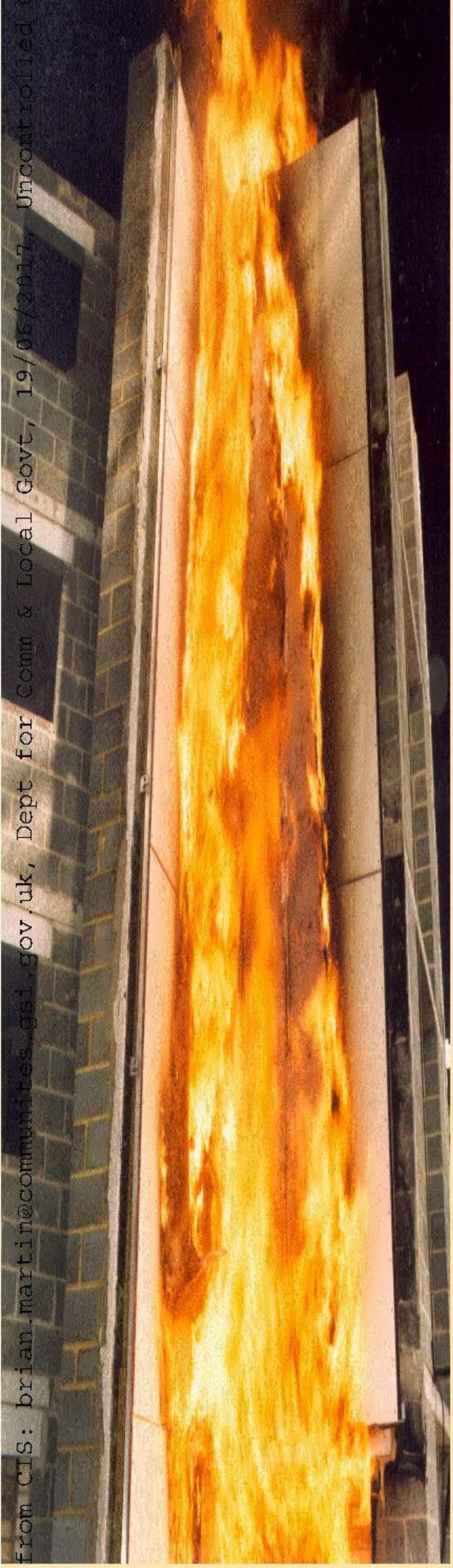
IHS

bre press



Fire performance of external thermal insulation for walls of multi-storey buildings

BRE

FRS

OFFICE OF THE DEPUTY PRIME MINISTER

Second edition

BRE
Garston, Watford, WD25 9XX

2003

Fire performance of external thermal insulation for walls of multi-storey buildings

Sarah Colwell and Brian Martin
FRS

BRE FRS

OFFICE OF THE
DEPUTY PRIME MINISTER

Prices for all available
BRE publications can be
obtained from:
BRE Bookshop
151 Rosebery Avenue
London EC1R 4GB
Tel: [redacted]
Fax
email:
brebookshop@emap.com

BR 135
ISBN 1 86081 622 3

First published 1988
Second edition 2003

Published by
BRE Bookshop
by permission of
Building Research
Establishment Ltd

This guide has been produced by FRS as part of a contract placed by the Office of the Deputy Prime Minister (ODPM). Any views expressed in it are not necessarily those of the ODPM.

Contents

Introduction

Following a fire in a multi-storey residential housing block in Scotland in the summer of 1999 (Figure 1), a parliamentary inquiry was undertaken by the then Environment Sub-committee of the Environment, Transport and Regional Affairs Committee to investigate the potential risk of fire spread in buildings by way of external cladding systems. As part of their recommendations[1], the sub-committee asked that the relevant guidance in this area be reviewed. As a consequence, revision was started of the recommendations given in the first edition of this guide[2], which provided information on the design and application of external thermal insulation used in external cladding systems for multi-storey buildings.

This second edition seeks to update and build upon the previous advice by providing a method of assessing the fire performance of such cladding systems from full-scale fire test data and offering design principles that reflect the changes in the type of products and systems now in use.

Figure 1 Garnock Court, Irvine

Legislation

The Building Regulations in the UK generally set out the standards that need to be achieved in relation to the design and building work in the construction of domestic, commercial and industrial buildings. The regulatory systems in Scotland and Northern Ireland differ from those in England and Wales, but the underlying principles are similar.

The Regulations and supporting standards set out acceptance criteria for a wide range of inter-related technical provisions. Care should be taken at the design stage as the needs of one provision may conflict with the needs of another and designers must be able to satisfy each provision without contravening another.

Where external cladding systems are concerned it will be necessary to consider the following issues at least.

- Resistance to moisture/condensation (Part C in England and Wales, Part G in Scotland)
- Wind loading (Part A in England and Wales, Part C in Scotland)
- Ventilation (Part F in England and Wales, Part K in Scotland)
- Conservation of fuel and power (Parts L1 and L2 in England, Part J in Scotland)
- Fire resistance (Part B3 *Internal fire spread (structure)* in England and Wales, Part D2 *Structural protection* in Scotland)
- External fire spread (Part B4 *External fire spread* in England and Wales, Part D10 *Fire spread on an external wall* in Scotland)

Issues relating to the fire resistance performance of external cladding systems, eg in relation to boundary conditions, are not discussed in this guide. Provisions for fire resistance can be found in the relevant sections of Approved Document B[3] for England and Wales and Part D6 of the Technical Standards for Scotland[4].

This guide provides a basis upon which the external fire performance of external cladding systems can be assessed. It does not specify where this performance standard should be adopted; this is a matter for regulators and specifiers. However, the performance standard set out could be adopted where the implications of rapid fire spread by way of the external cladding system are considered to be unacceptable, such as tall buildings (above 18 m) that may be out of the reach of conventional firefighting techniques, and areas where people sleep, when external fire spread may present an unacceptable risk to the occupants.

