# FIRE AUSTRALIA

May 2003

## Firestorm

## The North East and East Gippsland Fires

## Flashover and Nozzle Techniques continued...


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# Fire rated insulated (sandwich) panels

*By John Rakic on behalf of the Passive Fire & Smoke Containment Alliance*

## Introduction

By far one of the most topical issues at present relating to the field of Passive Fire & Smoke Containment is that of the fire resistance properties and/or the reaction to fire properties of insulated (sandwich) panels. Insurance companies world wide have in recent times taken a very strong stance following on from the number and severity of fires involving insulated (sandwich) panels used as wall and/or roof lining materials; in particular those manufactured from steel clad Expanded Polystyrene, (EPS) core materials. Facilities that incorporate EPS based insulated (sandwich) panels here locally in Australia are finding it very difficult and/or very expensive to get property protection and/or business interruption insurance. This fact is a surprise to many Australian based building owners or facility operators who are looking to get first time insurance or renew an existing insurance policy for their facility, especially as their facility was designed, built and complies with the Building Code of Australia [1], (BCA). It is questionable whether the average building owner is aware that the BCA requirements are the minimum requirements only, and that they deal predominately with life safety only, not with the protection of property and/or protection against business interruption. They are certainly finding this out the hard way when they are dealing with their insurance broker.

*Picture showing the Flashover during a room corner test on an EPS sandwich panel construction – photo courtesy of SP Swedish National Testing and Research Institute*

This article, which is envisaged to be the first in a series of articles on this topic, will:

- provide some general information relating to insulated (sandwich) panels and the different core materials employed in these products,
- compare and contrast the important distinction between fire resistance properties and reaction to fire properties, as they relate to insulated (sandwich) panels,
- provide some basic information on the relevant international fire testing protocols for both reaction to fire properties and fire resistance properties, and
- provide an overview on the proposed changes to the Building Code of Australia [1] and the fire related testing requirements that will form a part of showing compliance with these new proposed requirements.

*Picture showing structural damage to EPS type sandwich panels due to a fire, which spread, within the combustible cavity of the panels themselves- photo courtesy of the NSW Fire Brigade*

### *What is an Insulated (sandwich) panel?*

Insulated (sandwich) panels are single piece factory engineered units typically comprising two metal faces and a fully insulating core. The facings are fully bonded to the core so that the panel acts compositely when under load, in most cases, providing free standing and load bearing panels. Facings used for insulated panels are predominantly of steel. The core material is usually a material that provides good thermal insulation properties. The insulating core is typically bonded to the facings using a conventional adhesive bond.

### *Types of insulating core materials*

The fire properties of core materials can vary significantly according to the generic type of insulating core and the specific proprietary formulation. The following paragraphs provide guidance on the performance of the four main generic types of core material when considered the material is considered in isolation. However, it should be noted that when the core material is incorporated into a steel faced insulated (sandwich) panel system, the protection provided by the metal facings, joints, fixings and the support system may greatly modify the fire performance indicated for the core insulation materials 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. EPIC [12]

#### Rigid polyurethanes

Rigid polyurethane (PUR) materials are cellular thermosetting insulation materials that form a char when subject to heat and flame impingement. The char acts as an insulator that 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 have shown that

*Fires in building made form insulated (sandwich) panels have caused huge losses which have been born by the insurance industry and have resulted in additional protection requirements imposed by insurance on building owners, above and beyond the Building Code of Australia*

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) insulation materials 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. Accordingly some steel faced PIR cored panel systems will give a fire resistance for both integrity and insulation (AS1530 Part 4[2]) as well as satisfying the large scale reaction to fire requirements of the Factory Mutual, FMRC 4880[3] for example.

**Mineral fibre**

Mineral fibre insulating core materials are created by bonding mineral fibres together using organic binders. In isolation the fibre performance to AS1530 Part 1[4] may be non-combustible or of limited combustibility. When incorporated within insulated panels the mineral fibre core does include some potentially combustible elements, mainly the organic binders within the insulating core material and the organic adhesives used to bond the metal faces to the core material. Most mineral fibre panels will therefore not be rated non-combustible or of limited combustibility as a total system. 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. Accordingly most steel faced mineral fibre cored panel systems will give a fire resistance for both integrity and insulation (AS1530 Part 4[2]) as well as satisfying the large scale reaction to fire requirements of the Factory Mutual, FMRC 4880[3] for example.

