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Wood Information Sheet

WIS 2/3-3

Subject: Fire
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Flame-retardant treatments for timber products

In many situations, timber and wood-based materials may be used in their natural, untreated state. However, flame-retardant (FR) treatments extend their use to situations that demand enhanced 'reaction to fire' properties.

This Wood Information Sheet (WIS) covers treatments that may be applied to wood and wood-based products both factory and site applied to upgrade their fire performance to Euroclass B or C or National class 0, 1 or 2.

This WIS is an overview of the subject with signposts to more detailed sources that are listed at the end. Further essential reading on this subject is the Wood Protection Association's *Flame Retardant Specification Manual* [1].

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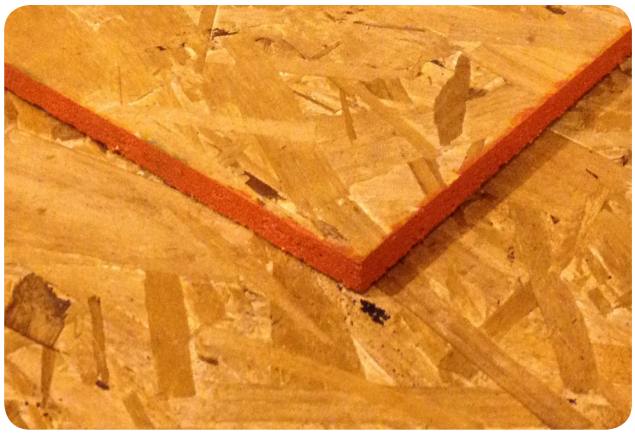

Figure 1: SmartPly oriented strand board, treated during manufacture.
Photo: Coillte

Key points

- Flame retardant treatments can enhance the reaction to fire performance of wood-based products. Reaction to fire performance is about combustibility and ignitability of a material rather than its ability to resist the passage of fire.
- There are three main types of flame-retardant treatments: impregnation with inorganic salt solutions or leach-resistant chemicals, chemicals inherently incorporated into the product at point of manufacture and surface coatings.
- These can be applied or incorporated into the product in a number of ways: during manufacture, post manufacture (often through a third party process) and on site.
- Any additional coating that is applied to a product that has a proven fire performance will likely affect this performance.
- There are two classification systems for flame retardance under UK building regulations: National class (uses BS Standard) and Euroclass (uses EN Standard). Manufacturers wishing to market products in the rest of Europe should follow the Euroclass system.
- Some European countries use the additional classifications for smoke and flaming droplets/particles, which are not regularly called upon in the UK.
- It is important to ensure that the field of application covers the particular application.
- Applying flame-retardant chemicals to a CE marked product invalidates the CE mark, even though it often remains visible.

Types of flame-retardant treatment

The term 'flame retardant' means treatments that enhance the reaction to fire performance of wood-based products. Reaction to fire performance is about combustibility and ignitability of a material (its contribution to fire growth) rather than its ability to resist the passage of fire (which is proved by fire resistance testing).

Unless a manufacturer is able to provide test evidence to the contrary, it should be assumed that flame-retardant treatments make no significant contribution to increasing the fire resistance of structures.

There are three main types of flame-retardant treatments:

- impregnation with inorganic salt solutions or leach-resistant chemicals
- chemicals inherently incorporated into the product at point of manufacture
- surface coatings.

These can be applied or incorporated into the product in a number of ways:

- during manufacture
- post manufacture (often through a third party process)
- on site.

Flame retardants incorporated during manufacture

Flame retardants can be incorporated during production. This is often the case for engineered timber products, such as OSB, MDF and chipboard.

Figure 1 shows a typical FR board treated during manufacture.

Advantages of flame retardants incorporated during manufacture

- Factory production control can ensure the quality of product is constantly maintained. The incorporation under factory conditions often allows the process and manufacture of the product under third party certification schemes.
- Often the treatment is through the entire product, making it less easy to remove by processes such as machining or washing, or accidentally by abrasion or leaching. Thus this treatment is likely to be more permanent in service than surface coatings.
- If the treatment is incorporated throughout the thickness of the product the cutting of the product post manufacture does not always reduce its fire performance.
- Treatments can be formulated to confer protection from decay and insect attack as well as fire.
- Products which cannot be vacuum pressure impregnated post production (for instance OSB or MDF) can have their reaction to fire performance enhanced during manufacture.

