

Enhanced Fire Resistance During Construction

FrameProtect™

Reduced growth of fire



Untreated open panel with I-Joist floors
Rapid fire growth



IWS-FR treated open panel with IWS-FR treated floors
Reduced fire growth



FrameProtect™
No spread of flame and potential to self extinguish

Reduced separating distances to neighbouring buildings



Table of Contents

Foreword	03
1.0 BACKGROUND	
1.1 Timber frame	04
1.2 Timber frame fires - recent history	05
1.3 Information on timber frame's performance under fire	05
2.0 CURRENT METHODS OF TIMBER FRAME CONSTRUCTION	
2.1 Open panel	06
2.2 Closed panel	06
2.3 Timber floors	07
3.0 WIDER CONSIDERATIONS	
3.1 Fire strategy	08
3.2 Compartmentation	09
3.3 Automatic suppression systems	10
3.4 Shielding	11
3.5 Alarms	12
3.6 Flame retardants	12
4.0 Laboratory Testing Process	
4.1 Laboratory testing process	14
5.0 RESULTS AND ANALYSIS	
5.1 Cone calorimeter tests	15
5.2 Single burn item tests	16
5.3 Larger scale tests	18
6.0 ESTABLISHED PERFORMANCE	
6.1 Use of FRs	20
6.2 Closed panel treated frame	20
6.3 Systems approach	21
7.0 RECOMMENDATIONS	
7.1 Recommendations	22
8.0 CONCLUSIONS	
8.1 Conclusions	25
References	26

General Guidelines For Using This Report

Frame UK reserve the right to amend or update the technical information contained within this report without giving prior notice. The information contained is correct at the time of publication, Feb 2011. For current product updates and technical data please refer to www.frameuk.com. Publications posted on the website will supersede all previous Frame UK guides and information sheets.

Foreword by Bob Pepper

Fire Performance

Our research into timber frame fire performance is designed to qualify current practice, use this current practice as a benchmark and try and introduce a commercially viable, superior solution.

Recent history has repeatedly shown that there is a need to further investigate the risks associated with building large, multi-storey projects in timber frame. There are a number of parties with a vested interest including the Chief Fire Officers Association (CFOA), the Association of British Insurers (ABI), and the Health and Safety Executive (HSE). They all have their own specific agendas but there is a common need to clarify the position of timber frame in large, multi-storey construction. Through our research we, in collaboration with Intelligent Wood Systems (IWS) and the UK Timber Frame Association (UKTFA) believe that we can prove that appropriately designed and constructed timber frame buildings are as safe as any form of construction.

In collaboration with IWS who have introduced the **IWS-FAST**[®] (Fire, Acoustic, Structure, Thermal) system which is an integrated approach to improving building performance and is "built-in" to **FrameProtect**[™].

As the title of the report suggests Frame UK has successfully tested a system that provides fire protection both internally and externally and as part of a wider strategy provides "Enhanced Fire Resistance During Construction." The wider strategy will focus on three key areas:

1. Fire prevention
2. Limit growth of fire
3. Reduce peak heat output

The **FrameProtect**[™], where adopted, will minimise concerns regarding timber frame during construction as it:

- Reduces ignitability, fire propagation and spread of flame
- Reduces generated heat significantly – test results shows in excess of 70 times reduction
- Provides extra time to escape the site
- Behaves in a predictable manner
- Extends response times for fire crews to tackle situations
- Improves structural performance during and after incidents
- Can minimise the cost of subsequent remedial action through reducing damage and allowing fires to be extinguished
- May reduce the cost of insurance premiums
- Can reduce separating distances by at least 50%

Do you want to take the risk or will you **FrameProtect**[™]?

Bob Pepper
Frame UK Chairman



1.0 Background

1.1 Timber Frame

The timber frame industry's supply chain is under pressure to reduce the risk of fire during construction. Timber frame material section sizes and sheathing are vulnerable to ignition under relatively low levels of fire sources. Once ignited the timber wall panels and floor joists will quickly spread the flame across the building. The heat generated by timber frame on fire is such that collateral damage to neighbouring buildings can be significant.

It should be recognised that, although timber frame is an attractive target for arsonists and is quick to ignite during construction, completed structures built using timber frame comply with building regulations and are no more likely than any other form of construction in service to ignite or spread fire quickly.

In 2008, the Scottish timber frame industry accounted for 75% of all new housing, including 75% of flats. In the UK as a whole timber frame accounts for 25% of all housing, including 15,000 over 2 storey developments. In 2009, the UK's timber frame share of new houses fell slightly to 24.4%, although the longer term trend shows consistent growth. These statistics demonstrate timber frame is a mainstream method of delivering housing units.

There are two popular methods of timber frame construction, both resulting in a similar final composition. One which supplies the basic structural frame and the other which pre-fits more of the building layers required to achieve the finished specification:

Open Panel Timber Frame

The majority of timber frame buildings constructed are open panel, where wall panels are delivered to site comprising of vertical timber studs with a top and bottom timber rail with external sheathing generally made from Oriented Strand Board (OSB).

Insulation, windows, services and linings are fitted on-site.



Open panel timber frame. Photo courtesy of Milner Associates (formerly CCB Evolution)

Timber Frame benefits:

- » Is fast - requires 20% fewer on-site labour days and ensures faster construction overall ([UKTFA website](#))
- » Reduces the number of skilled labour hours on-site
- » Is well suited to brownfield sites with poor soil conditions (favouring lighter buildings) and sites with restricted access
- » Is easy to transport and offers quality control and fewer post erection quality problems
- » Complies with the Code for Sustainable Homes - It scores big points for low environmental impact of materials, responsible sourcing, construction waste reduction, airtightness, sound insulation and the lifetime homes plan
- » Provides carbon savings - Wood is effectively a carbon-neutral material (even allowing for transport), and timber frame has the lowest CO₂ cost of any commercially available building material. For every cubic metre of wood used instead of other building materials, 0.8 tonne of CO₂ is saved from the atmosphere. Every timber frame home saves about 4 tonnes of CO₂ ([UKTFA website](#))
- » Offers greater environmental credentials - Timber is organic, non-toxic and naturally renewable
- » Maximises thermal performance, producing an airtight dwelling with improved sound insulation

Closed Panel Timber Frame

Closed panel is becoming more prevalent in the UK due to several key benefits including less time on-site and an airtight structure. Pre-made structural panels are made in a factory and delivered to site where they are assembled together to form walls, floors and roofs.

Insulation, windows, services and linings can all be factory fitted. The benefits are better tolerance, greater consistency, faster erection and from day one is more robust against vandalism.



Frame UK Closed Panel Production

1.2 Timber Frame Fires - Recent History

In August 2010 the Department of Communities and Local Government (CLG) compiled a Fire Statistics Monitor for the period April 2009 to March 2010.

Table 1: Fire Statistics Monitor – April 2009 to March 2010 (England only)

	Timber frame	Other build methods	Ratio
Completed buildings	802 fires	47,600 fires	1:59
During construction	50 fires	400 fires	1:8

When you consider that 17% of new houses in England are constructed with timber frame the statistics shown in Table 1 clearly support the argument that timber frame buildings during construction are no more vulnerable to fire than other build methods. Similarly when you consider that 2.4% of the existing housing stock have been built using timber frame a 1:59 ratio is a positive reflection.

Over the last 5 years there have been several high profile timber frame fires on multi-storey projects during construction:

- 2006 – Colindale (believed to be discarded cigarette in rubbish piles)
- 2007 – 3 major fires (arson)
- 2008 – 3 major fires (arson)
- 2009 – Peckham (arson)
- 2010 – 3 major fires including Basingstoke (arson)

See Appendix 1 for full details.

“The structural timber used in construction is not easy to set alight. Almost all the major construction site fires involving timber frame are known or suspected to be the result of deliberate and determined malicious damage”.

UKTFA

(UKTFA, 16 Steps)

These fires have come under close scrutiny from the media due to the speed and intensity in which the fires develop. In addition, due to the unpredictable nature of timber frame fires and the intensity of the heat generated, the firefighters have been unable to effectively fight the fires and can do no more than try and contain the blaze and limit collateral damage to buildings in close proximity. The majority of fires on timber frame sites have been set deliberately demonstrating the need for tightened security and the adoption of best practice.

