BS 7346-7:2013

BSI Standards Publication

Components for smoke and heat control systems –

Part 7: Code of practice on functional recommendations and calculation methods for smoke and heat control systems for covered car parks

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Contents

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Foreword

Publishing information

This part of BS 7346 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 August 2013. It was prepared by Technical Committee FSH/25, *Smoke, heat control systems and components*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 7346 supersedes BS 7346-7:2006, which is withdrawn.

Relationship with other publications

BS 7346 is published in the following parts:

- *Part 4: Functional recommendations and calculation methods for smoke and heat ventilation systems, employing steady-state design fires – Code of practice;*
- *Part 5: Functional recommendations and calculation methods for smoke and heat ventilation systems, employing time-dependent design fires – Code of practice;*
- *Part 7: Code of practice on functional recommendations and calculation methods for smoke and heat control systems for covered car parks.*

Information about this document

This is a full revision of the standard, and introduces the following principal changes:

- car parks with stacker systems;
- reference to guidance on the ventilation of loading bays and coach parks.

Use of this document

As a code of practice, this part of BS 7346 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this part of BS 7346 is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

Background to smoke control in car parks

Ventilation of covered car parks is usually recommended in order to limit concentrations of carbon monoxide (CO) and other vehicle emissions in the day-to-day use of car parks and to remove smoke and heat in the event of a fire. The same equipment is often used to satisfy both requirements. This standard, recognizing the dual use of such systems, also provides guidance on usage for vehicle emission ventilation.

The recommendations in this standard are provided for smoke and heat control systems installed in car parks, with or without sprinkler protection. The main benefit of sprinklers is to control the size of fire to be dealt with by the fire and rescue service. This is reflected in the design fire sizes recommended for car parks with and without sprinklers.

NOTE In 2006, the Department for Communities and Local Government (DCLG) commissioned the Building Research Establishment Group (BRE) to carry out a three-year project on fire spread in car parks [1]. The work included a series of 11 full-scale fire tests, including two cars on a "stacker" test rig. The data has been used to validate the appropriateness of the steady-state design fires quoted in this document. Where a time-dependent design fire is used, the data within the report can be referenced where appropriate.

Car park ventilation systems can be designed for one or more of three purposes in the event of a fire:

a) to assist fire-fighters to clear smoke from a car park during and after a fire;

b) to provide relatively smoke-free access for fire-fighters to a point close to the seat of the fire;

c) to protect means of escape from the car park.

At the time of publication, smoke control is not required in UK legislation to provide relatively smoke-free access or protect means of escape in car parks. Nevertheless, it is possible in some cases to design a ventilation system that will assist both. Smoke and heat exhaust ventilation systems (SHEVS) or impulse ventilation systems might be suitable.

The system requirements differ depending upon the purpose. Not all types of ventilation systems are suitable for all purposes. Recommendations and criteria are provided for the design of systems for all three purposes.

Clearance of smoke during the fire and after the fire has been suppressed will assist in search and rescue operations, checking for primary and additional seats of fire, as well as returning the building to its normal use.

a) *To assist fire-fighters to clear smoke from a car park during and after a fire.*

Smoke clearance systems are intended to assist fire-fighters by providing ventilation to allow speedier clearance of the smoke once the fire has been extinguished. The ventilation might also help reduce smoke density and temperature during the course of a fire. These systems are not specifically intended to maintain any area of a car park clear of smoke, to limit smoke density or temperature to within any limits, or to assist means of escape.

It is possible that some smoke clearance systems could actually worsen conditions for means of escape if set in operation too early by encouraging smoke circulation and descent of the smoke layer. For this reason it might be preferable to either delay operation after automatic actuation or to provide only manual actuation from a fire service override switch.

b) *To provide relatively smoke-free access to fire-fighters to a point close to the seat of the fire.*

Relatively smoke-free access is provided specifically in order to assist fire-fighters in carrying out fire-fighting operations. The system is designed to operate automatically in response to a suitable fire detection system and ensures relatively smoke-free access by fire-fighters to a point close to the seat of the fire. Primarily, such systems assist fire-fighting by:

1) detecting the origin of the fire to a specific location in the car park, allowing easier identification by fire crews;

2) moving the smoke and heat from that location towards a specific extract point or points;

3) creating a relatively smoke-free approach zone or bridgehead clear of the fire. This allows fire-fighters to assemble personnel and equipment in favourable conditions and fire-fighting operations to be carried out more quickly, safely and efficiently.

Because of 3), it is vitally important that the location of all fire-fighting access points into the car park are accounted for during the design process. It is of little benefit if the smoke and heat is moved towards, for example, the only access route available to fire-fighters for fire-fighting purposes.

In large or complex car parks where impulse fans are employed, there might be multiple extract points. Such systems could be configured to move the smoke in one of several directions, depending on the location of the fire. Again, it is important to ensure that there are suitably located fire-fighting access points to allow the bridgehead to be created for each design fire scenario considered.

In addition, correctly designed smoke and heat control systems of this type could also prove advantageous to fire-fighters by diluting and cooling smoke and preventing the build-up of high local temperatures. As a result, it is possible to install them as part of a fire-engineered solution or as compensation for the lack of other fire protection measures, e.g. sprinklers.

It is important that the design of no smoke and heat control system, when installed, worsens the level of safety for occupants and fire-fighters, using as a basis for comparison above-ground car parks with natural cross-ventilation with permanent openings.

c) *To protect means of escape from the car park.*

Where smoke and heat control systems are installed in car parks for purposes other than protecting the means of escape, there is a need to avoid smoke prejudicing escape. If there is any concern that automatic operation of a smoke and heat control system could prevent persons from escaping, it is preferable to either select an alternative system design or introduce an appropriate delay period before full activation of the system.

Smoke ventilation recommendations in car parks are outlined in *The Building Regulations Approved Document B* [2], *The Building Regulations (Northern Ireland) Technical Booklet E* [3] and *Scottish Building Standards Technical Handbooks* [4]. These guidance documents recommend provision of systems for purpose a), smoke clearance, only. Systems for purposes b) and c) are therefore usually provided either as part of a fire engineered solution or as a compensating feature for other fire protection measures that might not fully conform to those recommendations.

The following types of ventilation might be considered as alternatives and recommendations on the design criteria for each are given in this British Standard:

- natural ventilation (see Clause **7**);
- ducted mechanical ventilation (see Clause **8**);
- impulse ventilation (see Clauses **9**, **10** and **11**);
- smoke and heat exhaust ventilation system (SHEVS) (see Clause **12**).

Further considerations

Any ventilation system, unless permanently open, is dependent upon suitable power supplies and controls for correct operation.

Ventilation systems interact with other building services and fire protection systems in normal operation, whether by design or as a by-product of operation.

In some car parks, especially underground car parks associated with residential buildings, there are storage areas accessed directly from the car park. These are used by residents to store personal possessions, and thus such storage areas will contain materials which are not known to the designer since there is no control over such private areas.

1 Scope

This part of BS 7346 gives guidance on functional recommendations and calculation methods for smoke and heat control systems for covered parking areas for cars and light commercial vehicles.

NOTE 1 It is assumed that cars powered by fuels other than petrol or diesel will have a fire performance similar to vehicles powered by petrol or diesel. This assumption might be revised in a future edition of this standard if further information suggests it is necessary.

It is intended for system designers, installers of systems, regulatory authorities, for example building control officers and fire safety officers, and those who manage the fire safety of car parks.

It gives recommendations for systems designed for open-sided car parks and for enclosed car parks. It covers:

- systems intended to protect means of escape for occupants of the car park or the building housing the car park;
- systems intended to assist active fire-fighting operations; and
- systems intended to provide smoke clearance following suppression of a fire.

It includes recommendations for natural open-sided ventilation and for ducted mechanical ventilation. It includes guidance on performance-based smoke control using impulse ventilation systems and smoke and heat exhaust ventilation systems (SHEVS). Time-dependent and steady-state design methods are included as appropriate for each smoke control approach. Control of vehicle pollutant emissions is included where it influences the optimization of smoke control. Following the BRE fire tests on car stacker systems, it also includes recommendations for fire sizes and fire suppression in these types of installations.

Smoke and heat control systems for loading bays and coach parks are not covered by this standard.

NOTE 2 Guidance on loading bays and coach parks can be found in the FETA publication, Design of smoke ventilation systems for loading bays and coach parks – a guide for system designers *[5].*

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 5839-1, *Fire detection and fire alarm systems for buildings – Part 1: Code of practice for system design, installation, commissioning and maintenance*

BS 7346-4:2003, *Components for smoke and heat control systems – Part 4: Functional recommendations and calculation methods for smoke and heat exhaust ventilation systems, employing steady-state design fires – Code of practice*

BS 7346-5:2005, *Components for smoke and heat control systems – Part 5: Functional recommendations and calculation methods for smoke and heat exhaust ventilation systems, employing time-dependent design fires – Code of practice*

BS 7671, *Requirements for electrical installations – IET wiring regulations – Seventeenth edition*

BS 8519, *Selection and installation of fire-resistant power and control cable systems for life safety and fire-fighting applications – Code of practice*

BS 9999:2008, *Code of practice for fire safety in the design, management and use of buildings*

BS EN 12101-2, *Smoke and heat control systems – Part 2: Specification for natural smoke and heat exhaust ventilators*

BS EN 12101-3, *Smoke and heat control systems – Part 3: Specification for powered smoke and heat exhaust ventilators*

BS EN 12101-7, *Smoke and heat control systems – Part 7: Smoke duct sections*

BS EN 12101-8, *Smoke and heat control systems – Part 8: Smoke control dampers*

BS EN 12101-10, *Smoke and heat control systems – Part 10: Power supplies*

BS EN 15650, *Ventilation for buildings – Fire dampers*

BS EN 60529:1992, *Degrees of protection provided by enclosures (IP code)*

BS EN 60947-6-1, *Low-voltage switchgear and controlgear – Part 6-1: Multiple function equipment – Transfer switching equipment*

BS EN 60947-6-2, *Low-voltage switchgear and controlgear – Part 6-2: Multiple function equipment – Control and protective switching devices (or equipment) (CPS)*

BS EN ISO 13350, *Industrial fans – Performance testing of jet fans*

3 Terms and definitions

For the purposes of this part of BS 7346, the following terms and definitions apply.

