8 Fire testing

Fire testing in relation to the regulations is relatively small scale and only gives an indication of the way a product may perform in fire and a comparison of the relative ranking of various products.

The fire performance of insulated panels is influenced by the nature of the protective facings, the design of the panel joints and the detailing at junctions. It is only possible to determine the likely practical performance by considering the insulated panel system under realistic large scale testing (see 8.1.2).

This section briefly describes the fire tests relevant to insulated panels and includes a summary table showing the relationship between the present British Standard tests and the new European Harmonised test methods.

In assessing the performance of panel systems various fire test procedures are available. These are generally divided into two main categories:

a) reaction to fire tests;

b) fire resistance tests.

Walls

For walls the level of performance recommended for external cladding systems in building regulations guidance documents varies depending on a number of factors (see sections 3 to 4) such as:

height of the building

purpose group (use) of the building

proximity of the external wall to an adjacent building or site boundary

In low-rise buildings that have historically presented a relatively low risk to the occupants (e.g. offices and storage) there are no specific fire performance requirements for an external wall if it is located well away from adjacent buildings or a site boundary.

However, where the overall fire risk to life is greater as a result of the height, use or location of a building it may become necessary for the external walls to satisfy specified fire test criteria.

Roofs

In the case of roofs, tests assess the required level of performance in terms of spread of flame and the potential penetration of an external fire through the roof.

8.1 Reaction to fire

Reaction to fire tests are intended to classify materials or insulated panel systems in terms of their contribution to flame spread and heat output in the early stages of fire development.

The main reaction to fire tests that are currently referred to in UK building regulations guidance documents include:

BS 476:

Part 3: 1958 External fire exposure roof tests [9]
Part 4: 1970 Non-combustibility test for materials [10]

Part 6: 1989 Fire propagation for products [6]

Part 7: 1987 Surface spread of flame test for materials [5]

Part 11: 1982 Assessment of the heat emission from building products [11]

8.1.1. Surface properties

In the early stages of fire development the main aim is to ensure that the exposed surfaces do not propagate flame or contribute sufficient heat to promote the rate of fire growth.

The flame spread and heat contribution properties of linings and other exposed surfaces is generally classified in terms of performance in tests to BS 476: Part 7 and BS 476: Part 6 respectively.

To achieve a Class 0 rating it is necessary to achieve both a Class 1 surface spread of flame to BS 476: Part 7 and a satisfactory result in BS 476 Part 6.

Except in small rooms internal linings are required to provide a Class 1 or Class 0 surface. The external surface of a wall may also require to be classified in accordance with BS 476: Part 7 and Part 6 depending upon the use, location and height of the building (see table 3, page 19 and table 9, page 26).

8 Fire testing

Insulated panels with metal facings and thin protective coatings [pvc/pvdf] generally achieve a Class 0 rating in accordance with the British Standard Tests.

8.1.2. Non combustible materials

BS 476: Part 4 and BS 476: Part 11 are designed to demonstrate that a material will contribute negligible heat when subject to the temperatures experienced in a fully developed fire. The tests involve placing a sample of material in a furnace at a temperature of 750°C. If no sustained flaming is observed and there is no significant increase in the furnace temperature the material is classified as non-combustible or of limited combustibility.

The tests are severe and assess the heat contribution of a material throughout its thickness. Materials that would be classified as non-combustible include steel, stone, concrete, brick etc. Materials consisting primarily of non-combustible constituents such as mineral or glass fibre products may not necessarily be categorised as non-combustible due to the presence of organic binders and, in the case of insulated panels, adhesives . In general a material containing more than 1% of organics is unlikely to be classified as non-combustible or of limited combustibility.

8.1.3. Large-scale tests

Whilst the reaction to fire tests in the BS 476 series have a proven track record for many traditional materials they rely on the testing of relatively small samples of less than 1m^2 in area. The tests are therefore ineffective in identifying the possible effects of failure of the joint or facings of the panel systems. These effects only become apparent in much larger scale tests.