Disadvantages of flame retardants incorporated during manufacture

- The process is unlikely to be viable for bespoke or short production runs.
- It cannot be assumed that the addition of fire retardant chemicals within the manufacturing line of an existing non FR product will simply change only its reaction to fire properties. The product must be assumed to be different to the non FR product and be re-evaluated for its non fire properties.

Flame retardants applied post manufacture

The materials to be treated are sent post manufacture to a third party processing plant where the product is treated under controlled conditions. Simple dipping in a treatment solution does not usually result in loadings of chemicals sufficient to upgrade the reaction to fire performance of timber based products. It is therefore often necessary to employ an industrial process involving vacuum and pressure conditions to force the flame-retardant chemical solutions into the timber or board. Solid wood and plywood are suitable for vacuum pressure impregnation.

Figure 2 shows a proprietary process for impregnation with flame retardant.

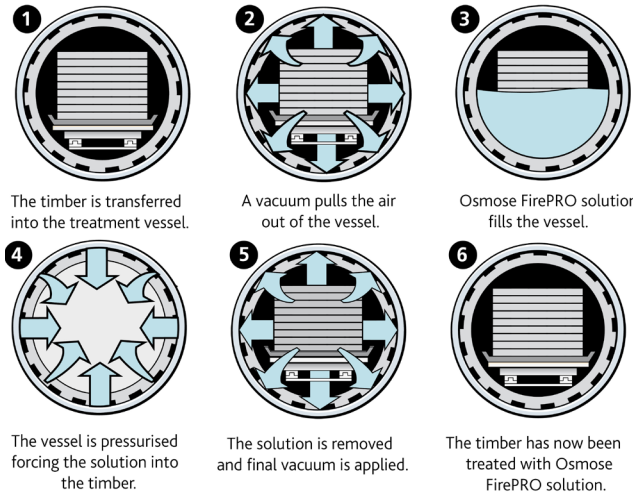

Figure 2: FirePRO treatment process.
Illustration: Osmose

The timber impregnated with the flame-retardant chemicals normally forms an envelope around an internal untreated zone of timber. Therefore, timbers should be machined to approximately their final dimensions before the treatment is carried out. This minimises the removal by machining of the most effectively treated timber. Machining operations post treatment must be restricted to cross cutting only as it is possible to negate the effect of treatment if all, or most, of the treated material is removed. Special precautions may be necessary to protect operators and in the disposal of wood-waste containing treatment.

Advantages of flame retardants applied post manufacture

- The incorporation under factory conditions allows the treatment process to take place under a third party certification scheme. Factory production control can ensure the quality of product is constantly maintained.
- Since the treatment penetrates to some depth below the surface, it is less easy to remove by processes such as machining or washing, or accidentally by abrasion or leaching. Thus this treatment is likely to be more permanent in service than surface coatings.
- The chemicals are generally cheaper than those used in site-applied coatings.
- Impregnation treatments can be formulated to confer protection from decay and insect attack as well as fire.
- Whole bespoke products can be treated after manufacture, for example, staircases.

Disadvantages of flame retardants applied post manufacture

- The materials to be treated must be sent to a special processing plant, incurring transport and handling costs, as well as the cost of processing.
- The capacity of the treatment plant limits what can be treated. For example, large, curved glulam arches or portals are unlikely to fit in any existing treatment vessel.
- Processing must be scheduled to fit in with the construction sequence.
- Not all wood-based sheet materials are suitable for impregnation processing due to swelling and strength loss with some types.
- Products which have a CE mark applied prior to treatment will require a new Declaration of Performance to be issued after treatment to declare the improved reaction to fire classification and any change in the non-fire properties that may have occurred through the process of treatment. This activity will require the involvement of a Notified Body.

Treatments applied on site

Treatments applied on site are often surface only treatments. These coatings have much the same range of types as the non-flame-retardant paints or varnishes – clear unpigmented varnishes, emulsion paints and matt or gloss oil-bound paints as well as acid catalysed systems. Thus, the methods of application (brushing, spraying or by roller) are similar. There are some water-based treatments that soak into the timber, but these need careful application and fire test evidence must be studied to ensure they really do suit the application and the timber used.