Mechanisms of fire spread

An explanation of the key stages associated with the fire spread on the outside of the building envelope by way of the external cladding system is set out here and refers to Figure 2.

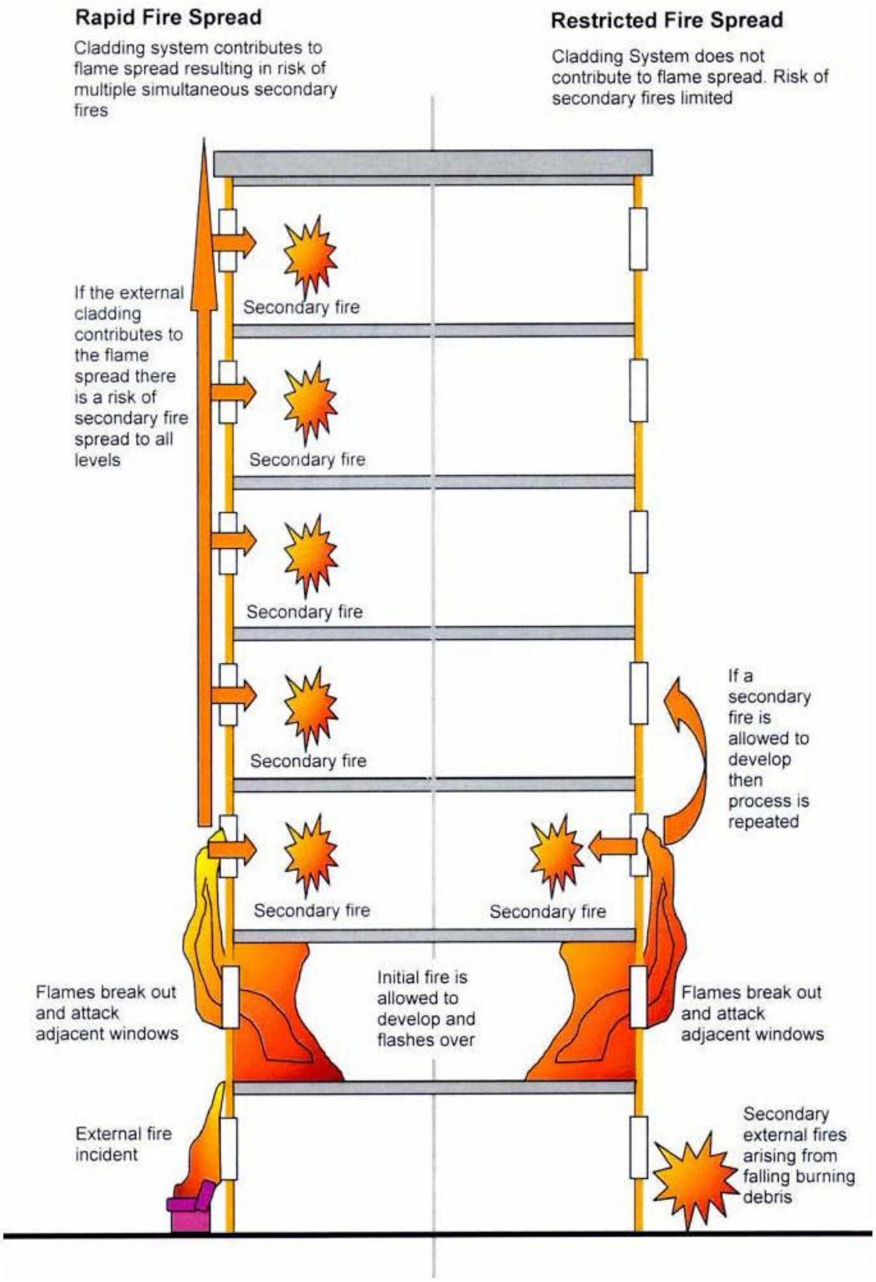


Figure 2 Mechanisms for external fire spread by way of the external cladding system

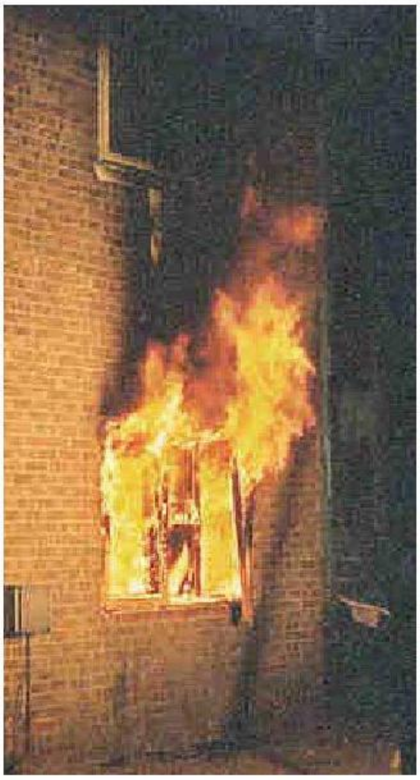


Figure 3 Fire break out from a post-flashover room on a masonry facade

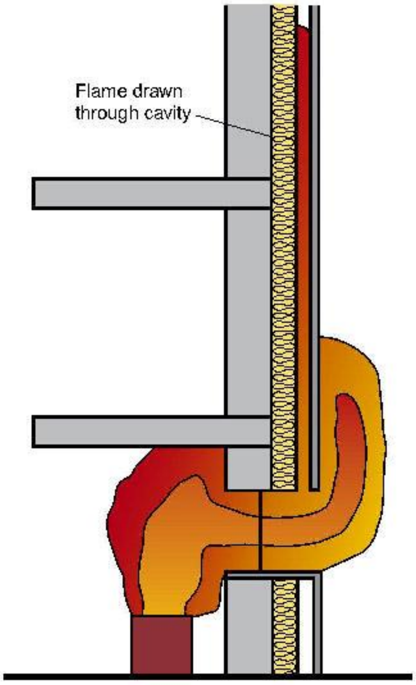


Figure 4 Fire spread through cavities

1 Initiation of the fire event

This type of fire event can be initiated from a fire occurring inside the building or by an external fire in close proximity to the building envelope, such as fires involving general waste or malicious fire setting.

