

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This part of BS 7346 supersedes BS 7346-7:2006, which is withdrawn.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