For this reason the insurers (Loss Prevention Council and Factory Mutual) have developed their own test procedures which are intended to establish the large scale performance of insulated panel systems. For instance the LPC test (LPS 1181) utilises a room 10m long by 4.5m wide by 3m high, which is constructed with the particular panel system under investigation.

The typical ignition source is a timber crib that provides a relatively severe heat source with a maximum heat output of 1MW. The standards require that the extent of flame spread is limited and that flashover does not occur within the compartment.

8.2 Fire resistance

The fire resistance of a building element provides some measure of its ability to survive a fully developed fire. Fire resistance is measured in terms of the time a building element will survive the test conditions before specified failure criteria are reached.

The relevant British Standards for the fire resistance of insulated panel elements are:

BS 476: Part 20: 1987 General principles [16]

BS 476: Part 22: 1987 Fire resistance of non-load bearing elements [7]

Note: The majority of external wall applications are not subject to fire resistance requirements. Applications where fire resistance are required are set out in sections 3.3: 4.5: 4.7.

The fire resistance test assesses the integrity and insulation performance of insulated panels.

Integrity. Fire resisting separating elements (walls, floors, doors etc.) are required to satisfy the integrity criterion of the test. This requires that no through gaps or openings occur in the construction and that no sustained flaming occurs on the unexposed face of the structure.

Insulation. Where fire resistance is required, external wall elements may also be required to satisfy the insulation criterion for a specified time. This requires that the average temperature of the unexposed face of the separating element does not exceed 140°C and the maximum temperature at any one point does not exceed 180°C.

8.3 European fire tests – reaction to fire

As a result of efforts to harmonise fire test standards throughout the European Union, British Standard fire resistance and reaction to fire tests will gradually be replaced by harmonised European standards. Where a national standard is to be replaced by a European harmonised standard, there will be a co-existence period during which either standard may be used. At the end of the co-existence period the national standard will be withdrawn.

The Euroclass scheme will classify all roof and wall products into one of seven reaction to fire classes namely: A1, A2, B, C, D, E and F according to their performance in four harmonised tests. Because the British and European test methods are very different in nature there is no direct correlation between the performance of any particular material or system in the British and European tests.

The least combustible products will be classified A1 and A2 based upon the results of a furnace test (EN ISO 1182) and an oxygen bomb calorimeter (EN ISO 1716).

Products classified as A1 or A2 under the European system are broadly comparable to the British classification of non-combustible or material of limited combustibility respectively. Class A1 is not generally achievable with a panel with an insulating core due to the organic content of the adhesives and binders.

At the other end of the scale the classifications will involve a small burner test (EN ISO 11925-2), which will be used to assess the ignitability of products in categories B to E.

However, the main test used for discriminating between products in categories B, C and D will be EN 13823 also known as the Single Burning Item or SBI test. This test involves subjecting panels to a fire source with a heat output of 60kW and measuring the flame spread and contribution to heat output of the panel.

8.4 European fire tests – fire resistance

The harmonised fire resistance test (EN1363-1 and EN1364-1) is fundamentally the same as the equivalent BS 476: Part 20 and Part 22. The changes are unlikely to reduce the level of safety achieved in buildings. The classification procedure in terms of minutes of integrity and insulation is similar.

8.5 Comparison between British and European systems

Table 12 provides a comparison for insulated panels between the British Standard test requirements and the likely European equivalents.

Table 12. Comparison of equivalent British and European classifications

Performance criterion	Scotland	England, Wales and Northern Ireland	Euroclass*
Reaction to fire	Non-combustible Non Combustible Low risk Medium risk High risk	Non Combustible Material of limited combustibility Class 0 Class 1 Class 2	A1 A2 B C D
Fire resistance [insulation integrity]		15 minutes 30 minutes 60 minutes etc.	15 minutes 30 minutes 60 minutes etc.
Roof	Low vulnerability (see section 4.6)	Class AA: AB: AC	**

** For England and Wales the corresponding Euroclasses above are the proposed classes set out in the draft European Supplement to Approved Document – B which at the time of printing is out for public comment. They are given for informative guidance only.*

*** A harmonised procedure for the assessment of roofing systems is being developed but it is anticipated that this will not be available for some time.*

9 Fire performance and classification of insulated panels

9.1 9.1. Background

There have been a number of high profile fires involving insulated panels incorporating a polystyrene core. This type of panel has been widely used internally in the food processing industry to create insulated cold or freezer stores within the building enclosure.