2 Fire break out

Following the initiation of a fire inside the building, if no intervention occurs, the fire may develop to flashover and break out from the room of origin through a window opening or doorway. Flames breaking out of a building from a post-flashover fire will typically extend 2 m above the top of the opening **irrespective of the material used to construct the outer face of the building envelope** (eg Figure 3).

3 Interaction with the external envelope

It is at this stage of the fire scenario that the fire performance of the complete external cladding system, including any fire barriers, is of critical importance. Once flames begin to impinge upon the external fabric of the building, from either an internal or an external source, there is the potential for the external cladding system to become involved and to contribute to the external fire spread up the building by the following routes.

- **Surface propagation**
  The reaction to fire characteristics of the materials used within the external cladding system will influence the rate of fire spread up the building envelope by way of the surface of the external cladding system.
- **Cavities**
  Cavities may be incorporated within an external cladding system or may be formed by the delamination or differential movement of the system in a fire. If flames become confined or restricted by entering cavities within the external cladding system, they will become elongated as they seek oxygen and fuel to support the combustion process. This process can lead to flame extension of five to ten times that of the original flame lengths **regardless of the materials used to line the cavities.** This may enable fire to spread rapidly, unseen, through the external cladding system, if appropriate fire barriers have not been provided (Figure 4).

4 Fire re-entry

Window openings or other unprotected areas within the flame envelope provide a potential route for fire spread back into the building. This creates the potential for fire to bypass any compartment floors that may be present, leading to a secondary fire on the floor above. If secondary fires are allowed to develop without intervention before flashover occurs, then flames may break out again thus extending the flame envelope and threatening other openings further up the building, **irrespective of the materials used on the building envelope.**

5 Fire Service intervention

Where the external cladding system is not significantly contributing to the spread of fire from one storey to the, then intervention by emergency services should prevent continued fire propagation by way of the building envelope. However, where the external cladding system is contributing to the fire propagation rate, the potential exists for the fire to affect multiple storeys simultaneously, thus making firefighting more difficult.

Generic cladding systems

Materials for external finishes

The following materials are typically used to provide external cladding applied to the face of building envelopes:

Clay Used in panel systems as small standard-sized components, such as tiles and terracotta slip systems.

Concrete Pre-cast concrete panels as slabs applied to a solid background or as cladding to a structural frame, independent of any in-fill walling.

Thin stone Can be used with or without insulation as a natural veneer or epoxy-bonded to honeycomb backing panels.

Metal Steel, stainless steel, copper, bronze and aluminium are generally used in sheet form for cladding to walls as:
- Profiled metal sheeting
- Metal panelling
- Aluminium and steel profiled cladding

Brickwork Used in a wide range of applications and is a suitable cladding for other materials such as concrete.

Glazing Found as a component in the majority of facades in a variety of forms, such as in-fill panels, windows, and suspended glazing. Single, double or fire-resisting glazing may be used.

Insulating materials

Insulating materials typically used in external cladding systems fall into three groups:

- **Non-combustible materials and materials of limited combustibility** (as defined in Tables A6 and A7 of Approved Document B[3]). Generally mineral-fibre-based products such rock fibre and glass wool which are formed into batts, typically 600 mm × 1200 mm or on continuous rolls, typically using resin binders. The thickness of these products can vary significantly depending upon the thermal performance specification.
- **Thermosetting**
  Products such as polyurethane foam (PUR), polyisocyanurate foam (PIR) and phenolic foam are used to provide insulation for external cladding systems and are typically provided as 600 mm × 1200 mm sheet product of varying thicknesses to meet thermal performance requirements. These products are often faced with materials such as glass fibre or aluminium foil.
- **Thermoplastic**
  Expanded polystyrene (EPS) is the most widely used product in this group, which also includes extruded polystyrene (XPS). It can be supplied in both a fire-retarded and non-fire-retarded form. Again the material is generally supplied as 600 mm × 1200 mm batts at various thicknesses to meet thermal performance requirements.

The insulation material is typically fixed to the supporting structure using a combination of mechanical fixings (both plastics and steel), adhesives and in some cases railing systems on uneven surfaces.

Construction types

Two system types have been identified for discussion here:

- rendered and non-ventilated render systems, and
- ventilated cavity systems

Non-ventilated applied finishes

These systems require a continuous background structure, such as an external wall, to give the necessary support and fixing for the materials forming the external face of the building. The system is typically composed of two elements (Figure 5):

- the insulating material, which is fixed to the background structure, typically an external wall, to provide the necessary level of thermal performance, and
- the external surface membrane that provides the weather protection to the insulating layer.

Ventilated cavities

These systems typically consist of an external wall with an inner structural leaf, insulated on its outer face (Figure 6). There are a number of different types of product represented within this description. They include rainscreen cladding systems and drained and/or ventilated cavity systems.

The principle behind this type of system relies upon an airspace that can be drained, back ventilated and, if required, pressure-equalised. The systems have an external surface membrane or cladding assembly, and an insulation layer fixed to either the external wall or the cladding panel, together with an appropriate breather membrane. In practice, the insulation layer may not always be present.