3.1 addressable fire detection system

system in which signals from detectors, manual call points or any other devices are individually identified at the control and indicating equipment

3.2 aerodynamic free area

product of the geometric area and the coefficient of discharge

[SOURCE: BS 7346-4:2003, **3.1.2**]

3.3 bridgehead

area or part of a building, from which fire-fighting teams can be safely committed to attack a fire

3.4 car stacker system

vehicle stacking arrangement which allows cars to be parked more efficiently per unit area of car park space – usually a mechanical device which stores vehicles either above or beneath another (in a tiered or multi-tiered configuration)

3.5 ceiling jet

any layered flow of ceiling level gases away from the point of impingement, driven by that layer's buoyancy

3.6 coefficient of discharge

ratio of actual flow rate, measured under specified conditions, to the theoretical flow rate through an opening

*NOTE Adapted from BS 7346-4:2003, **3.1.11**.*

3.7 computational fluid dynamics (CFD) model
computer simulation model where the fundamental equations of heat and mass transfer are solved using numerical methods

[SOURCE: PD 7974-2:2002, **3.8**]

3.8 cross-flow ventilation
ventilation system based on creating an airflow throughout the volume of a space, from outside, through an inlet, and exiting to the outside

NOTE A space can be a car park or car park storey.

3.9 design fire
hypothetical fire having characteristics which are sufficiently severe for it to serve as the basis of the design of a smoke and heat control system

*NOTE Adapted from BS 7346-4:2003, **3.1.14**.*

3.10 directed message
specific message/warning through a public address system to individuals identified by CCTV as being at risk

3.11 dispersal
removal of a smoke hazard by dilution to a safe concentration using clean air

3.12 equivalent area
area of a sharp-edged orifice through which air would pass at the same volume flow rate, under an identical applied pressure difference as the opening under consideration

NOTE 1 This is a measure of the aerodynamic performance of an opening.

NOTE 2 For a plain opening with no obstructions the equivalent area is equal to the measured area. For other openings the equivalent area is equal to the aerodynamic free area divided by 0.6.

3.13 exhaust ventilation system
combination of exhaust ventilators, ducts, power supplies and controls used to remove smoky gases from a car park

NOTE The exhaust ventilators are usually fans.

3.14 extract point
location of an intake opening to an exhaust ventilator or to a duct which leads to an exhaust ventilator, where smoke is removed from a car park

3.15 fire compartment
enclosed space, comprising one or more separate spaces, bounded by elements of structure having a specified fire resistance and intended to prevent the spread of fire (in either direction) for a given period of time

[SOURCE: BS 7346-4:2003, **3.1.16**]

3.16 fire engineered solution
fire safety strategy and design based upon calculations tailored to the circumstances of a specific building

3.17 fire load
sum of the heat energies which could be released by the complete combustion of all the combustible materials in a space including the facings of walls, partitions, floors and ceilings, and contents including for car parks all cars present

*NOTE Adapted from PD 7974-1:2003, **3.10**.*

3.18 fire operational position
position or configuration of a component specified by the design of the system during a fire

[SOURCE: BS 7346-4:2003, **3.1.17**]

3.19 fire resistance
ability of an item to fulfil for a stated period of time the required fire stability and/or integrity and/or thermal insulation, and/or other expected duty specified in a standard fire resistance test

[SOURCE: BS 4422:2005, **3.369**]

3.20 fire service override switch
manually operated switch to enable fire-fighters to initiate or terminate the operation of a fire safety system or other device

3.21 fixing
device used to secure plant or equipment to the structure of a building

3.22 frequency inverter
electronic device used to control the speed of fans by controlling the frequency of the electrical power feeding the electric motor driving the fans

3.23 impulse
product of force and the time for which that force acts

NOTE This is numerically equal to force (jet thrust) when the time is taken to be 1 s. When divided by the cross-sectional area over which the force acts this equals a pressure.

3.24 impulse fan
axial, centrifugal or mixed-flow fan designed to induce air movement by thrust

NOTE An impulse fan is also known as a jet fan.

3.25 impulse ventilation system (IVS)
set of fans used to exert thrust on the air within a space to accelerate air to create a desired pattern of movement of air and smoke within that space

NOTE An example of a space is a car park or car park storey.

3.26 integrity
the ability of a specimen of a separating element to contain a fire to specified criteria for collapse, freedom from holes, cracks and fissures and sustained flaming on the unexposed face

[SOURCE: BS 476-20:1987, **2.9**]

3.27 jet fan
fan used for producing a jet of air in a space and unconnected to any ducting

NOTE A jet fan is also known as an impulse fan.

3.28 means of escape
structural means whereby in the event of fire a safe route or routes is or are provided for persons to travel from any point in a building to a place of safety

3.29 mechanical cross ventilation
system of smoke control where mechanical means are used to sweep air horizontally through the space to remove smoke

NOTE 1 The mechanical means is usually fans.

NOTE 2 An example of a space is a car park or car park storey.

3.30 multi-criteria fire detection
fire detection system with detector heads monitoring two or more fire phenomena

3.31 natural cross ventilation
system of smoke control where openings are used to allow wind and/or buoyancy to sweep air horizontally through a space to remove smoke

NOTE An example of a space is a car park or car park storey.

3.32 override control
control included in an automatically operating smoke and heat control system to allow manual operation or manual shut-down of all or part of that system

3.33 pressure differential system
system of fans, ducts, vents and other features provided for the purpose of creating a lower pressure in a smoke control zone than in a protected space

NOTE Adapted from BS 7346-4:2003, ***3.1.32****.*

3.34 rate of rise heat detection
automatic fire detection which initiates an alarm when the rate of change of the measured phenomenon with time exceeds a certain value, for a sufficient time

3.35 replacement air
clean air entering a building to replace smoky gases being removed by the smoke and heat control system

NOTE Adapted from BS 7346-4:2003, ***3.1.34****.*

3.36 signalling system
network of electrical cables, radio and optical cables, carrying signals between sensors, control panels, computers, and active devices or any combination of these

NOTE This does not include power supply cables.

3.37 smoke and heat control system
arrangement of components installed in a building to limit the effects of smoke and heat from a fire

[SOURCE: BS 7346-4:2003, **3.1.37**]

3.38 smoke and heat exhaust ventilation system (SHEVS)
system in which components are jointly selected to exhaust smoke and heat in order to establish a buoyant layer of warm gases above cooler, cleaner air

[SOURCE: BS 7346-4:2003, **3.1.39**]

3.39 smoke clearance system

smoke and heat control system whose primary purpose is to remove smoke from a space after a fire has been controlled or extinguished

NOTE Secondary benefits might include an easing of the conditions to which fire-fighters are exposed while approaching and fighting the fire.

3.40 smoke control damper

device that can be opened or closed to control the flow of smoke and hot gases

NOTE In the fire operational position, the smoke control damper can be open (to exhaust smoke from the space) or closed (to avoid smoke spreading to other zones).

[SOURCE: BS 7346-4:2003, **3.1.42**]

3.41 smoke control zone

defined area within a car park provided with smoke control to prevent smoke moving into adjacent zones

3.42 stagnant area

area in which there is little or no air movement resulting in an undesirable build up of contaminated air

3.43 steady-state design fire

design fire based on the largest fire with which a smoke control system is expected to cope

3.44 steady-state design method

fire engineering method of calculating the design of a smoke and heat control system based on the largest fire with which the smoke and heat control system is expected to cope

3.45 thrust

force created at the discharge of an impulse fan

NOTE Thrust is a function of velocity and air mass usually measured in Newtons.

3.46 time-dependent design fire

design fire based on the most severe fire growth rate with which a smoke control system is expected to cope

3.47 vehicle emission ventilation

ventilation system designed to remove or dilute to a safe concentration products of combustion emitted by vehicle engines in normal use

3.48 zone model

combination of mathematical formulae describing a physical process by reducing that process to a limited number of simplified zones or regions where each zone is described by a small number of formulae

NOTE 1 The zone model is usually empirically derived.

NOTE 2 Zone models are often expressed in the form of a computer program.

[SOURCE: BS 7346-5:2005, **3.1.51**]

4 Smoke and heat control system selection

*COMMENTARY ON Clause **4***

The major potential source of ignitable material in a car park is the cars themselves. Smoke from a car fire spreads through the car park, directed by the shape of the building and the effects of wind pressures on openings, unless that smoke flow is controlled.

4.1 Design objectives

The designer should choose one of the following design objectives.

a) Clearance of smoke during the fire and after the fire has been suppressed, with the smoke control serving to assist in checking for secondary seats of fire as well as returning the building to its normal use.

b) Creating and maintaining a relatively smoke-free route through the car park open space on the fire's storey for fire-fighters to approach close to the car on fire, with the intention of facilitating active fire suppression.

c) Protection of escape routes for occupants within the same storey as the car on fire, to preserve a smoke-free path to either the exterior of the building, or to a protected stairwell which leads to a final exit to a place of safety.

NOTE The techniques available to achieve these objectives are:

a) smoke and heat exhaust ventilation systems (SHEVS), where a sustained region of clear air is maintained beneath a smoke reservoir containing thermally buoyant smoke;

b) cross-flow ventilation where air is induced to flow through the car park driven either by wind forces or by fans;

c) impulse ventilation intended to provide smoke-free access close to the car on fire for fire-fighters.

The systems are designed to control smoke from one fire at a time situated at any one point within the car park.

4.2 Selection of system

4.2.1 Where the objective is solely to achieve clearance by horizontal cross-flow through the car park storey one of the following should be used.

- Natural cross ventilation specified as permanent openings, see Clause **7**.
- Mechanical cross ventilation achieved using conventional mechanical ventilation, see Clause **8**.
- Mechanical cross ventilation using impulse fans, see Clause **9**.

NOTE The above three forms of cross-flow ventilation are only suitable for achieving smoke clearance.

4.2.2 Where the objective is to provide fire-fighters with a clear air access path to the car or other combustible material on fire, the following methods should be used.

- A SHEVS, having a minimum clear height, see Clause **12**.
- An impulse ventilation system designed to achieve a clear approach for fire-fighters to at least one side of the car on fire, see Clause **10**.

4.2.3 If there is any concern that automatic operation of a smoke and heat control system could adversely affect persons escaping, the system designer should either select an alternative system design or introduce an appropriate delay period before full activation of the system.

5 Design fires

COMMENTARY ON Clause ***5***

Reliable design fire information is essential for the design of systems intended to assist fire-fighter intervention or to protect means of escape. A design fire is not used for the design of systems intended for smoke clearance only, as these systems can follow separate prescriptive rules.

A developing fire in a car or light commercial vehicle typically starts in the engine compartment or in the passenger compartment. Violent crashes causing rupture of the fuel tank and immediate large fires are unlikely in a car park. Typical fire growth in the passenger compartment starts slowly, accelerating once the fire becomes reasonably well ventilated. This often occurs when a window or sun-roof breaks. The contents of the passenger compartment usually represent the main fuel load, and the seating, linings and instrument panel are often made of materials which burn vigorously.

