Composite Panel

What are Composite Panels?

Composite panels are a pre fabricated insulated building material with typically two metal skins bonded to an inner insulation core. Some are available with plastic or fabric lining instead of metal for one or both skins. Such panels are in widespread use in modern buildings, either externally as wall or roofing material, or internally as compartmentation or linings. They are an inexpensive, light and easy to install product with superior insulation and hygiene qualities to many similar building materials.

There are many different types of composite panel. Panels are differentiated by the core material used for insulation. The type of insulation used is the single most important factor in relation to the performance of the panels in a fire situation. Some of the insulation cores include:

- Expanded Polystyrene (EPS)
- Fire Retardant EPS
- Polyurethane (PUR)
- Polyisocyanurate (PIR)
- Modified Phenolic
- Foamed glass
- Glass Fibre
- Mineral Wool

Fires in Composite Panel

When exposed to a fire, composite panels have been known to experience a number of problems:

1. Delamination

A fire starting outside the panel will create enough heat to heat the insulation material inside the panel. Insulating materials will behave differently, however if heated to high enough temperatures the insulation material can shrink away from the outer metal sheets. As a result the panels lose their structural stability. The same thing may occur if the adhesive used to bond the outer metal sheets to the insulated core fails when heated.

2. Combustible Cores

A fire will spread quickly in a panel with a combustible core resulting in delamination and a collapse of the structure. Combustible cores can be ignited inside the core, as a result of electrical cables passing through, damaged cores, etc. A fire outside the panel can also ignite the core if the insulation material reaches its flashpoint or auto ignition temperature.

3. Construction

Many structures using composite panels are self supporting structures. As a result when a number of panels are destroyed the stability of the entire structure is put at risk.

4. Fire Fighting

Once the core becomes involved in the fire it is very difficult to extinguish as the two outer sheets prevent the application of water to extinguish.

5. Products of Combustion

Depending again on the type of insulation, fires involving composite panels can create a large volume of dense smoke, which is normally toxic.

Performance of Core Materials in a fire

Expanded Polystyrene (EPS) or Extruded Polystyrene (XPS)

EPS is made by impregnating polystyrene breads with pentane which are then steam heated.

Polystyrene is a thermoplastic material. Its fire behaviour ranges from the situation where the softened material collapses or falls without ignition having taken place to that where the material ignites and subsequently falls while burning. Both types of polystyrene when subjected to heat soften quickly and shrink away from heat sources in excess of 100 degrees. The flash/ignition temperature of thermoplastic materials is quoted in the range of 350 to 490 degrees.

Both types of polystyrene (in particular where an inadequate joint system is used) have a very poor fire performance when subjected to ignition sources above 100kW heat output. Tested EPS Panels have shown that the core starts to shrink away from the metal sheets at around 100°C. This is when the process of delamination will begin. A particular concern is the ability of such panels to re-ignite after the inception risk has been extinguished.

An improved performance is obtained where mineral wool edged EPS and XPS panels are used.

Fire retardants are often added to polystyrene. These have the effect of reducing or delaying the combustion of the material. **However, once ignited the combustibility and hazard is the same.** The retardants may also add to the smoke production and toxicity of the fumes once the fire has taken hold.

EPS is probably the most common type of core found in composite panels in Australia, normally with a fire retardant added. It has excellent thermal insulating properties, which make it ideal for cool room applications and panels satisfy the strict hygiene requirements of the food industry. But its most important characteristic is it's price. EPS panels are very cheap to produce and as a result they are used not only in cool room applications, but in any situation where a cheap, light weight cladding material with good aesthetic appearance, is required.

Polyurethane

Unlike Polystyrene, Polyurethane is a thermosetting plastic. This refers to materials which do not soften when heated but undergo localised charring with flaming combustion if flammable vapours are given off in suitable quantity. In this way PUR behaves in a similar way to timber and wood products when subjected to fire.

