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Smoke and heat control systems - Part 5: Guidelines on functional recommendations and calculation methods for smoke and heat exhaust ventilation systems

Systèmes de contrôle de fumées et de chaleur - Partie 5 : Guide de recommandations fonctionnelles et de calcul pour les systèmes d'exutoires de fumées et de chaleur

Rauch- und Wärmefreihaltung - Teil 5: Anleitung zu funktionellen Empfehlungen und Rechenverfahren für Anlagen zur Rauch- und Wärmefreihaltung

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Contents

Page

Foreword

This CEN Technical Report (CEN/TR 12101-5:2005) has been prepared by Technical Committee CEN/TC 191 “Fixed firefighting systems”, the secretariat of which is held by BSI.

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This Technical Report is based on the text of British Standard BS 7346-4:2003.

Introduction

0.1 General introduction

Smoke and heat exhaust ventilation systems (SHEVS) create a smoke free layer above a floor by removing smoke. They can, therefore, improve conditions to allow the safe escape and/or rescue of people and animals, to protect property and to permit a fire to be fought while still in its early stages. Ventilation systems for smoke removal also serve simultaneously for heat exhaust and can exhaust hot gases released by a fire in the developing stage.

The use of such systems to create smoke free areas beneath a buoyant smoke layer has become widespread. Their value in assisting in the evacuation of people from buildings, reducing fire damage and financial loss by preventing smoke logging, facilitating fire-fighting, reducing roof temperatures and retarding the lateral spread of fire is firmly established. For these benefits to be realised it is crucial that smoke and heat exhaust ventilators operate fully and reliably whenever called upon to do so during their installed life.

Components for a SHEVS need be installed as part of a properly designed smoke and heat exhaust system. Natural SHEVS operate on the basis of the thermal buoyancy of the gases produced by a fire.

The performance of these installations depends, for example, on:

— the temperature of the smoke;

— the fire size;

— the aerodynamic free area of the ventilators, or the volume of smoke exhausted by powered ventilators;

— the wind influence;

— the size, geometry and location of the inlet air openings;

— the size, geometry and location of smoke reservoirs;

— the time of actuation;

— the arrangements and dimensions of the building.

Ideally the design fire upon which calculations are based shows the physical size and heat output of the fire changing with time in a realistic manner, allowing the growing threat to occupants, property and fire-fighters to be calculated as time progresses. Such time-based calculations of the time-to-danger usually have to be compared with separate assessments of the time recommended for safe evacuation of occupants of the building or of the time recommended for initiation of successful fire-fighting. These latter assessment procedures fall outside the scope of this Technical Report, although it is anticipated to supplement this Technical Report with design procedures for time-dependant fires in the future. In these calculations fire growth curves are selected that are appropriate to the precise circumstances of the building occupancies, fuel arrangements and sprinkler performance, where appropriate. Where such information is available, these calculations are conducted on a case-by-case basis using recommended fire safety engineering procedures. Even where such an approach is adopted, appropriate performance recommendations, e.g. minimum clear height, external influences, can be drawn from this Technical Report.

Where such time-based calculations are not feasible, it is possible to use a simpler procedure based on the largest size a fire is reasonably likely to reach in the circumstances. This time-independent or steady-state design is not to be confused with steady fires, which achieve full size instantly and then burn steadily. Rather the procedure assumes that a SHEVS that is able to cope with the largest fire can also cope with the (usually earlier) smaller stages of the fire.

In practice, it is much easier to assess the largest reasonably likely size of fire than to assess the growth rate of that fire.

0.2 Smoke exhaust ventilation design philosophies

0.2.1 Protection of means of escape (life safety)

A common approach to protect a means of escape is to achieve a smoke-free height beneath a thermally buoyant smoke layer below a ceiling. A SHEVS uses this principle to allow the continued use of escape routes that are in the same space as the fire, e.g. within enclosed shopping malls and many atria. The rate of smoke exhaust (using either natural smoke exhaust ventilators or powered smoke exhaust ventilators) is calculated to keep the smoke at a safe height above the heads of people using the escape routes, and to keep the radiated heat from the smoke layer at a low enough value to allow the escape routes to be used freely, even while the fire is still burning.

0.2.2 Temperature control

Where the height of clear air beneath the thermally buoyant smoke layer is not a critical design parameter, it is possible to use the calculation procedures in 0.2.1 in a different way. The rate of smoke exhaust can be designed to achieve (for a specified size of fire) a particular value for the temperature of the gases in the buoyant layer. This allows the use of materials that would otherwise be damaged by the hot gases. A typical example is where an atrium façade has glazing that is not fire-resisting, but which is known to be able to survive gas temperatures up to a specified value. The use of a temperature control SHEVS in such a case could, for example, allow the adoption of a phased evacuation strategy from higher storeys separated from the atrium only by such glazing.

0.2.3 Assisting the fire-fighting operation

In order for fire-fighters to deal successfully with a fire in a building, it is first necessary for them to drive their fire appliances to entrances that give them access to the interior of the building. They then need to transport themselves and their equipment from this point to the scene of the fire.