Some surface treatments are very specific regarding the substrates it is possible to treat. The manufacturer should always be consulted for third party test evidence to prove suitability.

Surface coatings may also be classified by their response to fire. Some coatings are designed to intumesce on heating (to swell up, foam and char) and, by so doing, entrap a thermally insulating layer of gas against the surface. The foams impede both the passage of heat and oxygen to the substrate and products of combustion from it. Other coatings, on heating, evolve gases or vapours which interfere with the chemistry of the flaming reactions.

A loading of flame retardant – at least to the minimum recommended quantity – *must* be applied evenly in each and every area to be protected. The fire test evidence should detail how the specimens were prepared for the test, if the treatment was applied with the timber in the horizontal position it may not be possible to get the required loading with substrates on site that are vertical, particularly with site applied products that are water based with limited ability to penetrate into the substrate.

Advantages of site-applied coatings

- Coatings applied to the surface of the timber have minimal effect on the physical properties of the substrate.
- Surface coatings are usually applied to the substrate at the point of use by simple and relatively cheap methods.
- There is no limit on the size of the piece to be treated.
- There is no additional transport to a processing plant.
- The coatings are either decorative in themselves or may enhance the natural beauty of timber.
- Because of their foaming action, intumescent coatings expand to fill or seal over gaps in the flame-retardant surface, which otherwise might be weak points to be exploited by the fire. While other coating types which evolve gases on heating may have the same sealing effect, a physical barrier of foam is perhaps longer lasting than a gaseous barrier.

- Flame-retardant paints which include antimony trioxide are as leach resistant and moisture insensitive as the corresponding conventional paints. These paints are recommended for use in humid interior environments or for exterior applications on buildings and do not need additional non-contributory finishes as protection against moisture.

Disadvantages of site-applied coatings

- It is more difficult to control quality on site, raising doubt that the correct loading for the required flame spread rating has been applied
- Although the coating product may have been manufactured under a third party certification scheme, such as EN ISO 9001, the application of it is often not covered. The application on site is critical to the performance of the coating and the manufacturer's instructions must be followed closely. Where possible coating products should be installed on site by an individual who is an approved member of a third party installer certification scheme.
- While it is possible for intumescent coatings to swell and seal off small gaps in the treated area, no second line of defence against fire attack exists as it does with deeper seated treatments, should areas be damaged by machining operations or moisture effects. Surface coatings are also more sensitive to damage by impact and abrasion than impregnation treatments.
- Intumescent coatings (but also some non-intumescent types) are especially sensitive to moisture. Their effectiveness may be destroyed by long exposure to high humidity conditions or washing the surface. Protective over coatings may offer some protection. The protective overcoat specified by the manufacturer should be used since other types may adversely affect the development of foam on heating. The overcoat protects the outer surface only; if it is penetrated, or if moisture gets behind it through the wood, the intumescent coating may be damaged. The fire test evidence must include any of these secondary coating applications which form the finished composite coating.
- The need for high loadings often renders the decorative effects of flame retardants inferior to those of conventional surface coatings.
- The protection can be negated by covering with unsuitable materials or by removal during redecoration. Complete retreatment of the new surface created is then necessary whereas, with impregnation treatments or with products where the fire retardant is incorporated during manufacture, some protection may be retained in the timber product.
- While the brushing qualities are in some cases not as good as those of the conventional equivalent, improvement by thinning is not advisable because a minimum loading must be applied to achieve a required reaction to fire performance. Obtaining such a loading by many thin coats would be uneconomic in labour terms.
- Some coatings do not give the timber the appearance desired by the specifier.

Compatibility of FR timber products and treatments with additional coatings

Any additional coating that is applied to a product that has a proven fire performance will likely affect this performance. The addition of a decorative coating can make a significant difference to its performance, particularly in the Euroclass test methods. The addition of varnishes, paints, coatings, veneers and laminates can often greatly decrease the performance of a flame-retardant product and new test evidence must be gained to prove that the new composite product still achieves the required performance.

