FIRE + RESCUE

Fire safety guideline

Impulse fans in carparks

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Fire Safety Branch
Community Safety Directorate

NSW GOVERNMENT

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Contents

1 Purpose

This purpose of this document is to provide impulse fans that are suitably designed to operate within a sprinkler protected carpark.

Note: The terms impulse fans and jet fans refer to the same type of fans. For consistency, the term impulse fan will be used throughout the guideline.

2 Scope

This guideline details Fire and Rescue NSW (FRNSW) requirements for:

a) design which satisfies the *National Construction Code* (NCC) objectives for mechanical ventilation of a sprinkler protected carpark

b) detailed design considerations for a performance solution incorporating use of impulse fans

c) the provision of supporting information for the analysis and assessment of the performance solution

d) manual override of impulse fan operation to facilitate fire brigade intervention

e) consultation on any performance solution proposing use of impulse fans in non-sprinkler protected carparks.

Guidance is also provided on FRNSW interpretation of Australian Standard AS 1668.1:2015[1] and AS 1668.2:2012[2] with regard to impulse fans used in carparks.

3 Application

This guideline applies to a proposed performance solution which includes the installation of impulse fans within a sprinkler protected carpark.

Note: Where impulse fans are proposed in a non-sprinkler protected carpark, refer to Section 9 of this guideline.

This guideline is intended to be used by fire engineers and certifying authorities when preparing or assessing a proposed fire engineered performance solution.

Note: The certifying authority is ultimately responsible for ensuring the design satisfies all NCC performance requirements when determining and issuing the corresponding construction and occupation certificates.

[1] AS 1668.1:2015 *The use of ventilation and airconditioning in buildings, Part 1: Fire and smoke control in buildings (Incorporating Amendment 1)*.
[2] AS 1668.2:2012 *The use of ventilation and airconditioning in buildings, Part 2: Mechanical ventilation in buildings (Incorporating Amendment Nos 1 and 2)*.

4 Definitions

The following definitions apply in this guideline:

computational fluid dynamics (CFD) – means the use of computer-generated models to simulate the aerodynamic behaviour around objects within a space.

fire brigade – means a statutory authority constituted under an Act of Parliament having as one of its functions, protect life and property from fire and other emergencies.

fire detection control and indicating equipment (FDCIE) – means a component conforming to AS 7240.2. The component may include the fire indicator panel (FIP) (also known as the fire brigade panel), any sub or mimic panels, associated equipment such as the fire fan control panel, and sprinkler control assembly.

fire fan control panel (FFCP) – means a component of the FDCIE designed to provide control and indication of air-handling equipment required to operate in fire mode.

fire safety system – means an active and/or passive system which warns people of an emergency, provides safe evacuation, restricts or extinguishes fire.

national construction code (NCC) – means the *National Construction Code (NCC) 2022, Building Code of Australia Volume One*.

performance-based design brief (PBDB) (formerly known as fire engineering brief (FEB)) – a documented process that defines the scope of work for the fire engineering analysis. Its purpose is to set down the basis, as agreed by the relevant stakeholders, on which the fire safety analysis of the proposed building and its performance solutions will be undertaken.

performance solution report (PSR) (formerly known as fire engineering report (FER)) – a final report including the agreed PBDB, all modelling and analysis including that required to demonstrate the proposed building provides a level of safety at least equivalent to the relevant deemed-to-satisfy provisions, and any other information required to demonstrate that the building and its fire safety system satisfies the relevant performance requirements.

performance solution – means a method of complying with the NCC performance requirements other than by a ‘deemed-to-satisfy’ solution.

5 Background

The primary purpose of a ventilation system in a carpark is to address the requirements for amenity and air quality (i.e. to prevent and disperse build-up of carbon monoxide gas from motor vehicles). The NCC and *Australian Standard* AS 1668.1:2015 state that carpark ventilation systems are not required for smoke control. In the event of a fire, however, the ventilation system is required to ramp up to full exhaust capacity to assist with exhausting smoke generated by the fire in a controlled manner.

Impulse fans are a form of mechanical ventilation within an enclosed carpark. They are low profile fans installed on the underside of ceilings, providing air velocity and momentum to entrain contaminated air towards an exhaust point.

The operating principle of an impulse fan is significantly different to that of a conventional ducted system. While there is some supply air for fresh air make up, impulse fans are located in strategic positions within the carpark, usually in the centre of the drive lane, to push air towards the exhaust points. The supply and exhaust points may or may not utilise fans as normally expected within a conventional ducted system.