Recent research has shown that the widespread use of plastics in body panels has resulted in cars containing a higher fire load (see BRE report, Fire spread in car parks *[1]) and there is the potential for fire to spread to adjacent cars, even across an empty parking bay. There is statistical and experimental evidence to the effect that fire spread from car to car needs to be considered as a distinct possibility, and that the heat output from a single car needs to be regarded as being larger than in past decades (see* Natural fires in closed car parks *[6]).*

Sprinklers are unlikely to extinguish a fire inside a vehicle, as most vehicles are designed to keep water (rain) out. Nevertheless, the effect of sprinklers in wetting the external surface of adjacent vehicles has been shown to slow or prevent fire spreading to the adjacent vehicle (see BRE report, Fire spread in car parks *[1]). See* ***9.1.16*** *and* ***16.2*** *for recommendations to reduce the risk of interaction between sprinklers and impulse fans.*

The capacity of car parks can be increased by the use of stackers, where mechanical systems can place one car closely above another. This arrangement could allow rapid fire spread from one car to another. However, experiments have shown that this spread can be significantly controlled by a suitably designed and installed sprinkler system (see BRE Report 256618 [7]).

There are two distinct approaches to using a design fire. One is to adopt a steady-state design fire and the other is to adopt a time-dependent design fire.

A steady-state design fire is based on the assumption that fires larger than the design size occur acceptably infrequently, and that the smoke and heat control system based on this design fire can cope successfully with all smaller fires (and by implication with all earlier stages of the same fire).

A steady-state design fire does not require the assumption that a real fire burns steadily. Calculation procedures are relatively straightforward, and might use simple computer zone-model techniques, although simple calculation methods can often serve.

A time-dependent design fire tracks the growing and often the declining stages of the heat output as a function of time, and is used to calculate the consequences typically in terms of the onset of a defined hazard. These methods tend to be complicated, and to rely on computer modelling. Sources for time-dependent design fires are ideally full-scale test fires using large calorimeters. Some of these empirical fire growth curves for cars can be used in a simplified form, although none correspond very closely to the "time-squared" growing fires commonly adopted for growing fires in buildings.

Other suppression systems might be an acceptable alternative to sprinklers.

5.1 Car fires

For steady-state design methods, the design fire should either use the appropriate value of heat release rate and other parameters from Table 1 or an alternative appropriate in the circumstances of the particular design, which should be detailed in the documentation specified in Clause **18** together with a justification as to why this alternative is appropriate. Where the experimental data has been placed in the public domain, a reference to the publication should be used as justification.

Table 1 **Steady-state design fires**

Fire parameters	**Indoor car park without sprinkler system**	**Indoor car park with sprinkler system**	**2 car stacker with sprinklers**
Dimensions	5 m × 5 m	2 m × 5 m	2 m × 5 m
Perimeter	20 m	14 m	14 m
Heat release rate	8 MW	4 MW	6 MW

NOTE It is not practical within this British Standard to give guidance on a suitable design fire size for stacker systems where sprinklers are not installed or where they exceed two cars high.

Time-dependent design fires should be based on an experimental test fire, which should be described and justified in the documentation specified in Clause **18**. Where the experimental data has been placed in the public domain, a reference to the publication should be used as justification.

5.2 Stores and storage within car parks

Provided that the nature of the combustible storage and the associated fire load would not give rise to a fire that would exceed the original design fire for the cars, the system should be assumed to be capable of dealing with a fire involving the storage.

The values for fire parameters in Table 1 should be used when comparing the likely steady-state design fire output adopted for the combustible storage.

However, the following should be taken into account:

a) the type of combustible materials stored;

b) the amount and disposition of the fire load;

c) the degree of fire resisting enclosure if provided;

d) the provision of sprinklers;

e) the size of the store/compartment involved.

6 Vehicle exhaust pollution control

*COMMENTARY ON Clause **6***

As well as providing smoke control for car parks in the event of a fire, there is an equally important everyday requirement for the ventilation of vehicle exhaust fumes. This is needed to avoid, in particular, excessive concentrations of carbon monoxide or other noxious gases.

For additional guidance on ventilation for vehicle exhaust pollution control in car parks, see The Building Regulations Approved Document F [8], The Building Regulations (Northern Ireland) Technical Booklet K [9] and Scottish Building Standards Technical Handbooks, Section 3 [4].

6.1 General

Any dual-purpose system intended to fulfil both environmental ventilation and smoke control during a fire should meet the performance recommendations for both roles.

One of the four alternative approaches to vehicle exhaust pollution control in **6.2** to **6.5** should be used.

Where a mechanical means of ventilation is used, the system should be designed such that there are no stagnant areas in daily ventilation mode.

6.2 Naturally ventilated car parks

For naturally ventilated car parks, permanent ventilation should be provided. The ventilation should have an aggregate equivalent area of at least 5% of the floor area of each car park storey. At least half of this should be equally arranged between two opposing walls.

6.3 Mechanical and natural ventilation of car parks

Permanent natural ventilation with an aggregate equivalent area of at least 2.5% of the floor area should be combined with a mechanical ventilation system capable of at least three air changes per hour.

6.4 Mechanically ventilated car parks

For basement or enclosed car park storeys, mechanical ventilation should be provided to at least six air changes per hour. In addition, wherever it is possible for cars to queue in the building with engines running, e.g. at exits and ramps, provision should be made for a local ventilation rate of at least 10 air changes per hour.

6.5 Detailed quantitative assessment of contaminants

As an alternative to **6.4**, the mean predicted pollution levels should be calculated and the ventilation designed to limit the concentration of carbon monoxide to not more than 30 parts per million averaged over an 8 h period and peak concentrations, such as by ramps and exits, not to go above 90 parts per million for periods not exceeding 15 minutes.

7 Natural dispersal smoke ventilation

7.1 Car parks which are open sided

7.1.1 Car parks should be naturally ventilated using the principle of wind-assisted cross-flow ventilation.

7.1.2 This form of ventilation should not be used for protection of means of escape in case of fire. It is suitable for smoke clearance and for fire-fighter assistance.

7.1.3 Ventilation openings should be permanently open and free of obstructions.

NOTE Due to the required area and locations of openings, natural ventilation can be unsuitable for underground car parks.

7.2 Car parks which are not open sided

7.2.1 Naturally ventilated car parks that are not open sided should be provided with some natural ventilation on each storey. The natural ventilation should be by permanent openings at each car parking level with an aggregate equivalent area of at least 2.5% of the floor area at each level. The distribution arrangements of the openings should be such that an aggregate equivalent area of 1.25% is equally provided between two opposing walls to give a good cross flow.

7.2.2 Smoke vents at ceiling level may be used as an alternative to permanent openings in the walls. These smoke vents should also have an aggregate equivalent area of permanent openings totalling at least 2.5% of each floor area, at each level and be arranged to provide a through draft.

7.2.3 Where openings have louvres, grilles, bird guards or similar devices installed, the equivalent area provided should take into account the restriction caused by these devices.

7.2.4 Where part of the open area is provided by ramps, entrances, etc., the ventilation area provided should include only the permanently open equivalent area of any doors, grilles or shutters across these openings.

7.2.5 For the purpose of smoke control, and as an alternative to permanent openings in the walls, automatic smoke ventilators conforming to BS EN 12101-2 may be provided in the ceiling, arranged to provide a through draught. The smoke ventilators might provide all or part of the required equivalent area. The smoke ventilators should open automatically upon detection of a fire in the car park. Smoke control dampers conforming to BS EN 12101-8 may also be used, see Clause **13**.

8 Ducted mechanical extract for smoke clearance

*COMMENTARY ON Clause **8***

The objective of the smoke clearance system design is to:

a) assist fire-fighters by providing ventilation to allow speedier clearance of the smoke once the fire has been extinguished;

b) help reduce the smoke density and temperature during the course of a fire (see Figures 1a and 1b).

This system is not specifically intended to maintain any area of a car park clear of smoke, to limit smoke density or temperature to within any limits or to assist means of escape.

8.1 General

8.1.1 The system should be independent from any other system (other than any system providing normal ventilation to the car park) and be designed to operate at 10 air changes per hour.

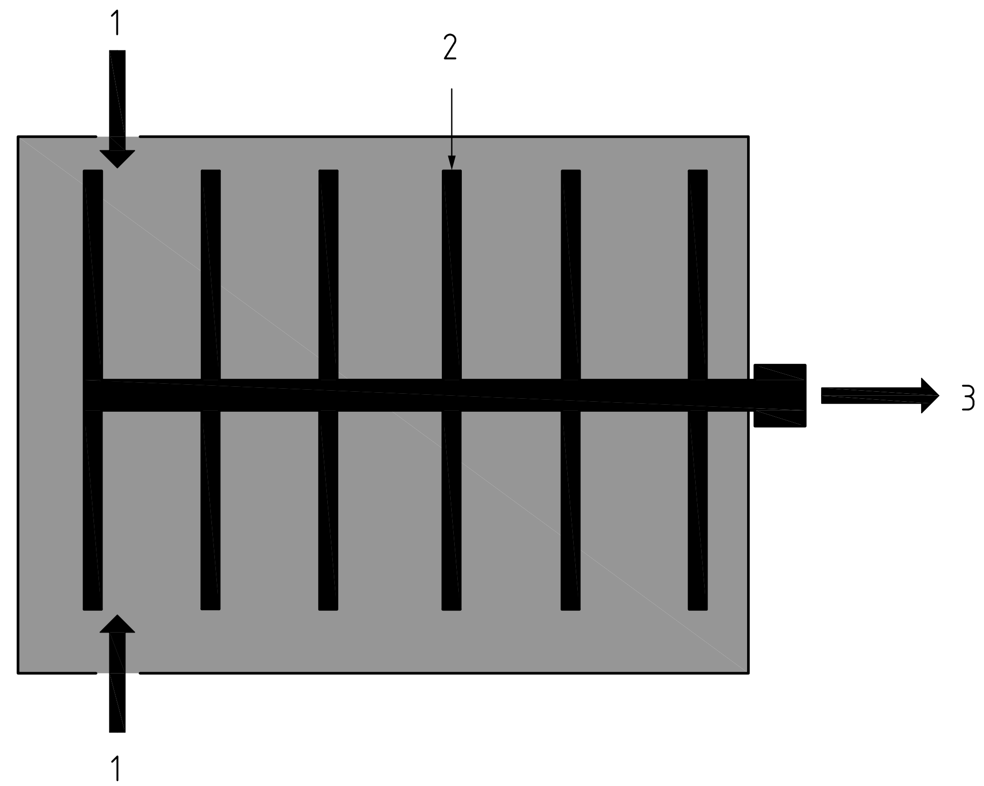
8.1.2 The discharge points for the smoke exhaust system should be located such that they do not cause smoke to be recirculated into the building, spread to adjoining buildings, or adversely affect the means of escape.

8.1.3 The main extract system should be designed to run in at least two parts, such that the total exhaust capacity does not fall below 50% of the rates set out in **8.1.1** in the event of failure of any one part and should be such that a fault or failure in one does not jeopardize the others.

8.1.4 The system should have an independent power supply, designed to operate in the event of failure of the main power supply.

8.1.5 Extract points should be arranged so that 50% of the exhaust capacity is at high level and 50% is at low level and evenly distributed over the whole car park.