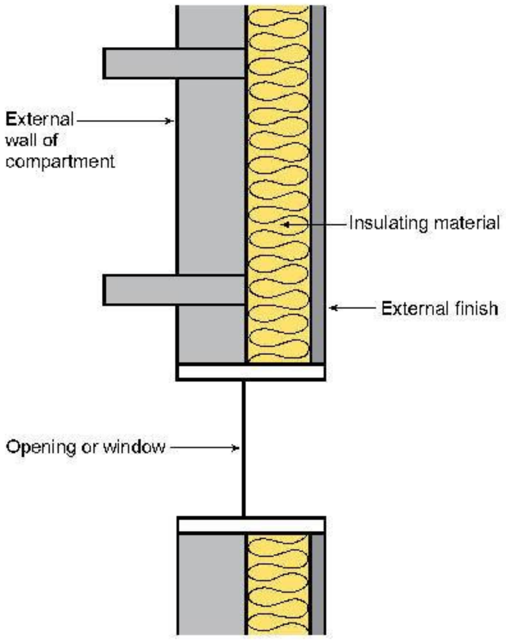


Figure 5 Render systems

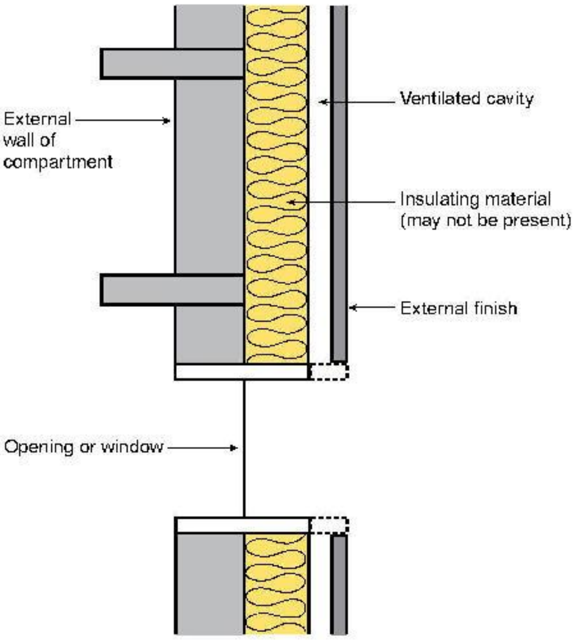


Figure 6 Ventilated-cavity cladding systems

Fire performance design principles for external cladding systems

General

Generic fire performance design principles are presented in this guide for information. Prescriptive solutions are not given as data from recent full-scale fire tests and feedback on earlier design guidance suggest that the rapidly changing market and wide range of applications over which external cladding systems are used do not lend themselves to this type of design solution.

In order to assist specifiers and designers in addressing some of the fire performance issues, a set of design principles has been developed based on recent full-scale research programmes. These principles represent a number of key elements that have been identified, but are not exhaustive; other elements and principles may be worthy of consideration. General fire performance guidance for external cladding systems is also given in the appropriate Approved Document[3] and Technical Standards[4]. Innovative designs and variations in material selection and design can only be fully assessed by full-scale testing[5].

The following general points should be considered when designing and specifying external cladding systems.

1 The installation and fixing methods employed should be sufficiently robust to withstand the potential thermal exposure and fire spread characteristics associated with this type of fire incident without exhibiting significant fire spread or system collapse such as:
- Loss of strength as the system is heated
- Forces generated by retained thermal expansion of fixings and components
- Movements and distortions arising from thermal expansion if unrestrained

2 The external finish should not unduly support fire propagation.

3 The systems should not prematurely delaminate or spall providing potential entry routes for fire to access unprotected cavities or combustible material within the system.

System-specific details: rendered systems

As the requirements to improve the thermal performance of buildings increases, so the volume of insulation material used within buildings also increases. Where rendered insulation systems are used on the outer face of the building envelope, the typical performance of these systems in fire can be summarised as follows.

The area of external cladding within the flame envelope will typically begin to expand and the external render finish may delaminate from the insulation and primary structure of the building envelope as it is heated by the fire source (see Figure 5). As the external render finish begins to move under the applied heat it will tend to develop cracks and fissures in the surface, allowing the fire to penetrate the external finish and attack the insulation layer beneath. If the external finish and any supporting mesh are not adequately restrained as the system expands, the fixings may become detached from the insulation layer and the primary substrate, and the system can begin to delaminate and fall away. As the system exposes increasing quantities of insulation material, this may lead to increased fire spread through the system together with the production of falling debris and the potential for system collapse.

Fixing details

To prevent rapid fire spread and system collapse, all external cladding systems should be installed with suitable through-fixing methods to ensure that the system will not suffer disproportionate collapse during a fire. The systems are typically fixed to the supporting structure using a combination of mechanical fixings (both plastics and steel) and adhesives.

- **Adhesive-based systems**
  The increasing quantities and therefore weight of insulation material used within render systems may preclude the future use of solely adhesive-based systems. Dependent upon the fixing details, the systems can be unstable in fire if they have no mechanical restraint from the external finish to the wall. Should the insulating material be consumed or degraded during a fire, the adhesion within the system will be lost, allowing the external finish to move independently of the wall and giving rise to potential system delamination or collapse. An adhesive-based fixing method can be supplemented with mechanical fixing to provide increased system stability.
- **Mechanical fixings**
  There are a number of mechanical fixing methods available. They range from steel systems to plastics systems, with combinations of plastics fixing and steel pin systems also available. The guidance given in BRE Defect Action Sheet DAS132[6] should be noted and is now revised as follows:
  > **"Use no fewer than one stainless steel fixing (in addition to those of plastics) per square metre of insulation. The fixings should be sized and fitted to resist the increased duty that may be required under fire conditions."**

  Whilst the fixing systems must have the mechanical strength to support the external insulation and cladding systems under normal operating conditions, they should also be capable of retaining the systems in the case of fire and assist in preventing excess fire spread.

Although the insulation may be adequately retained to the substrate, the stability of the finish coats should also be considered in order to avoid excessive system delamination that may generate voids into which the fire may spread. For this purpose, the use of mechanical fixings to attach the base coats to the substrate or through-fixing details at fire barriers should be considered.

