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Review of HSE Building Ignition Criteria

HSL/2006/33

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Science Group: **Fire and Explosion**

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EXECUTIVE SUMMARY

Objectives

The aims of this work were to:

1. Investigate the origins of the current building ignition criteria and assess its suitability with regard to treatments and preservatives.
2. Identify materials being used as exterior construction elements that might be exposed to radiation from neighbouring fires.
3. Investigate the ignition properties of the new building materials identified.
4. Recommend an exemplar building material that is characteristic of most combustible sidings.

Main Findings

The Building Regulation guidance criterion of 12.6 kWm^{-2} accurately represents the piloted ignition threshold of soft wood for continuous radiant exposures of 10-20 minutes. While specific cases have been shown to ignite under lower fluxes, they are not characteristic of real fire spread scenarios. Fireballs, BLEVEs and other transitory events do not establish a heat-transfer equilibrium and need to be assessed separately.

A single exemplar material cannot be recommended because of the wide variance in the nature of building exterior materials. Test data have been identified for a number of plastics and façade materials as pure materials but no data have been found for building products tested in situ. Plastic sidings are polymerisation products that may retain some unreacted monomer, which can easily be released under low energy fluxes. On the basis of current data, mostly tested by Thomson and Drysdale, a critical ignition heat flux of 10 kWm^{-2} is recommended for plastic and composite skinned building materials.

1 INTRODUCTION

When siting and assessing fuel, chemical storage and processing plants it is important to mitigate any possible thermal incident. To assess the potential hazard the site assessment should consider, not only the characteristics of possible fires, but also the effect these will have on nearby structures.

Thermal radiation incident upon an object will cause three effects; a fraction will be reflected, a fraction will pass through the object (if transparent) and the remainder will be absorbed and cause a temperature rise. The size of this rise will depend on a number of factors including the intensities and wavelengths of the radiation, the absorption of the material at those wavelengths, the thermal conductivity, thermal capacity and density of the material.

To evaluate the risk to nearby structures and populations the susceptibility of building materials to radiation must be assessed. The building regulations use experimental data from American whitewood as an exemplar material to characterise all combustible material. The basis for this choice is reviewed and new alternate building materials are assessed against this exemplar.

2 SURVEY OF MATERIALS

A survey of commonly used building materials has split industry into sectors in which they will be most frequently encountered.

2.1 MATERIALS FOR RESIDENTIAL PREMISES

2.1.1 Masonry

The principle building materials for houses remain clay bricks. Concrete and natural stone rendering is also frequently found.

2.1.2 Wood cladding

The proportion of exterior wall covered by combustible material (thickness >1 mm) is limited by The Building Regulations 2000 - Approved Document B (ADB) to ensure that, if the wall were on fire, the radiant heat flux incident on a neighbouring building, would be less than 12.6 kWm^{-2}.

2.1.3 Glass/windows

There is a trend towards larger windows in modern buildings. This provides more light but will also increase the exposure of room contents to any external incident thermal radiance.

2.1.4 PVC guttering / windows

Most modern buildings use plastic moulded guttering and may use plastic windows or windowsills in place of glass and wood. If easily ignited these fittings have the potential to act as a pilot and spread flames over the surface. However, plastic guttering, windows and doors are manufactured from unplasticised or rigid polyvinyl chloride that is naturally fire retardant. PVC may also be used for external furnishings such as oil heater tanks and refuse bins.

2.1.5 Paint / Preservative coatings

Coatings are applied to exterior surfaces for decoration and weatherproofing. The chemical compositions vary but most paints are composed of an organic resin that binds the pigment to the surface to provide protection and a titanium dioxide-based pigment that has the effect of scattering light and making the paint opaque.

2.1.6 Asphalt roofing

Bitumen (also known as asphalt or tar) is a viscous liquid generated by distillation of crude oil. It is principally used as asphalt concrete for pavements and as a waterproof roofing material. The chemical structure is composed of large polycyclic asphaltene droplets suspended in maltene, a less viscous liquid. This condenses onto a mineral substrate to create a waterproof layer. These are used as tiles or outer layers on roofs over layers of felt (thick paperboard coated in bitumen). For the purpose of this report, asphalt has been defined as a bitumen coating over a roofing material. It is believed that asphalt concrete will not support combustion.

2.2 MATERIALS FOR CARAVANS AND MOBILE HOMES

Because mobile homes are not expected to have the same lifetime as permanent homes, the materials used are generally lighter and less structurally sound. This might include fibreboard or plywood with plastic skins or painted coats, many larger caravans use an aluminium skin.

2.3 MATERIALS FOR LIGHT INDUSTRY / WAREHOUSING / OFFICES

2.3.1 Steel cladding

Steel cladding is still commonly used for inexpensive warehouses. It is prepared pre-packed and is easily and quickly assembled on site.

2.3.2 Profiled steel cladding

Profiled steel is a steel sheet layered with a plastic coating, approximately 0.3 mm thick, for decoration and protection. The plastic may be polyester but is more typically PVC ($-CH_2CCl_2-$) or PVDF ($-CH_2CF_2-$) derivatives. It provides the same advantages as steel cladding, but is more decorative and resistant to weathering. This might form part of a pre-built sandwich panel.

2.3.3 Polymethyl methacrylate (PMMA)

PMMA is a transparent plastic used to replace glass where weight or impact resistance are important. It is more commonly called Perspex or Plexiglas and is manufactured in two forms. Cast PMMA has superior physical properties and is thermoplastic while extruded PMMA is cheaper and will burn and melt more readily. Cast PMMA is more commonly used on exterior surfaces as it has a higher resistance to UV light.

2.3.4 Polycarbonate

Polycarbonate is also used as an alternative to glass in windows and skylights. It is more expensive than PMMA but tougher and can be used for vandal proof windows.

2.3.5 Fibre Reinforced Plastics (FRP)

Although still relatively expensive, FRP is becoming more common in building due to its flexibility and high strength to weight ratios. Carbon fibre-reinforced plastic is used to reinforce older structures as an equal weight is stronger than steel, but glass is most commonly used as the matrix (GRP). The fire properties vary widely depending on the nature of the matrix and resin components.

3 EXPERIMENTAL TECHNIQUES

A gas ignition temperature is measured as the lowest temperature at which sustainable combustion takes place. If it is measured as spontaneous ignition it is termed the auto ignition temperature.

In liquids this is the surface temperature at which there is sufficient vapour pressure for gaseous combustion to initiate and cause evaporation such as to maintain or increase the vapour pressure and continue combustion. The flash point is the lowest temperature at which a flammable atmosphere has formed but combustion cannot evaporate enough fuel to continue burning.

Solids cannot be characterised as easily because of low thermal conductivity and no mass transfer. The point of ignition can be measured as a surface temperature, a mass flux (pyrolysis) or a heat flux (radiation). The experimentally measured, lowest thermal intensity capable of ignition is the minimum heat flux and the lowest thermal intensity theoretically possible is the critical heat flux.

Measurements on solids have been carried out by a variety of methods. The most common is the cone calorimeter, which exposes a small sample of test material, between 5 and 200 cm^2, to heat from a cone shaped electric radiator either in the vertical or horizontal orientation. Other sources of radiation include gas flame furnaces, carbon arcs and tungsten lamps. Of these the radiant flame furnace best characterises the wavelength profile of a flame. The standards ASTM E 1354-92, ASTM E 1474-92, ANSI/NFPA 264A and ISO 5600 are all modified versions of the cone calorimeter test.

4 EXPERIMENTAL DATA

4.1 MATERIALS FOR RESIDENTIAL PREMISES

4.1.1 Masonry

Clay, concrete and stone are non-combustible and will not ignite under any heat flux. However concrete will lose load-bearing strength both during and after exposure to high temperatures. Silicious aggregates in the concrete may also cause spalling.

Solid clay bricks are still stable and inert after six hours exposure to temperatures of 750 ºC, although perforated bricks do not perform as well.[1]

4.1.2 Wood cladding

It has been found by thorough investigation that ignition in wood depends on a range of factors. Because wood is not an inert material, there is competition between different thermal degradation pathways. Under long periods of very low heat fluxes, self-heating will occur. However, ignition models are based on wood bursting into flaming ignition at a critical surface temperature of approximately 350 ºC. Based on ignition times from heat fluxes greater than 15 kWm^{-2}, the theoretical critical heat flux intensities to ignite wood in an infinite period have been calculated by Toal et el in the region of 6.4 - 13.7 kWm^{-2}. The lowest recorded heat flux leading to ignition is 4.3 kWm^{-2} by Shraub and Bender although most fire scenarios limit the time of exposure to 20 minutes which results in much higher minimum heat fluxes.[2, 3]

4.1.2.1 Airflow

The results from experiments using a radiant panel or a carbon arc do not agree with those using a tungsten lamp. This is because the tungsten lamp does not induce a convective flow and so measurements are taken in still air. An imposed external draught generates turbulent flow near the sample surface and encourages mixing of volatiles with air. This turbulence results in the formation a flammable atmosphere closer to the sample surface where volatiles are still hot. The experiments conducted with a convective flow are more likely to represent realistic scenarios.[4]

4.1.2.2 Moisture

As expected, the time to ignition increases with moisture content. Water absorbs heat from the hottest areas of the sample and delays ignition and transfers this to cooler regions by condensation thereby completely changing the thermal character of the sample. Clearly, oven-dried wood represents the worst-case scenario and Simms and Law found that by increasing the moisture content to 60 %, the minimum heat flux for piloted ignition doubled. Applying these findings to building separation found that wood ignition at 16.75 kWm^{-2} took five minutes, which rose to ten minutes at 10% moisture content. The experimental data on wood with known moisture contents are shown in Figure 4.1 as time to ignition plotted against the incident heat flux. The line labelled ignition criteria is the relationship suggested by Lawson & Simms for a critical heat flux of 12.6 kWm^{-2}, below which, ignition is not thought to occur within the

20-minute timeframe. This is derived from experiments of oven-dried wood where realistic scenarios will be of the order of 10 % moisture by weight and is calculated from data taken for piloted ignition because, in a realistic scenario, ignition from burning brands cannot be discounted. The value of 12.6 kWm^{-2} is thought to be conservative to introduce a margin of safety into building planning.[5]

4.1.2.3 Species, Density & Thickness

Different types of wood have different thermal properties with denser grains requiring more energy to heat. Thickness is also significant because thinner samples cannot conduct heat away from the exposed face; therefore it requires less energy to raise their temperature. At a low heat flux this results in a longer time to ignition. Above 120 kWm^{-2} the times to ignition converge because thicker samples do not have the time to conduct heat away from the exposed face. Beyond 2 cm, increasing thickness has no further effect. The experimental data from Wesson has not been included in the comparison of minimum heat fluxes because Wesson used a tungsten lamp as a radiation source, which did not produce the wavelengths characteristic of flame radiation.[6]