As a result of these fires, guidance on the design of panel systems used internally in large cold storage areas has been published by the International Association of Cold Storage Contractors (European Division) [17].

This publication is referred to in Appendix F of Approved Document B which makes a distinction between the different fire risks associated with internal insulating structures and external cladding.

> "Insulating core panel systems are used for external cladding as well as for internal structures. However, whilst both types of panel system have unique fire behaviour characteristics, it is those used for internal structures that can present particular problems with regard to fire spread".

The external envelope

It is generally accepted that the fire risks associated with insulated panels with thermosetting cores (rigid polyurethanes) used in the external building envelope are much lower than those associated with internal partitioning applications of polystyrene panels, particularly within the food processing industry.

Whilst the informed consensus is that the use of cladding panels incorporating combustible cores does not represent a risk to the occupants of most buildings there is concern that fire fighting operations may be made more difficult. There may also be additional factors to be considered in certain types of buildings where a total evacuation is not feasible (e.g. hospitals and high rise buildings). In taking account of these concerns the recommendations of this design guide often go beyond the minimum requirements of building regulations.

By applying good design practice and the appropriate selection of products [section 10 & 11] the level of fire safety can be readily improved over and above that required by current building regulations guidance documents.

9.2 Factors affecting fire performance of insulated panel systems

The fire performance of different types of insulating panel system can vary considerably and will depend upon a number of factors including:

- facing material;
- security of joints between panels;
- the degree of restraint (fixings) provided to the facings;
- flammability of core material;
- flammability of other organic components – adhesives, binders etc.

9.2.1. Facing materials

The performance of any core material and in particular polymer cored panels is strongly influenced by the protection afforded to the core by the facings. If steel facings are firmly secured by through fixings and the inter-panel joints are designed to retain their integrity during a fire a substantial degree of protection can be provided to the underlying core. This form of construction will restrict flame spread and reduce the heat contribution to a fire.

External insulated panels have been specifically designed to absorb the considerable forces – wind, snow, static loads etc – to which the roofs and walls of buildings are subject and to transmit the forces to the supporting structure. They are also required to be weather tight and control energy loss through air tightness at the joints. As a result the panels are securely fixed to the supporting structure and the joint design is designed to be robust and effective.

9.2.2. Fixings and joints

To obtain the best fire performance the internal and external facings should be firmly secured to the structure with through fixings. The design and detailing of inter-panel joints and closure at the panel edges is also fundamental. The more effectively the joints are sealed the less the flames will impinge directly on the core material reducing flame spread and heat contribution. Detailed guidance regarding panel fixing and jointing is given in section 11.

9.2.3. Core materials

The fire properties of core materials can vary significantly according to the generic type of core and the specific formulation. The following paragraphs provide guidance on the performance of the four main generic types of core material when considered in isolation.

However, when the core material is incorporated into a steel faced insulated panel building system, the protection provided by the metal facings, joints, fixings and the support system may greatly modify the performance indicated for the core insulants in isolation. The practical performance of the complete insulated panel system should only be evaluated by a full-scale test and the following information should be viewed accordingly.

Rigid polyurethanes

Rigid polyurethane (PUR) materials are cellular thermosetting insulants that form a char when subject to heat and flame impingement. The char acts as an insulator which affords some protection to the underlying product. However, PUR will burn by charring and pyrolising producing significant quantities of smoke in the process.

When incorporated into panels however, large-scale tests [18] have shown that there is no hidden flame spread within the panel cores with external panel systems. Decomposition under these conditions is significantly different from testing the product in isolation.

Whilst the smoke level in large-scale tests has been deemed to be acceptable, the smoke production from rigid polyurethane is less than polystyrene but can still be very substantial.