6 Interpretation of requirements

6.1 NCC and Australian Standards

Note: The revisions of AS 1668.1:2015, AS 1668.2:2012[3] and AS 1670.1:2018[4] are referenced standards within the NCC 2022. Updates to AS 1668.2 and AS 1670.1 were released in 2024. This guideline outlines requirements that should be addressed in the design until such time as the revised standards are called up as referenced documents within in-force NCC.

F6D11 of the NCC requires a system of ventilation, whether compliant natural ventilation (Section 4 of AS 1668.4:2012) or compliant mechanical ventilation, to be achieved on every storey of a carpark (except open-deck, which are naturally ventilated with natural relief openings). The relevant standard of performance for a system of mechanical ventilation is AS 1668.2:2012.

E2D12 of the NCC states that a Class 7a building, including a basement, provided with a mechanical ventilation system in accordance with AS 1668.2 must also comply with Clause 5.5 of AS 1668.1.

Clause 5.5 of AS 1668.1 details design requirements for mechanical carpark ventilation systems. Design requirements relevant to the scope of this guideline are detailed below and summarised in Table 1 Summary of Australian Standards requirements for impulse fans.

Clause 5.5.1(a) and Clause 5.5.5 of AS 1668.1 indicate that centre-line discharge should not be aligned with fire protection devices (i.e. impulse fans should be located centrally and discharge centrally between devices such as sprinkler heads and smoke or heat detectors) to prevent interference with fire protection systems.

Clause 4.4.2 of AS 1668.2:2012 permits the use of impulse fans in carparks; however, this is restricted to the provision of a single impulse fan serving a dead spot in the carpark.

Clause 5.5.1(c) of AS 1668.1 and Clause 4.4.2(e) of AS 1668.2 do not permit impulse fans to be arranged in series.

Informative notation to Clause 5.5.1 of AS 1668.1 notes impulse fans are not required to conform with Clause 4.8.1 of AS 1668.1, as they are not considered to be smoke control systems (captured in the definition of essential/safety service under Clause 5.5.1(d) of AS 1668.1, as defined in AS/NZS 3000). However, such fans are intended to be operable in the event of a fire by way of manual override.

Clause 5.5.3 of AS 1668.1 makes provision for a separate switch enabling emergency personnel to facilitate restart and manual control, with the number of switches dictated by number of fire compartments and the location of switches dictated by whether or not a fire detection control and indicating equipment (FDCIE) panel is present.

Clause 5.5.3 and Table 4.1 of AS 1668.1 provide:

a) Where more than one fan is utilised in a fire compartment, fans will be controlled by a common switch. Where multiple fire compartments, a separate switch shall be provided for the fans in each fire compartment.

[3] AS 1668.2:2012 (incorporating Amendment Nos 1 and 2) *The use of ventilation and airconditioning in buildings, Part 2: Mechanical ventilation in buildings*.
[4] AS 1670.1:2018 *Fire detection, warning, control and intercom systems – System design, installation and commissioning, Part 1: Fire*.

b) Where a FDCIE panel is present, the switch/es must be incorporated at the fire fan control panel (FFCP). Where a FDCIE panel is not present, the switches shall be located at the designated building entry point.

c) Switches should provide the following functionality in the following sequence: ON, AUTO, OFF. AUTO is required to be located between ON and OFF to avoid electrical overload during manual activation. Indication is not required.

Clause 5.5.5 of AS 1668.1 and Clause 7.6.8.4 of AS 1670.1 require fans to shut down when any of the following occurs: initiation of fire mode, activation of a sprinkler system in the carpark and activation of the impulse fan smoke detection system.

Clause 5.5.4 of AS 1668.1 requires supply air smoke detection be provided in accordance with AS 1670.1.

Clause 7.6.8.5 of AS 1670.1:2018 requires provision of Class A aspirating smoke detectors (ASD) in the immediate area of impulse fan influence. The location of ASD sampling points in addition to the sampling pipe design and system transport time must specifically relate to impulse fan applications.

Informative commentary to Clause 7.6.8.5 of AS 1670.1:2018 notes that where the sole use of the ASD is to shut down impulse fans, the ASD need not cover the entire carpark nor initiate a fire alarm condition.