Fire barriers

If fire enters a void in the system, whether created by a fire or as part of an existing design, and the insulation is exposed to the fire source, any combustible material present may become involved and the potential for the fire to propagate throughout the system exists if adequate fire barriers are not installed. The relative fire performance of the three insulation groups described above are summarised as follows.

- **Non-combustible materials and materials of limited combustibility**
  (as defined in Tables A6 and A7 of Approved Document B[3]). All material within the fire envelope will be damaged during the course of a fire. Rock-fibre-based products tend to lose some integrity but the material typically remains intact. Whilst not exhibiting fire propagation, glass fibre material that has been directly exposed to the fire source may become degraded and in some cases melt away. An example is shown in Figure 7.

Figure 7 Limited combustible core, after test

- **Thermoset products**
  Unless the material becomes directly exposed to the fire source, ie following significant delamination and cracking of the external render finish, these materials will char in the vicinity of the fire source. Damage to the insulating material is typically confined to the area within the flame envelope and immediate periphery. If the insulation is directly exposed to the fire source, fire spread may occur through the system if adequate fire barriers are not employed. (See Figure 8.)

Figure 8 Thermosetting core without adequate fixings or fire breaks

- **Thermoplastic products**
  For example, expanded polystyrene (EPS) will typically soften and melt in the early stages of a fire, generating a void behind the external render finish coat. If inadequate fixings have been used and without the support of the insulating material, the finish coats will sag and crack, producing a direct entry route to the insulation material for the fire. Once ignition of the material occurs, rapid fire spread can be observed if suitable fire barriers and fixing details are not provided. Owing to the relatively low softening and melting point of EPS, damage can occur to the insulation layer well away from the seat of the fire. Figure 9 shows the result of a fire test without fire barriers, and Figure 10 illustrates the effectiveness of fire barriers when used at each floor level within an EPS system.

Figure 9 EPS rendered system without fire barriers after test

Figure 10 EPS rendered system with fire barriers after test (render removed to show damage to EPS)

Design principles for fire barriers

A number of full-scale experimental studies have shown that in order to meet the performance criteria for rendered systems set out in this guide, any fire travelling through the system should be contained to the floor level immediately above the fire origin. To achieve this, fire barriers should be installed at each floor level above the first floor level (ie starting with the second storey).

Design details such as those provided in DAS132[6] have been available for some time, and whilst they offer one potential solution, development in the types of systems now in use and experience of these fire break details in practice, have lead to the development of alternative proprietary fire barriers.

Typically, the fire barrier should be constructed from non-combustible insulation material, as defined in Table A6 of Approved Document B[3] and cover the full depth of the insulation used in the system. The fire barrier should be at least 100 mm high.

The key design elements for fire barriers are as follows.

- The fire barrier should form a continuous band through the insulation layer at each floor level. Any abutting of material should ensure that no cavity exists for fire to track or pass through.
- The non-combustible material should be bonded and tied back to the wall and the external render finish to ensure that no fire path can be created

between the non-combustible material and the primary substrate and between the non-combustible material and the external render finish.

- Through-fixing of the render base coat to the primary substrate, with all-steel fixings, should also be considered to ensure that no movement of the external render finish away from the fire barrier is possible. It is important that there is no potential for fire between the external render coat and the fire barrier.

Fire barriers should also be considered for use in vulnerable areas such as window openings and doorways. In some cases it may also be necessary to consider the use of vertical fire barriers to prevent lateral fire spread.

The potential effectiveness of a fire barrier design can only be fully assessed as part of a system test at large scale.

System-specific details: ventilated cavities

Figure 6 shows the typical design details for ventilated cavity systems. The external wall panel supports are generally constructed from timber battens or metal railing systems. Aluminium railing systems are predominantly used because of their relatively light weight and ease of maintenance. The walls are typically fitted with insulating material laid between the support railings, and the external decorative panels are fitted to the railing system leaving a ventilation cavity between the panels and the insulation.

Should these systems become involved in a fire, evidence has shown that the external decorative panel within the fire envelope will generally be consumed, exposing the insulation within the system to the fire source and allowing the fire to enter the cavity.

Once the fire is within the cavity, it may propagate unseen through the system if adequate fire barriers are not employed. This may result in significant risk of system collapse or fire break out at significant distances from the fire origin.

In order to mitigate against rapid fire spread and potential system collapse, the selection of materials used to construct these systems should address these issues and provision of fire barriers should be considered.

Performance of materials in fire

Insulation

The performance of insulating material when subjected to this type of fire scenario has been outlined in the previous section. Typically, non-combustible materials are used in these systems as it is difficult to prevent fire entering the cavity and spreading through the insulating material.

Railing system

The temperatures within the fire envelope (see Figure 2) may achieve local temperatures in excess of 600 °C. Regardless of the external panel construction, if fire enters the cavity and comes into contact with the aluminium railing system, it will begin to lose its local strength and integrity as it is heated. Under prolonged fire exposure conditions the railing system will melt, which may lead to localised system collapse.

If timber railing systems are ignited by the fire source they may allow fire to propagate through the system if adequate fire barriers are not installed. This may lead to the detachment of the external panels or collapse of the system.

External panel

Materials used for external panels used can vary from non-combustible through to combustible.

- **Non-combustible materials and materials of limited combustibility** (as defined in Tables A6 and A7 of Approved Document B[3]). Typically cementitious-based products through to natural products such as stone veneers and coated metal panels. The cementitious panels and stone-based products tend to spall and crack within the fire envelope providing access for the fire to the cavity. They may also generate large pieces of falling debris if the integrity of the fixings to the railing systems is lost during the fire. Metal panels such as aluminium may fall from the system if the strength of the fixings is affected by the local fire source. They may also melt, generating molten metal debris if exposed directly to the sustained flame envelope.