The charred mass may shrink or stay in place, in the latter case the char provides an insulation barrier that controls the flow of heat to the un-decomposed mass and flow of vapours from it. In this way, voids are not generated and fire spread in the panel core does not occur.

PUR foam has a flash ignition temperature of around 320 degrees. In fire tests similar levels of rate of heat release were found as for EPS and XPS though PUR did not show any inclination to re-ignite after the inception risk was extinguished. This is a clear indication of the difference between thermoplastics (e.g. polystyrene) and thermo-setting resins (e.g. polyurethane and phenolic).

PUR is made by a reaction of a hydroxyl group of a polyester, polyether or polyalcohol with a di-isocyanurate. PUR is usually treated to prevent ignition by a low heat source, but a larger flame will ignite and spread rapidly, with abundant smoke and toxic decomposition giving off hydrogen cyanide, oxides of nitrogen and carbon monoxide.

PUR is also found in many buildings as a layer of insulation that has been sprayed on to the side of walls or the underside of roofs. Its thermosetting characteristics allow it to set hard when sprayed in this fashion.

Polyisocyanurate (PIR)

Like polyurethane, PIR is a thermosetting plastic. PIR foams are a modified version of PUR and act similarly to PUR in mechanical and thermal terms. However, PIR has a higher temperature resistance and a relatively low combustibility property. It is reasonably resistant to all but large ignition sources with smoke and decomposition similar to PUR. Generally PIR performance is superior to PUR but this does vary widely depending on the formulation of individual products and the quality control.

The flash ignition temperature of PIR is typically around 460°. PIR foams have a strong tendency to form a protective char and the amount of volatile gas produced is low. If tested as a foam in a typical reaction to fire test (AS1530.2), flaming combustion does not occur. Typically, the char does not shrink away from the hot surface but tends to intumesce at temperatures well above 500°C. This results in extra protection of the underlying foam layer from the high temperatures in the fire. Panel voids through which the fire can spread due to shrinkage of the insulant core material does not occur with PIR.

The use of an approved panel, which has been tested to either LPC or FM standards, is paramount when using Polyisocyanurate.

Modified Phenolic Foam

Modified Phenolic is a comparatively new open celled material which is designed primarily to address the levels of fire resistance required from composite panels. It has been classified by test as non-combustible in accordance with BS476: Part 4: 1970 (1984). Modified phenolic panels are more suited to temperature controlled stores that do not exceed 6.3 metres in height. It is claimed to be the most thermally efficient insulant commercially available and its closed cell structure does not absorb water, which is a key consideration where hygiene is an issue. As it is a new product its moisture absorption characteristics are less well proven though manufacturers claim an excellent resistance to the passage of water vapour and to water absorption.

Regarded as practically non-combustible it has a very high fire resistance and a very low smoke emission in a fire condition. Similar in its reaction to fire as PIR in that it forms a protective char when exposed to flame. Under tests conditions it has been shown that there is no flame spread away from the flame source. Low smoke generation is another feature with similar levels to mineral fibre given off (polystyrene gives off 155 times more smoke than phenolic).

As a material (not a composite panel) it achieves a Class 0 rating under BS476 Part 6 *Fire Propagation*, Class 1 under BS476 Part 7 *spread of flame* and Class P (not easily ignitable) under BS476 Part 5: *Ignitability*. Tested as composite panel under LPS 1181 and 1208 it showed better performance in fire than PIR and achieved a fire resistance of up to 2 hours insulation and integrity.

Modified Phenolic would appear the obvious solution to EPS as it has excellent thermal properties and is considered non-combustible. Unfortunately however Modified Phenolic is much more expensive than EPS to produce. In addition there are currently very few if any manufacturers of modified Phenolic Panels in Australia, which adds further to the cost of this product.

Rock Fibre / Mineral Wool / Stone Wool

Mineral Wool is produced by liquefying stone in a melting furnace at approximately 1500 degrees C and then spinning the liquid stone into fibres, impregnating to provide water repellence and then hardening again in a special furnace. The stone wool is then cut to size in boards or mats.