Lawson and Simms also investigated different species of wood with the intention of determining the critical heat flux for each species. They concluded that the thermal constants of the different species had no effect on the critical heat flux as the system had sufficient time to reach a heat-transfer equilibrium. The only differences occurred from losses by radiation, because different species had different emissivities. They concluded that the critical heat flux of wood was 14.7 kWm^{-2} and 15.1 kWm^{-2} for cedar or whitewood and oak, iroko or freijo respectively although this was later reported as being 20 % too low. After further testing Simms concluded that the mean value for critical intensity of piloted ignition of unprotected dry wood was 12.6 kWm^{-2}. McGuire subsequently suggested the same value be used to limit fire-spread between buildings. This value has been plotted as the ignition criteria in Figure 4.1.[7, 8, 9, 10]

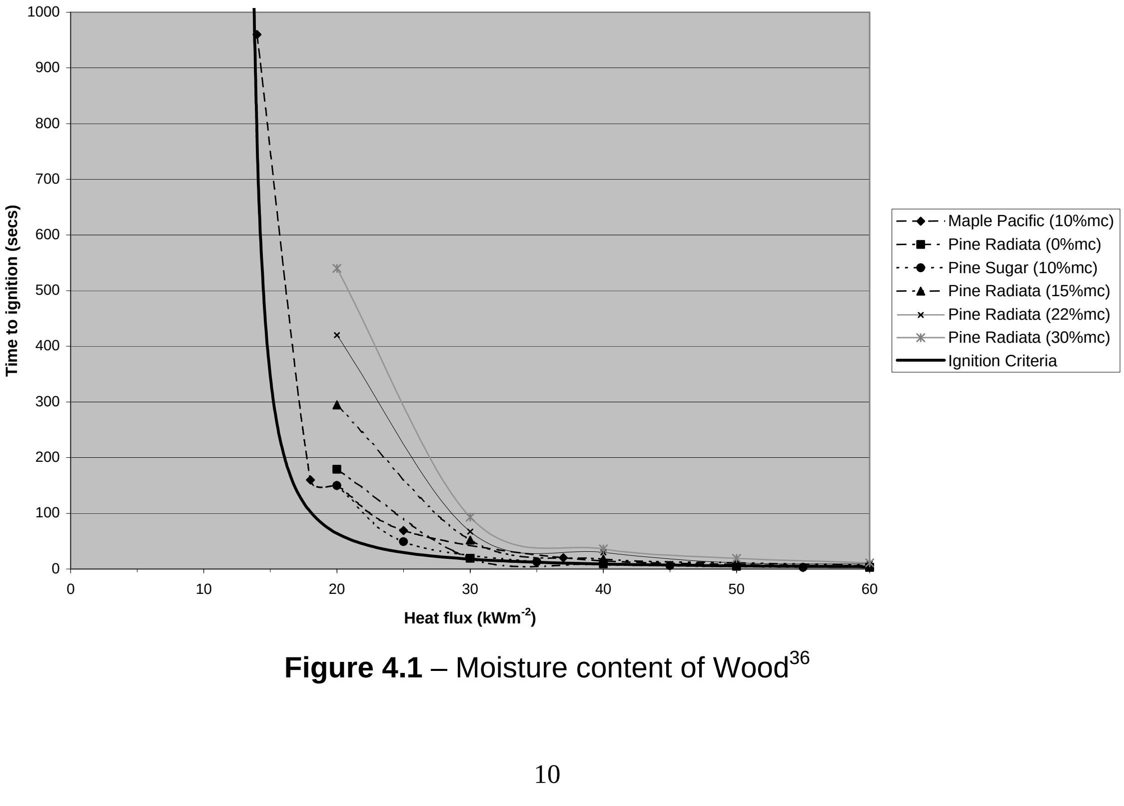

Figure 4.1 – Moisture content of Wood[36]

4.1.2.4 Grain

The surface properties of wood change depending on the orientation of the grain. Most ignition studies consider wood with the grain running parallel to the surface. However, Spearpoint compared these results with end grain ignition. At high heat fluxes, the time to ignition of end grain specimens was of the order of twice the side (parallel) grain specimens, however, at low heat fluxes this trend was reversed. Spearpoint found the minimum heat flux for end grain maple was 8 kWm^{-2} and estimates the critical heat intensity to be 7.5 kWm^{-2}.[11]

The maximum safe heat flux that cannot ignite a combustible exterior lining is quoted in ADB as 12.6 kWm^{-2}. This is taken from Building Research Establishment data. This figure was calculated for oven-dried specimens exposed for an infinite period. In a realistic scenario the moisture content will be higher and the time of exposure will be shorter, creating a margin of safety in the predictions. As a comparison, Swedish Building Regulations use a higher critical value of 15 kWm^{-2}.[12, 13, 14]

4.1.3 Glass/windows

There are many types of glazing for different uses. Glass is non-combustible and will not ignite, but thermal stress will cause the glass to crack or shatter and allow hot air to enter the enclosure with potential ignition of furnishings. Full-scale tests indicate that tempered glass can withstand a heat flux of 12.5 kWm^{-2} but will fail in 23 minutes when exposed to a heat flux of 25 kWm^{-2}.[15]

Normal glass has been found to crack at heat fluxes as low as 5 kWm^{-2} but not to fall out and expose the interior of the room unless much higher heat fluxes were used, ~ 35 kWm^{-2}. Double-glazing performed marginally better. However, the response of glazing depends on the type of glass and the residual stress in the mounting. No safe heat flux can be given with any confidence.[16, 17, 18]

The transmissive properties of glass vary depending on the characteristics of the specimen being tested but 3 mm thick, normal glass is assumed to transmit 80 % of radiant heat. The ignition susceptibility of furnishing foam assemblies has been measured between 5 and 15 kWm^{-2} depending on materials tested.[19, 20, 27]

4.1.4 PVC guttering / windows

No critical heat flux for unplasticised PVC has been identified in the literature though Masařík has summarised a series of round robin tests to identify a piloted ignition temperature of 441 ºC. In comparison the piloted flaming ignition temperature for wood is assessed by Janssens as 300 ºC and 350 ºC for hard- and soft-woods respectively. Silcock and Shield have found that PVC will ignite faster than the Lawson and Simms model predicts. Some experimental data for PVC is presented in Figure 4.5.[21, 22, 43]

4.1.5 Paint / Preservative coatings

Little experimental data are available on the effect of coatings on ignitibility. The ignition properties of a sample are dependent on the nature of both the surface and substrate and it is difficult to predict the response of a coated wall in a thermal event. British Standards classify surfaces according to their propensity to support surface flame spread. The classes range from 0 for a non-combustible surface through to Class 4. Some paints have been tested to British Standards on the surface spread of flame and comply with class 0, providing no more than three coats are applied. Experiments conducted by Moysey & Muir found that while coatings influenced the time to ignition, the results fell within the variance between new and seasoned wood. They concluded that the paint blistered and pealed at low heat fluxes and left the wood exposed. The exception to this was aluminium paint, which increased the minimum heat flux by approximately fifty percent.

In general non-specialised coatings burn off at low heat fluxes but do not have sufficient mass to initiate flaming combustion without volatiles from the substrate. Once the paint is removed, the ignition properties of the substrate remain unchanged. Figure 4.2 shows experimental results from Moysey and Muir. Only red oil paint behaves markedly different from the others due to different absorption characteristics. The paints were applied to samples of cedar.[23]

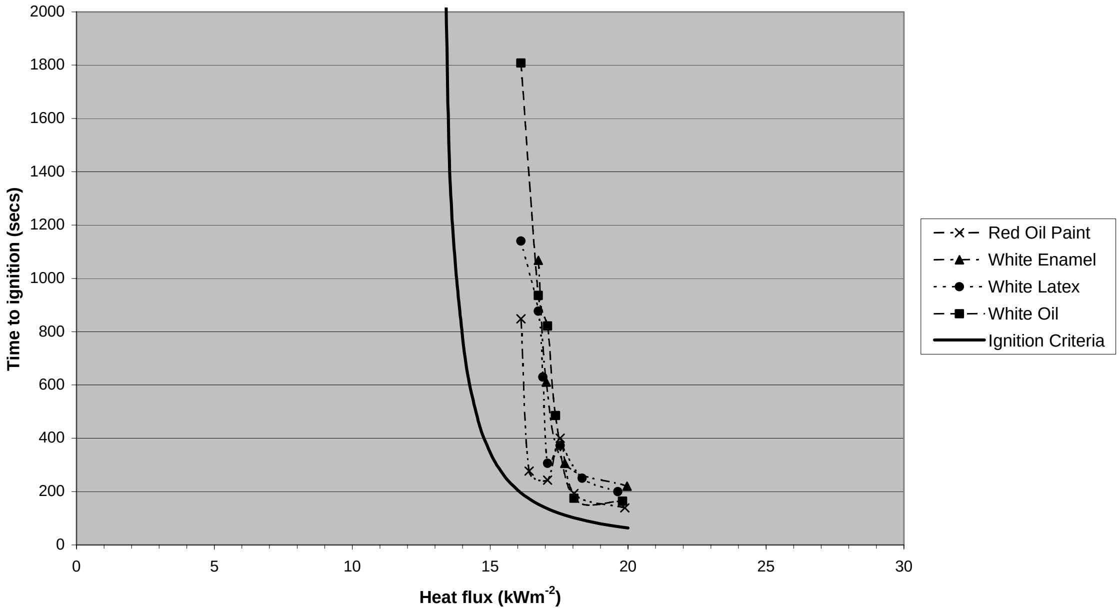

Figure 4.2 – Effect of paint type on time to ignition[23]

Staggs et al recently published a paper presenting the results from a series of tests on plywood and chipboard coated with varying thicknesses of gloss paint that supports this view. They found that coating the substrate with up to 100 gm^{-2} (1 coat) of gloss paint increased the time to ignition without changing the eventual heat release rate. Further paint layers reduced this effect. Above a paint density of approximately 200 gm^{-2} (2 coats), the samples ignited more quickly than the uncoated samples under the same radiant heat flux. This effect is more pronounced at lower heat fluxes. The time to ignition for different paint loadings under three heat fluxes is plotted in Figure 4.3.[24]