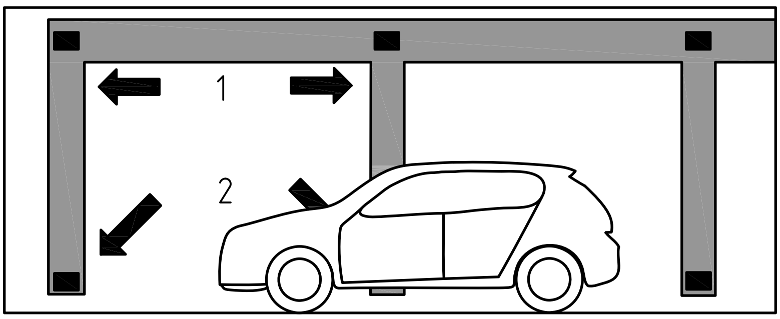
Figure 1a **Typical mechanical ventilation using a ducted smoke clearance system: plan view**



Key

1 Inlet
2 Ductwork
3 Extract

Figure 1b **Typical mechanical ventilation using a ducted smoke clearance system: section view**



Key

1 50% high level extract
2 50% low level extract

8.1.6 The fans and associated control equipment should be wired in protected circuits designed to ensure continued operation in the event of a fire (see Clause **14**).

8.1.7 The system should be initiated by one or more of the following:

a) smoke detection;

b) rapid rate of rise heat detection;

c) multi-criteria fire detection;

d) a sprinkler flow switch.

A fire service override switch is required in addition to any of a) to d).

8.1.8 Care should be taken to ensure that there are no stagnant areas in either daily ventilation or smoke ventilation operational mode.

8.1.9 Provision should be made for the supply of replacement air to the car park.

8.1.10 The velocity of air within escape routes and ramps should not exceed 5 m/s in order to avoid impeding the escape of occupants of the building.

8.2 Performance recommendations for equipment

8.2.1 All fans intended to exhaust hot gases used within a car park ventilation system should be tested in accordance with BS EN 12101-3 to verify their suitability for operating at 300 °C for a period not less than 60 minutes (class F300).

NOTE For further information on equipment for removing hot smoke, see BS EN 12101-3.

8.2.2 Where smoke extract fans are located within the building, but outside the fire compartment which they serve, they should be enclosed with elements of structure having a fire resistance at least equal to that required for the part of the building within which it is situated and in no case less than 1 h.

8.2.3 Ductwork, dampers and fixings should conform to Clause **13**.

8.3 Calculation procedures

The exhaust ventilation system should be designed to provide a minimum of 10 air changes per hour for each car park storey or fire compartment served by that system.

9 Impulse ventilation to achieve smoke clearance

*COMMENTARY ON Clause **9***

The objective of the smoke clearance system design (see Figure 2) is to:

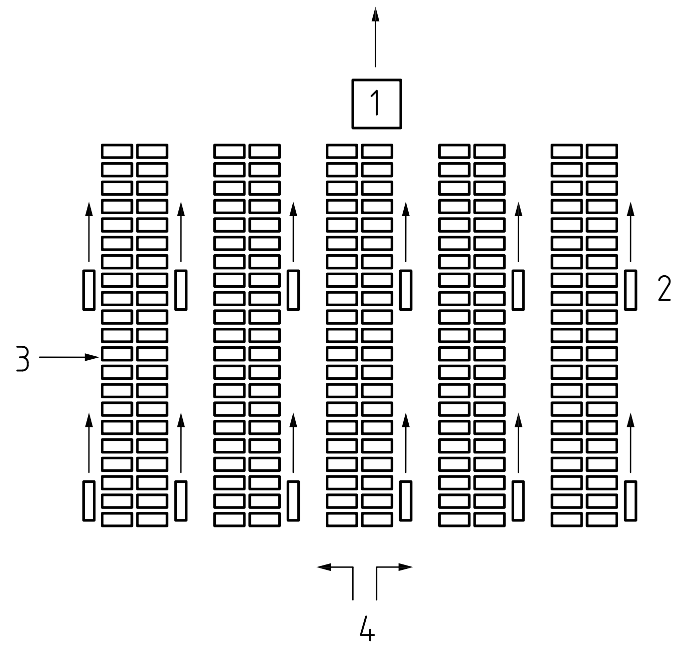
a) assist fire-fighters by providing ventilation to allow speedier clearance of the smoke once the fire has been extinguished;

b) help reduce the smoke density and temperature during the course of a fire.

This system is not intended to maintain any area of a car park clear of smoke, to limit smoke density or temperature to within any specific limits or to assist means of escape.

It is possible that some smoke clearance systems, if set in operation too early, might actually worsen conditions for means of escape by encouraging smoke circulation and descent of the smoke layer. For this reason it could be preferable to delay operation after automatic detection of fire.

Figure 2 **Typical mechanical ventilation using an impulse smoke clearance system**



Key

1	Extract	3	Parking bays
2	Impulse fans	4	Fresh air supply

9.1 General

9.1.1 On detection of a fire, the extract fans should immediately respond to provide the required rate of extract.

9.1.2 After an appropriate delay, if any, the impulse fans should activate in such numbers as necessary to direct the smoke efficiently towards the extract points for a fire. The delay period should reflect the designed means of escape period.

NOTE 1 The delay is necessary to ensure that escaping occupants are not compromised by the action of the impulse fan system.

NOTE 2 The delay employed to achieve this outcome depends on one or more factors:

- *the size and geometry of the car park;*
- *the number and location of extract and impulse fans;*
- *the numbers and type of occupants;*
- *the number and location of suitable exits; and*
- *travel distance to exits.*

9.1.3 Any delay period should be confirmed in agreement with the approving authorities.

9.1.4 The air change rate within the car park should be at least 10 air changes per hour.

9.1.5 Consideration should be given to the location of the means of escape within the car park when locating the position of the extract point(s).

9.1.6 The positions of the stairwell, means of escape corridor and lobby doors, where present, should be co-ordinated with impulse fan locations and impulse orientations to avoid exposing the doors to dynamic pressure effects which might cause smoke to enter the lobby, stairwell and/or corridors.

9.1.7 Care should be taken to ensure that there are no stagnant areas in either daily ventilation or smoke ventilation operational mode.

9.1.8 Provision should be made for the supply of replacement air to the car park.

9.1.9 The velocity of air within escape routes and ramps should not exceed 5 m/s in order to avoid impeding the escape of occupants of the building.

9.1.10 The resistance to airflow and turbulence caused by downstand beams and any other obstruction should be taken into account when siting the impulse fans.

9.1.11 Notwithstanding the requirements for daily ventilation, in the event of fire, the extract fans, where present, should be immediately activated to provide a minimum airflow rate equivalent to 10 air changes per hour within the car park.

9.1.12 Care should be taken to ensure that the number of impulse fans activated does not induce the movement of a volume of air greater than that which the extract fans are capable of extracting.

9.1.13 The system should be independent from any other system (other than any system providing normal ventilation to the car park).

9.1.14 The discharge points for the smoke exhaust system should be located such that they will not cause smoke to be recirculated into the building, spread to adjoining buildings, or adversely affect the means of escape.

9.1.15 The main extract system should be designed to run in at least two parts, such that the total exhaust capacity does not fall below 50% of the rates set out in **9.1.4** in the event of failure of any one part and should be such that a fault or failure in one will not jeopardize the others.

9.1.16 Where a suppression system is to be installed, the impulse system should be designed in such a way as to ensure that it does not adversely affect the activation or efficiency of the suppression system (e.g. water mist/sprinkler systems) (see **16.2**).

9.1.17 Each part of the extract system should have an independent power supply, which will operate in the event of failure of the main power supply.

9.1.18 The fans and associated control equipment should be wired in protected circuits designed to ensure continued operation in the event of a fire (see Clause **14**).

9.1.19 The system should be initiated by one or more of the following:

a) smoke detection;

b) rapid rate of rise heat detection;

c) multi-criteria fire detection;

d) sprinkler flow switch.

A fire service override switch is required in addition to any of a) to d).

9.1.20 All fans intended to exhaust hot gases used within a car park ventilation system should be tested in accordance with BS EN 12101-3 (class F300) to verify their suitability for operating at 300 °C for a period not less than 60 minutes.

NOTE For further information on equipment for removing hot smoke, see BS EN 12101-3.

9.1.21 Where smoke extract fans are located within the building, but outside the fire compartment which they serve, they should be enclosed with elements of structure having a fire resistance at least equal to that required for the part of the building within which it is situated and in no case less than 1 h.

9.1.22 Ductwork, dampers and fixings should conform to Clause **13**.

9.2 Calculation procedures

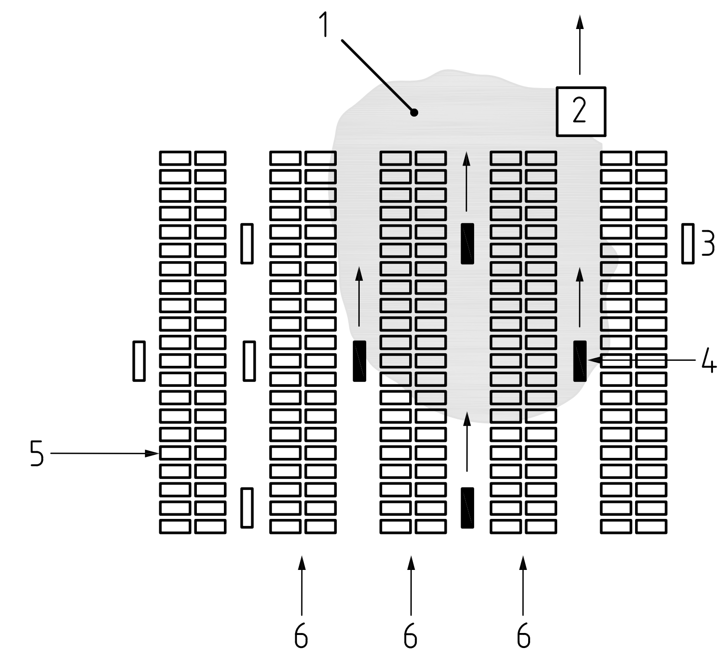
The exhaust ventilation system should be designed to provide a minimum of 10 air changes per hour for the largest car park storey or fire compartment served by that system and should be applied to the calculated volume of each car park storey or compartment.

10 Impulse ventilation to assist fire-fighting access

*COMMENTARY ON Clause **10***

The objective of the smoke control design is to aid access by the fire service to more quickly locate and tackle a fire and carry out search and rescue as necessary. See Figure 3.

Figure 3 **Typical mechanical ventilation using an impulse system for fire-fighter access**



Key

1	Controlled smoke flow	4	Operational impulse fans
2	Extract	5	Parking bays
3	Inoperative impulse fans	6	Supply air

NOTE Only impulse fans coloured black are operating.

10.1 System design criteria

10.1.1 The design should be based on calculation. Whatever calculation method is adopted, the design should be based on the following performance criteria.