HSE Guidance

(Timber frame buildings) *“In situations where fire spread from a construction site might endanger the lives of people in adjacent properties, and effective precautions, to reduce this risk to an acceptable level cannot be identified or implemented, alternative build methods with a lower fire risk must be adopted.”*

(pg.53 Fire Safety in Construction, Health and Safety Executive)



1.3 Information on Timber Frame's Performance Under Fire

Recently local authorities and fire protection officers have called into question the use of timber frame on 3+ storey buildings.

“When timber-framed buildings catch fire the actual structure burns. It often leads to total collapse and that puts the safety of our firefighters at risk. The potential for fire spread was clearly of major concern at this incident, and shows that the Chief Fire Officers Association is right to be increasingly concerned about the number and severity of fires in timber-framed buildings under construction”
John Bonney, Hampshire Fire and Rescue Service Chief Officer (BBC news website, Sept 2010)

The CLG's Fire Statistics Monitor provides supporting evidence to timber frame buildings under construction spreading fire quickly, the following table (overleaf) demonstrates the distribution of area of damage.

Table 2: Fire Statistics Monitor – April 2009 to March 2010 (England only) – Fire in dwellings under construction

Area of Fire and Heat Damage	No Special Construction		Timber Frame	
	Count	Percentage	Count	Percentage
None	39	17%	1	3%
0-5m ²	97	43%	12	38%
6-10m ²	34	15%	4	13%
11-20m ²	16	7%	1	3%
21-50m ²	19	8%	2	6%
51-100m ²	13	6%	3	9%
101-200m ²	8	4%	4	13%
201-500m ²	1	0%	2	6%
Over 500m ²	0	0%	3	9%
Total	227	100%	32	100%

The orange shading in Table 2 indicates the type of construction that has a higher percentage of fires in the respective area of fire and heat damage. Timber frame fires under construction expanded to an area of over 51m² in 37% of cases whilst only 10% of other build methods did. It should be remembered that these are only figures for one year and although significant are not conclusive on their own.

The figures for non-residential buildings show a similar pattern to those above with 26% of fires in timber frame construction spreading to an area of over 51m² compared to 8% in alternative build methods.

2.0 Current Methods of Timber Frame Construction

2.1 Open Panel

The majority of timber frame constructed today is open panel and this is known to:

- Ignite quickly and easily
- Spread fire quickly
- Act as a fire crib
- Generate such heat that collateral damage to neighbouring buildings can be significant



Open panel timber frame. Photo courtesy of Milner Associates (formerly CCB Evolution)

Open panel timber frame's fire performance relies heavily on the gypsum plasterboard. When you consider that the plasterboard isn't generally fixed until the structure is complete then the dangers of unsecured multi-storey timber frame during construction become very evident.

2.2 Closed Panel Timber Frame

Closed panel provides improved fire performance as a result of the plasterboard on pre-fitted panels, however:

- Plasterboard can be compromised leaving unprotected timber based materials
- Fire can be started from cavity/external side where there is no protection
- Window and door apertures are exposed if not fitted out



Frame UK Closed Panel Production

Brian Coleman, chairman of the London Fire Authority, said: "Supporters of timber frame buildings say once they're built they're completely safe. But we know people drill holes in walls, which damages the building fabric and allows the timber to become exposed." (BBC News Website)

Although the chairman of the London Fire Authority was referring to finished structures the same point could be made about closed panel timber frame under construction, where holes can still be drilled and a determined arsonist could easily compromise the fabric of the building. This questions both the use of closed panel in isolation and compartmentation.

2.3 Timber Floors' Fire Performance

A holistic approach should be adopted when performing a fire risk assessment, considering both walls and floors. With that in mind it is critical to consider the fire performance of the three alternative generic timber joists:

I-Joists/I-Beams

- OSB/hardboard web burns quickly
- Once the webs have gone there is no structural integrity
- It may be possible to treat I-Joists post-manufacture with intumescent or other chemicals, this is yet to be demonstrated



Open panel timber frame with I-Joist floor

"Timber engineered 'I' beams are susceptible to structural collapse at an early stage" (Fire Safety in Construction, Health and Safety Executive, Oct 2010)

Open web Joists

Open web joists have 2 parallel timber chords, top and bottom, connected with structural metal webs.

- Metal webs will buckle and twist
- Nailplate grips will fail due to charring of timber chords



"In respect of open-web joists, tests have shown that nailplate joints will only support load for 2-4 minutes in a fire and their open web structure is likely to permit the more ready spread of the fire across the floor cavity" (Joist Selector for Domestic Intermediate Floors, Timbersolve, supported by DTI under "Partners in Innovation" programme 2002)

It would be clear that once fire has charred the flanges of an open web joist the steel, if not buckled through heat, will detach itself from the timber as the fire spreads. This will lead to failure of the floor earlier than would be anticipated with solid timber floor constructions. The floor failure creates instability in the supporting walls that lose the lateral support.

Solid Timber Joists

- Larger section takes longer to char
- Predictable performance
- Tests showed they provide 15 minutes towards fire resistance (Joist Selector for Domestic Intermediate Floors, Timbersolve, supported by DTI under "Partners in Innovation" programme 2002)



Floor Joists Comparison (Contributions to fire resistance)

Joist Selector for Domestic Intermediate Floors, Timbersolve, 2002

- | | | |
|----------------|---|-------------------|
| • Solid timber | - | approx 15 minutes |
| • I-Joists | - | 4-7 minutes |
| • Openweb | - | 2-4 minutes |

Studies performed in the US and Canada state the failure of engineered timber joists can occur in as little as 6 minutes when left unprotected (i.e. without plasterboard) compared to 19 minutes for solid timber.

This information clearly supports **FrameProtect™**'s holistic system, where FR Treated solid timber joists are critical to provide an enhanced fire performance system. It is possible that retardants could be developed that significantly improve the performance of open web joists and I-Joists.

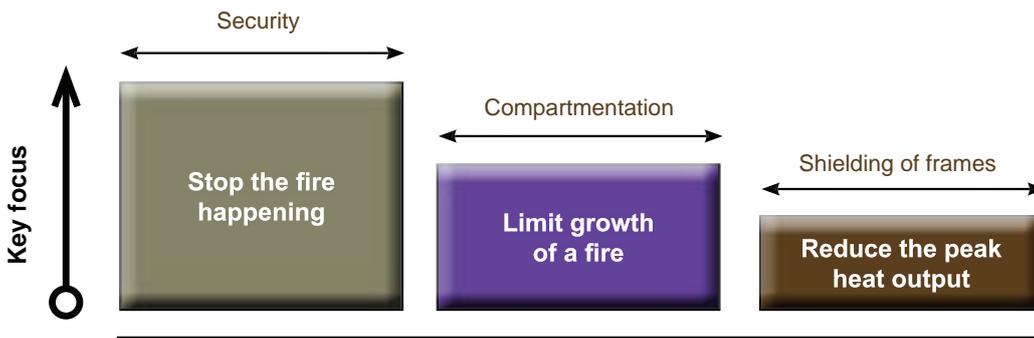
3.0 Wider Considerations

3.1 Fire Strategy

It is essential for every building project to have a well thought out fire strategy in place. This strategy will generally consider 3 action areas:

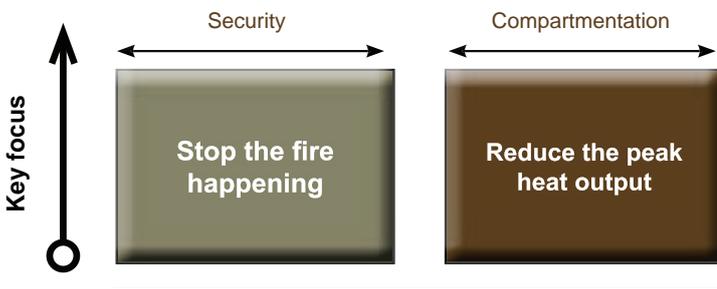
1. Fire prevention (stop the fire happening)
2. Limit growth of fire
3. Reduce peak heat output

Diagram 1: Industry's Current Actions



The above diagram demonstrates the industry's current actions, with the key focus being on-site security and management. Site security is not however foolproof and relies heavily on human actions such as staying alert and establishing and monitoring effective checks. While site security is undoubtedly essential it should not be relied upon in isolation.