Comprising inorganic (and therefore non-combustible) material, specific grades of mineral rock fibre insulants have been classified by test as non-combustible in accordance with AS 1530.1 - 1994. However, as the binder content, i.e. the additive used to bind the rock fibres, of the insulation increases the resistance of the insulation to combustion is reduced.

The fire performance of the actual grade of Mineral Rock Fibre insulant should be confirmed with the manufacturer.

The facings and the core of the panel are only held together with the adhesive which in most factory made panels fails at temperatures between 130 and 300 degrees C. Forms of mineral wool can resist temperatures up to 1000 degrees. Therefore, even though the core material is non-combustible and will not promote the spread of fire, a fire outside the panel can still cause delamination to occur in the area around the fire, however it is unlikely to ignite the core and the potential for fire spread is low.

Glass Wool/Glass Fibre

Glass wool is formed by sand, soda and other materials that are melted together to form glass and then processed to form thin resilient fibres. A binder is sprayed over the fibres to bind them together to form glass wool. When the glass wool is pressed together the volumetric weight changes and the properties of the material gradually changes

Glass wool can resist temperatures of 650 degrees. Fibre glass insulation is made of sand and therefore cannot burn. The only raw material that can burn is the binder and in most cases the content is so low that it is classified as non-combustible. Despite the fact the binder is not resistant to temperatures over 250 degrees, glass fibre can be used at even higher temperatures (500 degrees) with good results. The binder only decomposes in the hottest layers, the binder on the cold side of the insulation will remain unchanged.

Glass fibre insulation is commonly used in a "built-up" insulated cladding system. A "built-up" system is constructed on site by attaching insulated bats to the inside of a wall, the underside of a roof or above a ceiling. Different methods are used to hold the insulation in place, such as cladding the internal surface with gyprock or lining with an Aluminium foil material.

Cellular glass

Pure glass without resins or binders is totally non-combustible. It maintains its physical properties up to 430 degrees, the glass itself does not melt until after 570 degrees and a new foaming phase begins at 1000 degrees.

Construction of Panels

Panel Joints

Some factory made panels have cleverly designed edge details which enables panels to be interlocked to provide an assembly in which there is no contact between the inner and outer metal faces so that the flow of heat from one facing panel to the other is no greater at the joint than in the rest of the panel.

Some EPS panels now use an edge strip between the panels of mineral wool to prevent the spread of fire in the core between the panels.

Methods of Support

The way in which a panel is supported is also important in how it performs in a fire. Many of the cool room structures constructed of composite panels within a building are self supporting structures. They do not have any frame to which they are attached. As a result fire involving even part of the structure can potentially result in a total collapse.

Structures supported by a steel support structure will perform better if the fire does not progress within the core. It is also important that both metal skins of the panel are fixed to the support structure so that if delamination does occur both metal skins will still be supported by the steel frame and will not collapse.

Testing the Fire Performance of Panels

International authorities conducting tests to evaluate the performance of various panel structures in fires include the Loss Prevention Council (LPC) in the UK and FM Global (FM) in the USA.

Until recently there were no tests conducted in Australia in relation to the performance of composite panel structures in fires. The AS1530 suite of tests have been used for some years to test the behaviour of individual materials in controlled fire situations, however there has not been any test to evaluate the performance of a structure in a fire situation.

In May 2003 the AS !SO 9705 – 2003 standard was accepted and published. This standard defines a testing methodology for full scale fire tests appropriate for evaluating the performance of the various types of composite panels here in Australia.

AS ISO 9705 – 2003

This standard defines the testing methodology for a Full Scale Room Test. A room is constructed with a single opening and a fire source is placed in the corner of the room. The performance of the various construction materials and methods of construction is evaluated by recording the flame spread and the time taken for flashover. Products of combustion are also collected and analysed if required. At present the standard does not define guidelines for evaluating the results of these tests.

We understand that a number of Australian panel manufacturers are currently having there products tested by the CSIRO and we await the results of these tests.