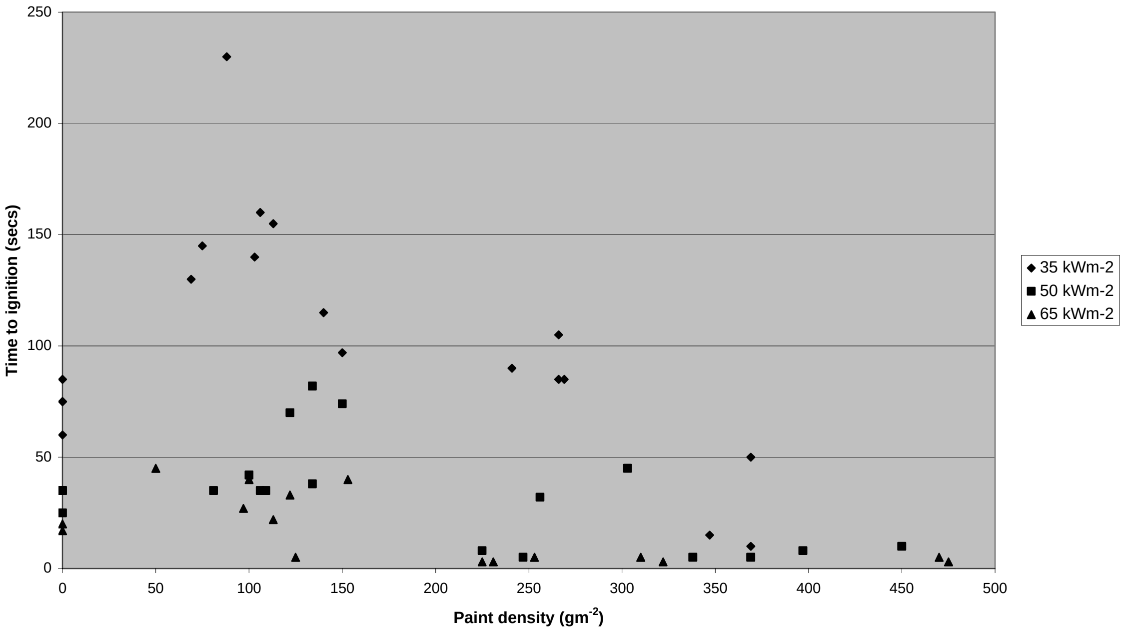

Figure 4.3 – Effect of paint density[24]

This is further supported by work performed at Warrington Fire that has investigated fire spread on multiple layers of paint in public buildings.

A minimum value for heat flux for a paint layer alone has not been identified from the literature, although Dreisbach applied paint of varying thickness to a concrete block surface and could not achieve ignition with heat fluxes less than 50 kWm^{-2} regardless of the number coats.[25]

4.1.6 Asphalt roofing

Moysey & Muir considered a range of construction materials including asphalt shingles. They found that fire behaviour differed from wood and ignition occurred slightly sooner at heat fluxes in excess of 20 kWm^{-2} and much sooner at lower heat fluxes. Asphalt roofing is mostly composed of bitumen, which is easier to thermally degrade than cellulose and so volatiles are released at lower temperatures. Furthermore, asphalt does not form a char so flames spread more easily. The lowest tested value for heat flux that was found to ignite asphalt was 12.6 kWm^{-2} as opposed to a value of 14.5 kWm^{-2} given for wood.[13, 14]

This is supported by asphalt combustion experiments conducted by Noumowe. Although the heat flux was not measured, gas analysis indicated that pyrolysis began at approximately 300 ºC. Experimental data for ignition of asphalt is compared to other cladding materials in Figure 4.5.[26]

4.2 MATERIALS FOR CARAVANS AND MOBILE HOMES

Shipp has conducted a short series of tests into the recommended separation distance between mobile homes. It was found that aluminium skinned caravans did not ignite at heat fluxes below 50 kWm^{-2} whilst a plywood-skinned park home vehicle ignited at 17 kWm^{-2} although these data are taken from only two tests involving brief intense heat fluxes.[27]

4.3 MATERIALS FOR LIGHT INDUSTRY / WAREHOUSING

4.3.1 Steel cladding

Steel loses its load-bearing strength at high temperatures due to softening. A typical value for loss of strength is 550 ºC. Therefore, when used structurally, steel is encased by an insulating material. However, because of its high density a large amount of energy is required to raise its temperature and cladding should perform relatively well when exposed to high heat fluxes.[1]

Moysey & Muir looked at the protective properties of aluminium and galvanised sheeting on cedar exposed to an external heat flux of 25 kWm^{-2}. Both had the effect of keeping the surface temperature under 150 ºC and preventing ignition. Matt painted steel was not as effective and the surface temperature approached 350 ºC after ten minutes exposure. This was a worse performance than a layer of aluminium paint.

The principle conclusion drawn from these tests is that the surface finish of the sample plays a very large part in determining the response to thermal radiation. The maximum safe heat flux for wood protected by steel cladding is 63 kWm^{-2} and 23 kWm^{-2} for galvanised and matt finishing.[13, 14]

4.3.2 Profiled steel cladding

PVC siding has been investigated by Dietenberger, who found that at heat fluxes above 55 kWm^{-2}, ignition occurred in 18 s but, at lower heat fluxes, the PVC would shrink and char before igniting. The lowest heat flux investigated was 35 kWm^{-2}, which caused ignition in 380 s.[28]

4.3.3 Polymethylmethacrylate (PMMA)

Both cast and extruded forms of PMMA are classed as readily combustible and are considered Class 3 and 4 materials in Building Regulations. This may be due to differences in degrees of polymerisation. Minimum heat fluxes for 6 mm thick, clear PMMA have been measured at 8 - 10.6 kWm^{-2}.[29, 8]

4.3.4 Polycarbonate

Both Braun et al and Quintiere et al have reported the minimum heat release rate for polycarbonate as 30 kWm^{-2} when the sample is held vertically. However, Kashiwagi et al report this dropping to 12 - 15 kWm^{-2} when the sample is held horizontally. This is still preferable to the values reported for PMMA and polycarbonate is used where exposure to high temperatures is likely. The experimental results from Thomson & Drysdale for ignition tests of different plastics are presented in Figure 4.4.[30, 31, 32]

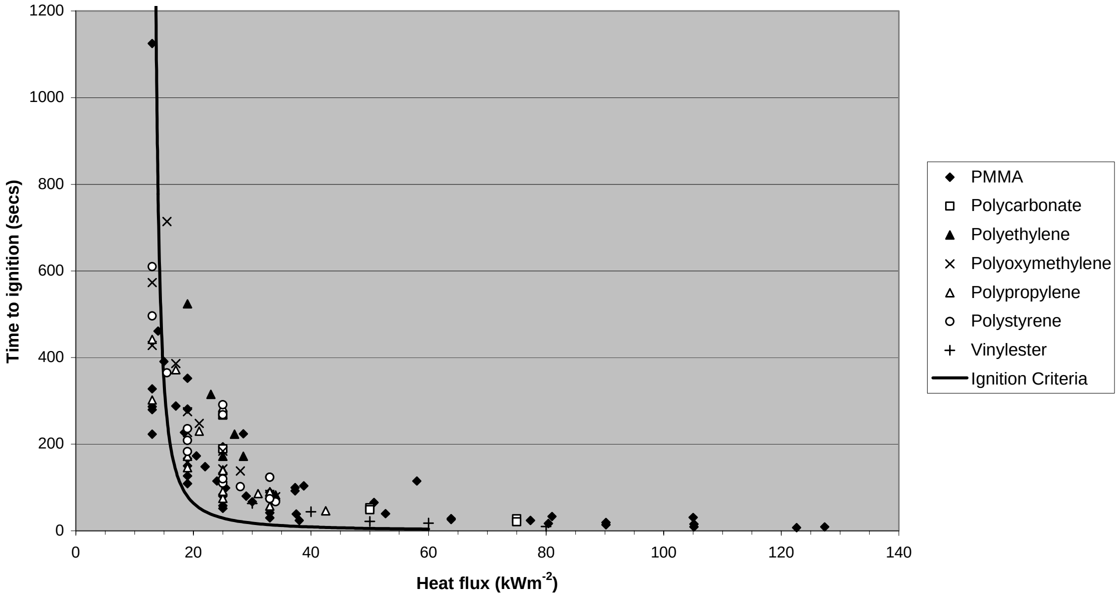

Figure 4.4 – Time to ignition of plastics [41, 42]

1. Fibre Reinforced Plastics (FRP)

For glass reinforced plastic (GRP) the ignition temperature and minimum heat flux increases as the percentage of non-combustible glass increases.

Gibson et al have investigated the fire performances of four types of glass-reinforced plastic. They found that composites with a phenolic resin performed far better than epoxy, polyester or vinyl ester composites with an ignition time 300 to 350 s longer at low heat fluxes. The experimentally determined ignition performances of several façade materials are compared in Figure 4.5. [33]

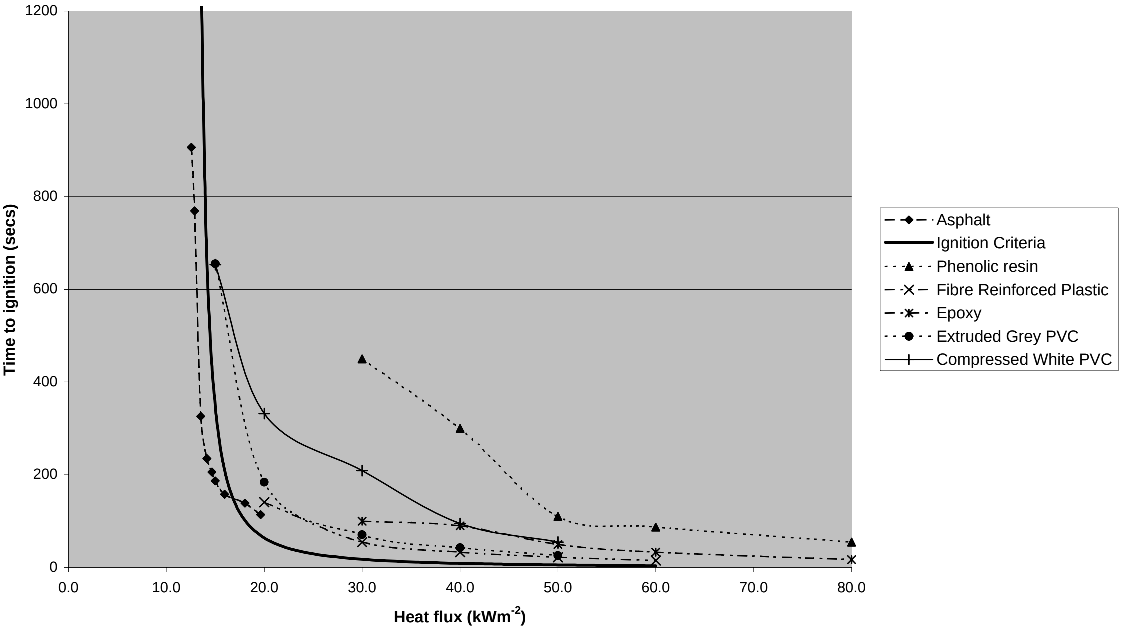

Figure 4.5 – Time to ignition of facade materials [23, 33, 42]

5 DISCUSSION

5.1 SUMMARY OF CRITERIA AND DATA

The UK Building Regulations use a minimum heat flux for ignition of combustible building materials of 12.6 kWm^{-2}, which has been obtained through experimentation of small samples of wood, heated in a cone calorimeter.