Diagram 2: Risk Assessment Focus



Fire Engineers and HSE assessors are now aiming to stop the fire occurring and, should a fire occur, ensure the separation distances are effective by reducing the peak heat output.

Frame UK and the IWS Consortia believe that there is a third, more effective, strategy to reduce the risk of timber frame under construction (page 30).

3.1.1 Boundary Conditions & Separation Distances

Timber frame under fire conditions generates such heat that collateral damage to neighbouring buildings can be significant. Two examples would be the fires in Colindale and Peckham.

2006 July – Colindale

The fire raged through the block of flats, still under construction, and quickly spread to surrounding buildings. Up to 2,500 people were evacuated from the area and it took 100 fire fighters five hours to put out the blaze.

2009 November – Peckham, south London.

The fire destroyed a partially completed multi-storey development of timber-framed affordable homes and badly damaged two adjacent blocks of flats. About 150 fire fighters attended and 310 people were evacuated from their homes.

These fires demonstrate the need to develop wider boundary conditions where developers using timber frame are not adopting a robust fire system.

3.1.2 Peak Heat and Fire Growth Relationship

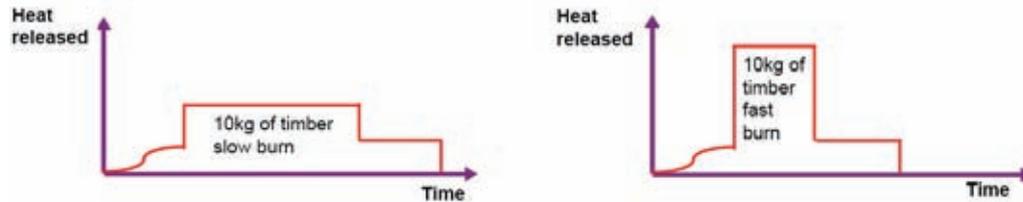
Why is peak heat important?

In a fire the energy given off is typically measured as total heat release and peak heat release. The peak heat release in a fire is the key aspect relating to fires in buildings and the effect on neighbouring structures. Two fires may have the same total heat released but can have different peak heat released.

Key point: Peak heat from a fire will determine the impact of the fire on neighbouring buildings.

e.g. A fire load of say 10kg of timber can be slow burning presenting a low fire peak heat or can be fast burning which releases heat faster thus typically producing a higher peak heat. In either case the total heat released based on 10kg of timber may be the same.

Diagrammatic view of burning timber heat graphs – same volume of energy but different peak heat.



Is radiant heat important?

A fire will emit heat as a form of energy. Heat emitted from a fire will warm the air causing hot air to rise and simultaneously an effect called radiant heat. The impact of radiant heat on timber frame fires can be significant as radiated heat will travel horizontally and this can cause heat to build up on neighbouring buildings local to a fire source. Radiant heat emitted from the fire is dependent on the type of flame and fuel source. The amount of radiant heat (or heat flux as it is called in Fire Engineering) emitted from a fire can be measured as the maximum energy delivered to a receiving surface. The heat received at a neighbouring building, if significantly high, can cause ignition of the neighbouring building.

If embers or brands of ignited material that can land on neighbouring structures are present, then the ignition of timber elements in the neighbouring structure will occur at a lower radiant heat value than that is necessary to ignite the timber with heat alone. BRE 187 provides guidance on radiant heat and is based on the assumption that where the radiant heat energy at the received surface is at 0.3 Cal/cm²/s timber will ignite if there is contact with flames carried by embers given off during a fire. Without contact with any ignition source timber requires to receive heat energy of 0.8 Cal/cm²/s to catch fire.

Current research is on-going with the principle that radiant heat received by timbers will cause charring at 300° which in turn means a loss in section and strength. Combustion of timber due to heat alone will occur at higher levels of heat. It is the lower heat levels at which charring and possible ignition with contact to naked flames can occur and it is generally accepted to be 12.5kilowatts/m².

Key Point: Maximum radiant heat per surface area that is received will determine if the neighbouring structure will ignite under heat or heat plus a flame source such as flying ember. A simple relationship can be assumed between peak heat and radiant heat, i.e. the higher the peak heat the higher the radiant heat.

Peak heat and radiant heat relationships

Fires with lower peak heat will have reduced radiant heat.

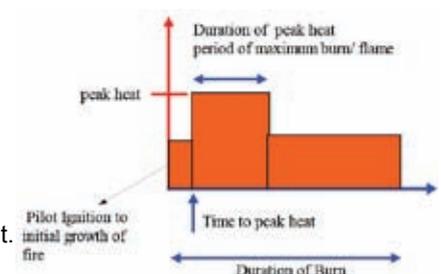
Why is the fire growth relationship important?

Fire generates heat which in turn creates conditions for ignition of flammable materials. If the growth of fire is reduced the amount of peak heat is reduced. If the peak heat is reduced the potential for rapid spread of fire is reduced. In addition if the growth of the fire is reduced then there are benefits in:

- Longer escape times / routes
- More time to fight the fire
- Less requirements to provide a shield to a fire to protect neighbouring buildings

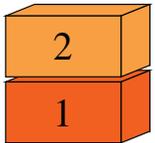
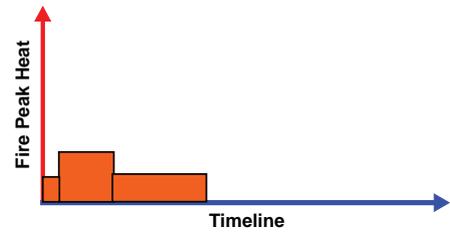
The following diagrams represent the fire growth curve when certain assumptions are made.

The number of units is indicated on the left hand side and the assumed heat profile on the right.

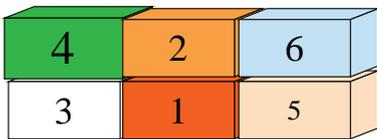
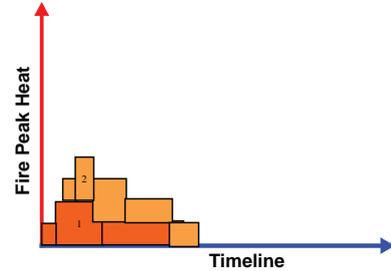




Single unit free to ignite and burn

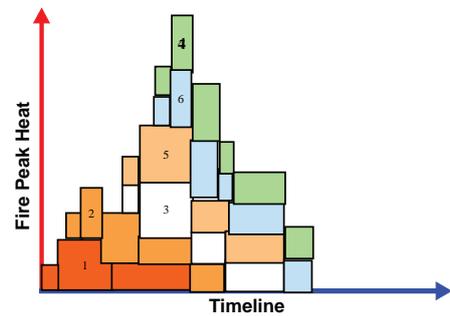


Two storey unit free to ignite and burn



If all the units are free to ignite in a steady way the fire load is intense and peak heat builds up quickly.

Peak heat rapidly achieved and fast burn times due to the heat build-up and fire spreading to each block.



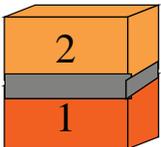
3.2 Compartmentation

Compartmentation is a popular form of fire protection for timber frame buildings under construction. Compartmentation is the process of sub-dividing a building into completely separated sections with fire resistant floors and walls to limit the spread of fire, smoke and gases.

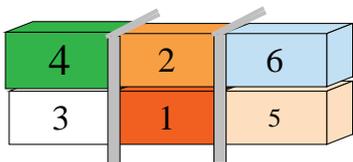
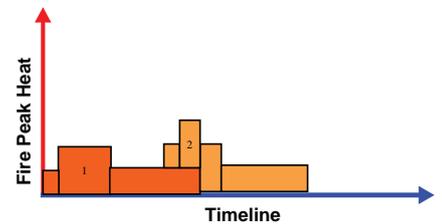
Effective Compartmentation

To provide compartmentation during the construction process requires a full time barrier between the heat source and the area being protected. The barrier is to provide, for an agreed time period, appropriate resistance to the transfer of heat and flame. In addition the supporting structure is to be sufficient to hold up the barrier for the agreed time.