In extensive and multi-storey complex buildings this can be a long process and involve travel to upper or lower levels. Even in single-storey buildings the fire-fighters within the building need, amongst other things, an adequate supply of water at sufficient pressure to enable them to deal with the fire. The presence of heat and smoke can seriously hamper and delay fire-fighters' efforts to effect rescues and carry out fire-fighting operations. The provision of SHEVS to assist means of escape or to protect property aids fire-fighting. It is possible to design a SHEVS similar to that described in 0.2.1 to provide fire-fighters with a clear air region below the buoyant smoke layer, to make it easier and quicker for them to find and to fight the fire. Temperature control designs are of less benefit.

This Technical Report does not include any functional recommendations for key design parameters where the primary purpose of the SHEVS is to assist fire-fighting. Such functional recommendations need to be agreed by the fire service responsible for the building in question. However, the calculation procedures set out in the annexes of this Technical Report can be used to design the SHEVS to meet whatever recommendations have been agreed.

0.2.4 Property protection

Smoke exhaust ventilation cannot by itself prevent fires growing larger but it does guarantee that a fire in a ventilated space has a continuing supply of oxygen to keep growing.

It follows that smoke exhaust ventilation can only protect property by allowing active intervention by the fire services to be quicker and more effective. Property protection is therefore regarded as a special case of 0.2.3. Depending on the materials present, a property protection design philosophy can be based on the need to maintain the hot buoyant smoke layer above sensitive materials (similar in principle to 0.2.1), or the need to maintain the smoke layer below a critical temperature (similar to 0.2.2). In either case, the functional recommendations for key parameters on which the design is based need not be the same as where the primary purpose is life safety and will depend on the circumstances applying in each case. These key functional recommendations need to be agreed with all relevant interested parties. The calculation procedures in the annexes of this Technical Report can be used to design the SHEVS.

0.2.5 Depressurization

Where a smoke layer is very deep, and storeys adjacent to the layer are linked to it by small openings, e.g. door cracks or small ventilation grilles in walls, it can be possible to prevent the passage of smoke through the small openings by reducing the pressure of the gases in the smoke layer. This approach is known as depressurization, and in the form described is mainly used for atrium buildings. The primary purpose of the technique is to prevent the entry of smoke into the spaces adjacent to the atrium, and not to provide protection to the atrium itself. The most common name given to the technique is atrium depressurization.

The design of atrium depressurization places additional recommendations on the design of the SHEVS installed in the atrium. These recommendations are given in 6.11.

0.3 Applications of smoke and heat exhaust ventilation

SHEVS can create and maintain a clear layer beneath the smoke to:

a) keep the escape and access routes free;

b) facilitate fire-fighting operations;

c) reduce the potential for flashover and thus full development of the fire;

d) protect equipment and furnishings;

e) reduce thermal effects on structural components during a fire;

f) reduce damage caused by thermal decomposition products and hot gases.

SHEVS are used in buildings where the particular (large) dimensions, shape or configuration make smoke control necessary.

Typical examples are:

— single and multi-storey shopping malls;

— large retail units;

— single and multi-storey industrial buildings and sprinklered warehouses;

— atria and complex buildings;

— enclosed car parks;

— stairways;

— tunnels;

— theatres.

The choice of either a powered or natural SHEVS depends on aspects of the building's design and sitting in relation to its surroundings.

Special conditions apply where gaseous extinguishing systems, e.g. systems conforming to EN 12094 or ISO 14520, are used. Usually, gaseous extinguishing systems are not compatible with a SHEVS.

1 Scope

This Technical Report gives recommendations and guidance on functional and calculation methods for smoke and heat exhaust ventilation systems for steady-state design fires. It is intended for a variety of building types and applications, including single-storey buildings, mezzanine floors, warehouses with palletized or racked storage, shopping malls, atria and complex buildings, car parks, places of entertainment and public assembly and un-compartmented space within multi-storey buildings.

This Technical Report does not include any functional recommendations for design parameters where the primary purpose of the SHEVS is to assist fire-fighting.

NOTE Such functional recommendations need to be agreed with the fire service responsible for the building in question. The calculation procedures set out in the annexes of this Technical Report can be used to design the SHEVS to meet whatever recommendations have been agreed.

This Technical Report does not cover the following:

— smoke clearance, where smoke is exhausted from a building after the fire has been suppressed;

— cross-ventilation, where wind-induced or fan-induced air currents sweep smoke through and out of the building, usually as part of fire-fighting operational procedures;

— ventilation of stairwells, which usually represents a special application of smoke clearance and which does not necessarily protect the continued use of the stairwell;

— fully-involved fires.

2 Normative references

Not applicable.

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this Technical Report, the following terms and definitions apply.

3.1.1
adhered plume
spill plume rising against a vertical surface and into which air entrains on one side, although there may be free ends

NOTE This is sometimes referred to as a single-sided plume.

3.1.2
aerodynamic free area
product of the geometric area and the coefficient of discharge

3.1.3
ambient
property of the surroundings