The Dutch government uses two criteria to assess damage to four characteristic materials: wood, synthetic materials, glass and steel. The two levels of criteria relate to ignition/destruction and visible damage e.g. charring, peeling.[43]

Table 5.1 – Ignition intensities of materials in Dutch Building Regulations

Material	*Critical intensity kWm^{-2}*	
	Level 1	*Level 2*
Wood	15	2
Synthetic materials	15	2
Glass	4	-
Steel	100	25

The results of the present literature search are summarised below and all data is plotted in Figure 5.1.

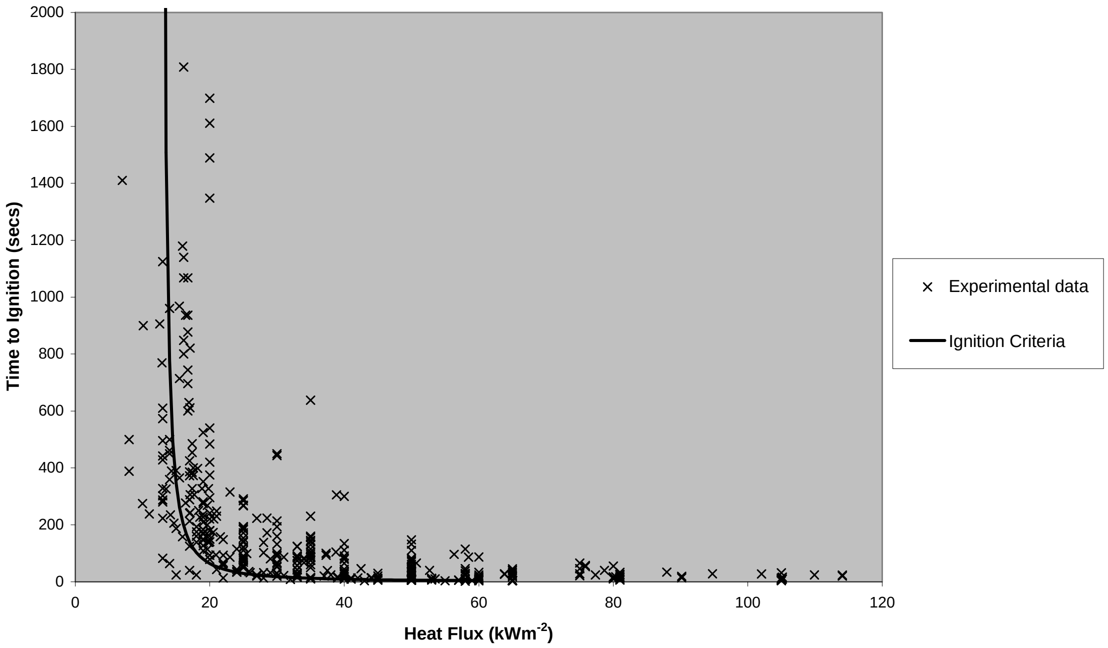

Figure 5.1 – Time to ignition plotted against heat flux

5.2 MATERIALS FOR RESIDENTIAL PREMISES

- Wood

The minimum heat flux for ignition of wood varies depending on the surface effects. Wood is not inert and it undergoes exothermic degradation at low heat fluxes, ~ 4.3 kWm^{-2} eventually beginning to self-heat and char over several hours. End grain wood has been shown to ignite at heat fluxes as low as 8 kWm^{-2}, however, most trials have found the critical ignition criteria of wood to be approximately 12-15 kWm^{-2} for a continuous irradiance.

- Glass

Glass cannot be oxidised and so will not combust but can still be damaged and destroyed by radiation. As the temperature of glass increases it expands. This creates strain between the heated glass in the visible part of the window and the unheated part of the glass protected within the housing of the window frame. Cracking of a 6 mm thick glass windowpane occurs under a flux of approximately 4-5 kWm^{-2} but the pane will remain in place, protecting the interior. Fall out of the windowpane occurs under heat fluxes of 25-40 kWm^{-2}, which includes failure of the window frame.

- PVC

Experimental data have been found that suggest some PVC materials will ignite at lower heat fluxes than wood. PVC is manufactured by polymerisation and many chemicals are added to alter the properties of the plastic. The final properties of a plastic depend on the quantity and nature of fillers, dyes, fire-retardants and UV light stabilisers.

- Coatings/Preservatives

Coatings change the surface properties of the substrate and white paint reflects more heat than coloured paint but thin layers will not produce sufficient volatiles to cause ignition of the substrate alone. The overall effect of coatings depends on the loading. Thin layers (2 layers) reflect more radiation from the substrate surface, delaying ignition. As the paint loadings increase (6 layers), the mass of volatiles increase and the ignition time is decreased. A critical heat flux of thick loadings for paint has not identified.

- Asphalt

Although asphalt may be considered as a coating, more data have been identified. Asphalt will clearly ignite below the Building Regulation guidance criteria of 12.6 kWm^{-2}. Where this material is used a new criteria needs to be identified.

5.3 MATERIALS FOR CARAVANS AND MOBILE HOMES

Only one study has been identified on combustion of mobile homes and it did not investigate ignition criteria. A plastic skinned plywood home was thought to ignite at approximately 17 kWm^{-2} while a reflective caravan performed much better. Ignition studies of bare plywood and fibreboard found they ignited at heat fluxes lower than wood, as might be expected.

Since caravans and mobile homes use lighter materials a lower ignition criteria may be needed. Unfortunately insufficient experimental data have been found to suggest a value.

5.4 MATERIALS FOR LIGHT INDUSTRY / WAREHOUSING

- Steel

If steel cladding is mounted over a wooden support the steel may conduct heat into the wood, causing ignition. The critical heat flux for steel cladding is 63 kWm^{-2} and 23 kWm^{-2} for reflective and matt finishing respectively.

- Profiled Steel

A number of façade materials have been investigated including plastics and composites. Evidence suggests that these behave differently to cellulosic materials and while ignition under high heat flux takes longer, ignition at low heat flux occurs sooner. As these are products of polymerisation reactions, a quantity of monomer and small chain polymers may be retained within the structure where they will be released under relatively low energy fluxes. As a result, these materials cannot be considered inert below a critical temperature and the ignition model does not predict the behaviour of these materials accurately.

Although PVC contains a large proportion of chlorine, experimental trials indicate that at low heat fluxes, 3 mm thick layers will ignite more quickly than wood. No data have been found for PVC coated steel. Other plastics have been shown to ignite at heat fluxes of the order of 13 kWm^{-2} within 5 to 10 minutes and no critical heat flux has been proposed although data suggests it should be of the order of 8 kWm^{-2}. Again these data represent solid plastics and are not representative of profiled steel.

6 CONCLUSION

6.1 MATERIALS FOR RESIDENTIAL PREMISES

- The Building Regulation guidance criterion of 12.6 kWm^{-2} accurately represents the ignition threshold of most soft woods. While specific cases have been shown to ignite at lower fluxes, they are not characteristic of the majority of scenarios where aid will arrive within 10-20 minutes to prevent fire-spread.

- The limiting factor of window tenability is the ignition resistance of the window frame, which may be wood or uPVC.

- Asphalt roofing and high loadings of paint/preservatives will ignite at heat fluxes of approximately 12 - 12.6 kWm^{-2}.

6.2 CARAVANS AND MOBILE HOMES

- Only one study of two tests has been identified for mobile homes.

- The nature of the building materials used suggests that a lower ignition criteria is required but further experimental tests are required in this field.

6.3 MATERIALS FOR LIGHT INDUSTRY / WAREHOUSING

- Test data have been identified for a number of plastics and façade materials as pure materials but no data have been found for building products tested in situ.

- There is a requirement for building exterior materials to have a limiting flame spread but no requirement for a critical heat flux. If there were a requirement for a limiting thermal irradiance it would ensure all manufacturers test their products and these data could be used as part of a fire engineered approach to building design. Draft standards already exist for the ignitability testing of building materials but they are not mandatory.[45]

- On the basis of current data, mostly tested by Thomson and Drysdale, a critical ignition heat flux of 10 kWm^{-2} is recommended for plastic and composite skinned building materials.

7 FURTHER WORK

A lack of information has been identified in the following areas.

- Thermal irradiance ignition testing of finished profiled steel products.
- Thermal irradiance ignition testing of finished plastic window products.
- The critical ignition heat flux of high loadings of paint/preservatives over combustible and non-combustible substrates.