The ability to ensure that the fire cannot move around the ends of a compartment wall and the stability of the wall to hold the compartment walling up are the critical elements in the design of compartmentation. The following diagrams relate to the peak heat and fire growth relationship (Section 3.1.2) when effective compartmentation is in place.

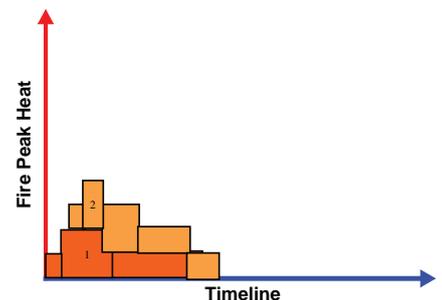


When a full effective compartmentation or growth of fire reduction is provided between floors then the fire is delayed in its spread to unit 2 and the peak heat is reduced



If an effective compartmentation between the mid-block and outer units can be achieved then the fire load is much reduced

Clearly removing blocks 3 to 6 by effective compartmentation reduces the total burn



However, compartmentation in isolation is by no means a robust and favourable defence:

- Adds significant time and costs
- Involves plasterboard going up on every room prior to building being watertight
- Can be compromised

“Compromised compartments (e.g. with unprotected openings) do not work either during construction or in completed buildings and can undermine fire precautions catastrophically.” (Fire Safety in Construction, Health and Safety Executive, 2010)



Frame UK's opinion – compartmentation is beneficial but cannot be taken in isolation

3.3 Automatic Suppression Systems

A relevant example of automatic suppression systems would be the use of water sprinklers. This can be a very effective means of reducing the spread of fire. A sprinkler system operates when heat at the site of a fire causes a glass component in the sprinkler head to fail, thereby releasing the water from the sprinkler head.

“To minimise the risk of fires spreading fire suppression systems such as temporary sprinklers should be installed in large timber framed construction sites” states the London Assembly (Fire Safety in London - Fire risks in London's tall and timber framed buildings, December 2010).

However, there can be on-site issues with temporary sprinklers:

- Requires insulation and protection during the construction process
- The installation of the system would mean areas of timber frame being exposed and at risk before the system is operational as it would be the timber frame structure that would physically support the sprinkler system

The Welsh Assembly has recently made sprinklers mandatory in all new (completed) homes, which is a positive step for increasing safety within completed buildings, however, this requirement does not apply during the construction phase and therefore does not reduce the risk.

Frame UK's opinion – sprinkler systems do not currently offer a solution that is effective during construction

3.4 Shielding

Protection for one building from another building that has caught fire can be achieved using heat resistant walls. These walls are called shields and can be made from a number of materials and systems. The principle of the shield is to mitigate the risk and effects of radiant heat generated from a fire.

A shield to be effective requires an understanding of the heat that will be generated and consideration of the reduction of heat that will be achieved for the building or escape route. The ability to support the shield under the heat and flames possible is also very important together with propagation of flames around edges.

To provide a shield around a building or on a limited area of a face of a building can be an effective solution to reducing separation distances between buildings during a construction process. The process considers the total loss of the frame and that the frame will have been engulfed in a fully developed fire. The shield is a last line of defence and does not provide any contribution to stopping fire growth or deterrent to possible arson attack.

Frame UK propose the use of shields that are integral to the frame. The use of closed panel construction provides not only resistance to fire growth from within but provides fire protection from radiant heat external to the building.

On some projects the use of a non-combustible sheathing board attached direct to a timber frame will provide both shielding benefits and in services structural and acoustic performance.

Frame UK's opinion – shields deliver defence against radiant heat if correctly designed and installed. Integral shields comprising [FrameProtect™](#) add value to all aspects.

3.5 Alarms

Heat Alarms – these are designed to work in completed buildings where an alarm can be raised in areas which are considered to be one compartment. A fire in a compartment will set off the alarm, thus warning occupiers of the danger, allowing them to escape. In the meantime the alarm allows the fire brigade to come to the scene before it has breached all parts of the building. In timber frame during the construction phase the fire spread can be so rapid that the alarms are only moderately appropriate.

Smoke Alarms – these are designed to work in a similar way to heat alarms in completed buildings where issues such as dust and debris are not as significant as on a construction site. In addition the exposed nature of the site will mean condensation build-up which in turn can cause malfunction.

Frame UK's opinion – alarms do not currently offer a solution that is effective during construction

3.6 Flame Retardants

To date the timber frame industry has been reticent to adopt flame retardants (FR) due to commercial considerations. However, this report will clearly demonstrate the enhanced performance a suitable FR can provide.

So, how do FRs work?

- Chemicals remain dormant until heated
- They form carbon char and harmless compounds to insulate wood
- Dilutes the flammable gases and reduces temperature
- Reduces flame spread and fire process significantly
- Limits smoke production

Wood Protection Association (WPA) study on the durability of impregnation treatments confirmed that :-

- » Protection lasts - provided they are suitable for the given environment
- » WPA Manual & draft European Standards take into account use in dry, humid & exterior conditions
- » Intumescent coatings typically have a life of 5 years (draft ETAG 028)

(Arch Timber Protection Flame Retardant Treatments CPD, 2010)

There are two main methods of treatment; impregnation and coatings.

Impregnation Treatments

- Controlled factory conditions
- Full traceability
- Impregnation of all faces
- Lasts for the life time of the building as a built in component and where not exposed to weathering over long periods

FRs applied by impregnation treatments cool and dilute volatile gases produced by the fire. As the chemicals thermally degrade they take heat out of the fire and release water vapour and non combustible gases. After the initial degradation they promote the production of char which prevents oxygen getting to the unburned wood and reduces the generation of further volatile gases.

Coatings

- Film forming - e.g. intumescent
- A requirement to re-coat after 5 years
- Non-film forming
- Usually applied on site to one face only
- Potentially less evidence of control and traceability
- Less robust against handling damage

Although FR coatings can be very effective, correct application and maintenance requirements can be difficult to monitor from a quality perspective. Generally, coating products should only be used to upgrade internal timbers that are already in-situ (in refurbishment, repair, maintenance and upgrading projects).

Pressure impregnation is the most effective method for treating timber used in new build projects. A wide variety of both solid timbers and board materials can be given a highly effective, assured and long-term FR protection.

When considering what FR to apply to your system it is worthwhile employing the relevant aspects of the Wood Protection Association's Fire Retardant Specifiers Checklist (19th January 2010):

1. What fire performance is required?
2. What fire performance properties are claimed by a specific product?
5. Evidence should be provided of compliance with the hygroscopicity test in prEN 15912. This ensures that in-service exposure to high humidity will not degrade the fire performance or cause surface disfigurement.
7. Quality assurance

In the Timber Trade Journal (TTJ) 11/18 December 2010 a new point is added to the checklist, "*If brush or spray site applied surface coating fire products are specified, performance is only as good as its application*".

3.6.1 Health and Safety

A wide range of FRs are widely used in many applications such as fire extinguishers, surface coatings, forest-fire fighting, textiles / furniture, plastics/synthetics and timber.

The chemical nature of the FR varies widely depending upon the end use. For example in the textile/synthetic sectors, brominated and antimony compounds are commonly used and there are environmental concerns over their persistent, bioaccumulative, and toxic nature. Likewise there are certain FRs for timber that are brominated or highly acidic.

The toxic nature of certain products types has had an impact on perceptions and raised concerns about their safety. However, the FR used by Frame UK for timber framing utilises specific chemistries that are free of all metals and halogenated compounds, including brominated and therefore has more favorable environmental credentials.

Frame UK's opinion – FRs designed specifically for timber frame construction can offer an effective solution in conjunction with a holistic system

4.0 Laboratory Testing Process

Small sample tests – cone calorimeter

Benchmark performance of treated and untreated samples

A cone calorimeter is a modern device used to study the fire behaviour of small samples of various materials in condensed phase. It is widely used to establish timber engineering product's fire performance.