- **Combustible panels**
  Typically vinyl or glass-reinforced plastics-based panels, these products should have good surface spread of flame characteristics to prevent rapid fire spread across the surface of the system. Once the panels become involved in the fire, they have the potential to generate falling debris and also provide a route for fire to propagate up the outside of the building.

Fire barriers

The objective of the fire barriers installed in ventilated cavity systems is to prevent fire propagation through the cavities and any combustible materials used within the system, whilst maintaining an airflow though the system that allows the ventilated cavity to operate effectively during normal circumstances.

A number of fire barrier designs have been proposed, including intumescent grill systems and through-fixed steel plates, but the key elements for producing an effective fire barrier for the ventilated cavity systems when examined experimentally were found to be:

- fixing to the masonry/pre-cast concrete substrate,
- fitting independent of the sheeting rails, and
- extension across the full depth of the cavity and in some cases protrusion from the front face, to allow for movement of the panels during test.

However, the nature of the fire barriers required to prevent fire spread was found to depend, in the main, upon the nature of the cladding system itself. Limited experience has shown that effective fire barriers can be designed and installed for these systems. The fire barriers required the vertical sheeting rails to be cut and therefore interrupted at regular intervals. Certain barrier systems were found to be adequate for some sheeting materials but not for others. Consequently such barrier systems need to be considered in the light of the complete system and may not be suitable for all applications.

At this time it is not possible to provide detailed design guidance for fire barriers in these systems as insufficient data are available. As more experience is gained in the design and use of these systems, additional information will become available.

In practice it has been found that small-scale tests do not reflect the fire hazard associated with full-scale cladding systems, and the only effective method of assessing the fire performance of the fire barriers is to test the complete system at large scale.

The use of fire protection solely around the windows and the use of intumescent grill fire barriers were generally found to be inadequate in preventing fire spread.

References

[1] House of Commons Environment, Transport and Regional Affairs Committee. *Potential risk of fire spread in buildings via external cladding systems*. 14 December 1999 (HC109).

[2] Rogowski B F W, Ramaprasad R and Southern J R. *Fire performance of external thermal insulation for walls of multi-storey buildings*. BRE Report BR135. Garston, BRE Bookshop, 1988.

[3] Department of Transport, Local Government and the Regions. *The Building Regulations 2000 Approved Document B: Fire safety*. London, The Stationery Office, 2000.

[4] Scottish Executive. *Technical Standards for compliance with the Building Standards (Scotland) Regulations 1990*. Amended 2001.

[5] British Standards Institution. Fire performance of external cladding systems. Part 1.Test method for non-loadbearing external cladding systems applied to the face the building. *British Standard* BS 8414-12002. London, BSI, 2002.

[6] BRE. External walls: external combustible plastics insulation: fixings. *BRE Defect Action Sheet* DAS132. Garston, BRE Bookshop, 1989.

Annex A: The performance criteria and classification method of BS 8414-1:2002

Figure A1 Example of a typical test facility

Definitions

Level 1
A height 2.5 metres above the top of the combustion chamber opening (Figure A3).

Level 2
A height 5.0 metres above the top of the combustion chamber opening (Figure A3).

Start temperature, T_s
The mean temperature of the thermocouples at level 1 (see Figure A3) during the five minutes before ignition.

Start time, t_s
The time when the temperature recorded by any external thermocouple at level 1 equals or exceeds a 200 °C temperature rise above T_s, and remains above this value for at least 30 seconds (see Figures A3 and A5).

System
The complete cladding assembly, including any sheeting rails, fixings, cavities, fire barriers and weathering membranes or coatings.

Test method

Background

As part of a Partners in Innovation programme, sponsored jointly by the then Department of the Environment and members of the Industry, a full-scale test and classification method to assess the fire performance of external systems was developed and published in 1999 as BRE Fire Note 9[A1]. It is this document that is currently referred to in the 2000 edition of Approved Document B[A2] as an alternative means of demonstrating fire performance for external cladding systems.

At the request of the then Environment Sub-committee of the Environment, Transport and Regional Affairs committee, BRE Fire Note 9 was offered to BSI for consideration as a full British Standard[A3]. This has resulted in the publication of BS 8414-1:2002 *Test method for non-loadbearing external cladding systems applied to the face of the building*[A4].

A second part of BS 8414 will be developed to address glazed, curtain wall and built-up systems.

Principle of test (BS 8414-1:2002)

The test facility has been designed to allow the external fire performance of both applied and supported non-loadbearing external cladding systems to be determined (see Figure A1).

The test facility allows external cladding systems to be installed as close to typical end-use conditions as possible. The test faces consist of a masonry vertical main test face, into which the combustion chamber is located, and a masonry vertical return wall or wing, set at 90° to the main test face. The test specimen should be installed with all the relevant components and should be assembled in accordance with the manufacturer's instructions.

The main test face is at least 8 m in height and 2.6 m wide with the return wing being 8 m in height and 1.5 m wide (Figure A2).

The test standard provides thermal performance criteria to permit the use of alternative heat sources. A wooden crib is typically used as the heat source for this test, although a gas burner can be used as an alternative. The combustion characteristics of the crib give a total nominal heat output of 4500 MJ over a 30-minute period at a peak rate of 3±0.5 MW.

The full details of the test methods can be found in the Standard[A4] and whilst the definitions are repeated in the box on the left for ease of reference, in all cases the interpretation of test results should be made with full regard to the Standard. Figures A2, A3 and A4 show schematics of the test facility and thermocouple locations.

Instrumentation

Type K thermocouples are used to monitor temperature at two array locations within the system under test. Figures A3 and A4 summarise the locations of the thermocouples used to monitor the temperatures during the test. At level 2 (see Figure A3) the thermocouples are positioned at the mid-depth of each combustible layer, where combustible is defined as a material not meeting the requirements of Tables A6 or A7 in Approved Document B[A2], that is greater than 10 mm thick. Thermocouples are also located at the mid-depth of any cavity that may be present (see Figure A4).