**Phenolic foams**

Phenolic foams contain a polymeric structure that 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.

Accordingly most steel faced Phenolic foam cored panel systems will give a fire resistance for both integrity and insulation (AS1530 Part 4[2]) as well as satisfying the large scale reaction to fire requirements of the Factory Mutual, FMRC 4880[3] for example.

Despite their good fire properties, many Phenolic core materials have difficulties in achieving the additional mechanical resistance, (impact strength) requirements typical for external envelope panels.

**Expanded polystyrene**

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. Both fire resistance and reaction to fire tests in accordance with AS1530 Part 4[1] and ISO9705 [5] 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. 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.

## *Why are Insulated (sandwich) panels used?*

Insulated (sandwich) panels are used extensively for the external roof and wall cladding of buildings in most construction sectors. They are selected for their thermal and energy saving properties and their construction and installation cost saving benefits.

## *What are the trends relating to the use of Insulated (sandwich) panels?*

With the well publicized issues relating to so called "Green House" gas emissions and the fact that we are depleting our ozone layer, new thermal transmission and air tightness regulations for external roof and walls systems in commercial buildings will be inevitable here in Australia, following the lead of other developed countries. We have already seen some local regulatory changes affecting our residential building stock. These issues will see a significant increase in the use of insulated (sandwich) panels.

## *What are the fire related regulatory / fire testing issues?*

**The difference between "reaction to fire" and fire resistance" testing**

National Regulations typically have specific requirements relating to wall and ceiling linings and/or insulated (sandwich) panels, for both "reaction to fire" properties and

"fire resistance" properties. For both properties, fire-testing standards are typically referenced from which ratings of products can be determined and used to show compliance against nationally accepted thresholds.

The following sub sections should help explain what the subtle but important difference is between "reaction to fire" and "fire resistance" properties.

**Reaction to fire properties and contribution to "fire load"**

Wall and ceiling (roof) lining materials, such as insulated (sandwich) panels, of course depending on the materials and/or installation characteristics, can add significantly to so call "fire load" within the enclosure they are bounding. An increase in "fire load" means that the *products themselves will assist in propagating the spread of fire and smoke in many fire scenarios.* This fact is recognised in most National Building Regulations, where there is some attempt to control the types and quantities of materials used and to limit the impact on flame and smoke spread in the advent of a fire.

Complying materials, according to National Regulations have typically been required to undergo a small-scale *reaction to fire test*, and to achieve ratings under pre-determined thresholds for fire and/or smoke spread, according to the circumstances of their use.

Real fires and reputable international research has questioned the validity of using small-scale reaction to fire tests to accurately determine the suitability of a product for use as a wall and ceiling lining, and the international trend, in many ways fast tracked by the insurance industry's own initiatives, is to move towards more expensive, but more definitive, full-scale reaction to fire tests.

**Fire resistance properties**

Insulated (sandwich) panel systems, may be used as fire resistant barriers as required under National Building Regulations. In this specific scenario, in addition to the reaction to fire property requirements, the wall or roof / floor / ceiling system must in fact be capable of being an effective barrier against the spread of a fire between respective fire compartments or fire cells.

Complying materials according to National Regulations are required to undergo a fire resistance test, and to achieve rating or grading periods, usually in hours or minutes for structural adequacy (load bearing capabilities under fire), integrity (ability to retard the passage of hot flames and gases), and insulation (ability to limit the temperature rise from the exposed face / fire side, to the non-exposed / non-fire side).

## *Australian National Requirements*

The technical provision relating to Building Control have been consolidated Nationally in Australia under the Building Code of Australia [1], BCA, which has been in all States & Territories through their respective Building Control related legislation. The Australian Building Codes Board, ABCB, currently maintains the BCA.

**Australian Reaction to fire requirements**

The reaction to fire requirements for wall and ceiling lining materials, are currently the subject of proposed change. The Regulatory proposal (Regulation Document) and Regulatory Assessment (Draft Regulatory Impact Statement) are currently open for public comment, (refer to ABCB web site at www.abcb.gov.au).