- Time to ignition of the specimen
- The calorific value of the product (MJ/kg) (energy stored)
- Total heat release (MJ/m²)
- Total heat release plotted against time
- Heat release rate (kW/m²)
- Smoke production (m²)
- The physical behaviour of the product
- A prediction of product performance in the SBI tests



The testing undertaken was for timber studwork/flooring and sheathing/panel products (plywood, OSB, chipboard).

Single Burn Item (SBI) tests (EN 13823:2002)

The SBI test replicates a small fire in the corner of a room, constructed from the product to be tested. A flame from a burner with a known output is applied to the product. This provides a comparison to treated and untreated framing sections.

The key outputs from the SBI tests undertaken are:

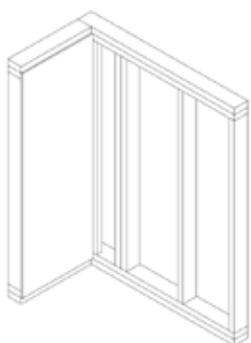
- Total heat released in a test from the sample panel
- Spread of the fire across the sample panel
- Behaviour of the sample panel under the heat source



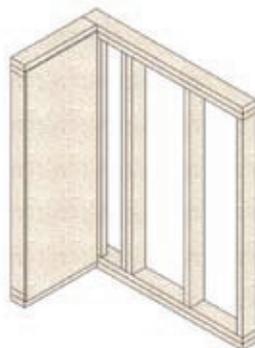
IWS SBI Tests at CIF

In the first series of tests IWS tested:

1. Open panel timber frame – without treatment to the product
2. Open panel timber frame – with IWS FR treatment to the product
3. Closed panel **FrameProtect™** – with IWS FR treatment (with enlarged opening for service holes)
4. Closed panel **FrameProtect™** – with IWS FR treatment (large area of plasterboard removed to expose frame and insulation)



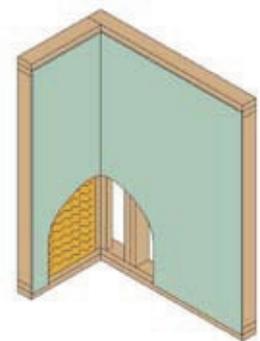
1



2



3



4

5. Results and Analysis

The following results were measured independently by CIF and the analysis has been taken from mA Report - FR-MA-2-11-10.

5.1 Cone Calorimeter Tests

All figures compared to OSB

		Chipboard Untreated (18.3mm)	Plywood treated (9.7mm)	Timber stud treated
Time to ignition		~ OSB	180% OSB	76% OSB
Time to flameout		N/A due to thickness	75% OSB	N/A due to thickness
% mass lost			86% OSB	
Total heat release			58% OSB	
Heat release rate	60 seconds	116% OSB	47% OSB	59% OSB
	180 seconds	112% OSB	53% OSB	54% OSB
	300 seconds	91% OSB	71% OSB	43% OSB

The **time to ignition** shows that IWS FR treatment prolongs the time to ignition for plywood. The value for plywood is considerably enhanced over both OSB and chipboard. The time to ignition value for the IWS FR treated solid timber product is shorter than for OSB; this is probably due to the behaviour of the solid timber compared to panel product wood in this test. Information from the FR product research team suggests that whilst this sample ignited quickly, BS476 Part 7 surface spread of flame data confirms that the FR treatment significantly reduces the spread of flame with a BS Class 2 result achieved.

The **time to flameout** (time for flaming to stop after the first ignition) is reduced for the IWS FR treated plywood compared to the OSB. In this test both samples burned through, however the plywood lost less mass than the OSB. This indicates that flameout was due to the charring of material stifling the flame in the plywood case. In the OSB tests, flameout was due to the total consumption of the sample in the test.

The **total heat release** (over the duration of the test) is greatly reduced for the IWS FR treated plywood over the OSB. This is related to the decreased mass lost by the plywood in the test. The treatment prevents it being burned up by promoting char and hence prevents energy release.

Time specific heat release. These figures show reduced heat release at each stage of the test for both of the IWS FR treated components. The chipboard figures are slightly increased over the OSB result. These results show that the fire treated components will contribute less heat to the developing fire than the untreated components. The heat release is a key parameter for the spreading of the fire throughout the structure.

From the results of the full envelope it shows the IWS FR treated plywood material:

- Takes longer to ignite than the untreated materials
- Stops flaming in less time than the untreated materials
- Loses less mass than the untreated materials and therefore could be correlated to release less heat to the fire (as SBI)

Both the IWS FR treated plywood and studs contribute significantly less heat to the overall fire as the fire propagates through the bulk of the material. This implies a significantly lower contribution to the growth of the fire.

5.2 Single Burn Item Tests Timeline (Open panel)



TEST 1

Untreated Open Panel sample	Test photos					
	Notes	Ignition of constant fire load	Flame growth at location of fire source noticeable Vertical height of flame increased quickly Fire spread across timber in the corner		Timbers in corner studs and OSB clearly ignited and flames noted to be present on timbers away from the fire load. Signs of fire spreading horizontally to sole plate and to head binder plus sheathed return wall	
	Heat release	At 0 mins = 0	At 5 mins = 25MJ		At 10mins - 80MJ	At 15mins
	Rate of growth					

TEST 3

Closed panel sample - service holes	Test photos				
	Notes	Ignition of constant fire load	Flames seen to enter enlarged service hole As seen through the service hole. Vapour control layer behind plasterboard seen to burn but not break through		Fire continues from original fire source No fire spread
	Heat release	At 0 mins = 0	At 5 mins = 0.6MJ	At 10 mins = 1MJ	At 15 mins
	Rate of growth				

NB. The preliminary findings of these tests as witnessed by mA are noted in the photographic report given above.

21 mins

					
		<p>Fire growth evident away from original fire source</p> <p>Fire spread to adjacent panels - growth downwards</p> <p>Significant heat from test</p>	<p>End of test - original fire source stopped</p> <p>Flames continue on the timber frame</p> <p>Frame removed from rig to extinguish</p> <p>Significant heat from fire evident</p>	<p>End of test - panel hosed down</p> <p>Full panel required hosing</p> <p>Damage to full panel - small section of OSB and framing left only</p>	<p>Final damage to panel - all components affected are damaged beyond repair</p> <p>Timber studs charred between 10% and 100% at far right hand corner</p>
- 150MJ	At 20mins - 220MJ	Total heat release = 230MJ			
		Rate of growth (FIGRA test value) = 1075			

			
<p>Fire from source only</p> <p>Fire only</p>	<p>Flames from original fire source only</p> <p>Fire enters service hole but no apparent problems</p>	<p>End of burner ignition (original fire source)</p> <p>No embers, charred sole plate and scorched plasterboard noted only</p>	<p>Scorched plasterboard removed to show untouched timber studwork behind vapour control layer</p> <p>Some charred (surface only) battens</p> <p>No damage to frame structure or insulation</p>
Heat release = 1.5MJ	At 20 mins = 2.5MJ	Total heat release = 2.5+MJ	
		Rate of growth (FIGRA test value) = Not measurable	

5.3 Single Burn Item (SBI) Analysis

		Untreated OSB & Stud	Treated Plywood & Stud	Treated Plywood & Stud as a % of Untreated OSB & Stud
FIGRA (W/s)		1076	413	38
Total Heat Release	5 mins	24	14	58
	10 mins	82	37	45
	15 mins	156	50	32