A general misconception is that manufacturing a product made of components which have a performance of Euroclass B, for example, will lead to the finished product being Euroclass B, without further testing. This is not always the case. For example, purchasing a Euroclass B laminate and securing it to a Euroclass B FR MDF board can result in a product with a worse performance than Euroclass B. Only a laminate that has been fixed in the same way to the same board and successfully tested will demonstrate compliance. If the laminate was tested on a material of limited combustibility such as plasterboard, then the same performance cannot be expected on an FR MDF board, and the classification evidence is not valid for the application in this end use.

In the case of intumescent coatings more than one company has advised that over-painting its intumescent finish with polyurethane varnishes would have destructive effects on the ability of the coating to foam or intumesce. Conversely, another company has had satisfactory tests performed on softwood painted with the intumescent flame-retardant paint alone, the flame-retardant paint over painted with emulsion paint and the flame-retardant paint over painted with oil-based undercoat and gloss paint.

The suppliers should always be consulted before painting over any flame-retardant timber products.

Performance requirements

UK Building Regulations

Table 1 lists the relevant building regulations that apply in various UK jurisdictions.

Each of these countries requires products to achieve a defined performance within certain areas of buildings. In all cases the National test evidence (BS) is accepted alongside the European classification evidence (EN). The National classifications do not automatically equate with the equivalent European classifications, therefore products cannot typically assume a European class, unless they have been tested accordingly.

Table 1: Building regulations governing fire

Country	Document
England and Wales	*Approved Document B Fire Safety* [2]
Scotland	*Technical Handbooks* [3]
Northern Ireland	*The Technical Booklet E Fire* [4]

Table 2 lists the National and European fire test classes and their co existence within UK building regulations.

European building regulations

Across Europe each member state has its own building regulations and in each case they must accept European evidence as an alternative to their own national evidence as in the UK. For this reason it is often beneficial to have European test evidence as it is likely to be accepted throughout Europe where the British national evidence would not be.

Table 2: National and European fire test classes and thier coexistance with building regulations

National Class (BS)		Euroclass to EN 13501-1 (EN)		
Performance	**Required test evidence**	**Performance**	**Required test evidence**	**Definition**
Non combustible	BS 476-4	**A1**	EN ISO 1182 & EN ISO 1716	Class A1 products will not contribute in any stage of the fire including the fully developed fire. For that reason they are assumed to be capable of satisfying automatically all requirements of all lower classes
Limited combustability	BS 476-11	**A2-s3, d2**	EN 13823 & EN ISO 1182 or EN ISO 1716	Satisfying the same criteria as class B for the EN 13823. In addition, under conditions of a fully developed fire, these products will not significantly contribute to the fire load and fire growth
0	BS 476-6 & BS 476-7	**B-s3,d2**	EN 13823 & EN ISO 11925-2	As class C but satisfying more stringent requirements
1 & 2	BS 476-7	**C-s3,d2**	EN 13823 & EN ISO 11925-2	As class D but satisfying more stringent requirements. Additionally under thermal attack by a single burning item they have a limited lateral flame spread
3	BS 476-7	**D-s3,d2**	EN 13823 & EN ISO 11925-2	Products satisfying criteria for class E and capable of resisting, for a longer period, a small flame attack without substantial flame spread. In addition, they are also capable of undergoing thermal attack by a single burning item with sufficiently delayed and limited heat release
4	BS 476-7	**E/E-d2**	EN ISO 11925-2	Products capable of resisting, for a short period, a small flame attack without substantial flame spread
Unclassified	No test	F	No performance determined	Products for which no reaction to fire performance are determined or which cannot be classified in one of the classes A1, A2, B, C, D or E

Note: Performance requirements not specified in this table. Where a Euroclass classification includes 's3,d2', this means that there is no limit set for smoke production and flaming droplets/ particles.

Fire test evidence

National classification system

Surface spread of flame testing is undertaken to *BS 476-7. Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products* [5]. The Standard defines four Classes: 1 to 4 in decreasing order of performance. Most untreated timber and wood-based sheet materials are Class 3; those with a density of less than 400 kg/m^3 are Class 4.

Class 0 is required for surfaces in escape routes and circulation areas in public buildings. This has a reaction to fire performance superior to Class 1, and includes results from *BS 476-6. Fire tests on building materials and structures. Method of test for fire propagation for products* [6]. This test assesses the contribution of a material as fuel to a fire.