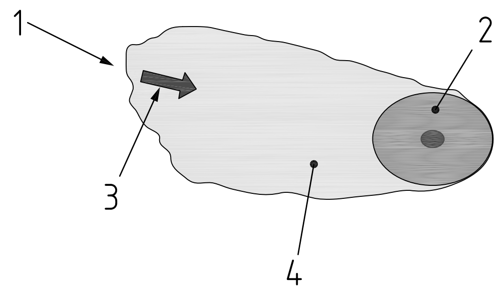
10.1.2 The extract rate should be calculated for the removal of the mass of mixed air and smoke impelled towards the exhaust intakes. Calculations should be based on a design fire from Table 1, or another design fire acceptable to the approving authorities. All supporting calculations and justifications should be fully documented (see Clause **18**).

10.1.3 The system should be such that all car park levels and other parts of the building, other than the one where the fire is located, are kept substantially free of smoke, such that occupants of those levels can identify their route of escape.

10.1.4 There should be fire-fighter access from the exterior or from protected stairwells, positioned to allow fire-fighters to have at least one clear approach route to any possible fire location.

10.1.5 Designs should be such that the fire-fighters will have 10 m visibility at 1.7 m height up to a point within 10 m of the fire (see Figure 4).

Figure 4 **Area with at least 10 m substantially clear approach to fire for fire-fighters**



Key

1 Fire-fighter access point
2 Visibility within 10 m of the fire can be zero
3 Fire service approach
4 Visibility in this area is at least 10 m

10.1.6 The design should take account of the presence of any downstand beams and of their orientation in assessing the effect on the ceiling jet, and hence on the minimum induced airspeed necessary to overcome and to turn back the ceiling jet.

10.1.7 The positions of the stairwell, means of escape corridor and lobby doors, where present, should be co-ordinated with impulse fan locations and impulse orientations to avoid exposing the doors to dynamic pressure effects which might cause smoke to enter the lobby, stairwell and/or corridors.

10.1.8 The design objectives of the system should be met even after failure of the impulse fan closest to the fire. Failure of this fan should be taken into account in any CFD modelling undertaken.

10.1.9 The ventilation system should be able to control the flow of smoke wherever the fire occurs within the car park.

10.1.10 The capacity of main smoke extract fans and any associated ducting should be calculated on the basis that the pressure in the car park close to the extract intakes is equal to the external atmospheric pressure.

10.1.11 Provision should be made for the supply of replacement air to the car park.

10.1.12 The velocity of air within escape routes should not exceed 5 m/s in order to avoid impeding the escape of occupants of the building.

10.1.13 Inlets for replacement air should be large enough (if natural openings) or should be sufficiently extensive and evenly distributed (if air is supplied by fans via ducts) to ensure that the airspeed in the incoming jets formed inside the inlets does not create a recirculation of smoke. The maximum inlet air speed should be 2 m/s.

NOTE This is intended to ensure that the car park storey is maintained below external atmospheric pressure except close to the intakes for the main smoke extract. This gives a measure of additional protection to lobbies, stairwells and/or corridors used for fire-fighting access and for evacuation of occupants.

10.1.14 The number of impulse fans activated should not cause the volume of air movement to be greater than that volume extracted by the extract fans.

10.1.15 For a smoke and heat control system, the car park should be divided into smoke control zones of not more than 2 000 m^2, with a fully addressable fire detection system able to indicate the fire's location to the system's main control panel.

NOTE An addressable fire detection system also assists the fire and rescue service to locate and tackle the fire more quickly.

10.1.16 The system should be initiated by one or more of the following:

a) smoke detection;

b) rapid rate of rise heat detection;

c) multi-criteria fire detection.

A fire service override switch is required in addition to any of a) to c).

10.1.17 Designs based on the creation of smoke control zones within a larger volume should either:

- have physical partitions to create channels for the smoke and the induced air flow, thus separating neighbouring zones; or
- using computational fluid dynamics (CFD) modelling, show that the system meets the design objectives and limits the spread of smoke to other zones in the car park.

10.1.18 Where a suppression system is to be installed, the impulse system should be designed in such a way as to ensure that it does not adversely affect the activation or efficiency of the suppression system, e.g. water mist/sprinkler systems (see **16.2**).

10.1.19 On detection of a fire, the extract fans should immediately respond to provide the required rate of extract.

10.1.20 After an appropriate delay, if any, the impulse fans should activate in such numbers as necessary to direct the smoke efficiently towards the extract points for a fire. The delay period should reflect the designed means of escape period.

NOTE 1 The delay is necessary to ensure that escaping occupants are not compromised by the action of the impulse fan system.

NOTE 2 The delay employed to achieve this outcome depends on one or more factors:

- *the size and geometry of the car park;*
- *the number and location of extract and impulse fans;*
- *the numbers and type of occupants;*
- *the number and location of suitable exits; and*
- *travel distance to exits.*

10.1.21 Any delay period should be confirmed in agreement with the approving authorities.

10.1.22 Information as to the clear approach routes should be automatically displayed at the fire service main point of entry into the building.

10.1.23 The impulse fans designated to operate to control the flow of smoke and to protect the other parts of the car park should be activated in sufficient numbers so as to limit the spread of smoke.

10.2 Equipment rating

10.2.1 The aerodynamic performance of the impulse fan should be tested in accordance with BS EN ISO 13350.

10.2.2 At least two extract fans should be installed to serve each smoke control zone of the car park. The fans should have sufficient capacity to give the full design extract rate with any one fan discounted. The fans should be mounted in parallel, but mounting in series may be acceptable.

10.2.3 All fans should conform to at least class F300 of BS EN 12101-3:2001, that is, they should be suitable for handling a temperature of 300 °C for a period of not less than 60 minutes.

10.2.4 All ancillary equipment, electrical or mechanical, associated with the main fan installation and potentially exposed to the same hot fire gases, should be capable of maintaining its performance and structural integrity for the same time/temperature criteria as specified for the fans, i.e. 300 °C for a period of at least 60 minutes.

11 Impulse ventilation to protect means of escape

11.1 System design objectives

*COMMENTARY ON **11.1***

The objective of the smoke and heat control system is to provide for the protection of escape routes for occupants within the same storey as the car on fire, to preserve a smoke-free path to either the exterior of the building, or to a protected stairwell which leads to a final exit to a place of safety. See Figure 3, which illustrates the way in which, with the selective activation of the impulse fans, the flow of smoke can be controlled.

Care should be taken to ensure that routes for access to a point of escape are not compromised due to poor visibility or accessibility.

11.2 System design criteria

11.2.1 Impulse ventilation to protect means of escape should conform to Clause **10**, with the following additional recommendations.

11.2.2 There should be a sufficient number of storey exit doors/escape routes maintained unaffected by smoke for the estimated population initially in the car park storey to evacuate safely, with all storey exits in the extract direction in the affected smoke control zone discounted.

11.2.3 All zones outside the defined smoke path between fire source and extract point should be usable.

11.2.4 Within the affected smoke control zone, escaping occupants should be able to move to a clear storey exit such that they are not affected by the smoke and heat generated by the fire. The design should show that the available safe egress time from the affected smoke zone is greater than the required safe egress time plus a suitable safety margin.

*NOTE Following any delay considered appropriate (see **10.1.20**), the impulse fans will operate and move smoke and heat more rapidly than by natural means, therefore the impact of the fans operating in the smoke affected zone needs also to be considered as part of this analysis.*

11.3 Equipment rating

The criteria detailed in **10.2** should also be used here.

12 Smoke and heat exhaust ventilation systems (SHEVS)

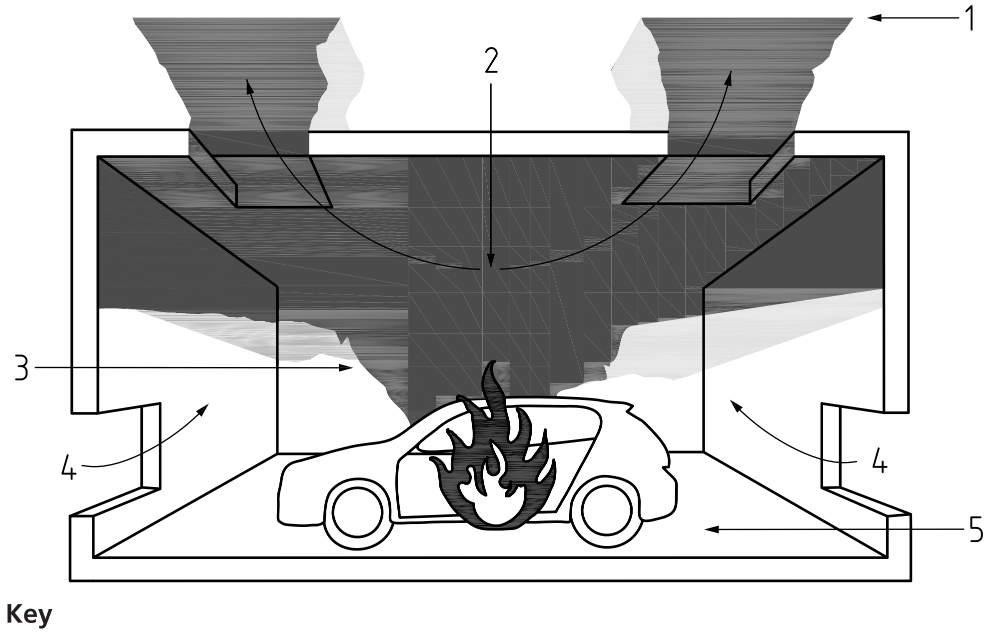
*COMMENTARY ON Clause **12***

In a smoke and heat exhaust ventilation system (SHEVS), the hot smoky gases resulting from the fire float above the denser cold air beneath. This maintains good visibility in the clear air beneath the smoke layer, allowing free movement either for evacuation or for fire-fighter access to the fire (see Figure 5).

The minimum clear height can be different for these two objectives, in view of the protective clothing and training available to fire-fighters.

The concept and design procedures are described in detail in BS 7346-4 for steady-state design fires, and in BS 7346-5 for time-dependent design fires.

Figure 5 **Design regions for a single volume space**



Key

1	Wind	4	Air inlets and doors
2	Smoke reservoir and exhaust	5	Fire
3	Smoke plume		

A SHEVS should be designed in accordance with BS 7346-4 and BS 7346-5, with certain exceptions specific to car parks detailed in a) to g) below.

a) The SHEVS should be used as a dual purpose smoke control and vehicle exhaust emission control system, provided it meets the required flow rates for both conditions.

b) Where the SHEVS is designed to protect means of escape for occupants, the clear height should be at least that detailed in BS 7346-4 (i.e. 2.5 m or 0.8 times the ceiling height, if the resultant figure is lower than 2.5 m).

c) Where the SHEVS is designed to provide a clear, smoke-free approach to the fire for fire-fighters, the clear height should be at least 1.75 m.

d) The design fire, whether steady-state or time-dependent, should be based on **5.1** rather than the car fire cited in BS 7346-4.

e) The system should be independent from any other ventilation or HVAC system in the building other than for the control of vehicle emission pollutants.

f) All other performance recommendations and calculation procedures should be as detailed in BS 7346-4 for steady-state designs, and as detailed in BS 7346-5 for time-dependent designs, of the SHEVS as well as for recommendations specific to car parks within the scope of this standard.

g) Openings should be provided to allow the air to enter or exit the car park. These inlets should conform to the recommendations of BS 7346-4, and where the vehicle entrances and/or exits are required for the SHEVS, e.g. in emergency mode, the system should ensure that any gates are automatically moved into the fire operational position specified by the design of the SHEVS.

