, pipework or alike, a clearance of 1800 mm lasting no longer laterally than 2000 mm should be the absolute minimum clearance maintained. Where this scenario occurs, appropriate padded protection and hazard signage should be provided.

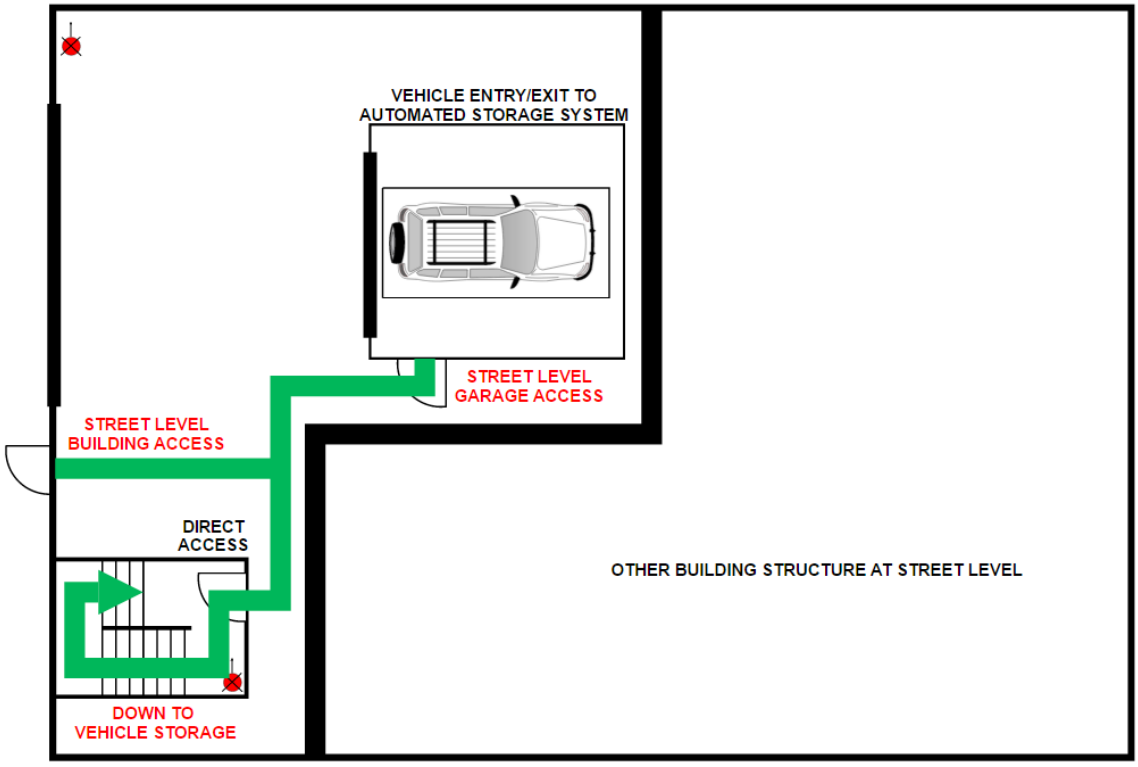


Figure 7A: Street level entry point to below ground storage.

NOTE: Numbering of figures is incorrect (not sequential)