Table 1 Summary of Australian Standards requirements for impulse fans

Item	Detail	Relevant Standard
Location	Centre-line discharge should not be aligned with fire protection devices.	AS 1668.1:2015 Cl. 5.5.1(a) & Cl. 5.5.5
Configuration	Cannot be installed in series.	AS 1668.1:2015 Cl. 5.5.1(c) AS 1668.2:2012 Cl 4.4.2(e)
Power wiring	No special requirements (i.e. fire-resistant cabling).	AS 1668.1:2015 Cl. 5.5.1 AS 1668.1:2015 Table 4.1
Automatic control	Shut down when any of the following occurs: initiation of fire mode, activation of a sprinkler system in the carpark and activation of the impulse fan smoke detection system.	AS 1668.1:2015 Cl. 5.5.5 AS 1670.1:2018 Cl. 7.6.8.4
Manual control (i.e. override control)	Where FDCIE is provided, switches must be located on FFCP. Otherwise, switches shall be located at the designated building entry point. Switches must enable restart and manual control of fans. Where more than one fan is utilised in a fire compartment, fans will be controlled by a common switch. Where multiple fire compartments, a separate switch shall be provided for the fans in each fire compartment. Switches should provide the following functionality in the following sequence: ON, AUTO, OFF. AUTO is required to be located between ON and OFF to avoid electrical overload during manual activation.	AS 1668.1:2015 Cl. 5.5.3 AS 1670.1:2018 Cl. 7.6.8.2 AS 1668.1:2015 Table 4.1

Item	Detail	Relevant Standard
Indication	Indication is not required at the FDCIE.	AS 1668.1:2015 Cl. 5.5.3
Labelling	Clear, appropriate, durable and indelible of the function and operation of each fan switch, permanently and firmly secured below each switch.	AS 1668.1:2015 Table 4.1
Smoke detection	Smoke detection must be provided in accordance with AS 1670.1.	AS 1668.1:2015 Cl. 5.5.4
	Impulse fans shall be provided Class A aspirating smoke detectors in the immediate area of impulse fan influence. The location of same in addition to the sampling pipe design and system transport time must specifically relate to impulse fan applications.	AS 1670.1:2018 Cl 7.6.8.5
	Where the sole use of the ASD is to shut down impulse fans, the ASD need not cover the entire carpark nor initiate a fire alarm condition.	AS 1670.1:2018 Cl. 7.6.8.5
	Smoke detection provided to initiate car park ventilation in fire mode to be provided throughout circulation spaces.	AS 1670.1:2018 Cl. 7.6.5.5 AS 1670.1:2018 Cl. 7.5.1(a) AS 1670.1:2018 Cl. 7.5.2.2

6.2 FRNSW view on interpretation

Unless the design only comprises of single impulse fans serving dead spots, the installation of impulse fans is not a deemed-to-satisfy solution. The design is therefore performance based and requires a performance solution to be developed.

Relevant NCC performance requirements to be addressed in any such performance solution include E1P4, E2P2 and F6P4. The performance solution should specifically address the following:

a) It must demonstrate that the sprinkler design and performance is not adversely affected by the impulse fans.

b) It must demonstrate that tenable conditions within the carpark are not adversely affected by the impulse fans.

Note: The above performance requirements may be assessed by addressing the design considerations and recommendations outlined at Section 7.2.

FRNSW acknowledges that some studies have been undertaken to demonstrate that impulse fans located between rows of sprinklers has negligible impact on sprinkler performance. There are also only limited studies on the impacts on tenability conditions for various operating modes of impulse fans.

Note: Currently there is only limited information available, and no actual fire testing has been undertaken to verify these studies.

7 Design objectives, considerations and recommendations

7.1 Design objectives

The design and performance of impulse fans needs to satisfy the same NCC objectives for ventilation and fire performance as a conventional ducted ventilation system. The primary objective is mechanical ventilation of carbon monoxide from the carpark, which must not be compromised to satisfy fire safety objectives.

Commentary to Clause 4.1 of AS 1668.2:2012 states: '*This Standard applies to the provision of mechanical ventilation to enclosures intended to minimise the potential for adverse health effects from contaminants generated by combustion engines.*'

Where it is proposed that impulse fans will be provided in lieu of a conventional ducted mechanical ventilation system, relevant design objectives include:

a) consideration of the potential impact on the operation and effectiveness of installed fire safety systems (e.g. fire sprinklers and smoke or heat detectors), and

b) consideration of the potential impact on conditions within the carpark.

7.2 Detailed design

Consultation with relevant stakeholders is a requirement under A2G2(4)(a) of the NCC, and a legislative requirement for any performance solution proposed for any fire safety requirement in any building requiring a construction certificate. Accordingly, the design must be achieved through collaboration with relevant stakeholders in accordance with the performance based design brief (PBDB) process outlined in the *Australian Fire Engineering Guideline*.

Note: Following a shift in terminology, the FEB process is referred to as a performance-based design brief (PBDB) within the NCC and statutory instruments in New South Wales.