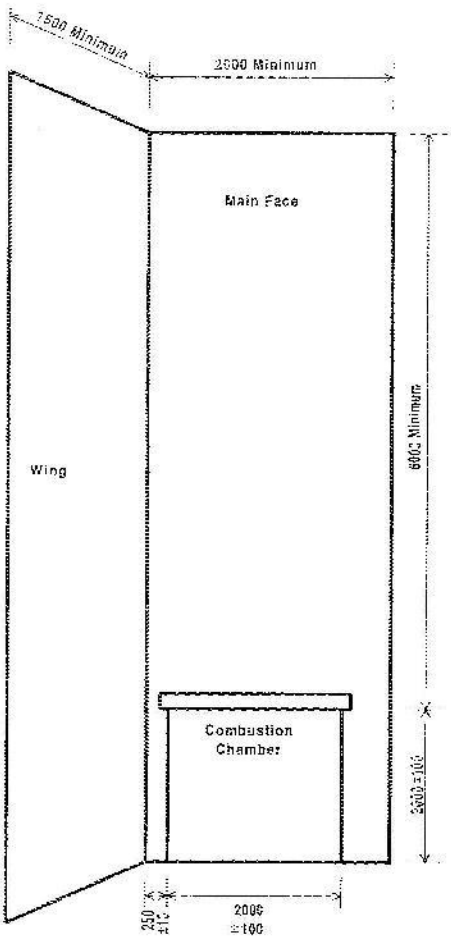


Figure A2 Schematic of test facility (all dimensions are shown in mm)

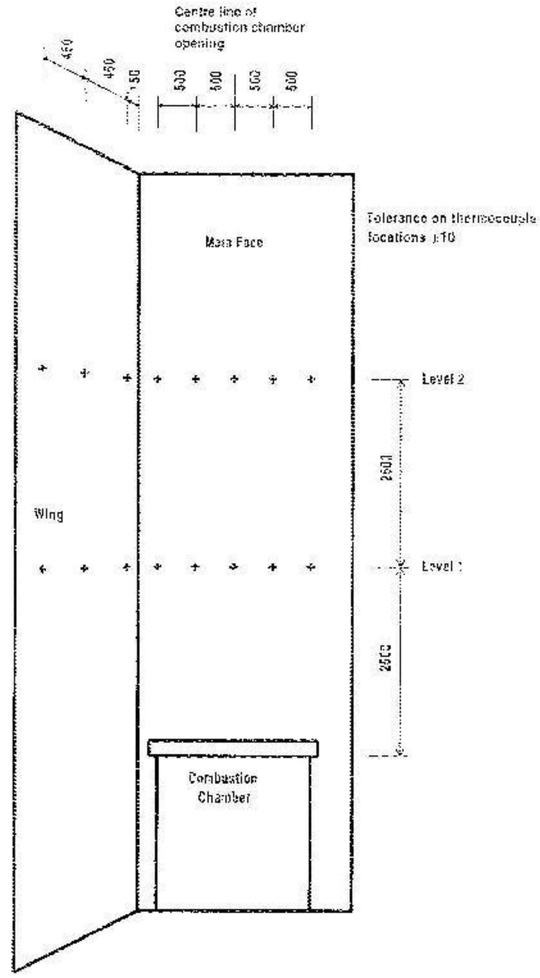


Figure A3 Location of thermocouples (all dimensions are shown in mm)

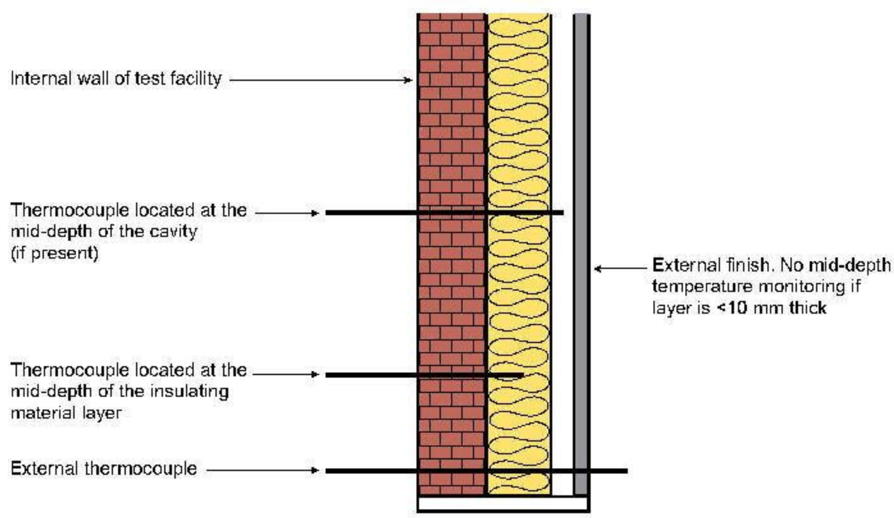


Figure A4 Thermocouple locations within the cladding layers

Performance criteria and classification method

The performance criteria and classification method set out here are based upon the BS 8414-1:2002 test method[A4]. The primary concern when setting the performance criteria for these systems is that of fire spread away from the initial fire source and the rate of fire spread. If fire spread away from the initial fire source occurs, the rate of progress of fire spread or tendency for collapse should not unduly hinder intervention by the emergency services.

The performance of the system under investigation is evaluated against three criteria:

- External fire spread
- Internal fire spread
- Mechanical performance

Fire spread start time, t_s

Fire spread is measured by type K thermocouples set at levels 1 and 2 (see Figure A3). The start time, t_s, for fire spread occurs when the temperature recorded by any external thermocouple at level 1 equals or exceeds a 200 °C temperature rise above the start temperature, T_s, and remains above this value for at least 30 seconds. An example graph is shown in Figure A5, where ignition of the heat source corresponds to time zero.