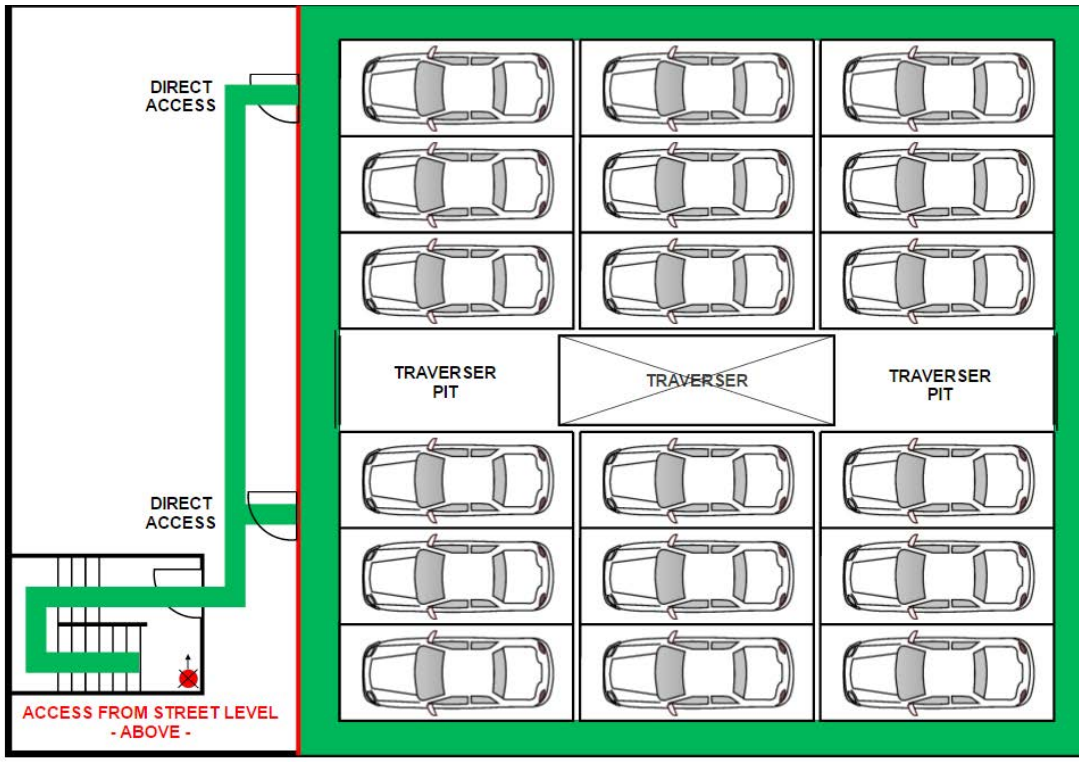


Figure 7B: Access to AVPS storage area from fire isolated stair.

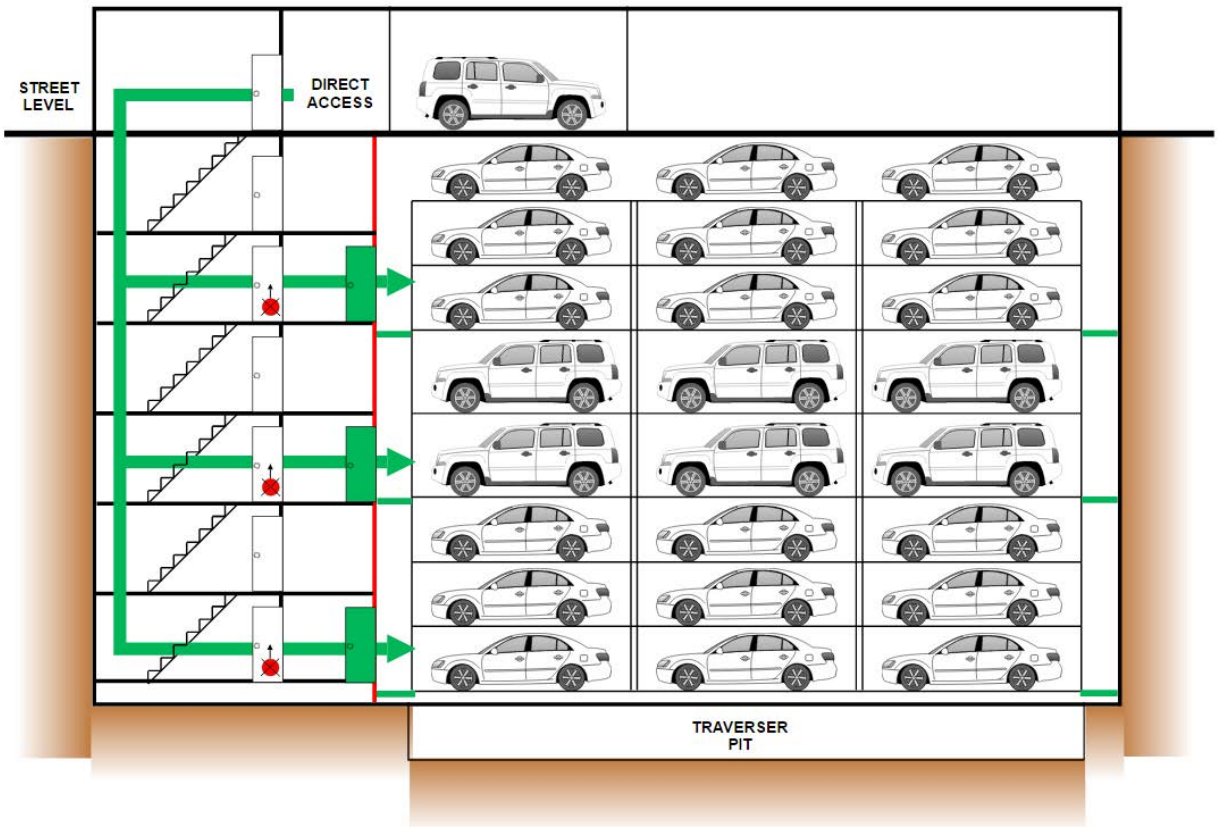


Figure 7C: Elevation view of below ground storage area access.