It is noted the design of each carpark and impulse fan system will be unique due to variance in principal building characteristics (including building layout and dimensions), and therefore airflow patterns during periods of fan operation will be specific to that inherently unique design. Notwithstanding this variance, minimum requirements that need to be addressed in the design include:

a) the installation of an automatic fire sprinkler system, in accordance with the NCC and AS 2118.1:2017

b) impulse fans located between rows of sprinklers, in driveways and access ways, and not above car parking spaces or other areas where there are stagnant fire loads. It should be demonstrated that the air jet from the impulse fans does not impinge on any sprinkler head

c) the provision for automatic shut down of impulse fans on detection of fire within the carpark, including detection by a system deemed suitable and/or by sprinkler system activation

d) the installation of a Class A aspirating smoke detection system to quickly shut down the impulse fan system and not activate the occupant warning system or notify the fire brigade, unless suitable for use in the carpark

e) the provision for manual control (i.e. override control) of the impulse fans for use of firefighters, at the FFCP where part of the design, so that the fans can be used during fire brigade intervention if required.

8 Analysis of the design

8.1 General

As each design is unique, analysis is to be undertaken on the given carpark layout and dimensions, fan layout and output, to determine air movement and velocity throughout the carpark space.

Design analysis is to be undertaken using computational fluid dynamics (CFD) modelling. The methodology, depth of analysis, scenario selection and detailed CFD modelling over the entire carpark environment is to be sufficiently detailed to address all fire safety issues. These matters must be agreed upon in the PBDB consultation process.

Where the PBDB proposes additional performance solutions that impact on jet fan performance, or the jet fan impacts other aspects of the carpark design, FRNSW recommends that these performance solutions be considered holistically with the proposed installation of impulse fans. Such additional performance solutions may include but are but not limited to extended travel distances in the carpark or rationalisation of the stair pressurisation system in the fire-isolated stairway/s serving the carpark.

In undertaking design analysis, FRNSW recommends that multiple impulse fan location scenarios should be considered. In determining location scenarios to assess, consideration should be given to:

a) the location of the impulse fan in relation to the exits

b) the location of the impulse fans in relation to unique geometrical features of the car park

c) the location of the impulse fan in relation to any supply and exhaust vents.

8.2 Impact on sprinkler performance

Design analysis should demonstrate negligible difference in sprinkler activation times when the fans are running at full design speed to when the fans are not operating (i.e. off). Analysis of sprinkler activation times should be undertaken, at minimum, for the following fire scenario locations (refer to Figure 1):

a) fire being located within the immediate air flow (i.e. directly in front of the fan), and

b) fire being located outside the immediate air flow (i.e. not within airstream of the fan).

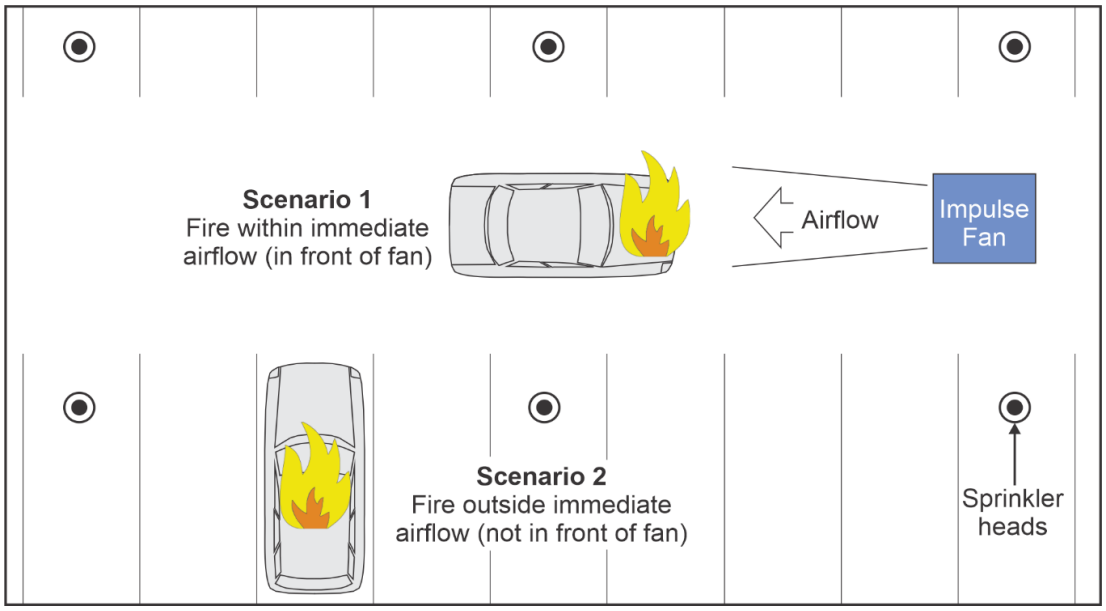

Figure 1 Fire scenario locations for analysis of sprinkler performance and tenability

8.3 Impact on tenable conditions

Design analysis should demonstrate that the impulse fans are shut down by the detection system in an appropriate time such that tenable conditions within the carpark are not adversely affected by the impulse fans prior to shut down.