8 APPENDICES

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Moysey & Muir [23]	1968	Asphalt	Shingles	Gas panel	-	12.6	906
Moysey & Muir [23]	1968	Asphalt	Shingles	Gas panel	-	12.9	769
Moysey & Muir [23]	1968	Asphalt	Shingles	Gas panel	-	13.5	326
Moysey & Muir [23]	1968	Asphalt	Shingles	Gas panel	-	14.1	235
Moysey & Muir [23]	1968	Asphalt	Shingles	Gas panel	-	14.7	206
Moysey & Muir [23]	1968	Asphalt	Shingles	Gas panel	-	15.0	187
Moysey & Muir [23]	1968	Asphalt	Shingles	Gas panel	-	15.9	158
Moysey & Muir [23]	1968	Asphalt	Shingles	Gas panel	-	18.0	139
Moysey & Muir [23]	1968	Asphalt	Shingles	Gas panel	-	19.6	114
Yang [34]	2003	Beech	-	-	-	20.0	1489
Yang [34]	2003	Beech	-	-	-	30.0	159
Yang [34]	2003	Beech	-	-	-	40.0	79
Yang [34]	2003	Beech	-	-	-	50.0	49
Hilado [35]	1998	Carpet	Acrylic	-	-	58.0	38
Hilado [35]	1998	Carpet	Acrylic	-	-	81.0	15
Hilado [35]	1998	Carpet	Acrylic	-	-	105.0	9
Hilado [35]	1998	Carpet	Nylon	-	-	58.0	29
Hilado [35]	1998	Carpet	Nylon	-	-	81.0	17
Hilado [35]	1998	Carpet	Nylon	-	-	105.0	13
Hilado [35]	1998	Carpet	Wool	-	-	58.0	26
Hilado [35]	1998	Carpet	Wool	-	-	81.0	9
Hilado [35]	1998	Carpet	Wool	-	-	105.0	6

Author	***Year***	***Material***	***Details***	***Radiant source***	***Paint Density (gm^{-2})***	***Heat flux (kWm^{-2})***	***Time to ignition (s)***
Lawson & Simms [7]	1952	Cedar	3/4 inch	Gas panel	-	17.0	125
Lawson & Simms [7]	1952	Cedar	3/4 inch	Gas panel	-	22.0	57
Lawson & Simms [7]	1952	Cedar	3/4 inch	Gas panel	-	24.0	36
Lawson & Simms [7]	1952	Cedar	3/4 inch	Gas panel	-	27.0	23
Lawson & Simms [7]	1952	Cedar	3/4 inch	Gas panel	-	28.0	13
Lawson & Simms [7]	1952	Cedar	3/4 inch	Gas panel	-	45.0	6
Lawson & Simms [7]	1952	Cedar	3/4 inch	Gas panel	-	60.0	4
Moysey & Muir [23]	1968	Cedar	Unweathered	Gas panel	-	15.5	968
Moysey & Muir [23]	1968	Cedar	Unweathered	Gas panel	-	16.1	800
Moysey & Muir [23]	1968	Cedar	Unweathered	Gas panel	-	16.7	600
Moysey & Muir [23]	1968	Cedar	Unweathered	Gas panel	-	17.4	327
Moysey & Muir [23]	1968	Cedar	Unweathered	Gas panel	-	19.0	148
Moysey & Muir [23]	1968	Cedar	Unweathered	Gas panel	-	19.8	139
Moysey & Muir [23]	1968	Cedar	Unweathered	Gas panel	-	20.9	94
Moysey & Muir [23]	1968	Cedar	Weathered	Gas panel	-	16.1	1068
Moysey & Muir [23]	1968	Cedar	Weathered	Gas panel	-	16.4	936
Moysey & Muir [23]	1968	Cedar	Weathered	Gas panel	-	16.7	744
Moysey & Muir [23]	1968	Cedar	Weathered	Gas panel	-	17.4	454
Moysey & Muir [23]	1968	Cedar	Weathered	Gas panel	-	18.2	398
Moysey & Muir [23]	1968	Cedar	Weathered	Gas panel	-	19.8	327
Yang [34]	2003	Cherry	-	-	-	20.0	1611
Yang [34]	2003	Cherry	-	-	-	30.0	193
Yang [34]	2003	Cherry	-	-	-	40.0	83
Yang [34]	2003	Cherry	-	-	-	50.0	49
Hilado [35]	1998	Clothing	Cotton	-	-	58.0	10

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Hilado [35]	1998	Clothing	Cotton	-	-	81.0	6
Hilado [35]	1998	Clothing	Cotton	-	-	105.0	3
Hilado [35]	1998	Clothing	Nylon	-	-	58.0	22
Hilado [35]	1998	Clothing	Nylon	-	-	81.0	26
Hilado [35]	1998	Clothing	Nylon	-	-	105.0	7
Moysey & Muir [23]	1968	Douglas Fir	-	Gas panel	-	15.9	1179
Moysey & Muir [23]	1968	Douglas Fir	-	Gas panel	-	16.7	696
Moysey & Muir [23]	1968	Douglas Fir	-	Gas panel	-	17.4	385
Moysey & Muir [23]	1968	Douglas Fir	-	Gas panel	-	18.8	327
Moysey & Muir [23]	1968	Douglas Fir	-	Gas panel	-	19.6	268
Moysey & Muir [23]	1968	Douglas Fir	-	Gas panel	-	20.6	220
Moysey & Muir [23]	1968	Douglas Fir	-	Gas panel	-	21.6	158
Hilado [35]	1998	Douglas Fir	3/4 inch	-	-	58.0	46
Hilado [35]	1998	Douglas Fir	3/4 inch	-	-	81.0	23
Hilado [35]	1998	Douglas Fir	3/4 inch	-	-	105.0	11
Gibson [33]	1995	Epoxy	-	Electrical heater	-	30.0	100
Gibson [33]	1995	Epoxy	-	Electrical heater	-	40.0	90
Gibson [33]	1995	Epoxy	-	Electrical heater	-	50.0	50
Gibson [33]	1995	Epoxy	-	Electrical heater	-	60.0	33
Gibson [33]	1995	Epoxy	-	Electrical heater	-	80.0	17

Author	***Year***	***Material***	***Details***	***Radiant source***	***Paint Density (gm^{-2})***	***Heat flux (kWm^{-2})***	***Time to ignition (s)***
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	5.2	1410
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	7.0	500
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	8.0	388
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	8.0	275
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	10.0	238
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	11.0	116
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	13.0	82
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	14.0	64
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	17.0	40
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	18.0	24
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	22.0	13
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	32.0	8
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	43.0	3
Lawson & Simms [7]	1952	Fibre insulation board	1/2 inch	Gas panel	-	58.0	2
Lawson & Simms [7]	1952	Freijo	3/4 inch	Gas panel	-	20.7	425
Lawson & Simms [7]	1952	Freijo	3/4 inch	Gas panel	-	26.4	67
Lawson & Simms [7]	1952	Freijo	3/4 inch	Gas panel	-	28.8	43
Lawson & Simms [7]	1952	Freijo	3/4 inch	Gas panel	-	33.6	32
Lawson & Simms [7]	1952	Freijo	3/4 inch	Gas panel	-	39.6	23
Lawson & Simms [7]	1952	Freijo	3/4 inch	Gas panel	-	46.8	13
Lawson & Simms [7]	1952	Freijo	3/4 inch	Gas panel	-	54.0	12
Lawson & Simms [7]	1952	Freijo	3/4 inch	Gas panel	-	68.4	5
Luzik [42]	1988	FRP	-	Tungsten Lamp	-	20.0	141
Luzik [42]	1988	FRP	-	Tungsten Lamp	-	30.0	55
Luzik [42]	1988	FRP	-	Tungsten Lamp	-	40.0	33

Author	***Year***	***Material***	***Details***	***Radiant source***	***Paint Density (gm^{-2})***	***Heat flux (kWm^{-2})***	***Time to ignition (s)***
Luzik [42]	1988	FRP	-	Tungsten Lamp	-	50.0	22
Luzik [42]	1988	FRP	-	Tungsten Lamp	-	60.0	15
Lawson & Simms [7]	1952	Iroko	3/4 inch	Gas panel	-	24.2	375
Lawson & Simms [7]	1952	Iroko	3/4 inch	Gas panel	-	27.6	86
Lawson & Simms [7]	1952	Iroko	3/4 inch	Gas panel	-	30.0	57
Lawson & Simms [7]	1952	Iroko	3/4 inch	Gas panel	-	39.6	30
Lawson & Simms [7]	1952	Iroko	3/4 inch	Gas panel	-	48.0	25
Lawson & Simms [7]	1952	Iroko	3/4 inch	Gas panel	-	54.0	20
Lawson & Simms [7]	1952	Iroko	3/4 inch	Gas panel	-	63.6	12
Yang [34]	2003	Kampas	-	-	-	20.0	1699
Yang [34]	2003	Kampas	-	-	-	30.0	443
Yang [34]	2003	Kampas	-	-	-	40.0	134
Yang [34]	2003	Kampas	-	-	-	50.0	79
Lawson & Simms [7]	1952	Mahogany	3/4 inch	Gas panel	-	16.8	359
Lawson & Simms [7]	1952	Mahogany	3/4 inch	Gas panel	-	20.4	241
Lawson & Simms [7]	1952	Mahogany	3/4 inch	Gas panel	-	24.0	93
Lawson & Simms [7]	1952	Mahogany	3/4 inch	Gas panel	-	26.4	64
Lawson & Simms [7]	1952	Mahogany	3/4 inch	Gas panel	-	34.8	31
Lawson & Simms [7]	1952	Mahogany	3/4 inch	Gas panel	-	39.6	18
Lawson & Simms [7]	1952	Mahogany	3/4 inch	Gas panel	-	63.6	6
Lawson & Simms [7]	1952	Mahogany	3/4 inch	Gas panel	-	72	4
Moghtaderi [36]	1997	Maple	Pacific (10%mc)	-	-	14.0	960
Moghtaderi [36]	1997	Maple	Pacific (10%mc)	-	-	18.0	160
Moghtaderi [36]	1997	Maple	Pacific (10%mc)	-	-	20.0	150
Moghtaderi [36]	1997	Maple	Pacific (10%mc)	-	-	25.0	69

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Moghtaderi [36]	1997	Maple	Pacific (10%mc)	-	-	37.0	20
Moghtaderi [36]	1997	Maple	Pacific (10%mc)	-	-	50.0	8
Moghtaderi [36]	1997	Maple	Pacific (10%mc)	-	-	65.0	5
Lawson & Simms [7]	1952	Oak	3/4 inch	Gas panel	-	23.4	241
Lawson & Simms [7]	1952	Oak	3/4 inch	Gas panel	-	26.4	93
Lawson & Simms [7]	1952	Oak	3/4 inch	Gas panel	-	39.6	24
Lawson & Simms [7]	1952	Oak	3/4 inch	Gas panel	-	46.8	17
Lawson & Simms [7]	1952	Oak	3/4 inch	Gas panel	-	50.4	13
Lawson & Simms [7]	1952	Oak	3/4 inch	Gas panel	-	68.4	6
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	38.8	305
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	56.3	96
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	58.5	86
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	75.8	53
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	75.8	57
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	78.7	40
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	87.9	34
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	94.8	28
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	102.0	27
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	109.9	24
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	114.1	20
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	114.1	23
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	125.6	13
Wesson et al [6]	1971	Oak	Oven dried	Tungsten Lamp	-	125.6	15
Yang [34]	2003	Oak	-	-	-	20.0	1348
Yang [34]	2003	Oak	-	-	-	30.0	214