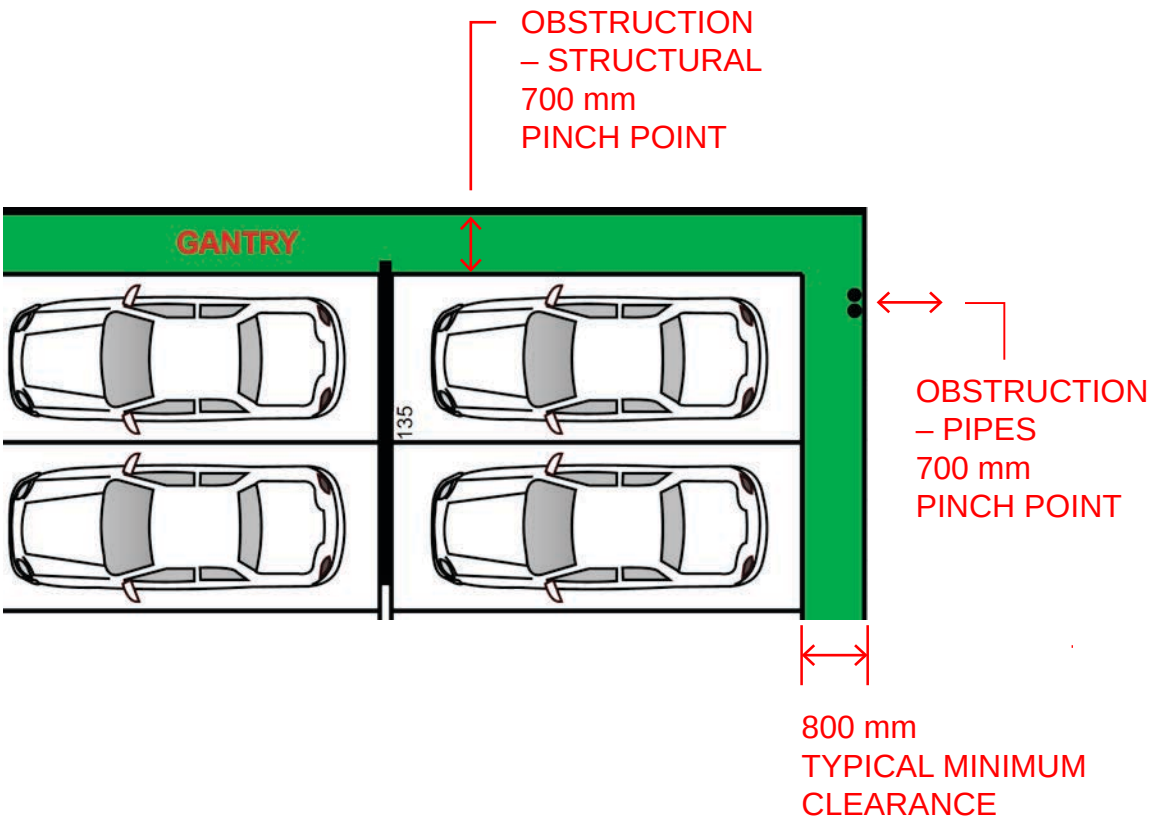


Figure 6: Minimum firefighter pedestrian access clearances.

Separation of areas caused by traverser aisle

A traverser aisle can create a 2.8 m separation between one side of a stack of stored

vehicles to the other side which cannot be bridged. It is not acceptable to expect firefighters to bridge this separation by any temporary means. A permanent safe means of access must be provided.

Accessing the storage area via a maintenance pallet

A number of fully-automatic VPS have 'maintenance pallets' that effectively allow maintenance personnel to travel throughout the system / storage area, on a specially designed pallet, as a vehicle normally would.

This maintenance pallet would not be used to transport firefighters during a fire event or whilst investigating an alarm of fire and must not be considered as an access system for firefighters. However, during a rescue / medical emergency firefighters may utilise this equipment. This would only occur after a thorough dynamic risk assessment and under the supervision of trained maintenance personnel.