Class 0 is identified in building regulations as requiring:

- a Class 1 surface spread of flame relating to *BS 476-7*, and
- an index of performance I of not more than 12 and a sub index i1 of not more than 6 when tested to *BS 476-6*.

European classification system

European reaction to fire classifications are written in accordance with *BS EN 13501-1. Fire classification of construction products and building elements. Classification using test data from reaction to fire tests* [7].

A 'classification' is not the same as 'certification' of a product, which is used to demonstrate a product's compliance with specific criteria that could be unrelated to those required by a classification document.

The European system defines seven levels of performance and the classification is based on test results, the types of which are shown in *Table 2*.

In addition to the Euroclass letter there are additional criteria for smoke and flaming droplets/particles for Euroclass A2, B, C and D products. Although these are not usually specified in the UK (being set as no limitation in all UK building regulations) they are included in some European building regulations. It is also possible for Euroclass E products to have the addition of d2 in some cases. *Table 3* and *Table 4* list further classifications.

Table 3: Additional smoke classifications

Class	Description
s3	No limitation of smoke production required
s2	The total smoke production as well as the ratio of increase in smoke production are limited
s1	More stringent criteria than s2 are satisfied

Table 4: Additional flaming droplets/particles classifcations

Class	Description
d2	No limitation of flaming droplets/particles
d1	No flaming droplets/particles persisting longer than a given time occurred
d0	No flaming droplets/particles occurred

There is a further additional suffix that may be encountered for timber flooring products. This would be reflected by a subscript 'fl', for instance; $A1_{fl}$, $A2_{fl}$, B_{fl}, C_{fl}, D_{fl}, E_{fl}, and F_{fl}.

In some cases it is possible to classify untreated wood-based products without further testing as long as these products meet the requirements set out in the relevant harmonised technical specification. However wood-based products which have a flame retardant would *always* need to have a European Reaction to Fire Classification to EN 13501-1.

The EN 13501-1 classification document is used by product manufacturers and their clients to demonstrate that the product has achieved the required level of performance. This can be for compliance with national building regulations, CE Marking, or individual specifications provided by groups such as insurers, railways, the military or the marine industry.

The purchaser of the product should have a copy of the classification document to satisfy themselves that the product meets their requirements or the requirements of their own clients. The manufacturer must be able to provide this document when claiming a European reaction to fire classification. The Classification document must be from a third party test laboratory. Do not accept company branded literature as this will not prove compliance on its own.

The classification achieved is valid only for the product as it is described in the classification document and the associated test reports. The following should all be present in a classification document for a flame-retardant timber based product:

- third party laboratory's name and address and Notified Body number
- product name
- product description
- references to any test reports and extended application documents that it is based on
- the classification itself
- field of application (including applicable product variations and end use applications)
- authorisation signatures.

The document should look the same throughout Europe, regardless of which laboratory produced it. Classification documents include a statement that they should be reviewed if over five years old to check if any recent changes to standards have affected the classification.

It is important to ensure that the field of application in the supplied classification covers your end-use application. The field of application is key to ensuring the product will perform satisfactorily once installed. It will usually include a description of any product variations that are allowed (or importantly not allowed) and also, critically, give the end-use applications where the stated Euroclass performance can be achieved. For flame-retardant timber treatments and treated products the key criteria to look for in the field of application will be subtly different, depending on what the classification has been based on. There are three main types:

- classifications for coating products that do not penetrate the surface
- classifications for treatments products that penetrate the surface
- classifications for treated timber products as a whole (timber based products already treated with flame retardant).

Table 5 shows examples of what to look for in the field of application for the different potential types of classification.

With treatments that penetrate the surface of a product the timber that is being treated can greatly affect the performance achieved. It is not possible to test on one substrate and get coverage for all timber based substrates in the same way that you can for coatings that sit only on the surface of the timber. For this reason it is critical that:

- When applying chemicals that penetrate into the surface of the timber product the species or type of product that is being treated must be as defined in the classification document.
- When having a product third party treated or purchasing an already treated timber product the classification must cover the treated timber product. If it is solid wood it must give the correct species in the product variation section of the field of application. If it is an engineered timber product it must give the trade name of the treated product. In the case of plywood it is also good practice to see that the species and number of veneers is stated as there is great variation in the treatability and performance of plywood.