In Australia, under the current requirements of our Building Code of Australia, the Spread-of-Flame, Smoke-Developed and Flammability Indices of a material are determined by testing the material in accordance with the small-scale reaction to fire test, Australian Standard/New Zealand Standard (AS/NZS) 1530.3[6] - "Simultaneous determination of ignitability, flame propagation, heat release and smoke release". This small-scale reaction to fire test standard sets out a test method for the assessment of materials and components according to their tendency to ignite and propagate flame, the heat they release once ignition has occurred, and their tendency to release smoke.

The proposal is to change the reaction to fire testing requirements to a full-scale test,

ISO 9705, Full-scale room test for surface products, from the existing small- scale reaction to fire test, Australian Standard/New Zealand Standard (AS/NZS) 1530.3[6].

The ISO 9705[5] full-scale test method may not in fact be the best test method for testing of insulating (sandwich) panels, as the test does not allow cater fully for the mechanical behaviour of the panels, such as the important influence on performance by way of the proprietary and relatively complex panel to panel joint systems, and the proprietary mechanical fastening of the panels. A relatively new ISO test method has been developed, ISO 13784 Part 1[7], which is a so called "free-standing set up", based on the basic principles of ISO 9705[5], but catering for the exacting requirements of testing insulted (sandwich) panels. This test method was developed after some pioneering work conducted by Patrik Johansson and Patrick Van Hees of SP Swedish National Testing and Research Institute [8].

**ISO 9705 - Reaction to fire testing standard**

The ISO9705 [5], Full-scale room test for surface products, test consists of a non-combustible test room of given dimensions, with an open doorway. This room is lined with the product under test, by fixing the product onto the non-combustible walls. A fire, of known size is ignited in one corner and the corresponding heat release and smoke production rates are measured. The schematic of the reaction to fire test configuration is shown as Figure 1 and actual photos of products under test are shown in Figures 2 to 9.

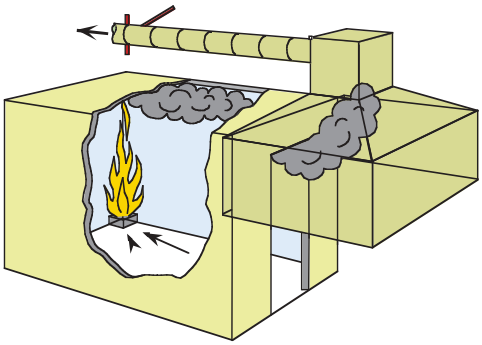

*Figure 1 – Schematic drawing of the room corner set-up according to ISO 9705 – schematic courtesy of SP Swedish National Testing and Research Institute*


*Figure 2 – Room corner test before Flashover – photo courtesy of Factory Mutual*


*Figure 3 - Room corner test conducted after Flashover – photo courtesy of Factory Mutual*

*Figures 4, 5, 6, 7, 8 & 9 - Typical progressive fire development under ISO13784 Part 1 testing showing contribution of insulated (sandwich) panels to fire – photos are at 1,3,5, 7, 9 & 11 minutes respectively – photos courtesy of SP Swedish National Testing and Research Institute*

*Figure 10 – AS 1530 Part 4 fire resistance test on two single leaf prototype door constructions*

**Australian Fire resistance requirements**

In Australia, fire resistant barriers, depending on the Classification (Occupancy Type) and Type of Construction (Rise in Storeys), are required to have particular Fire Resistance Levels, FRL's. These FRL's are determined by subjecting a prototype assembly to the standard fire resistance test, AS1530 Part 4[2], *Fire-resistance tests of elements of building construction.*

**AS1530 Part 4 - Fire resistance fire testing standard**

AS1530 Part 4[2], Fire-resistance tests of elements of building construction, is a full-scale test method that typically consists of a fire resistance furnace upon which elements of building construction are mounted and subjected to a standard time versus temperature heating regime. Key measurements and observations are recorded, the result of which are used to determine a Fire Resistance Level, FRL, in accordance with the Building Code of Australia requirements.

## *Insurance requirements versus National Regulatory requirements*

In more recent times, insurance companies have made their position relating to the insurance of facilities manufactured using insulated (sandwich) panels, particularly those made of combustible core materials, quite clear; that is, these facilities are a higher risk and will attract higher premium unless compliance with the insurance industries own standards are met.

The "defacto" insurance company standard is to have full compliance with Factory Mutual, FM internal approval standard, FM 4880[3]. This internal linings standard, amongst other things is applicable to FM so called Class 1, insulated wall or wall and roof/ceiling panels.