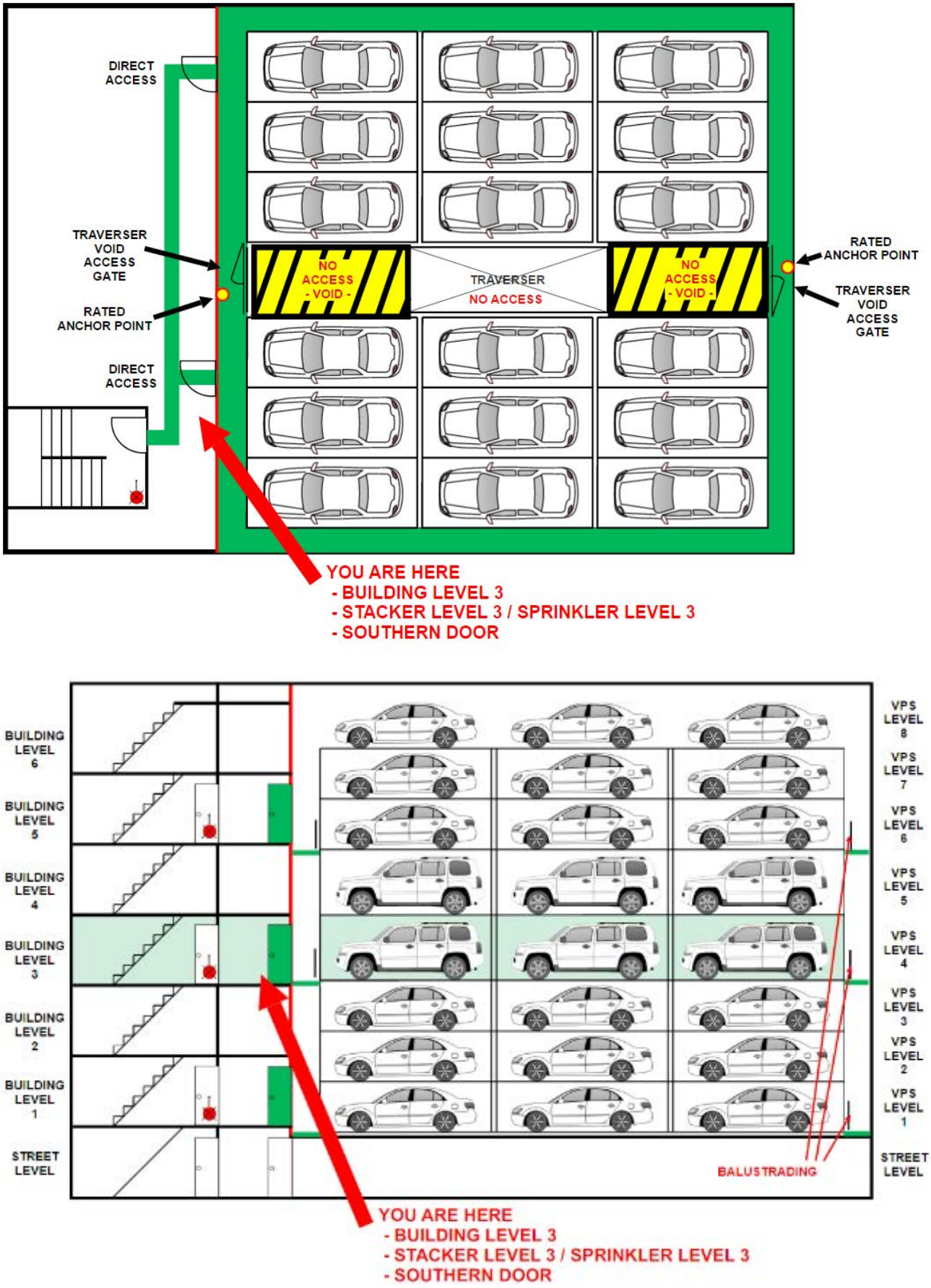
Signage

Appropriate signage should be provided on the outside of any door leading into the vehicle storage area. Signage should read:

'access to VEHICLE storage unit – Warning: fall hazard authorised personnel only – consider implementing working from heights procedures'.

Any door leading into the vehicle storage / carpark area and all internal hydrants in / near the staircase should have a simple but prominent permanent firefighter block plan displayed directly next/adjacent to it (refer to Figures 8A and B). These permanent plans should provide firefighters with a clear floor plan and cross section plan of the floor level and vehicle storage area and show features such as:

- safe pedestrian access routes within the vehicle storage area (shaded green);
- risk areas, such as voids or switchboards (shaded yellow for electrical risk and yellow with black diagonal lines for all other risks);
- additional safety provisions, such as anchor points, gates or balustrading;
- installed firefighting equipment, including hydrants and isolation valves;
- sprinkler zones (correlating to FIP data);
- building floor level; and
- fire walls / compartmentation (designated with red lines).



Figures 8A and 8B: Example of a firefighter block plan (plan and elevation view).