Note: While it is acknowledged that the shut down time will vary for various fire scenarios, the time to shut down the fans for each scenario assessed should be documented in the performance solution.

In order to demonstrate that conditions in the carpark are not adversely affected, it should be demonstrated that either:

a) tenability is maintained for the period of time occupants take to evacuate the carpark with a suitable factor of safety, or

b) conditions within the carpark, throughout the time of occupant evacuation, are at least equivalent to those which occur if the carpark was provided with a ventilation system complying with the deemed-to-satisfy provisions of the NCC.

Analysis of the impact on tenable conditions should be undertaken, at minimum, for the following fire scenario locations (refer to Figure 1):

a) fire being located within the immediate air flow (i.e. directly in front of fan), and

b) fire being located outside the immediate air flow (i.e. not within airstream of fan).

8.4 CFD modelling considerations

When performing CFD modelling to undertake the required design analysis detailed in Sections 8.1, 0 and 8.3, FRNSW requests:

a) the selection of multiple fire scenario locations to represent all potential worst-case scenarios within the carpark. FRNSW recommends providing a marked up architectural floor plan with the proposed fire scenario locations relative to the location of impulse fans and their respective airflow or airstream.

b) the completion of a grid sensitivity analysis to ensure that the appropriate grid resolution is provided at impulse fan locations, such that accurate air flow field results can be produced and the inlet and outlet geometry accurately represented. These results should be compared with manufacturer issued test results to confirm accuracy of the modelling.

c) the incorporation of time for shut down and the ramp-down fan speed of impulse fans to ensure consideration of contributing effects.

d) the specification of centreline velocity and angle of discharge to ensure accurate representation of airflow. Centreline velocity and angle of discharge should also be detailed in the PSR/FER, as relevant to the selected impulse fan make and model.

e) the placement of the fire base in Scenario 1 of Figure 1 (i.e. in front of the impulse fan) in the direct airflow downstream, which also correlates with the fan discharge angle.

f) the incorporation of structural beams, columns and/or any other obstructions (e.g. pipework or signage) that may affect the airflow pattern within the carpark.

Additionally, FRNSW requires the following information to be provided:

a) the number of impulse fans incorporated into the model

b) clarification on whether sprinkler spray will be included in modelling, and justified accordingly.

8.5 Fire brigade intervention

Manual control of the impulse fans should be provided for firefighters at the FFCP so that the impulse fans can be used during fire brigade intervention if required (e.g. to assist with extracting smoke out of the carpark during or after the fire).

Where impulse fans span multiple carpark levels, FRNSW recommends the clear and unambiguous labelling of each manual control switch according to the building level or zone the fan serves (e.g. Impulse fan – Basement 1, Impulse fan – LG1, Impulse fan – LG2 Zone 1).

FRNSW recommends that block plans clearly indicating the location of any impulse fan/s on each applicable level be provided adjacent to the FFCP. For ease of identification, the naming convention applied to manual control switch labels should be mirrored on the block plan.

8.6 Commissioning

The shut down operation of the impulse fan system is to be tested during the commissioning tests, prior to occupancy.

The test procedures for the applicable detection system (i.e. Class A – ASD) are to be in accordance with Clause 3.30 of AS 1670.1, encompassing design and installation requirements detailed in Clause 5.2. Results of testing must be recorded as itemised in baseline data in Clause 1.7.2 of AS 1670.1.

9 Impulse fans in non-sprinkler protected carpark

If impulse fans are proposed in a non-sprinkler protected carpark, the design and operation of the system should be discussed with FRNSW during the PBDB process.

Various items need to be addressed within the analysis, including but not limited to the potential impact on tenable conditions in the carpark and means of shutting down the fans. However, the details and extent of analysis should be discussed and agreed upon in the PBDB.

10 References

ABCB, 2021, *Australian Fire Engineering Guidelines – Edition 2021,* Australian Building Codes Board, Canberra, Australia.

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Fire and Rescue NSW
Community Safety Directorate
Fire Safety Policy Unit
1 Amarina Avenue
Greenacre NSW 2190

Phone (02) 9742 7434
Email *firesafety@fire.nsw.gov.au*
Web *www.fire.nsw.gov.au/firesafety*
LinkedIn *linkedin.com/showcase/frnsw-firesafety*