LPC Tests

The LPC tests are known as LPS1181, which tests external panels, and LPS1208, for internal panels.

LPS1181 provides two standards of panel:

- Grade A: Wall panels only capable of providing 30 minutes fire integrity and 15 minutes insulation.
- Grade B: These panels will not propagate (or promote) the spread of fire, but do not provide any fire or insulation rating.

The entire construction method is evaluated so a panel may gain approval by using a better attachment method to its supporting structure.

Panels tested to LPS1208 are also separated into two grades, based on the intended application:

- Normal Risk: Panels will provide 30 minutes fire integrity and 30 minutes insulation.
- High Risk: Panels will provide 60 minutes fire integrity and 60 minutes insulation.

FM Tests

FM Global test all building materials for their performance during a fire by the Factory Mutual Corner Test[1]. A corner structure with walls of 15m and 11m and a ceiling height of 7.6m is constructed and a wood crib placed 1ft from the wall in the corner. The wood crib used produces temperatures in the order of 500°C at the ceiling corner of the structure.

The FM approval system divides composite panels into two classes, based on performance during a corner test:

- Class 1 – The material has limited combustibility.
- Class 2 – The material will burn and the fire will self propagate.

Other Tests

Various other full scale tests have been conducted by various authorities and by panel manufacturing associations, however the testing methodologies vary widely. Different construction methods are used, different joint detail and even widely differing sizes of fire applied to the structure. As a result we can only make broad conclusions based on these tests.

Acceptability

The Building Research Establishment (BRE) in the UK, which incorporates the LPC, have published the following table, which rates the acceptability of various composite panels in terms of fire performance[2]. These ratings are based on the LPS1181 test.

Ratings

♦♦♦♦♦	*Excellent* performance (total heat release less than 100MJ)
♦♦♦♦	*Good* performance (peak heat release less than 800kW at any exposure level)
♦♦♦	*Satisfactory* performance (peak heat release more than 800kW but not more than 1500kW at any exposure)
♦♦	*Not recommended* (peak higher than 1500kW at any exposure)
♦	*Unacceptable* (re-ignite after inception risk extinguished and reach a peak greater that 400kW)

[1] FM Global Data Sheet 1-4: Fire Tests.
[2] Building Research Establishment Ltd, 2001

Sandwich Panel Type	**Ratings**
Expanded Polystyrene, standard joint	♦
Expanded Polystyrene, riveted joint	♦
Extruded Polystyrene, standard joint	♦
Polyurethane, standard joint	♦♦
Polyurethane, superior joint	♦♦
Extruded Polystyrene, riveted joint	♦♦
Polyisocyanurate (non LPCB approved)	♦♦
Expanded Polystyrene, rock fibre mineral wool edge strips	♦♦♦
Extruded Polystyrene, rock fibre mineral wool edge strips	♦♦♦
Polyisocyanurate, improved formulation/joint	♦♦♦♦
Polyisocyanurate development from LPCB company	♦♦♦♦
Modified Phenolic, standard joint	♦♦♦♦♦
Modified Phenolic, superior	♦♦♦♦♦
Rock fibre, mineral wool, stone wool	♦♦♦♦♦
Cellular Glass	♦♦♦♦♦

What is the Solution?

Unfortunately the answer to this question is that there isn't a single easy solution. Ultimately the type of panel to be used should depend on the application. For example cool room applications may still be able to use EPS panels as inception hazards are low, particularly if housekeeping is good and the size of facilities is limited to reduce the loss potential. Similarly a building that does not require a high level of insulation, such as a warehouse for dry goods, should not use a panel containing an EPS core.

For buildings being constructed the following issues should be considered:

1. Non-combustible core materials should be used where-ever possible.

2. The use of fire walls to divide processing and storage areas will reduce loss potential.

3. Automatic sprinkler protection should be considered for buildings with high fire loads and/or inception hazards.

4. The support structure and method of attachment will influence the performance of the structure in a fire situation.

Where the use of combustible core materials cannot be avoided, the following should be considered:

- Mineral wool edge strips on panels will reduce (but not eliminate) the potential for fire spread within the core.
- Sprinkler protection should be seriously considered in new structures.
- Separate these structures from other critical production or storage areas where possible.
- Maintenance and management controls become particularly critical.