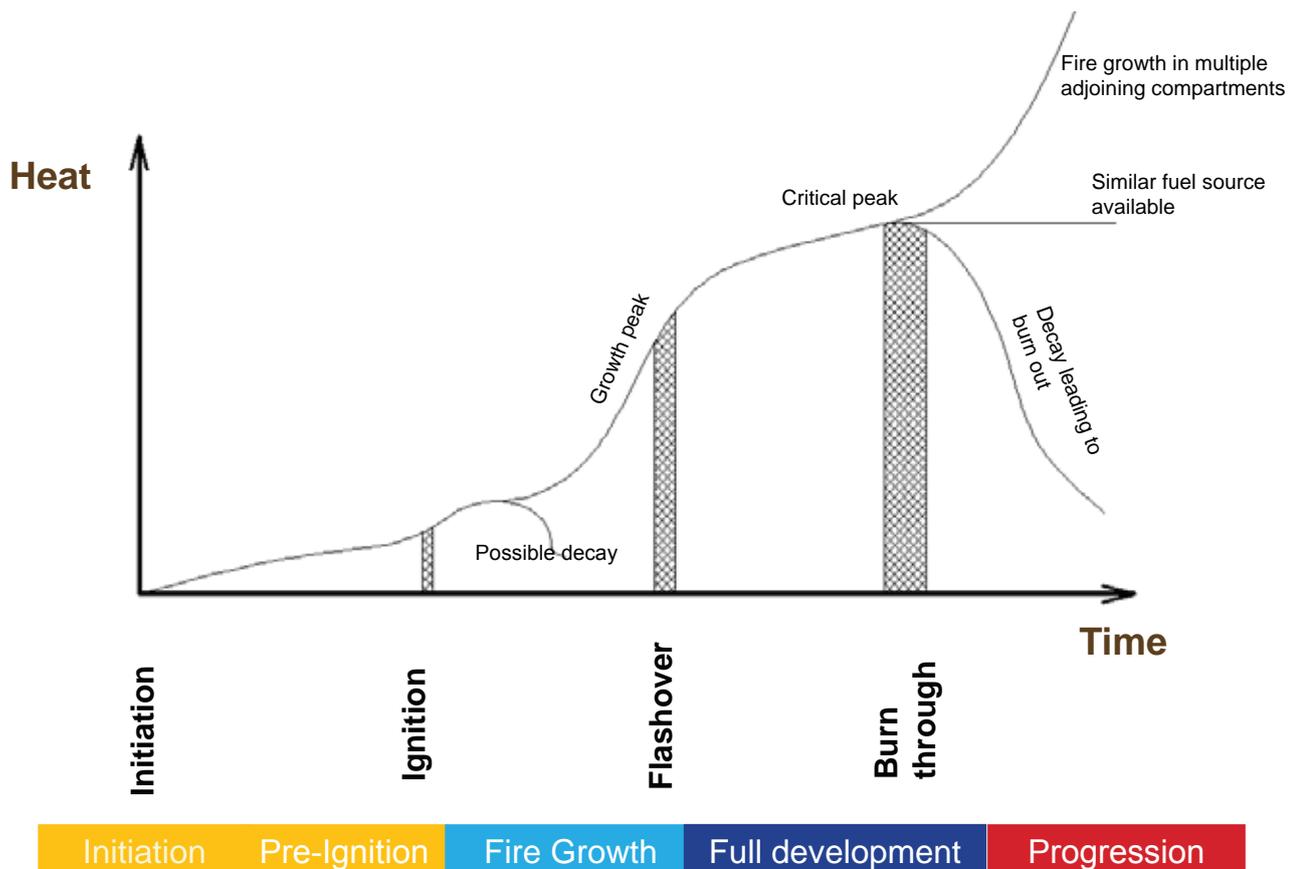
SBI Comparisons

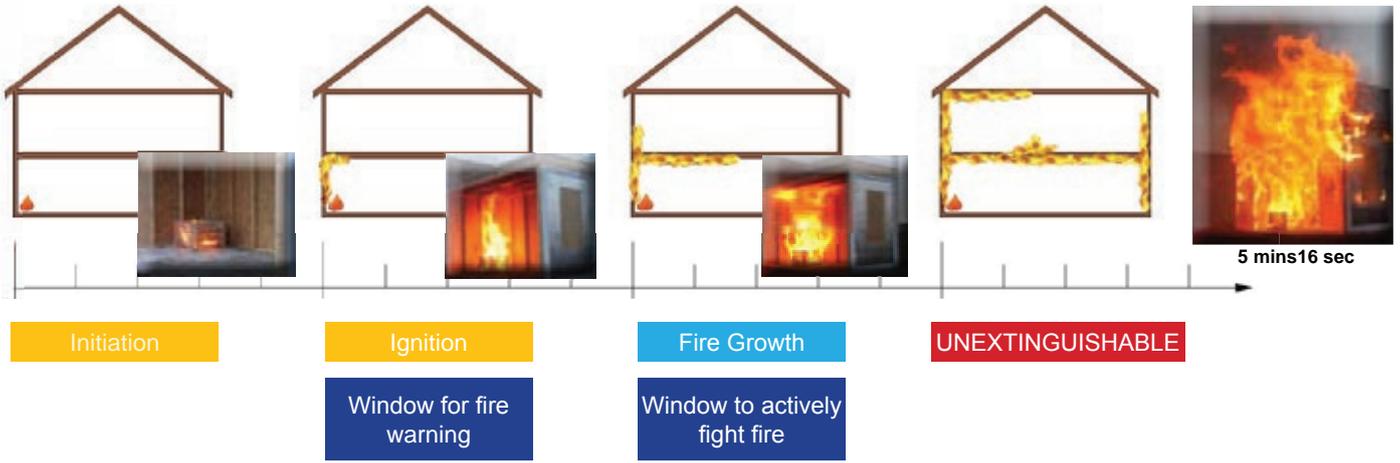
Heat Release Ratio:

- Untreated open panel : Treated open panel = 3.5 : 1
- Untreated open panel : **FrameProtect™** (vandalised) = 14 : 1
- Untreated open panel : **FrameProtect™** (with service holes) = 88 : 1

5.4 Larger Scale Tests

Frame UK and their partners performed a series of larger scale tests (bus shelter tests) to demonstrate the hypothesis that the initial lab testing provided. The tests were organised by Frame UK in partnership with IWS and Milner Associates and were witnessed by several senior fire officers and health and safety managers with extensive experience in timber frame construction. Prior to describing the results of the large scale tests it is important to explain the basics of fire growth.

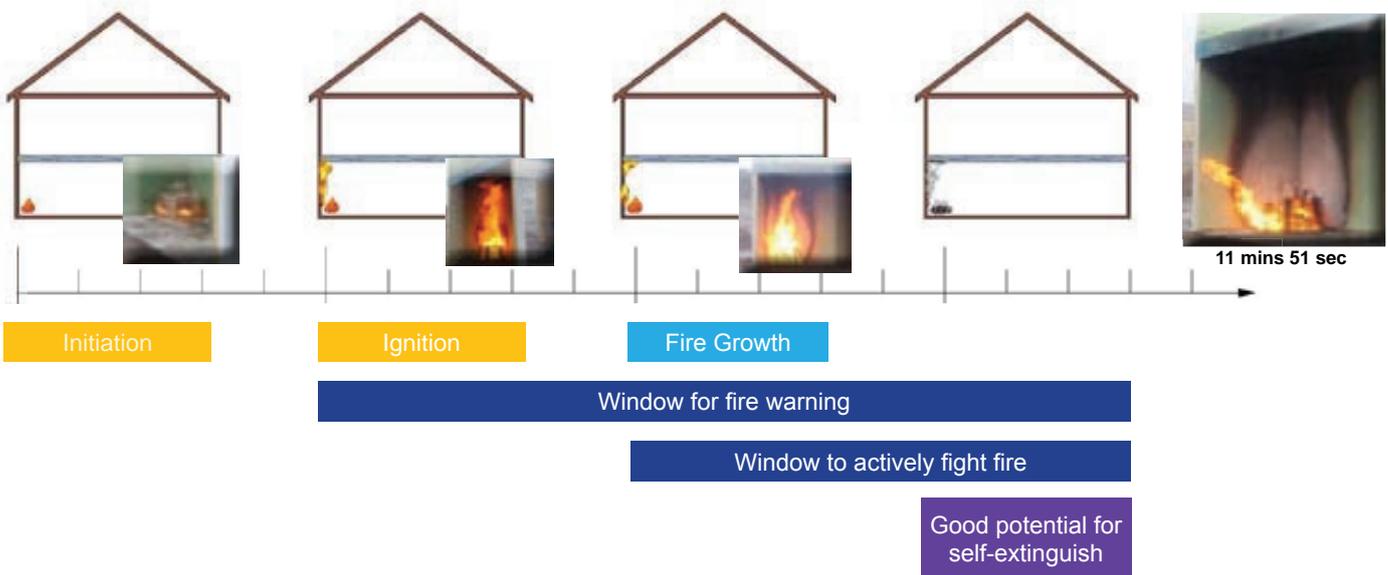




This test demonstrated that lightweight timber frame and I-Joists when ignited generate rapid and wide spread fire growth and provide an extremely small window of opportunity for firefighters to fight the fire. As recent high profile fires in timber frame builds have shown us, once the fire takes hold it is unextinguishable.