13 Smoke control duct sections and smoke control dampers

All smoke control duct sections should meet the requirements of BS EN 12101-7.

All smoke control dampers should meet the requirements of BS EN 12101-8.

NOTE Products used outside the EU do not require CE marking.

Consideration should be made for the application and whether it is single or multi-compartment. Additionally, it should be decided whether dampers will activate automatically in response to an alarm or whether they wait for fire-fighter or other input.

Smoke control duct sections and smoke control dampers should be designed and selected in accordance with Annex A.

14 Controls and power supplies

14.1 General

Where power is essential to initiate or maintain operation of smoke and heat control systems the controls and power supplies should be suitably rated or protected to ensure that power remains available for the required period.

A secondary power supply should be provided to operate automatically in case of failure of the primary supply.

The provision of power supplies should be in accordance with BS EN 12101-10.

NOTE This is not necessary when natural ventilation, failing to the fire condition on loss of power, is used.

14.2 Controls

14.2.1 The system should be initiated by one or more of the following:

a) smoke detection;

b) rapid rate of rise heat detection;

c) multi-criteria fire detection;

d) sprinkler flow switch.

A fire service override switch is required as an additional part of any option a) to d).

A manual fire service switch should not be used as the only form of initiation for systems designed to assist fire-fighting access and/or protect means of escape.

14.2.2 The design cause and effect should be made available to all parties very early in the process to allow procurement, installation and commissioning.

14.2.3 Operation in the case of a fire should override any environmental controls associated with the smoke and heat control system for controlling the normal environmental ventilation arrangements for the car park.

14.2.4 A smoke, rapid rate of rise heat detection, or multi-criteria system should conform to the requirements of BS 5839-1.

14.2.5 The type and location of detectors should be selected to initiate operation of the system as early as possible. The detectors should be located to minimize adverse effects from air movement caused by the environmental ventilation system.

*NOTE In some situations, a delay might be built into the operating system to hold off operation of all or part of the system for a set period. See Clause **9** to Clause **11**.*

14.2.6 Where zonal control is required, the detection system should be capable of locating the fire with an accuracy that allows the different zones of the smoke and heat control system to operate appropriately within the design.

14.2.7 Control panels for the smoke and heat control system should be separated from the main car parking area by a fire-resisting separation of at least 1 h.

14.2.8 Clearly labelled fire service override switches should be provided at agreed fire service access points. For automatic systems, the switches should provide off/auto control and where appropriate off/auto/on control. For manual systems, the switches should provide off/on control. Fire service override switches should be finished in the colour compliant with current fire service requirements and all switches should be labelled for fire-fighter use only and its purpose should be identified.

14.2.9 The fire service switch should not be located within the body of the car park itself.

14.2.10 The manual arrangements for re-setting the smoke extract system to normal after it has been activated automatically should be clearly separate from and not affected by the facilities for re-setting the fire alarm system after it has been operated.

14.2.11 No switch should be incorporated in the fire alarm system which can isolate the automatic operation of the smoke extract systems in the triggering of the alarm (e.g. for use when periodically testing the alarm system) unless a non-mutable audible warning is given in a position under regular observation whilst the smoke extract systems are isolated.

14.2.12 Any arrangements for interconnection of the smoke extract system with a building management system (BMS) should be such that any fault developing on the processing system, or any change from its normal operation including when it is being maintained, will not jeopardize the operation of the smoke extract systems.

14.3 Computerized control systems

*COMMENTARY ON **14.3***

Computerized control systems can be used to control a car park smoke and heat control system, and rely on the use of specific software to carry out the modes of operation required of that system.

14.3.1 Where computerized control systems are used as part of the operational requirements of a smoke and heat control system, any changes to the software controlling the fire safety functions should not adversely affect the operation of the smoke and heat control system.

14.3.2 A comprehensive description of the control software should be provided to the building owner and/or his site agent by the system designer, together with documentation of all changes made to the system after installation. This should be added to the documentation detailed in Clause **18** (see also BS 9999).

14.3.3 When changes are made to the software or associated computer system, a full check of the smoke and heat control system operation should be carried out in accordance with Clause **17** to confirm the continual functioning of the system and the results included in the documentation in accordance with Clause **18**.

14.3.4 Signalling systems providing the information to and from the computerized control centre should be protected from the effects of fire for a period of 1 h.

14.4 Power supplies

14.4.1 General

14.4.1.1 The electrical distribution system should be designed and installed by a competent person as defined in BS 7671.

14.4.1.2 The electrical arrangements should conform to BS 7671 and the relevant parts of BS EN 60947.

14.4.1.3 To maintain the operation of the life safety and fire-fighting systems, a secondary power supply, e.g. an automatically started standby generator or an alternative utility supply from another external substation, should be provided in accordance with BS 8519.

14.4.2 Dual circuits/diverse routes

Both the primary and the secondary supplies should be protected against fire and water damage and separated from each other by adopting diverse cable routes.

The diverse cable routes for the power supplies should be separate from any non-life safety/fire-fighting system circuits that could be detrimental to the operation of the life safety and fire-fighting system circuits.

Where the diverse routes come together in the same area, they should be separated from each other by a partition with a fire resistance period of at least 1 h.

NOTE This does not apply within the room containing the automatic change over device.

14.4.3 Fire protective enclosures for equipment

Any electrical substation or enclosures containing any of the following equipment should be separated from the remainder of the building by construction protected against fire and water damage for a period of at least 1 h:

- distribution boards;
- motor control panels;
- smoke control plant; and
- automatic changeover devices, with their associated switchgear.

NOTE A smoke control plant does not usually require separation from the car park it protects.

14.4.4 Automatic changeover devices

Changeover devices should conform to BS EN 60947-6-1 and BS EN 60947-6-2.

14.4.5 Control panels

Control panels serving the appropriate life safety and fire-fighting circuits should be protected to IP54 classification as specified in BS EN 60529:1992.

14.4.6 Cable selection

The cables selected for smoke ventilation installations should be fire-resistant cables meeting the requirements of BS 8519.

Cables selected for use with an automatic fire detection system should comply with BS 5839-1.

14.4.7 Cable installation practice

When installing cables that are required to maintain circuit integrity under fire conditions, the resistance to fire of the cable fixings, cable containment system and any joints should be at least equivalent to the survival time required for the cable.

Joints in cables, other than those contained within the enclosures of equipment, should be avoided wherever practicable.

Where fire-resistant cables have by their method of construction adequate mechanical protection (e.g. cables tested in accordance with BS 8491), they should either be fixed directly to the building structure, or be installed such that they are enclosed in or carried upon cable management or containment systems. If the cables are fixed directly to the building, the fixings should provide adequate support in the presence of the potential hazards (see Introduction).

Where fire-resistant cables require additional mechanical protection, they should be enclosed in or carried upon cable management or containment systems. Such systems should provide adequate support and maintain necessary mechanical protection in the presence of the potential hazards. The systems and their supports should be sized to cater for the reduction in the tensile strength of steel when directly exposed to a fire temperature.

14.4.8 Cable support systems

The support system should have a fire survival time equal to that of the cables it supports and for the same defined fire conditions.

When sizing the support brackets for containment routes, which are intended to support fire-resistant cables in a fire condition and where the circuits are to maintain their integrity for a pre-determined period, the drop rods and hangers should be sized to take into account the fact that the tensile strength of steel will be significantly reduced in a fire situation.

14.4.9 Inverters

Power supplies for systems derived from frequency inverters in order to vary the speed of the motor should be equipped with a fail-safe fire mode. The fire mode should effectively disable the motor protection function to enable, if necessary, the inverter/motor to run to destruction.

Where the smoke and heat control system is provided with speed control using frequency inverters, each extract and supply fan should be provided with a dedicated inverter. The inverters should be installed within the control panel or should be located separate from the main car parking area by a fire-resisting separation of at least 1 h. The mode of control in the event of an inverter failure should enable the fan to operate at its maximum speed.

If the ventilation system is required to have multiple speeds in fire mode, in order to perform the required duty, each speed should be separately hard-wired and initiated from the individual fire alarm interface modules.

14.4.10 Area of special risk

Smoke ventilation system cables installed within the car park should be installed to avoid locations above parking places as far as is practicable.

NOTE In the cable fire test rig in BS 8491, the maximum temperatures developed are approximately 850 ˚C but higher temperatures might be experienced directly above a burning car or van.

15 Pre-installation verification

Systems intended to provide specific conditions, whether for means of escape or fire-fighter access, based on the dilution of smoke or the provision of a clear area should be verified prior to installation (see **10.1.17**).

Where computer modelling is the preferred route for pre-installation verification agreement should be reached as to the conditions to be modelled between the designer and approving authorities prior to commencing modelling.

CFD modelling should be carried out in accordance with Annex B.

16 Interaction with other fire protection systems and other building systems

16.1 General

The smoke and heat control systems described in this standard should work in conjunction with mechanical, electrical and other fire protection systems within the building.

16.2 Interaction of impulse fans and sprinklers

Where sprinklers are installed within a car park fitted with an impulse ventilation system, the distribution of the impulse fans should be co-ordinated with the sprinkler installation in order that the jet stream from the impulse fan creates minimum interference with the sprinkler pattern.

NOTE 1 At the time of publication, little research has been carried out into the impact that the installation of impulse fans has on the performance of a sprinkler system.

NOTE 2 The performance of impulse fans is achieved in the creation of a high speed jet of air discharged from the fan outlet which induces into the jet stream. It is the high speed jet of air and the air movement that it creates that has the greatest impact on the activation of sprinkler heads and the disturbance of the sprinkler pattern.

Where impulse ventilation is designed to work in conjunction with sprinkler installations all impulse fan motors and terminal boxes should have a rating of IP55.

The effectiveness of sprinklers in controlling the spread of fire within a car park depends on the activation of the sprinkler heads located above the vehicle(s) on fire; therefore the distribution of the impulse fans, where possible, should be focused in the roadways.

NOTE 3 This has two benefits; the impulse fans will have a reduced impact on the activation of the sprinklers and the sprinkler pattern and secondly, as the impulse fans will be located in the roadway instead of above parked vehicles, they might benefit from improved performance.