Author	***Year***	***Material***	***Details***	***Radiant source***	***Paint Density (gm^{-2})***	***Heat flux (kWm^{-2})***	***Time to ignition (s)***
Yang [34]	2003	Oak	-	-	-	40.0	111
Yang [34]	2003	Oak	-	-	-	50.0	61
Moysey & Muir [23]	1968	Paint	Red oil (Cedar)	Gas panel	-	16.1	848
Moysey & Muir [23]	1968	Paint	Red oil (Cedar)	Gas panel	-	16.4	277
Moysey & Muir [23]	1968	Paint	Red oil (Cedar)	Gas panel	-	17.1	243
Moysey & Muir [23]	1968	Paint	Red oil (Cedar)	Gas panel	-	17.5	400
Moysey & Muir [23]	1968	Paint	Red oil (Cedar)	Gas panel	-	18.0	193
Moysey & Muir [23]	1968	Paint	Red oil (Cedar)	Gas panel	-	19.9	139
Moysey & Muir [23]	1968	Paint	White enamel (Cedar)	Gas panel	-	16.7	1068
Moysey & Muir [23]	1968	Paint	White enamel (Cedar)	Gas panel	-	17.0	611
Moysey & Muir [23]	1968	Paint	White enamel (Cedar)	Gas panel	-	17.7	306
Moysey & Muir [23]	1968	Paint	White enamel (Cedar)	Gas panel	-	20.0	220
Moysey & Muir [23]	1968	Paint	White latex (Cedar)	Gas panel	-	16.1	1140
Moysey & Muir [23]	1968	Paint	White latex (Cedar)	Gas panel	-	16.7	877
Moysey & Muir [23]	1968	Paint	White latex (Cedar)	Gas panel	-	16.9	630
Moysey & Muir [23]	1968	Paint	White latex (Cedar)	Gas panel	-	17.1	306
Moysey & Muir [23]	1968	Paint	White latex (Cedar)	Gas panel	-	17.5	373
Moysey & Muir [23]	1968	Paint	White latex (Cedar)	Gas panel	-	18.3	250
Moysey & Muir [23]	1968	Paint	White latex (Cedar)	Gas panel	-	19.6	200
Moysey & Muir [23]	1968	Paint	White oil (Cedar)	Gas panel	-	16.1	1808
Moysey & Muir [23]	1968	Paint	White oil (Cedar)	Gas panel	-	16.7	936
Moysey & Muir [23]	1968	Paint	White oil (Cedar)	Gas panel	-	17.1	821
Moysey & Muir [23]	1968	Paint	White oil (Cedar)	Gas panel	-	17.4	485
Moysey & Muir [23]	1968	Paint	White oil (Cedar)	Gas panel	-	18.0	175
Moysey & Muir [23]	1968	Paint	White oil (Cedar)	Gas panel	-	19.8	164

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	0	35.0	60
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	0	35.0	75
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	0	35.0	75
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	0	35.0	85
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	69	35.0	130
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	75	35.0	145
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	88	35.0	230
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	103	35.0	140
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	106	35.0	160
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	113	35.0	155
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	140	35.0	115
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	150	35.0	97
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	241	35.0	90
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	266	35.0	85
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	266	35.0	105
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	269	35.0	85
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	347	35.0	15
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	369	35.0	10
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	369	35.0	50
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	0	50.0	25
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	0	50.0	35
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	0	50.0	35
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	81	50.0	35
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	100	50.0	42
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	106	50.0	35

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	109	50.0	35
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	122	50.0	70
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	134	50.0	38
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	134	50.0	82
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	150	50.0	74
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	225	50.0	8
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	247	50.0	5
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	256	50.0	32
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	303	50.0	45
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	338	50.0	5
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	369	50.0	5
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	397	50.0	8
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	450	50.0	10
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	0	65.0	17
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	0	65.0	20
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	50	65.0	45
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	97	65.0	27
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	100	65.0	40
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	113	65.0	22
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	122	65.0	33
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	125	65.0	5
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	153	65.0	40
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	225	65.0	3
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	231	65.0	3
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	253	65.0	5

Author	***Year***	***Material***	***Details***	***Radiant source***	***Paint Density (gm^{-2})***	***Heat flux (kWm^{-2})***	***Time to ignition (s)***
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	310	65.0	5
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	322	65.0	3
Staggs [24]	2003	Paint	Dulux Gloss (Plywood)	Electrical heater	470	65.0	5
Staggs [24]	2003	Paint	Dulux Gloss (Chipboard)	Electrical heater	475	65.0	3
Bell	1995	Phenolic resin	40% glass	Electrical heater	-	35.0	638
Bell	1995	Phenolic resin	40% glass	Electrical heater	-	50.0	147
Bell	1995	Phenolic resin	40% glass	Electrical heater	-	75.0	66
Bell	1995	Phenolic resin	65% glass	Electrical heater	-	50.0	132
Bell	1995	Phenolic resin	65% glass	Electrical heater	-	75.0	46
Gibson [33]	1995	Phenolic resin	-	Electrical heater	-	30.0	450
Gibson [33]	1995	Phenolic resin	-	Electrical heater	-	40.0	300
Gibson [33]	1995	Phenolic resin	-	Electrical heater	-	50.0	110
Gibson [33]	1995	Phenolic resin	-	Electrical heater	-	60.0	87
Gibson [33]	1995	Phenolic resin	-	Electrical heater	-	80.0	55

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Moghtaderi [36]	1997	Pine	Radiata (0%mc)	Electrical heater	-	20.0	179
Moghtaderi [36]	1997	Pine	Radiata (0%mc)	Electrical heater	-	30.0	19
Moghtaderi [36]	1997	Pine	Radiata (0%mc)	Electrical heater	-	40.0	9
Moghtaderi [36]	1997	Pine	Radiata (0%mc)	Electrical heater	-	50.0	5
Moghtaderi [36]	1997	Pine	Radiata (0%mc)	Electrical heater	-	60.0	3
Moghtaderi [36]	1997	Pine	Radiata (15%mc)	Electrical heater	-	20.0	295
Moghtaderi [36]	1997	Pine	Radiata (15%mc)	Electrical heater	-	30.0	52
Moghtaderi [36]	1997	Pine	Radiata (15%mc)	Electrical heater	-	40.0	18
Moghtaderi [36]	1997	Pine	Radiata (15%mc)	Electrical heater	-	50.0	11
Moghtaderi [36]	1997	Pine	Radiata (15%mc)	Electrical heater	-	60.0	7
Moghtaderi [36]	1997	Pine	Radiata (22%mc)	Electrical heater	-	20.0	420
Moghtaderi [36]	1997	Pine	Radiata (22%mc)	Electrical heater	-	30.0	67
Moghtaderi [36]	1997	Pine	Radiata (22%mc)	Electrical heater	-	40.0	30
Moghtaderi [36]	1997	Pine	Radiata (22%mc)	Electrical heater	-	50.0	11
Moghtaderi [36]	1997	Pine	Radiata (22%mc)	Electrical heater	-	60.0	9
Moghtaderi [36]	1997	Pine	Radiata (30%mc)	Electrical heater	-	20.0	540
Moghtaderi [36]	1997	Pine	Radiata (30%mc)	Electrical heater	-	30.0	93
Moghtaderi [36]	1997	Pine	Radiata (30%mc)	Electrical heater	-	40.0	36
Moghtaderi [36]	1997	Pine	Radiata (30%mc)	Electrical heater	-	50.0	19
Moghtaderi [36]	1997	Pine	Radiata (30%mc)	Electrical heater	-	60.0	11
Moghtaderi [36]	1997	Pine	Sugar (10%mc)	Electrical heater	-	20.0	150
Moghtaderi [36]	1997	Pine	Sugar (10%mc)	Electrical heater	-	25.0	49
Moghtaderi [36]	1997	Pine	Sugar (10%mc)	Electrical heater	-	35.0	13
Moghtaderi [36]	1997	Pine	Sugar (10%mc)	Electrical heater	-	45.0	6
Moghtaderi [36]	1997	Pine	Sugar (10%mc)	Electrical heater	-	55.0	3

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density* (gm^{-2})	*Heat flux* (kWm^{-2})	*Time to ignition (s)*
Bilbao [37]	2001	Pine	Pinus Pinaster	Electrical heater	-	10.1	900
Bilbao [37]	2001	Pine	Pinus Pinaster	Electrical heater	-	14.3	389
Bilbao [37]	2001	Pine	Pinus Pinaster	Electrical heater	-	20.0	180
Bilbao [37]	2001	Pine	Pinus Pinaster	Electrical heater	-	25.8	36
Bilbao [37]	2001	Pine	Pinus Pinaster	Electrical heater	-	29.9	29
Bilbao [37]	2001	Pine	Pinus Pinaster	Electrical heater	-	44.1	13
Bilbao [37]	2001	Pine	Pinus Pinaster	Electrical heater	-	53.5	10
Bilbao [10]	2002	Pine	-	Electrical heater	-	14.0	450
Bilbao [10]	2002	Pine	-	Electrical heater	-	14.0	500
Bilbao [10]	2002	Pine	-	Electrical heater	-	15.0	24
Bilbao [10]	2002	Pine	-	Electrical heater	-	26.0	32
Bilbao [10]	2002	Pine	-	Electrical heater	-	30.0	30
Bilbao [10]	2002	Pine	-	Electrical heater	-	31.0	22
Bilbao [10]	2002	Pine	-	Electrical heater	-	41.0	9
Bilbao [10]	2002	Pine	-	Electrical heater	-	41.0	13
Bilbao [10]	2002	Pine	-	Electrical heater	-	44.0	13
Bilbao [10]	2002	Pine	-	Electrical heater	-	44.0	14
Bilbao [10]	2002	Pine	-	Electrical heater	-	53.0	9
Bilbao [10]	2002	Pine	-	Electrical heater	-	53.0	10
Bilbao [10]	2002	Pine	-	Electrical heater	-	58.0	7
Delichatsios [38]	2003	Pine	Radiata	-	-	20.0	484
Delichatsios [38]	2003	Pine	Radiata	-	-	25.0	153
Delichatsios [38]	2003	Pine	Radiata	-	-	30.0	132
Delichatsios [38]	2003	Pine	Radiata	-	-	45.0	30
Delichatsios [38]	2003	Pine	Radiata	-	-	50.0	22