Consideration should also be given to signage identifying non-guarded machinery, electrical risks, pinch points. All safety signage must comply with AS 1319.

Void / fall from height protection

Depending on the system design, a compliant balustrade to AS 1657 may be required to protect fire fighters from falling into a lift or traverser void. If a balustrade cannot be provided to all voids at the pedestrian access levels, then as much of the pedestrian access path as possible must be protected by balustrading. At the point where the protected path ends, a latched self-closing gate displaying the following signage should be provided; 'Attention: NO handrails are provided beyond this point - Initiate working from heights procedures'.

Where a vehicle lift void passes through a pedestrian access level, some designers have designed their system so that a balustrade can be installed around the void and the action of a traverser transferring a vehicle to or from a vehicle lift occurs over or above the balustrading (Refer to Figure 9).

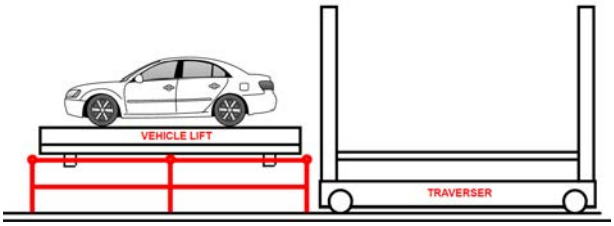


Figure 9: Example of a lift void being protected by balustrading.

Where there is a risk of falls, then consideration should also be given to providing load rated anchor points (with appropriate signage) in these areas to AS 1891.

Safety / hazard line marking should be provided around voids, as well as fall and trip hazards.

The lift transfers the vehicle to the traverser over the balustrading.

Lighting

Exit, emergency lighting and non-emergency lighting should also be provided inside the vehicle storage area along the firefighter pedestrian access paths. This should also include any gantries. The lighting should be provided at a low height level (approximately 1500-2000 mm) so that it is not greatly impacted by smoke in a fire situation. Exit and emergency lighting should be in accordance with relevant standard AS 2293.1; however the use of non-illuminated exits signs is discouraged.

Emergency service communication

Where fully-automatic VPS are proposed, an emergency telephone system or leaky cable radio communications system must be provided in accordance with the relevant local fire service requirements.

Additional considerations

Defining areas as confined spaces

Designers should define all vehicle storage areas as confined spaces. This will evoke local occupational health and safety legislation, which will require all future parties working within these areas to develop their own safety procedures in order to meet the necessary local regulations.

Compliance with such codes should reduce the likelihood of staff members or maintenance workers becoming

Figure 10: example of confined space signage.

trapped or injured within the transfer / storage area. If an incident does occur, the procedures should support the response from emergency services personnel.

The employer of a maintenance crew attending an AVPS must satisfy the confined spaces compliance codes or risk proceedings from local work health and safety regulators for failure to meet duties under relevant acts or regulations.

Machinery isolation

Tag Out Lock Out Systems should be installed on all systems / components within the vehicle storage area, as per compliance with local work health and safety / occupational health and safety acts, regulations and codes of practice.

LPG (liquefied petroleum gas) and hydrogen (fuel cell) fuelled vehicles

Due to the elevated hazards presented with fires and leaks involving LPG and hydrogen fuelled vehicles, LPG and hydrogen fuelled vehicles should not be stored or transported in an AVPS.

Designers should explore possible ways in which this restriction can be enforced, monitored and managed throughout the life of the building.

Additional hazard abatement measures

In an effort to reduce fuel loads within the carpark / vehicle storage area, private resident storage areas within these areas potentially comprising combustible materials, flammable liquids, cleaning products and other general consumables should be avoided and stored within other fire separated areas of the building.

Supporting discussion

Bibliography

ABCB, *International Fire Engineering Guidelines*, Canberra, Australia.

BHP, *Economical Carparks – A Guide to Fire Safety*. March 1999.

BRE Research, *Fires in Enclosed Car Parks*. October 2009

AS 2118.1, AS 2118.4 and *AS 2118.6 – Sprinkler Systems.*

AS 1668.2 – Ventilation requirements and systems for buildings in fire mode.

AS 2419.1 – Fire hydrant system.

AS 4072.1 - Components for the Protection of Openings in Fire–Resistant Separating Elements Part 1 – Service Penetrations and Control Joints

AS 1530.4 – Methods for Fire Tests on Building Materials, Components and Structures – Fire Resistance Test of Elements of Construction.

AS 5124 – Safety of Machinery – Equipment for power driven parking of motor vehicles – Safety and EMC requirements for design, manufacturing, erection and commissioning stages.

AS 1657 – Fixed platforms, walkways, stairways and ladders – Design, construction and installation.