These FM "defacto" insurance requirements exceed most National Regulatory requirements, as they are concerned about both life safety and protection of property / protection against business interruption, whilst the National Regulatory requirements, which are meant to reflect the respective National community / societal minimum acceptable levels of safety, which in the main only cater for life safety; that is protection of people, with little or no regard for protection of property or protection against business interruption. In terms of National Building Regulations, the latter are an issue for the building owner to deal with outside of the National Building Regulations.

The problem for a building owner and his designer, and to a large degree the general insurance industry is, that there are very few published National technical guides or National standards that deal specifically with the protection of property and/or the protection against business interruption.

## *Design Guide for the fire protection of buildings themselves*

In the United Kingdom, there is a Code of Practice for the Protection of Business [9], which was published in 2000 by the Fire Protection Association (UK). The Code was developed by the Loss Prevention Council's Building Protection Steering Group, BPSG, whose membership included both Insurers and Industry.

In Australia, the Passive Fire & Smoke Containment "Alliance"[10] is taking a leading role in the formation of an Australian Building Protection Steering Group, to promulgate its own National Code of Practice for the protection of property and the protection against business interruption. This Code will compliment the Building Code of Australia

and it is envisaged that key stakeholders in the Australian Building industry such as the Insurance Council of Australia, Property Council of Australia, Fire Protection Association Australia, Federation of Wall & Ceiling Industries Group, Society of Fire Safety, Australian Institute of Building Surveyors, Australasian Fire Authorities Council and others will embrace this initiative and work together to produce a document of this nature.

## Additional information

Published material in this area is difficult to find but searching the internet and contacting relevant international trade associations who are involved in this area are good places to start. Apart from the local Passive Fire & Smoke Containment Alliance [10] who are starting to provide some information in this area locally in Australia there is very few local and readily available reference sources in this area; hence the writing of this article. The author has found the following international organisations that may be of interest to the reader:

- EPIC [11] – Engineered panels in construction
- API [13] – Alliance for polyurethanes industry
- PIMA [14] - Polyidocyanurate Insulation Manufacturers Association, PIMA

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## References

[1] Building Code of Australia published by CCH Australia Limited on behalf of the Australian Building Codes Board, ABCB.

[2] AS1530 Methods of Test on building material, components and structures, Part 4 – 1997, Fire-resistance tests on elements of building construction, Standard Australia

[3] Factory Mutual Approval Standard, Class Number 4880, Class 1 Insulated Wall or Wall & Roof / Ceiling Panels, Plastic interior Finish Materials, Plastic Exterior Building Panels, Wall/ Ceiling Coating Systems, Interior of Exterior Finish Systems, August 1994, Factory Mutual Research Corporation

[4] AS1530 Methods of Test on building material, components and structures, Part 1- 1994, Combustibility test for materials, Standard Australia

[5] ISO9705 – Fire tests – Full-scale room test for surface products, First Edition, 1993, International Standards Organisation

[6] AS1530 Methods of Test on building material, components and structures, Part 3- 1999, Simultaneous determination of ignitability, flame propagation, heat release and smoke release, Standard Australia

[7] ISO 13784 - Reaction-to-fire tests for sandwich panel building systems — Part 1: Test method for small rooms, First Edition, 2002, International Standards Organisation

[8] Johansson, P & Van Hees P, Development of a test procedure for sandwich panels using ISO9705 philosophy, Nordest Project nr 1432-99, SP Swedish National Testing &Research Institute / SP Fire Technology, SP Report 2000:26.

[9] The Design Guide for the Fire Protection of Buildings –2000; A Code of Practice for the Protection of Buildings, December 1999, Fire Protection Association United Kingdom. Based on Loss Prevention Council loose-leaf format, 1996.

[10] Passive Fire & Smoke Containment Alliance, visit www.pfpa.com.au or contact

J-RAK Consulting at john@rakman.com.au

[11] Engineered Panels in Construction, EPIC, Surrey, UK, www.epic.uk.com

[12] Insulated panels for external roof and wall cladding – A guide to fire safety, specification and installation, Engineered Panels in Construction, EPIC, Surrey, UK, www.epic.uk.com

[13] Alliance for the Polyurethanes Industry, API, A Business Unit of the American Plastics Council, Virginia, USA, visit www.plastics.org

[14] Polyidocyanurate Insulation Manufacturers Association, PIMA, Virginia, USA, visit www.pima.org

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