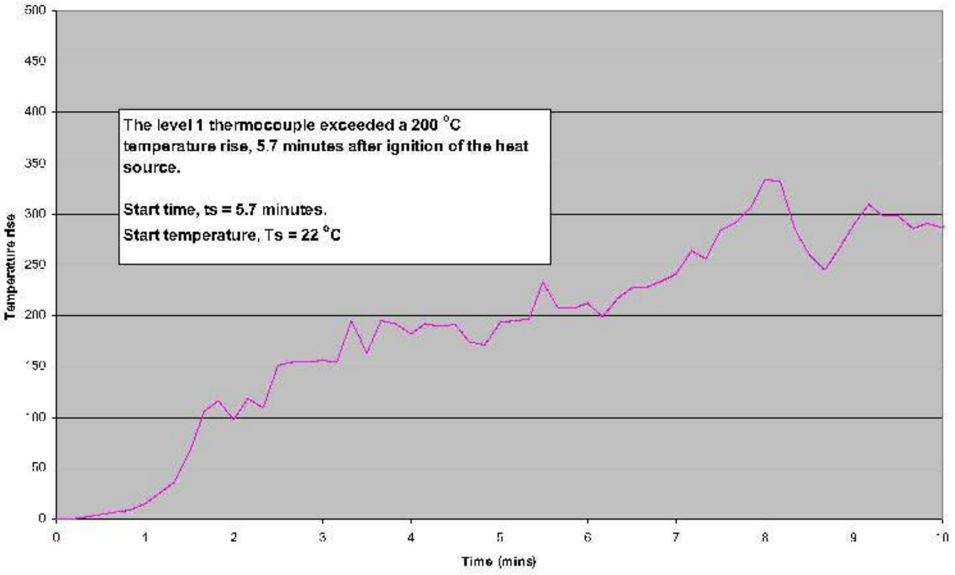


Figure A5 Level 1 thermocouple used to determine start time, t_s

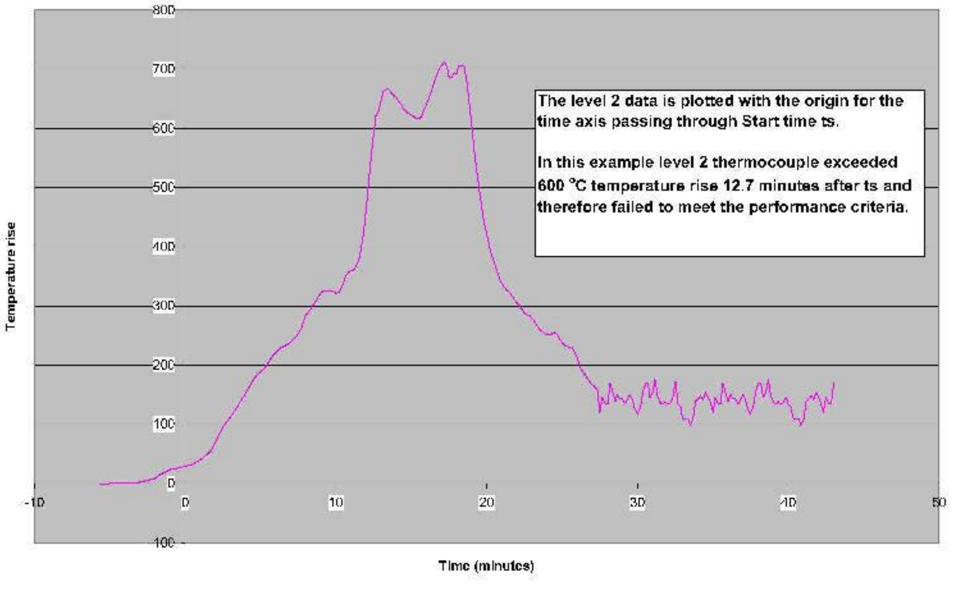


Figure A6 Level 2 thermocouple plotted with start time set to time zero

External fire spread

Failure due to external fire spread is deemed to have occurred if the temperature rise above T_s of any of the external thermocouples at level 2 exceeds 600 °C, for a period of at least 30 seconds, within 15 minutes of the start time t_s. An example graph is shown in Figure A6.

Internal fire spread

Failure due to internal fire spread is deemed to have occurred if the temperature rise above T_s of any of the internal thermocouples at level 2 exceeds 600 °C, for a period of at least 30 seconds, within 15 minutes of the start time t_s. An example graph is shown in Figure A6.

Mechanical performance

No failure criteria have been set for mechanical performance. However, details of any system collapse, spalling, delamination or flaming debris should be included in the test report. The nature of the mechanical failure should be considered as part of the overall risk assessment when specifying the system (see for example Figure A7).

Figure A7 After the test

References to Annex A

[A1] Colwell S A and Smit D J. Assessing the fire performance of external cladding systems: a test method. *BRE Fire Note* 9. Garston, BRE Bookshop, 1999.

[A2] Department of Transport, Local Government and the Regions. *The Building Regulations 2000 Approved Document B: Fire safety*. London, The Stationery Office, 200

[A3] House of Commons Environment, Transport and Regional Affairs Committee. *Potential risk of fire spread in buildings via external cladding systems*. 14 December 1999 (HC109).

[A4] British Standards Institution. Fire performance of external cladding systems. Part 1. Test method for non-loadbearing external cladding systems applied to the face the building. *British Standard* BS 8414-12002. London, BSI, 2002.

Fire performance of external thermal insulation for walls of multi-storey buildings

BRE Bookshop
151 Rosebery Avenue
London EC1R 4GB
Tel: [redacted]
Fax:
email: brebookshop@emap.com

BR 135
ISBN 1 86081 622 3