Polyisocyanurate (PIR)

Rigid polyisocyanurate (PIR) core products are extensively modified polyurethanes by the incorporation of the much greater heat resistant isocyanurate ring structures created by the trimerisation of three molecules of the polymeric isocyanate used in their formulation.

As a result, when tested in isolation, the rate of pyrolysis is reduced, the strength of the char is increased, and the protection to the underlying insulation is enhanced. This results in the reduction of the amount of damage created by the incident of fire with a consequent reduction of smoke production. This is confirmed by large-scale tests [18].

Accordingly some steel faced PIR cored panel systems will give a fire resistance in excess of 2 hours integrity and 15 minutes insulation (BS 476 Part 22) as well as satisfying the large-scale test requirements of the LPC test LPS 1181-2 and FMRC 4880/4471.

Mineral fibre

Mineral fibre products are created by bonding the core product with organic binders. In isolation the fibre performance to BS 476 Part 4 may be non-combustible or of limited combustibility. When incorporated within insulated panels the mineral fibre core includes organic binders and the facings are bonded using an organic adhesive. Most mineral fibre panels will therefore not be rated non-combustible or of limited combustibility.

However, fire performance of panels with mineral fibre cores is generally very good and these panels will normally produce less heat and smoke than panels, incorporating polymeric cores.

Steel faced MF cored panels are capable of being classified in accordance with the LPC standard [LPS 1181] and of providing significant levels of fire resistance, both integrity and insulation, according to BS 476 Part 22.

9 Fire performance and classification of insulated panels

Phenolic foams

Phenolic foams contain a polymeric structure which offers a considerable resistance to degradation by heat. Accordingly, like PIR products they are thermosetting, forming a char in isolation which adds a high degree if protection to the underlying insulation. The characteristics are maintained when the product is incorporated into insulated panels. Smoke production is also low by comparison with most other polymeric materials.

Despite their good fire properties, Phenolic core materials have not been used for roofs and walls because of difficulties in achieving the additional mechanical resistance requirements for external envelope panels.

Expanded polystyrene

Expanded polystyrene is only rarely used in external cladding systems. Polystyrene is a thermoplastic that melts when heated. Chemical flame retardants can be added but when exposed to sustained flame impingement even flame retardant polystyrene materials will burn vigorously and produce large quantities of black smoke.

The softening temperature is approximately 100°C and melting temperature 180°C. As the temperature increases the polystyrene melts and recedes from the heated surface creating a void between the facing panels. Flames entering the void cause flaming droplets to flow on both the external and internal sides of the cladding and this can accelerate fire spread.

Fire tests in accordance with LPS 1181 indicate that once flames have entered the core, fire can spread unchecked between the facings consuming the core material as it progresses. If the facings are unsecured with no through fixings early collapse can occur and accelerate the speed of flame spread [18].

However, if the facings remain secured and the joints remain tight there should be no unexpectedly sudden spread of flame across a wall or ceiling.

The production of thick black oily smoke from burning polystyrene can be very substantial.

9.3 Fire test performance of panel systems

The building regulations and insurance recommendations require specified levels of performance in terms of reaction to fire, fire resistance and the integrity of junctions with fire resisting construction.

In the following paragraphs the fire performance of generic types of panel system are discussed in the context of these recommendations. However, in each case the specifier should ensure that test data is available from an accredited test laboratory to confirm the required level of fire performance.

9.3.1. Reaction to fire (flame spread)

In most cases either the external or internal face of an insulated panel will need to comply with specified reaction to fire (flame spread) criteria (commonly this will be Class 0, Class 1 or Euroclass B).

By virtue of the protection provided by the facing, commercially available, steel faced insulated panels will generally achieve a Class 1 surface spread of flame rating in accordance with BS 476: Part 7 irrespective of the type of core material.

The performance in BS 476: Part 6 (for a Class 0 designation) or the tests for designation in accordance with Euroclass B may also be influenced by the nature of the core material and the joint design. Insulated panels with rigid urethane or mineral wool cores will generally achieve Class 0 and Euroclass B.

With regard to insurance industry tests, currently only panels with certain PIR, Phenolic or mineral fibre (MF) cores have passed the LPS 1181-2 and the FMRC4480 / 4471- Class 1 large scale tests.