16.3 Other ventilation systems

16.3.1 General

16.3.1.1 Where separate systems are installed for environmental/pollution control and smoke control

a) In the event of a fire, the environmental/pollution control system should close down. Any ducts or openings that form part of this ventilation system and which penetrate fire compartment boundaries (walls and floors) should have these penetrations protected using fire dampers manufactured to BS EN 15650 with a classification period to match the compartment boundary. All such fire dampers should close under the control of the signal from the smoke/fire alarm system.

b) The separate smoke control system should be immediately activated.

c) The system should be demonstrated to function reliably at commissioning and details should be given in accordance with Clause **17**.

16.3.1.2 A combined system that is used for day-to-day environmental and fume control, but which functions as a smoke control system in the event of a fire

a) The whole system should be designed as a smoke control system. It should only use smoke control components classified to the BS EN 12101 series. There should be no fire dampers in the system, which could close and prevent the system from working correctly.

b) The selection of the products to be used should follow the recommendations given in Clause **13**.

c) As the system is started or changed over, the dampers should move to the positions required to allow the smoke to be exhausted.

d) The smoke extract fans should be started immediately.

e) This should be demonstrated to function reliably at commissioning and details given in accordance with Clause **17**.

16.4 Lighting, signage, public address and voice alarm systems

In view of the importance of rapid evacuation of car park occupants for several of the smoke control systems detailed in this standard, consideration should be given to optimizing lighting, signage and public address and voice alarm systems in the car parks.

Sound levels of public address and voice alarm systems, and of the car park smoke control systems, should be such that when the car park smoke control systems are activated, messages are clearly audible and intelligible. The designers of the car park smoke control systems, public address and voice alarm systems should consult each other at the design stage to optimize the performance of the combined systems. For further discussion see Annex C.

16.5 Interaction with other smoke ventilation systems

COMMENTARY ON ***16.5***

If not properly co-ordinated with lobby doors that link to access routes from the building above, impulse fans can have an adverse effect on the performance of other smoke ventilation systems within the building.

For example, protected stairwells connected to the car park might be equipped with a pressure differential system. If the storey is more than 10 m below ground level and the stairwell is a fire-fighting shaft, then the stairwell would usually be pressurized.

The dynamic pressure head due to the stairwell door intercepting the air flow from an impulse fan might adversely affect the pressure difference across the storey-exit door.

To avoid the risk of impulse fans having an adverse effect on other smoke ventiliation systems within the building, the discharge of the impulse fans should be positioned so that the jet stream from the fans does not create adverse airflow conditions in the area of the lobby doors.

16.6 External/ground level escape routes

COMMENTARY ON ***16.6***

All smoke and heat control systems need to eject smoky gases to the exterior, at or above ground level. Care needs to be taken to ensure that this smoke does not create unacceptable hazards to people in the surrounding areas.

The location of smoke exhaust outlets for the smoke and heat control systems should be selected to minimize the risk of smoke adversely affecting people or vehicles in the surrounding area, taking wind effects into account.

Air inlets for the smoke and heat control system should not be located where smoky gases being exhausted by the same smoke and heat control system could be drawn in with the incoming air.

16.7 Security systems

COMMENTARY ON ***16.7***

Smoke control measures and building security might conflict unless the needs of both are taken into account during the design of the building. Smoke control measures, for example, often require openings for replacement air to enter the building whereas security against unauthorized entry requires that openings are impassable to people.

Security measures such as CCTV can be very useful in preventing arson, and/or as an adjunct to fire detection systems or when giving directed messages using the public address system.

Security systems should not adversely affect the operation of the smoke and heat control system. For example, where doors are recommended to act as air inlets, and can be closed off for part of the day, they should open automatically when the smoke and heat control system is activated.

Where CCTV is monitored by a control room, the operators of that control room should have the capability, that is the facilities and training, to monitor the fire detection system as well if this forms part of the fire strategy for the building.

Where CCTV is monitored by a control room, and there is a public address system, the control room operators should be trained to give directed messages as needed if this forms part of the overall fire strategy for the building.

17 Commissioning

All parts of a car park ventilation system should be inspected, tested, demonstrated and verified at the completion of installation.

At an early stage in the project all relevant documents relating to the system design should be submitted to the appointed regulatory authorities. These documents include:

- system design criteria;
- design objectives;
- system overview and performance;
- calculations to support the design;
- schematics;
- product specification;
- drawings;
- cause and effect chart; and
- CFD modelling report (where applicable).

Table 2 provides an example checklist covering the major components of the ventilation system. The system should be demonstrated to perform in day-to-day ventilation mode as well as for smoke clearance or smoke control.

Table 2 **Example checklist for commissioning of a smoke and heat control system**

Component	Installed ✓ [tick]	Tested ✓ [tick]
Natural ventilation systems		
Check that adequate openings are provided		
Check that openings are suitably distributed		
Check that openings will not be liable to obstruction		
All mechanical systems		
Provide full set of as installed drawings, written system description, calculations and cause and effect chart		
Verify by measurement that the extract fans are providing the correct rate of extract		
Verify by measurement that the supply fans are providing the correct airflow rate		
Check that there is no excess leakage through flexible connectors or ductwork		
Check free and correct operation of gravity operated non-return dampers		
Demonstrate the correct operation of fire/smoke dampers		
Demonstrate the correct operation of the system in the event of mains failure		
Demonstrate the correct operation of the system in the event of one fan failure		
Carry out a cable survey and check cable rating		
Confirm fans conform to BS EN 12101-3		
Check operation of fire service override switch		
Check that local isolators to all fans are suitably fire rated		
Verify that an adequate source of make up air is available		
Ducted mechanical system		
Verify airflow rates through each duct extract point		
Demonstrate the automatic operation of the system by the selected method of activation		
Confirm correct selection and installation of all fixtures and fittings used in the installation of ducting in compliance with relevant regulations and standards		
Confirm certification of ducting		
Impulse smoke clearance system		
Confirm operation of all impulse fans and operation in the correct direction		
Demonstrate the automatic operation of the system by the selected method of activation		
Check impulse fans are operating at the correct speed according to the agreed design strategy		
Demonstrate air movement in all parts of the car park in daily ventilation and smoke clearance mode		
Confirm impulse fans conform to BS EN 12101-3		
Impulse ventilation system for fire-fighter access and/or means of escape		
Demonstrate the correct activation and operation of the system by automatic means and compliance with the declared design for each zone		
Using cold smoke generation, demonstrate the control of airflow for each zone		
All systems		
Check the interaction between the car park ventilation system and all other detection, alarm, smoke control or any other life safety system		
Confirm that all other ventilation systems linked to the car park will shut down in the event of fire being detected in the car park		
Confirm calibration of carbon monoxide monitoring system		
Confirm free and correct movement of motorized dampers		

18 Documentation to be supplied with smoke and heat control system

18.1 General design recommendations

18.1.1 General

Documentation indicating that the design philosophy and calculation meet one, or a combination, of the design objectives given in **4.1** should be provided. This should be made available to the owner of the car park where the smoke and heat control system is installed and/or to the user of the system.

This documentation should comprise all the information necessary for clear identification of the installed system, e.g. drawings, description, list of components, certification of installation act, test certificates of components, details of calculations made.

Where a car park is altered, updated documentation on the smoke and heat control system should be provided and made available for the owner and/or user of the car park.

18.1.2 Fire safety management

The design should consider all aspects of access for maintenance and regular testing. The following information should be handed over on completion:

a) all details of the design (cause and effect);

b) the as installed information;

c) how to run the system;

d) how to maintain the system;

e) how to test the system and how often (see also BS 9999);

f) what records to be kept on maintenance and testing;

g) information for fire-fighters; and

h) product, installation and maintenance details of all fire and smoke safety components.

18.1.3 Fire-fighting

Where the car park employs a system that is designed to assist fire-fighting, sufficient information should be provided to enable attending fire-fighters to understand the system and operate any override controls as necessary.

In the case of smoke clearance systems, a simple plan with a description of the system, override controls and their location in the building should be provided.

For systems designed to assist fire-fighting or to protect means of escape, suitable plans showing the extract points and fans should be provided for each level of the car park, together with a brief description of the system's function. Additionally, where impulse fans are employed, their location should be indicated on the plan and information should be provided to identify the preferred fire-fighting access point and direction of approach for a car fire in any particular fire alarm/smoke control zone that is activated.

Suitable plans showing the extract points and fans, as well as the location of any manual override controls for fire-fighters (for example, control panels and/or switches) should be provided for each level of the car park.

NOTE This information can be provided in the form of plans for fire service use, held at a suitable location accessible to the fire service 24 h per day. Alternatively for more complex systems an electronic graphical representation could be provided adjacent to the fire alarm panel showing the zone involved and the preferred access stair core/direction, etc.

Further information on plans for fire service use is given in BS 9999:2008, Annex M.

18.2 System design documentation

Where appropriate, the documentation should include the following:

a) a justification for the choice of design fire;

b) where design calculations explicitly include wind pressure forces and/or wind pressure coefficients, identification of all zones of overpressure and suction on the building's surface;

c) the locations of all exhaust ventilator outlets and replacement air openings in the building;

d) assumptions and input parameters used in calculations of the external environment of the building;

e) wind load, snow load, and low ambient temperature assessments for any ventilators;

f) relative positions of the exhaust outlets and unprotected openings in neighbouring buildings, pedestrian areas and vehicle roadways in the neighbourhood of the building;

   NOTE This might be done by the provision of plan, elevation and section drawings complete with the relevant design information from a) to e).

g) full details of all the inlet air provisions, locations and their method of operation;

h) for mechanical systems, the total volume of air to be provided;

i) the calculated air flow speed at the inlets for this air.

18.3 Installation, maintenance and testing documentation

The relevant sections of Table 2 should be used to confirm that the installed system has not developed faults or deteriorated and remains compatible with the original design intent.

A regular maintenance and test programme should be carried out in accordance with the installers'/manufacturers' operating and maintenance instructions.

In addition, the following items, where applicable, should also form part of an ongoing and regular maintenance regime.

a) Examine for any corrosion associated with the smoke ventilation equipment.

b) Check for water ingress.

c) Check that fire resistance enclosures associated with the kit remain intact.

d) Check that any separate compartments remain sealed.

e) Inspect fixings and support for deterioration.

f) Check for any modifications to the car park that might impact on the performance of the ventilation system.

g) Confirm interactions with other recently installed smoke venting installations.

h) Check the correct functioning of fire doors and that they maintain their integrity.

i) Check operating instructions and labelling are still intact and replace as necessary.

j) Carry out lubrication of equipment as necessary.

k) Check for the reliability and correct function of fan failure provisions.

l) Check for the reliability and correct function of mains failure provisions.

m) Check that all grilles and guards remain intact, affective and clear of debris.

18.4 Computer control software

Where relevant, a comprehensive description of the control software should be provided to the building owner and/or the site agent by the system designer, together with documentation of all changes made to the system after installation.