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Hallman [39]	1972	PMMA	Black	Benzene Flame	-	37.3	93
Hallman [39]	1972	PMMA	Black	Benzene Flame	-	37.3	100
Hallman [39]	1972	PMMA	Black	Benzene Flame	-	52.7	40
Hallman [39]	1972	PMMA	Black	Benzene Flame	-	63.8	26
Hallman [39]	1972	PMMA	Black	Benzene Flame	-	80.4	17
Hallman [39]	1972	PMMA	Black	Benzene Flame	-	90.2	14
Hallman [39]	1972	PMMA	Black	Benzene Flame	-	105.1	9
Hallman [39]	1972	PMMA	Black	Benzene Flame	-	122.6	7
Hallman [39]	1972	PMMA	Clear	Benzene Flame	-	28.5	224
Hallman [39]	1972	PMMA	Clear	Benzene Flame	-	38.8	104
Hallman [39]	1972	PMMA	Clear	Benzene Flame	-	50.7	66
Hallman [39]	1972	PMMA	Clear	Benzene Flame	-	63.8	28
Hallman [39]	1972	PMMA	Clear	Benzene Flame	-	77.3	24
Hallman [39]	1972	PMMA	Clear	Benzene Flame	-	90.2	19
Hallman [39]	1972	PMMA	Clear	Benzene Flame	-	105.1	16
Hallman [39]	1972	PMMA	Clear	Benzene Flame	-	127.4	9
Hilado [35]	1998	PMMA	1/8 inch	-	-	58.0	115
Hilado [35]	1998	PMMA	1/8 inch	-	-	81.0	33
Hilado [35]	1998	PMMA	1/8 inch	-	-	105.0	31
Thomson & Drysdale [40]	1987	PMMA	Finnacryl	Electrical heater	-	13.0	1125
Thomson & Drysdale [41]	1989	PMMA	Finnacryl	Electrical heater	-	13.0	328
Thomson & Drysdale [41]	1989	PMMA	Finnacryl	Electrical heater	-	13.0	280
Thomson & Drysdale [40]	1987	PMMA	Finnacryl	Electrical heater	-	15.0	391
Thomson & Drysdale [40]	1987	PMMA	Finnacryl	Electrical heater	-	18.5	227
Thomson & Drysdale [41]	1989	PMMA	Finnacryl	Electrical heater	-	19.0	167

Author	***Year***	***Material***	***Details***	***Radiant source***	***Paint Density (gm^{-2})***	***Heat flux (kWm^{-2})***	***Time to ignition (s)***
Thomson & Drysdale [41]	1989	PMMA	Finnacryl	Electrical heater	-	19.0	150
Thomson & Drysdale [40]	1987	PMMA	Finnacryl	Electrical heater	-	22.0	148
Thomson & Drysdale [41]	1989	PMMA	Finnacryl	Electrical heater	-	25.0	84
Thomson & Drysdale [41]	1989	PMMA	Finnacryl	Electrical heater	-	25.0	80
Thomson & Drysdale [40]	1987	PMMA	Finnacryl	Electrical heater	-	25.5	99
Thomson & Drysdale [40]	1987	PMMA	Finnacryl	Electrical heater	-	29.0	80
Thomson & Drysdale [41]	1989	PMMA	Finnacryl	Electrical heater	-	33.0	42
Thomson & Drysdale [41]	1989	PMMA	Finnacryl	Electrical heater	-	33.0	42
Thomson & Drysdale [40]	1987	PMMA	Finnacryl	Electrical heater	-	38.0	24
Thomson & Drysdale [41]	1989	PMMA	Fire Retarded	Electrical heater	-	19.0	352
Thomson & Drysdale [41]	1989	PMMA	Fire Retarded	Electrical heater	-	19.0	281
Thomson & Drysdale [41]	1989	PMMA	Fire Retarded	Electrical heater	-	25.0	194
Thomson & Drysdale [41]	1989	PMMA	Fire Retarded	Electrical heater	-	25.0	184
Thomson & Drysdale [41]	1989	PMMA	Fire Retarded	Electrical heater	-	33.0	89
Thomson & Drysdale [41]	1989	PMMA	Fire Retarded	Electrical heater	-	33.0	89
Thomson & Drysdale [41]	1989	PMMA	Perspex	Electrical heater	-	13.0	287
Thomson & Drysdale [41]	1989	PMMA	Perspex	Electrical heater	-	13.0	223
Thomson & Drysdale [40]	1987	PMMA	Perspex	Electrical heater	-	14.0	461
Thomson & Drysdale [40]	1987	PMMA	Perspex	Electrical heater	-	17.0	288
Thomson & Drysdale [41]	1989	PMMA	Perspex	Electrical heater	-	19.0	127
Thomson & Drysdale [41]	1989	PMMA	Perspex	Electrical heater	-	19.0	109
Thomson & Drysdale [40]	1987	PMMA	Perspex	Electrical heater	-	20.5	173
Thomson & Drysdale [40]	1987	PMMA	Perspex	Electrical heater	-	24.0	115
Thomson & Drysdale [41]	1989	PMMA	Perspex	Electrical heater	-	25.0	58
Thomson & Drysdale [41]	1989	PMMA	Perspex	Electrical heater	-	25.0	52

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Thomson & Drysdale [40]	1987	PMMA	Perspex	Electrical heater	-	30.0	67
Thomson & Drysdale [41]	1989	PMMA	Perspex	Electrical heater	-	33.0	30
Thomson & Drysdale [41]	1989	PMMA	Perspex	Electrical heater	-	33.0	30
Thomson & Drysdale [40]	1987	PMMA	Perspex	Electrical heater	-	37.5	39
Hilado [35]	1998	PolyCarbonate	FR	-	-	25.0	267
Hilado [35]	1998	PolyCarbonate	FR	-	-	50.0	53
Hilado [35]	1998	PolyCarbonate	FR	-	-	75.0	28
Hilado [35]	1998	PolyCarbonate	Non-FR	-	-	25.0	189
Hilado [35]	1998	PolyCarbonate	Non-FR	-	-	50.0	49
Hilado [35]	1998	PolyCarbonate	Non-FR	-	-	75.0	21
Gibson [33]	1995	Polyester	-	Electrical heater	-	30.0	90
Gibson [33]	1995	Polyester	-	Electrical heater	-	40.0	65
Gibson [33]	1995	Polyester	-	Electrical heater	-	50.0	30
Gibson [33]	1995	Polyester	-	Electrical heater	-	60.0	23
Gibson [33]	1995	Polyester	-	Electrical heater	-	80.0	14

Author	***Year***	***Material***	***Details***	***Radiant source***	***Paint Density (gm^{-2})***	***Heat flux (kWm^{-2})***	***Time to ignition (s)***
Thomson & Drysdale [40]	1987	PolyEthylene	-	Electrical heater	-	19.0	524
Thomson & Drysdale [40]	1987	PolyEthylene	-	Electrical heater	-	23.0	315
Thomson & Drysdale [40]	1987	PolyEthylene	-	Electrical heater	-	27.0	223
Thomson & Drysdale [40]	1987	PolyEthylene	-	Electrical heater	-	28.5	172
Thomson & Drysdale [40]	1987	PolyEthylene	-	Electrical heater	-	34.0	83
Thomson & Drysdale [41]	1989	PolyEthylene	-	Electrical heater	-	25.0	141
Thomson & Drysdale [41]	1989	PolyEthylene	-	Electrical heater	-	25.0	172
Thomson & Drysdale [41]	1989	PolyEthylene	-	Electrical heater	-	33.0	90
Thomson & Drysdale [41]	1989	PolyEthylene	-	Electrical heater	-	33.0	90
Thomson & Drysdale [40]	1987	PolyOxyMethylene	Polyacetal	Electrical heater	-	15.5	714
Thomson & Drysdale [40]	1987	PolyOxyMethylene	Polyacetal	Electrical heater	-	17.0	386
Thomson & Drysdale [40]	1987	PolyOxyMethylene	Polyacetal	Electrical heater	-	21.0	248
Thomson & Drysdale [40]	1987	PolyOxyMethylene	Polyacetal	Electrical heater	-	25.0	184
Thomson & Drysdale [40]	1987	PolyOxyMethylene	Polyacetal	Electrical heater	-	28.0	138
Thomson & Drysdale [40]	1987	PolyOxyMethylene	Polyacetal	Electrical heater	-	34.0	79
Thomson & Drysdale [41]	1989	PolyOxyMethylene	Polyacetal	Electrical heater	-	13.0	428
Thomson & Drysdale [41]	1989	PolyOxyMethylene	Polyacetal	Electrical heater	-	13.0	573
Thomson & Drysdale [41]	1989	PolyOxyMethylene	Polyacetal	Electrical heater	-	19.0	227
Thomson & Drysdale [41]	1989	PolyOxyMethylene	Polyacetal	Electrical heater	-	19.0	275
Thomson & Drysdale [41]	1989	PolyOxyMethylene	Polyacetal	Electrical heater	-	25.0	122
Thomson & Drysdale [41]	1989	PolyOxyMethylene	Polyacetal	Electrical heater	-	25.0	143
Thomson & Drysdale [41]	1989	PolyOxyMethylene	Polyacetal	Electrical heater	-	33.0	84
Thomson & Drysdale [41]	1989	PolyOxyMethylene	Polyacetal	Electrical heater	-	33.0	84
Thomson & Drysdale [40]	1987	PolyPropylene	-	Electrical heater	-	17.0	372
Thomson & Drysdale [40]	1987	PolyPropylene	-	Electrical heater	-	21.0	230

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Thomson & Drysdale [40]	1987	PolyPropylene	-	Electrical heater	-	25.0	139
Thomson & Drysdale [40]	1987	PolyPropylene	-	Electrical heater	-	31.0	86
Thomson & Drysdale [40]	1987	PolyPropylene	-	Electrical heater	-	42.5	46
Thomson & Drysdale [41]	1989	PolyPropylene	Fire Retarded	Electrical heater	-	25.0	269
Thomson & Drysdale [41]	1989	PolyPropylene	Fire Retarded	Electrical heater	-	25.0	285
Thomson & Drysdale [41]	1989	PolyPropylene	Fire Retarded	Electrical heater	-	33.0	90
Thomson & Drysdale [41]	1989	PolyPropylene	Fire Retarded	Electrical heater	-	33.0	90
Thomson & Drysdale [41]	1989	PolyPropylene	-	Electrical heater	-	13.0	302
Thomson & Drysdale [41]	1989	PolyPropylene	-	Electrical heater	-	13.0	442
Thomson & Drysdale [41]	1989	PolyPropylene	-	Electrical heater	-	19.0	146
Thomson & Drysdale [41]	1989	PolyPropylene	-	Electrical heater	-	19.0	172
Thomson & Drysdale [41]	1989	PolyPropylene	-	Electrical heater	-	25.0	75
Thomson & Drysdale [41]	1989	PolyPropylene	-	Electrical heater	-	25.0	91
Thomson & Drysdale [41]	1989	PolyPropylene	-	Electrical heater	-	33.0	57
Thomson & Drysdale [41]	1989	PolyPropylene	-	Electrical heater	-	33.0	57
Thomson & Drysdale [40]	1987	Polystyrene	-	Electrical heater	-	15.5	365
Thomson & Drysdale [40]	1987	Polystyrene	-	Electrical heater	-	19.0	236
Thomson & Drysdale [40]	1987	Polystyrene	-	Electrical heater	-	28.0	102
Thomson & Drysdale [40]	1987	Polystyrene	-	Electrical heater	-	34.0	67
Thomson & Drysdale [41]	1989	Polystyrene	Fire Retarded	Electrical heater	-	25.0	268
Thomson & Drysdale [41]	1989	Polystyrene	Fire Retarded	Electrical heater	-	25.0	291
Thomson & Drysdale [41]	1989	Polystyrene	Fire Retarded	Electrical heater	-	33.0	124
Thomson & Drysdale [41]	1989	Polystyrene	Fire Retarded	Electrical heater	-	33.0	124
Thomson & Drysdale [41]	1989	Polystyrene	-	Electrical heater	-	13.0	496
Thomson & Drysdale [41]	1989	Polystyrene	-	Electrical heater	-	13.0	610