9.3.2. Fire resistance

The fire resistance of an insulated panel system is a function of the facing material, insulating core, joints between panels and the method of fixing.

Steel faced panels with a PIR core have achieved a fire resistance in excess of 2 hours in terms of integrity. PIR core panels can achieve approximately 15 minutes in terms of insulation. This generally meets the requirements for external walls located more than 1m from the boundary (note, however, that in some situations the Scottish Technical Standards require 30 minutes insulation).

Panels containing a mineral fibre (MF) core are able to provide a fire resistance in excess of 2 hours as regards both integrity and insulation.

To achieve the specified fire resistance the cladding system must be supported by a structure that will also provide the required fire resistance or has otherwise been designed to survive fire [19].

9.3.3. Junctions

The fire tests required by the regulations assess insulated panels as a product or system e.g. panel-to-panel joints. It is also essential that all the interfaces between panels on different planes, and panels with other construction elements – such as windows, doors, penetrations etc – are also designed and installed with maximum fire security in mind.

Sections 10 and 11 give good practice guidelines concerning the most common and important of these detailing areas together with recommendations for flashings and fixings.

9.3.4. Junctions with fire resisting constructions

At the junction between a roof, or an external wall with a compartment wall some guidance documents require that a strip of combustible core is removed and replaced with a strip of non-combustible or fire resisting material. This is to ensure that the core material does not provide a continuous path of combustible material that could allow fire to bypass the fire resisting construction.

However large-scale tests and analysis of actual fires have shown that some types of combustible core (particularly some types of PIR and Phenolic) will tend to char but may not promote the spread of fire spread beyond the fire resisting barrier.

Therefore if it can be demonstrated by suitable tests (e.g. following the principles of BS 476: Part 22 or a large scale ad-hoc test) that a particular insulated panel system will not promote fire spread past a compartment boundary it would, in many cases, be reasonable to omit a fire resisting or non-combustible break in the cladding.

9.3.5. Smoke production

When subject to sustained fire exposure insulated panels can produce considerable quantities of smoke as a result of degradation of a combustible core. However, the size of initiating fire necessary to cause significant degradation of the core and substantial smoke production is in itself likely to produce very large quantities of smoke. Therefore, the contribution of a insulated panel system designed and installed in accordance with the recommended good practice set out in this guide is unlikely to make a significant contribution to the risks to the occupants within buildings.

There are no statutory requirements covering the propagation of smoke by building materials. However, in certain cases where it is necessary for the occupants to remain within a separate compartment within the building for all or part of the duration of a fire the potential for smoke production and the impact of its spread on the occupants needs to be carefully assessed. This additional consideration would apply to buildings such as hospitals, high-rise buildings subject to phased evacuation or sensitive control installations (i.e. air traffic control) where immediate evacuation is not feasible.

9 Fire performance and classification of insulated panels

9.4 Recommended performance levels

Building Regulations are intended to set out the minimum standards necessary to achieve acceptable levels of safety.

The main use of insulated panels for the external roofs and walls of buildings has been in factories, warehouses and offices. In these types of buildings the risk to life from fire has historically been relatively low. More recently the use of insulated panels has extended to a wide range of applications within the commercial, retail and leisure sectors.

In other types of building, (e.g. hospitals, schools) the life safety consequences of fire can be much greater. It is therefore reasonable to specify more onerous fire safety performance standards for materials used in the construction of hospitals than in, for example, a warehouse or low-rise office building.

Based on the generic fire risk associated with the various building regulations purpose groups, this guide provides recommendations on the performance levels of external insulated panel systems that are considered appropriate for a range of generic situations. However, it should be noted that these recommendations are based on generic risk assessments and may go beyond the requirements of building regulations. Alternative specifications may be appropriate if shown to be acceptable by a risk assessment or fire safety engineering study (see section 7).

9.4.1. Insulated panel systems

The fire properties of cladding systems can vary considerably. The ultimate fire performance of insulated panels is determined by the facings, panel design, the panel-to-panel joint detail, the core insulant and to some extent the method of fixing.