In terms of what should be done to buildings currently containing EPS panels, this also depends on the application. Buildings with high fire loads or with a high level of inception hazard may require panels to be replaced or sprinkler protection to be installed.

Ultimately the decision to replace panels or protect these areas should be based on the loss potential for these buildings, not only in relation to building, stock and machinery values but also in relation to the importance of these structures to the ongoing operation of your business.

Some options to reduce the level of exposure in buildings constructed of poorly rated panels include:

- Replacing panels with a more acceptable alternative in terms of fire performance, such as mineral wool as opposed to EPS panel cores. This is particularly relevant if the building does not require the better level of insulation provided by EPS.
- Installing sprinkler protection will ensure fires are controlled in their incipient stages.
- The use of thermal barriers will reduce the time it takes for delamination to occur, but the combustible core material will still be present and therefore the problem remains.

Managing your Risk at the Moment

To protect your business and property, it is necessary to control the fire risks and the following are a number of measures that can be taken immediately to help achieve this.

1. In order to prevent combustible insulation from exposure to ignition sources, facings and joints should be maintained and kept in good condition. This is to retain the degree of fire resistance presented by the facings and to reduce the risk of fire spread to any void behind the panel. Regular inspections need to be made with written records maintained.

2. Repairs to composite panels should never involve the use of welding or other obvious ignition source. Likewise such 'hot work' should not be allowed in the vicinity of composite panels, unless they are protected by non-combustible or purpose made blankets, drapes or screens. A 'hot work permit' system should also be in place. Any work on panels should be subject to a risk assessment.

3. It is of vital importance that storage of combustible material, such as timber pallets or plastic crates, in yard areas is not against or within risk of walls containing composite panels. Ensure a distance of at least 15 metres from buildings with hazardous processes, nine metres from other buildings.

4. Forklift truck battery charging should be carried out well away from composite panels. Preferably this should be in a separate building or area.

5. Electrical examination and testing should be carried out annually on electrical equipment and cabling in the vicinity of composite panels. Thermal inspection of the systems at regular intervals is a cost effective and proactive tool in reducing exposure from electrically generated fires.

6. Where possible, services should not pass through insulated composite panels. If this is unavoidable, gaps around those services should be fire stopped to protect the insulation material. All electrical cables passing through insulated panels should be enclosed in conduits. Ideally all holes etc. should be precast at panel design and order stage to ensure greater panel integrity.

7. Attaching items to panels should be avoided where possible. If this is unavoidable, then steps should be taken to prevent the exposure of the insulation, and where necessary fire stopping should be in place around the fixing to prevent the fire resistance of the panel being compromised.

8. Make cleaning and preventative maintenance of food processing equipment a regular discipline. Cleaning flues and extract ducting of deposits should be a regular occurrence.

9. If a heater flue or other potentially hot trunking passes through panels, this must be installed in a non-combustible insulating sleeve no less than 40mm thick. Proprietary sleeve systems that can achieve 60 minutes fire resistance in terms of integrity and insulation are also acceptable. Gaps between the collar and panels should be filled with mineral fibre or other suitable non-combustible material.

10. Processes which involve a fire hazard should be located well away from composite panels.

11. The ideal situation is that all hazardous processes should be compartmented with non-combustible walls and ceiling panels of a minimum 60 minutes fire resistance. Doors and other openings should be of a similar rating and should be fitted with automatic closures.

12. Consider the installation of automatic heat and smoke detection equipment with off site monitoring to give early warning of a fire. This should ideally be supported by a response plan.

13. Heating and cooking equipment are major risks and should be fitted with automatic fire suppression systems.

Further Information

If you require further information about the risks associated with Composite Panels or have some more specific questions in relation to the handling of Composite Panels at your site, then contact RiskTech.

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