When changes are made to the control software or associated computer system, the results of a full check of the smoke and heat control system operation in accordance with Clause **17** should be included.

19 Maintenance and safety

The continuing reliability of the ventilation system should be ensured in accordance with BS 9999 and any suppliers' manuals. Any alteration to the building or smoke control system might compromise the original design intent and, consequently, all design and installation documentation should be included in a handover manual on completion of the installation so that the impact of any changes to the building can be properly evaluated.

NOTE Attention is drawn to the need to include the replacement air provisions within the maintenance regime.

Annex A (normative) Smoke control duct sections and smoke control dampers

*COMMENTARY ON **ANNEX A***

Smoke control duct sections and smoke control dampers are tested to confirm that they can maintain integrity, cross-section of opening and, in the case of dampers, also integrity when closed. Their multi-compartment classifications also give fire resistance, providing that they are installed and controlled following the guidance given in this annex.

A.1 General

Single compartment applications should be classified to 600 °C and multi-compartment applications should be tested to the fire test curve. It is possible that fans in accordance with BS EN 12101-3 might have lower classification temperatures, but this should be calculated with dilution leakage and they may be installed in protected areas as described elsewhere in this British Standard.

Smoke control duct sections should be checked to confirm that they do not lose cross-section in a fire or collapse and thus remove a part of the system design. They should also have a known leakage that has been recorded during a fire or elevated temperature test.

Smoke control dampers should be tested to prove that they can move to and stay open in a fire (dependent upon when they are activated) and move to closed away from the fire, remain closed and have a known leakage that has been recorded during a fire or elevated temperature test.

Smoke control dampers should not have fusible links and should move under power to their required position – open or closed, as described above.

NOTE This is true even for vents as it may be required that they stay closed for containment.

Power should be available to the smoke control dampers at all times, particularly for systems with manual intervention.

To get smoke out of an area, the dampers on the duct in these areas should open and remain open, the path through a duct should remain clear with dampers in the duct remaining open. All other dampers should remain closed to prevent smoke escaping into smoke free zones. Make up air should be used. Fans should be sized against the proposed open paths and areas to be cleared.

A.2 Single compartment smoke control duct sections

For single compartment applications any smoke control ducting used should not cross a fire compartment boundary. It should pass out directly through a wall or where it passes through a compartment boundary and it should be changed to multi-compartment smoke control ductwork just before the compartment wall. The installation at the wall should follow the manufacturer’s instructions as this is part of the classification. Single compartment ductwork should be fitted with single compartment smoke control dampers.

NOTE Most smoke control ductwork used in a car park will probably be single compartment because of the open space.

Single compartment smoke control duct sections should have classifications at 600 °C. Smoke control ducts should be classified in accordance with BS EN 12101-7 as single compartment smoke control duct sections. All hangers, joints, access panels and penetrations at walls should be installed according to the manufacturer’s instructions as this forms part of the classification.

A.3 Multi-compartment smoke control duct sections

In all areas after the first compartment wall, multi-compartment smoke control duct sections should be used and they should be classified in accordance with BS EN 12101-7 as multi-compartment control duct sections. All hangers, joints, access panels and penetrations at walls should be installed according to the manufacturer's instructions as this forms part of the classification.

Multi-compartment duct sections may be used in place of single compartment smoke control duct sections, but this should not be mixed in a run except when changing from single to multi at a fire compartment boundary.

A.4 Single compartment smoke control dampers

A.4.1 General

Where single compartment smoke control sections are to be used, then single compartment smoke control dampers should be used. All smoke control dampers should be installed according to the manufacturer's instructions as this forms part of the classification. Smoke control dampers fitted directly to external walls may be single compartment smoke control dampers.

A.4.2 With automatic activation

If the system automatically starts on the receipt of a fire or smoke alarm and the smoke control dampers move immediately to their required position and there is no override required at any point then single compartment smoke control dampers classified in accordance with BS EN 12101-8 suitable for automatic activation may be used. If an override is required for smoke clearance but only after the event, it should be noted that any dampers that are closed might remain closed as they have not been proven to open again after exposure to elevated temperatures.

NOTE Dampers used for make up air in the fabric of the building might not need to be classified, if it is proven that they will not be affected by the fire itself and if they do not have any requirement for containment at any point.

A.4.3 With manual intervention

If the system waits for the brigade to arrive before it is started or the system allows inputs to change how the smoke is to be controlled during an event, then single compartment smoke control dampers classified in accordance with BS EN 12101-8 suitable for manual intervention may be used. In this instance they should also be considered for make up air applications.

A.5 Multi-compartment smoke control dampers

A.5.1 General

Where multi-compartment smoke control sections are to be used, then multi-compartment smoke control dampers should be used. All smoke control dampers should be installed according to the manufacturer's instructions as this forms part of the classification. Multi-compartment smoke control dampers may be used as single compartment smoke control dampers, but not vice versa.

A.5.2 With automatic activation

If the system automatically starts on the receipt of a fire or smoke alarm and the smoke control dampers move immediately to their required position and there is no override required at any point then multi compartment smoke control dampers classified in accordance with BS EN 12101-8 suitable for automatic activation may be used. If an override is required for smoke clearance but only after the event, it should be noted that any dampers that are closed might remain closed as they have not been proven to open again after exposure to elevated temperatures.

A.5.3 With manual intervention

If the system waits for the brigade to arrive before it is started or the system allows inputs to change how the smoke is to be controlled during an event then single compartment smoke control dampers classified in accordance with BS EN 12101-8 suitable for manual intervention may be used.

NOTE Further information is given in the ASFP Blue Book, European version [10].

Annex B (normative) Computer-based models

*COMMENTARY ON **ANNEX B***

Computer-based models can simplify the task of calculations as a part of the design process. In the case of computational fluid dynamics (CFD) analysis, they can allow calculations to be made where there are no reliable correlation formulae on which to base a zone model.

B.1 Zone modelling

B.1.1 Where a zone model is used to determine the likely conditions within a car park, the designer should ensure that the model is suitable for the purpose.

Care should be taken to ensure that the model is used within its capabilities. Zone models are based on empirical relationships and therefore careful consideration should be given when extrapolating the model beyond its established limits.

NOTE In all cases, the use of zone models to model complex geometries might not give reliable results where flows of smoke and heat are complex. It also might not be possible to accurately account for impulse fans using this approach.

B.1.2 All mathematical formulae used in the model, modelling assumptions and values of input parameters should be explicitly included in the documentation made available to the owner of the building and the relevant approving authorities.

Full details of the model including simplifications to the geometry and the objectives of the modelling in quantifiable terms should be provided.

In addition, information concerning validation of the computer-based zone models, and justification for any extrapolation beyond established limits used in the design should be included in the documentation. Where such validation information exists in the publicly available literature, appropriate references should be cited.

B.2 CFD modelling

*COMMENTARY ON **B.2***

CFD modelling can be used to model the movement of heat and smoke in complex geometries and, if used appropriately, can give both designers and regulators confidence that the installed system will achieve its objectives.

B.2.1 A report should be prepared stating the modelling objectives, the CFD code used, the boundary conditions (inputs), geometry and scenario simplifications, grid specification and results.

The geometry of the car park should be modelled as accurately as practicable including all significant down-stand beams and obstructions, etc.

The modelling should be based on credible worse case scenarios.

The modelling should investigate the performance of the car park both when it contains a number of cars corresponding to the number of car parking spaces and the typical usage.

When modelling fires, the CFD model should present profiles of temperatures and smoke spread. If tenability criteria is required, smoke should be represented in terms of visibility distance through smoke to either reflective or illuminated signage. Results should, as a minimum, show in the horizontal plane smoke spread and temperatures at agreed heights from the finished floor level (for example head height).

B.2.2 Where CFD models are used, care should be taken not only to confirm validation of the CFD model itself, but also to ensure that the boundary conditions, mesh size, design fire size, geometry simplification and presence of vehicles are appropriate to the scenario being modelled. Care should also be taken to correctly model the specific characteristics of equipment, such as sprinkler or impulse fans.

B.2.3 A full description of the model, including its boundary conditions, the physics models used (e.g. radiation/turbulence), details of the meshing strategy and of convergence criteria (if applicable) should be included in the documentation made available to the owner of the building. Where possible, an electronic copy of the simulation files should be made available for review by a competent third party.

NOTE For a more comprehensive discussion of the use of CFD models, see PD 7974-2:2002, Annex A. See also the FETA guide to CFD modelling [11].

Annex C (informative) Lighting, signage, public address and voice alarm systems

C.1 Lighting and signage

*COMMENTARY ON **C.1***

For guidance on the design and installation of emergency lighting and signage, reference can be made to the appropriate part of BS 5266.

To facilitate evacuation from an underground car park, the following points can be taken into account:

a) adequate primary and escape lighting installations;

b) illuminated exit signs positioned over the exit doors from the car park to the final exit;

   NOTE The illuminated exit signs will be powered from adequate primary and secondary power supplies.

c) exit signs sited as low as practically possible (on pillars) in the car park, with directional arrows for the nearest escape route. Other ordinary information signage, and any appropriate flashing beacons can be positioned on the structural pillars to help the evacuation process;

d) primary and secondary lighting provided in plant rooms, the main smoke control panel enclosure, to facilitate any manual switching of the ventilation plant, and adjacent to any fire-fighters' override switches not situated in plant rooms.

Cars are often effectively soundproofed. This makes the visual signage in a car park even more important than usual. With the exception of SHEVS designs, the smoke control methods recommended in this British Standard will all allow a greater or lesser degree of smoke logging even close to the floor, over all or a part of the car park storey affected by fire and smoke.

It follows that there is an advantage in using flashing lights in an emergency to alert people in cars, and to draw their attention to written signs. These signs will point the way to the nearest exit for evacuation on foot. It is also important that these signs are not too far apart where smoke might be present and that, in a SHEVS design, the signs are located below the design smoke layer base.

It is good practice for signs to instruct people in the event of fire to turn off their engines, leave their cars and evacuate on foot.

Where car parks are associated with shopping centres and other occupancies where large numbers of persons are present, it is useful to provide similar signs instructing people (whether on foot or in cars) not to enter the car park when a fire is detected.

Where judged appropriate, automated exit barriers can be designed to open during a fire emergency.

Where considered appropriate any evacuation signal can be supplemented by flashing lights in order to attract the attention of people in cars.

C.2 Public address and voice alarm systems

If the noise created by a smoke control system compromises the audibility or effectiveness of the fire alarm system, it might be necessary to install flashing beacons to support sounders.

With regard to public address/voice alarm systems, installed within the car park demise, the volume/intelligibility of the systems can be increased to overcome the high noise outputs of the extract, impulse and, if required, supply fans serving the car park.

NOTE BS 5839-1 covers fire alarm systems and public address/voice alarm systems are covered by BS 5839-8.

The activation of the fire alarm system might be the same activation as the smoke control installation for mechanical smoke control systems.

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