To give guidance on panel selection relating to typical end uses, recommended performance levels are illustrated in Table 13. They combine the performance classifications from the current British Standard and Euroclass harmonised tests supplemented for certain Building Purpose Groups with additional information and certification from one or other of the larger scale tests [insurance industry tests – LPS 1181 / FMRC 4880/4471].

Whilst for many building group categories the requirements of the building regulations may be satisfied by reference to the British Standard tests or Euroclass levels, it is recommended that an enhanced level of performance be adopted particularly in higher risk building types [see table 13 opposite].

Note: Polystyrene as a core insulation in external cladding panels is rarely used, due to its poor performance in many major industrial fires [internal applications], and has in general been superseded by urethanes and mineral fibre cores. It is recommended that PS cored panels are only considered where their performance can be supported by relevant large-scale fire tests i.e. LPS 1181 or FMRC 4880/4471.

9.4.2. Recommendations for the choice of insulated panels

Table 13 presents recommended performance levels for insulated panels for use in roofs and external walls. These recommendations are based upon generic risk assessments. The performance specifications recommended in this table may exceed the minimum requirements of Building Regulations in England and Wales. In Scotland additional requirements for non-combustibility may apply to buildings in purpose group 2 (hospitals) or buildings with a floor at 18m or more above ground level.

The recommendations are based on the most commonly used steel faced insulated panels. Aluminium faced insulated panels may satisfy the reaction to fire requirements of the BS and corresponding Euroclass tests but are unlikely to meet the fire resistance or insurance industry test requirements.

Table 13. Recommended fire performance classifications for insulated panels for external wall and roof applications by purpose group*

Purpose group	Wall and ceiling facings	Roof performance	Fire resistance	Additional recommendation (EPIC)
2. Residential [Excl. dwellings] Schools; Hospitals etc.	Class 0	AA; AB; or AC	**For fire resistance requirements see Table 3 [Section 3, page 19]** **For Scotland – Section 4, page 21** **Walls** Fire resistance requirements depend upon: – boundary conditions **Roofs** There is generally no requirement for roofs to be fire resisting (but for exceptions see section 3.3.3; 3.3.4; 4.4.2 & 4.7)	LPS1181 Grade A or FMRC 4880 / 4771 – class 1 Limited combustibility core if more than single storey
	Euroclass B	N/A (see note 3)		Euroclass A2 if more than single storey
3. Offices	Class 0	AA; AB; or AC		LPS1181 Grade B or FMRC 4880 / 4771 – class 1
	Euroclass B	N/A (see note 3)		
4. Shops & commercial	Class 0	AA; AB; or AC		LPS1181 Grade A or FMRC 4880 / 4771 – class 1 Limited combustibility where top floor is more than 18m above ground
	Euroclass B	N/A (see note 3)		Euroclass A2 where top floor is more than 18m above ground
5. Assembly / Recreation	Class 0	AA; AB; or AC		LPS1181 Grade A or FMRC 4880 / 4771 – class 1 Limited combustibility where top floor is more than 18m above ground
	Euroclass B	N/A (see note 3)		Euroclass A2 where top floor is more than 18m above ground
6. Industrial	Class 0	AA; AB; or AC		Additional provisions may be specified for specific applications and insurance requirements
	Euroclass B	N/A (see note 3)		
7a. Storage & other non-residential	Class 0	AA; AB; or AC		Additional provisions may be specified for specific applications and insurance requirements
	Euroclass B	N/A (see note 3)		
7b. Car parks	Class 0	AA; AB; or AC		Additional provisions may be specified for specific applications and insurance requirements
	Euroclass B	N/A (see note 3)		

** The corresponding Euroclasses above are the proposed classes set out in the draft European Supplement to Approved Document – B which at the time of printing is out for public comment. They are given for informative guidance only.*

Notes

1. External insulated panels generally achieve Class 0
2. External insulated panels (roofs) generally achieve requirement AA or AB
3. External insulated panels (roofs) generally satisfy new requirement classification to prEN13501-5 for External Fire Performance