FrameProtect™ With IWS-Floors



This test demonstrated that where the **FrameProtect™** closed panel timber frame is treated with IWS-FR combined with a treated IWS-Floor it massively slows down the growth of the fire and reduces the spread of damage to a bare minimum, thus creating a large window to actively fight the fire and provides great potential to self-extinguish.

The Frame UK project team recommend that this combination of materials can be used in high risk scenarios, i.e. timber frame multi-storey projects in built up areas



6. Established Performance

6.1 Use of Flame Retardants

The results and analysis carried out support the HSE's opinion:

“Dutyholders should give serious consideration to the use of timber and/or materials that have received an appropriate fire protection/retardant treatment for timber buildings. This will not only provide additional safety during the construction phase, but gives added protection for the completed building.” (Fire Safety in Construction, Health and Safety Executive, Oct 2010)



FRs can significantly improve the fire performance of structural timber. Retardants are generally not designed specifically for timber frame and as such can have many weaknesses.

The **FrameProtect™** panel with IWS-FRs are water-based blends of synergistic fire retardant ingredients which were developed with only the timber building fabric in mind. IWS-FR:

- Was designed for the treatment of timber frame construction timbers and formulated for the specific fire scenarios for this end use
- Is highly concentrated liquids and require a single double vacuum treatment only to give the desired fire properties
- Does not contain halides (chlorides or bromides), metals, phosphates or volatile organic compounds
- Is neutral pH and non-corrosive to treatment plant components
- Is available in a water repellent form
- Does not need to be kiln dried after treatment
- Is non-corrosive to metal fixing and fastenings
- Has excellent smoke and smoke toxicity characteristics
- Provides impregnation on all faces
- Lasts for lifetime of building

6.2 Closed Panel

To date we have established that the **FrameProtect™**

1. Will provide the greatest defence against arson attack as:
 - It has the potential to self-extinguish
 - It significantly reduces fire growth
 - Even where significantly compromised the system will provide an enhanced fire protection system as it is robust from all angles
2. Tests have shown it reduces potential heat release up to 88 times making it significantly safer for neighbouring buildings
3. Gives firefighters greater confidence in their ability to extinguish a fire

In conduction with the **FrameProtect™** panel inclusive at the IWS-FR treatment effective growth of fire reduction between each of the units can be achieved. The fire load can be spread out in terms of the growth of the fire and peak heat released. Longer burn with slower growth allows the fire to be tackled. It could potentially enable project designers to reduce separation distances.

“IWS-FR, is the only FR designed specifically for timber frame construction that significantly improves the fire performance of timbers for the life of the building whilst also providing excellent ancillary properties “.

Dr Andrew Hughes, Technical Director, Arch Timber Protection

Tests have shown **FrameProtect™** reduces potential heat release **up to 88 times** making it significantly safer for neighbouring buildings

6.3 Systems Approach

Any structure is only as strong as its weakest component and this is very apparent when considering the fire resistance of timber frame buildings under construction. Products can be appraised in isolation but only systems can be appraised holistically. The most robust means of defence is to try and anticipate every eventuality for both fire ignition and spread.

FrameProtect™ is an integrated solution combining IWS floor and IWS FR treated wall elements.

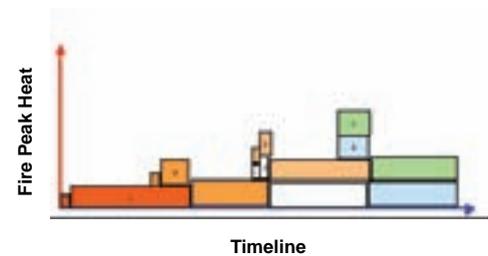
The **advanced system**, includes IWS-FR, IWS-Joist, studs, plywood, top and bottom rails, insulation, gypsum board, membranes etc.

The holistic system:

- Holistic approach to design and risk assessment
- Wall/floor junctions designed to minimise air gaps
- Water repellent treatment minimises expansion and contraction of structure, maintaining junctions and eliminating potential growth paths for fire
- Exclusive FR system provides enhanced protection and has been proven to self extinguish
- FR applied in an offsite, controlled environment after machining
- FR performance for the life of the building



If a fire starts in unit 1 **FrameProtect™** then system can stop the heat from growing to such an extent that ensures rapid growth does not occur

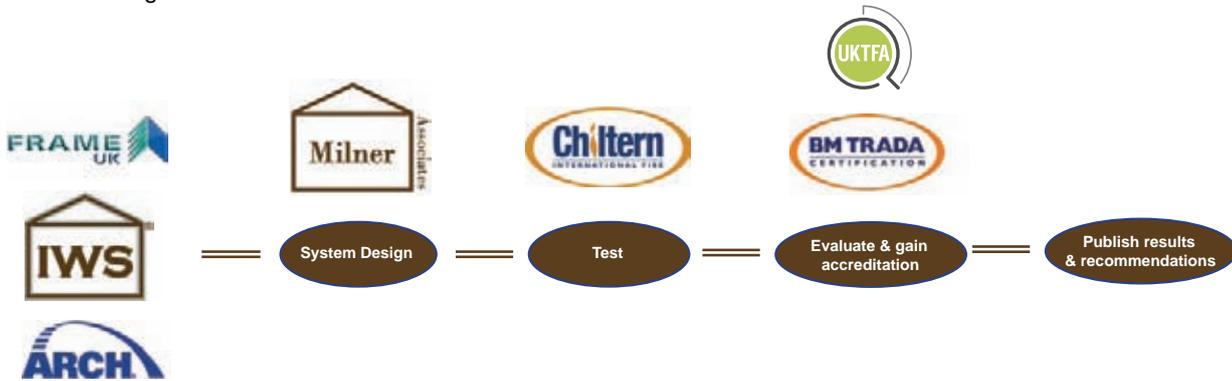


7. Recommendations

Frame UK and the IWS Consortia recommend several layers of protection:

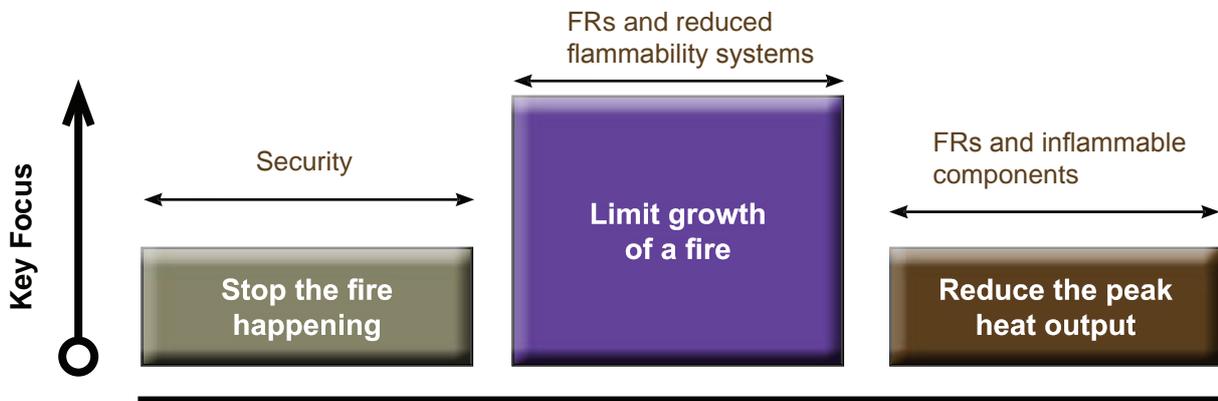
Collaborative R&D

Collaborative R&D with system providers, contractors and developers to ensure that the system is continually improved upon and the specified system is suitable on an individual project basis. The success of this project has relied heavily upon the combined expertise of the following:



7.1 Strategy

The Industry's current strategy focuses principally on preventative measures. Although IWS agree that the current strategy is a key element, it has been proven to be vulnerable when used in isolation. IWS have focused on limiting the growth of the fire, thus significantly reducing peak heat output and in addition making it more difficult for the fire to develop.