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Thomson & Drysdale [41]	1989	Polystyrene	-	Electrical heater	-	19.0	183
Thomson & Drysdale [41]	1989	Polystyrene	-	Electrical heater	-	19.0	209
Thomson & Drysdale [41]	1989	Polystyrene	-	Electrical heater	-	25.0	110
Thomson & Drysdale [41]	1989	Polystyrene	-	Electrical heater	-	25.0	120
Thomson & Drysdale [41]	1989	Polystyrene	-	Electrical heater	-	33.0	74
Thomson & Drysdale [41]	1989	Polystyrene	-	Electrical heater	-	33.0	74
Gibson [33]	1995	Vinyl Ester	-	Electrical heater	-	30.0	63
Gibson [33]	1995	Vinyl Ester	-	Electrical heater	-	40.0	44
Gibson [33]	1995	Vinyl Ester	-	Electrical heater	-	50.0	22
Gibson [33]	1995	Vinyl Ester	-	Electrical heater	-	60.0	18
Gibson [33]	1995	Vinyl Ester	-	Electrical heater	-	80.0	10

Author	*Year*	*Material*	*Details*	*Radiant source*	*Paint Density (gm^{-2})*	*Heat flux (kWm^{-2})*	*Time to ignition (s)*
Lawson & Simms [7]	1952	Whitewood	3/4 inch	Gas panel	-	20.4	213
Lawson & Simms [7]	1952	Whitewood	3/4 inch	Gas panel	-	24.0	78
Lawson & Simms [7]	1952	Whitewood	3/4 inch	Gas panel	-	25.2	43
Lawson & Simms [7]	1952	Whitewood	3/4 inch	Gas panel	-	28.8	33
Lawson & Simms [7]	1952	Whitewood	3/4 inch	Gas panel	-	32.4	20
Lawson & Simms [7]	1952	Whitewood	3/4 inch	Gas panel	-	39.6	15
Lawson & Simms [7]	1952	Whitewood	3/4 inch	Gas panel	-	54.0	9
Lawson & Simms [7]	1952	Whitewood	3/4 inch	Gas panel	-	70.8	4
Shields [43]	1995	PVC	Extruded Grey 3mm	-	-	15	655
Shields [43]	1995	PVC	Extruded Grey 3mm	-	-	20	184
Shields [43]	1995	PVC	Extruded Grey 3mm	-	-	30	71
Shields [43]	1995	PVC	Extruded Grey 3mm	-	-	40	43
Shields [43]	1995	PVC	Extruded Grey 3mm	-	-	50	26
Shields [43]	1995	PVC	Compressed White 5mm	-	-	15	653
Shields [43]	1995	PVC	Compressed White 5mm	-	-	20	332
Shields [43]	1995	PVC	Compressed White 5mm	-	-	30	209
Shields [43]	1995	PVC	Compressed White 5mm	-	-	40	95
Shields [43]	1995	PVC	Compressed White 5mm	-	-	50	55

9 REFERENCES

1. Malhotra, HL, Building materials and fire, Fire Prevention Science and Technology, Vol. 1, (1972)

2. Toal, BR, Silcock, WH, Shields, TJ, An Examination of Piloted Ignition Characteristics of Cellulosic Materials Using the ISO Ignitability Test, Fire and Materials, Vol. 14, (1987)

3. Shraub, H, Bender, EW, Radiant Ignition of Wall Finish Materials in a Small Home, NBS Report 7306, National Bureau of Standards, (1960)

4. Simms, DL, Experiments on the Ignition of Cellulosic Materials by Thermal Radiation, Combustion and Flame, Vol. 5, (1961)

5. Simms, DL, Law, M, The Ignition of Wet and Dry Wood by Radiation, Fire Research Note 586, (1965)

6. Wessen, HR, Welker, JR, Sliepcevich, CM, The Piloted Ignition of Wood by Thermal Radiation, Combustion and Flame, Vol. 16, (1971)

7. Lawson, DI, Simms, DL, The ignition of wood by radiation, Journal of Applied Physics, Vol. 3, (1952)

8. Simms, DL, On the Pilot Ignition of Wood by Radiation, Combustion & Flame, Vol. 7, (1963)

9. McGuire, JH, Limiting Safe Surface Temperature of Combustible Materials, Fire Technology, Vol. 5, (1969)

10. Bilbao, R et al, A Model for the prediction of the thermal degradation and ignition of wood under constant and variable heat flux, Journal of Analytical and Applied Pyrolysis, Vol. 62, Part 1, (2002)

11. Spearpoint MJ, Predicting the Ignition and Burning Rate of Wood in the Cone Calorimeter using an Integral Model, (NIST GCR 99-775), (1999)

12. Law, M, Heat radiation from fires and building separation, External fire spread: building separation and boundary distances, Building Research Establishment, CI/SfB 98(F47)(K22), (1991)

13. Simms, DL, On the Pilot Ignition of Wood by Radiation, Fire Research Note 496, (1962)

14. Carlsson, E, External Fire Spread to Adjoining Buildings – A Literature Review, The 3rd International conference on performance based codes and fire safety design, (2000)

15. Kim, AK, Taber, BC, Lougheed, GD, Sprinkler Protection of Exterior Glazing, Fire Technology, Vol. 34, Part 2, (1998)

16. Mowrer, FW, Window Breakage Induced by Exterior Fires, Proc. 2nd Intl. Conf. on Fire Research and Engineering, Society of Fire Protection Engineers, (1998)

17. Mowrer, FW, Window Breakage Induced by Exterior Fires (NIST-GCR-98-751), National Inst. Stand. and Technol., (1998)

18. Harada, K, Enomoto, A, Uede, K, and Wakamatsu, T, An Experimental Study on Glass Cracking and Fallout by Radiant Heat Exposure, Fire Safety Science, Proc. 6th Intl. Symp., Intl. Assn. for Fire Safety Science, (2000)

19. Babrauskas, V, Parker, WJ, Ignitability Measurements with the Cone Calorimeter, Fire and Materials, Vol. 11, (1987)

20. Sumi, K, Tsuchiya, Y, Ignitability studies on building contents, Fire Retards International Symposium, (1978)

21. Masařík, I, Final Report on Interlaboratory Tests (for the ISO TC 61/SC4/WG1 meeting), Fire Technical Institute, (1999)

22. Janssens, ML, Fundamental Thermophysical Characteristics of Wood and their Role in Enclosure Fire Growth (Ph.D. dissertation), Universiteit Gent, (1991)

23. Moysey, EB, Muir, WE, Pilot ignition of Building Materials by Radiation, Fire Technology, Vol. 4, Part 1, (1968)

24. Staggs, JE, Phylaktou, HN, McCreadie, RE, The Effect of Paint on the Ignition Resistance of Plywood and Chipboard, Fire Safety Science, Proceedings of the 7th International Symposium, (2003)

25. Dreisbach, J, Flammability Characteristic of Painted Concrete Blocks, (NIST GCR 02-832), (2002)

26. Noumowe, A, Asphalt Ignition in Case of Fire in Civil Engineering Structures: Chemical Analysis, Proceedings of the 10th International Interflam Conference, (2004)

27. Shipp, MP, Fire Spread between Caravans, BRE Information paper, IP 15, (1991)

28. Dietenberger, MA, Ignitibility Analysis of Siding Materials using modified protocol for LIFT Apparatus, 20th International Conference on Fire Safety, (1995)

29. Babrauskas, V, Ignition Handbook, ISBN 0-9728111-3-3, (2003)

30. Braun, E, Allen, PJ, Flame Spread on Combustible Solar Collector Glazing Materials, NBSIR 84-2887, (1984)

31. Quintiere, JG, Harkleroad, MF, New Concepts for Measuring Flame Spread Properties, NBSIR 84-2943, (1984)

32. Kashiwagi, T, Cleary, TG, Effects of Sample Mounting on Flammability Properties of Intumescent Polymers, Fire Safety Journal, Vol. 20, (1993)

33. Gibson, AG, Chandler, HW, Wilcox, JAD, Wu, YS, Hume, J, Fire Performance of Composite Materials for Offshore Use, Composite Materials for Offshore Use, I. Mech. E., 1994

34. Yang, L, Chen, X, Zhou, X, Fan, W, The Pyrolysis and Ignition of Charring materials under an external heat flux, Combustion and Flame, Vol. 133, (2003)

35. Hilado, CJ, Flammability Handbook for Plastics, (1998)

36. Moghtaderi, B, Novozhilov, V, Fletcher, DF, Kent, JH, A New Correlation for Bench-scale Piloted Ignition Data of Wood, Fire Safety Journal, Vol. 29, (1997)

37. Bilbao, R, Mastral, JF, Aldea, ME, Ceamanos, J, Betrán, M, Experimental and Theoretical Study of the Ignition and Smouldering of Wood including Convective Effects, Combustion and Flame, Vol. 126, (2001)

38. Delichatsios, M, Paroz, B, Bhargava, A, Flammability properties for charring materials, Fire Safety Journal, Vol. 38, (2003)

39. Hallman, J, Reed Welker, J, Sliepcevich, CM, Ignition of Polymers, SPE Journal, Vol. 28, (1972)

40. Thomson, HE, Drysdale, DD, Flammability of plastics, Fire and Materials, Vol. 11, (1987)

41. Thomson, HE, Drysdale, DD, Flammability of Plastics II: Critical Mass Flux at the Firepoint, Fire Safety Journal, Vol. 14, (1989)

42. Luzik, SJ, Fire and Explosion Investigation, Pacific Engineering and Production Co. of Nevada, Bruceton Safety Technology Center, (1988)

43. Shields, TJ, Silcock, GWH, A Protocol for Analysis of Time-to-Ignition Data from Bench scale tests, Fire Safety Journal, Vol. 24, (1995)

44. Methods for the determination of possible damage, CPR 16E, Committee for the Prevention of Disasters caused by dangerous substances, (1992)

45. BS 476 – 13: 1987 Fire tests on building materials and structures – part 13: Method of measuring the ignitability of products subjected to thermal irradiance