7.1.1 Stop the Fire Happening

Good Site Management

Good site management is an important step to reducing property damage and the potential for casualties. The UKTFA introduced an excellent site management and security monitoring tool, Site Safe, in 2010 developed in collaboration with fire authorities and the HSE. *“The initiative will involve a requirement for timber frame manufacturers to get clear agreement upfront from the main contractor/ developer that they understand the short-term risks when timber frame panels are under construction on large sites, and that they will take appropriate action to mitigate any risks. This process will be mandatory for all UKTFA members, and documented evidence that the discussion between the manufacturer and main contractor/developer has taken place will be maintained by the UKTFA member.”*

This approach will be backed up by a mandatory, two stage, independent audit. Stage 1 will involve checks to see that the short-term risks have been communicated adequately to the main contractor/developer. Stage 2 will require on-site assessment of the measures taken to mitigate the fire risk. It is increasingly common for a timber frame company to employ a third party service to carry out health and safety audits. It is the UKTFA's intention to expand this role to review actions taken to mitigate against fire during the construction phase and to make such inspections mandatory for large timber frame sites. Any issues identified will be passed to the main contractor and, where appropriate, the Health and Safety Executive." (UKTFA announces 'Site Safe' campaign 16 December, 2009 (Builders Merchants Journal)

The UKTFA's Site Safe has 16 steps as its foundations:

1. Compliance with CDM 2007
2. The Fire Safety Co-ordinator
3. The Site Fire Safety Plan
4. Checks, inspections and tests throughout construction
5. Communication and liaison
6. Promoting a 'fire safe' working environment
7. Fire detection and warning
8. Protecting emergency escape routes: the 35 metre rule
9. Building in fire protection along the way
10. Site security against arson
11. Protecting temporary buildings and accommodation
12. Safe storage of materials (including flammable liquids and LPG)
13. Designing out hot works
14. Keeping a tidy site
15. Dealing with plant and equipment
16. A 'no smoking' site



IWS support Site Safe and recommend that site management and security is tightened as far as possible. However, preventative measures will not solve the problem in isolation. A determined arsonist will find a way on to site into a position where they can start a fire and that is why protecting the actual building fabric itself is absolutely key.

7.1.2 Limit the Growth and Reduce The Peak Output

Adopting the following elements will assist in limiting the growth of the fire and reducing the peak heat output.

a) **FrameProtect™**

Frame UK recommend that only closed solutions that have an overall qualified performance are used. These solutions must be subjected to external, accredited assessment in line with UKTFA guidelines. Frame UK and their partners have a range of solutions designed to accommodate the various risk categories ranging from:

- Low risk - open panel with IWS Floors
- Medium risk - pre-insulated treated panels with IWS-FR Floors
- High risk - treated closed panel and IWS-FR Floors



b) FR Treatment

Not only does the IWS-FR considerably improve the overall fire resistance of the timbers and plywood, it is critical to the robustness of the solution from all angles. IWS-FR provides protection internally to the floor joists, timber frame walls and externally in the cavity through the plywood treated sheathing. IWS-FR provides protection to the studs so that if the arsonist compromises the panel the fabric will still provide a significant layer of protection.

IWS-FR

7.2 Timber Identification

IWS, in partnership with Arch Timber Protection, have introduced a timber identification scheme. This will enable building control inspectors, fire officers and firefighters to immediately identify the IWS-FR protection system.

"Marking scheme could be considered" to address fire and rescue service concerns
(Fire Protection Association, MMC presentation)



IWS-FR Treated Timber

IWS/Arch have identified a method of timber identification through a unique dye, IWS Fire Protection System will be purple.

7.3 Separating Distances

The potential for flammable structures to form a bridge between occupied buildings outside the boundary of the new build and those under construction (separating distances) is a recognised risk by the HSE.

Separating distances can be reduced by at least 50% using **FrameProtect™** System.

7.4 Certification

Frame UK, partners IWS and the UKTFA are collaborating with several leading bodies to develop a certification process for specific flame retardant applications to reduce the spread of fire and reduce the heat released during a local fire sourced condition. A certification scheme for the timber frame industry is critical as it will insure that solutions demonstrate the required performance levels through independent testing, technical appraisal and factory production control assessment. Every product manufactured will be qualified using the same criteria through an approved quality management system.

Frame UK recommend that all component manufacturer's aim to have their fire protection product incorporated into the end scheme to give timber frame manufacturers, developers, clients and the authorities confidence in the solutions available.

8. Conclusion

In conclusion, completed timber frame is as secure a form of building as any other and, as the CLG's data demonstrates, is no more likely to be set alight than alternative methods of build, either during construction or on completion. However, although there have been no casualties to date there are valid concerns over the fire behaviour of timber frame under construction, especially in high risk projects.

The **FrameProtect™** System, branded by Frame UK, where adopted, will minimise concerns regarding fire in timber frame products during construction as it:

- Reduces ignitability, fire propagation and spread of flame
- Reduces generated heat significantly – test results shows in excess of 70 times reduction
- Provides extra time to escape the site
- Behaves in a predictable manner
- Extends response times for fire crews to tackle situations
- Improves structural performance during and after incidents
- Can minimise the cost of subsequent remedial action through reducing damage and allowing fires to be extinguished
- May reduce the cost of insurance premiums
- Can reduce separating distances by at least 50%

Reduced growth of fire



Untreated open panel with I-Joist floors
Rapid fire growth



IWS-FR treated open panel with IWS-FR treated floors
Reduced fire growth



FR treated **FrameProtect™** panel with FR treated floors
No spread of flame and potential to self extinguish

Reduced separating distances to neighbouring buildings

You can break into a site, you can remove shielding products, you can compromise closed wall and floor panels and you can wedge a fire compartment door open. I have yet to see someone untreated an IWS-FR timber product. Fraser Steele, Glenalmond Timber Company

Reference Sources

UK Timber Frame Association website (www.uktfa.com)

Fire Statistics Monitor April 2009 to March 2010, Department of Communities and Local Government, Published: 20 August 2010, (www.communities.gov.uk/fire/researchandstatistics/firestatistics/firestatisticsmonitors)

English Housing Survey - Housing Stock Report (www.communities.gov.uk/documents/statistics/pdf/1750754.pdf)

16 Steps, UK Timber Frame Association, (www.uktfa.com/#/uktfa-literature-downloads/4538897734)

BBC news website, September 2010, (www.bbc.co.uk/news/uk-england-hampshire-11270132)

Fire Safety in Construction, Guidance for clients, designers and those managing and carrying out construction work involving significant fire risks, Health and Safety Executive, Second Edition 2010 (www.hse.gov.uk/pubns/books/hsg168.htm)

BBC news website, July 2010 (www.bbc.co.uk/news/uk-england-london-10645700)

Joist Selector for Domestic Intermediate Floors - An Aid to Builders and Specifiers, Produced by Timbersolve Ltd as part of a research and development project supported by DTI under the "Partners in Innovation" programme (http://www.timbersolve.co.uk/joist_guide_final.doc)

Fire Safety in London - Fire risks in London's tall and timber framed buildings, London Assembly, December 2010

Flame Retardant Treatments for Timber Based Products, CPD, Arch Timber Protection, 2010

Fire Retardant Specifiers Checklist, Wood Protection Association's (19th January 2010)

Timber Trades Journal, 11/18 December 2010

CIF (Chiltern International Fire) Report - Chilt/B10044

IWS Fire Protection System for Timber Framed Buildings, Milner Associates, November 2010

Site Safe, UK Timber Frame Association (<http://www.uktfa.com/#/sitesafe/4538986474>)

UKTFA announces Site Safe campaign, Builders Merchant Journal, December 2009

Modern Methods of Construction, What's It all About? Fire Protection Association, (www.arsoncontrolforum.org.uk/download/640)

Frame UK

Jenson House,
Cardrew Industrial Estate,
Redruth,
Cornwall,
TR15 1SS

t: +44 (0)1209 310560

f: +44 (0)1209 310561

e: info@frameuk.com