Care should be taken when reviewing Classification documents in regards to the term 'substrate'. *Table 5* explains one way of defining them but not all laboratories use the same terminology. Ensure that you have understood the meaning of a treated 'substrate' and the substrate that may exist behind the treated timber product, and that the two are not confused.

Durability of reaction to fire

In some situations it is required that the durability of the reaction to fire performance of a product be declared. The Technical Standard *PD CEN/TS 15912:2012 Durability of reaction to fire performance. Classes of fire-retardant treated wood based products in interior and exterior end use applications* [8] is one way that this performance can be determined. This specifically assesses the durability of the reaction to fire properties only. No change in any other properties are evaluated with this method. There are four DRF classes set out in the Technical Standard:

- ST– short term (this requires no testing under TS 15912)
- INT1– interior dry applications
- INT2– interior humid applications
- EXT– exterior applications.

The level of testing required increases through the classes. The DRF classes are not yet widely used outside the Nordic countries but, as knowledge of them increases, they may be used more widely to ensure the flame-retardant treated timber products being used will maintain their performance for extended periods. In the meantime the *WPA Flame Retardant Specification Manual* has a long-established and useful classification for impregnation flame-retardant products mirrored by the TS 15912 classifications. These are WPA types DI (dry interior), HR (interior humidity resistant) and LR (exterior leach resistant).

Table 5: Criteria in the field of application

	Classification based on:		
	Coatings that do not penetrate the surface (classification based on surface coating product only, not the composite product)	**Treatments that penetrate the surface** (classification based on the FR chemical product only, not the composite product)	**FR timber-based products** (classifications for the composite product incorporating the timber and the FR)
Criteria	**Product variations in field of application**		
Species/timber product	N/A	N/A	The species of timber used or the engineered timber product should be stated
Treatment applied	Required mass per unit area and method of application (for example, brush applied)	Usually this will detail the level of active chemical that must be in the finished timber product, this is usually measured in kg/m^3 in the UK and kg/m^2 in Europe. As this may change depending on other product variations this is sometimes displayed as a number of tables or charts indicating what the required retention level is for a given change in product variation	
Thickness	N/A	N/A	An allowable range in thickness of the finished product
Density	N/A	N/A	An allowable range in the density of the finished product
Colour	Any changes covered in the colour of the coating	Any changes covered in the colour of the treatment	Changes covered in the colour of the finished product
	N/A	N/A	
Which surface has been classified	N/A	N/A	The side that the classification covers, often this will be both sides in the case of board products (but not exclusively) and often only one side in the case of cladding systems
Criteria	**End use applications in field of application**		
Substrate	What substrate can be coated, this should include density and thickness as a minimum*	What substrate can be treated, this should include density, thickness and species as a minimum	What substrates can be used *behind* the FR treated timber product
Air gaps	What air gaps are permissible behind the treated 'substrate': • none • ventilated • non-ventilated • free standing • client specific		What air gaps are permissible between the product and a substrate or behind the product and substrate: • none • ventilated • non-ventilated • free standing • client specific
Joints	What joints are permissible in the treated substrate: • horizontal • vertical • horizontal and vertical • none		What joints are permissible in the product: • horizontal • vertical • horizontal and vertical • none
Mounting and fixing	How can the treated substrate be mounted or fixed, for example, screwed to battens		How can the product be mounted or fixed, for example, screwed to battens
Exposed edges	Are exposed edges covered? If cut edges are likely to be exposed ensure the classification covers this and if required look for detail of what secondary treatment may be required		

Note: If the field of application states only one species and type of substrate (for instance Picea abies tongued and grooved), then only this substrate is covered. Often, testing on standard substrate (in accordance with EN 13238) for this product type allows for more generic coverage. However, this must not be assumed and is covered only if it is in the field of application.

CE marking

From July 1st 2013 a manufacturer, importer or distributer placing a construction product on the market must, when there is a published harmonised Product Standard to cover their product, place a CE mark on the product. This is under the *Construction Products Regulation* [9] and is EU law being fully adopted into UK law. There are, at the time of writing, five key harmonised product standards for common wood-based products which are:

- *BS EN 13986 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking* [10]
- *BS EN 14080 Timber structures. Glued laminated timber. Requirements* [11]
- *BS EN 14081-1 Timber structures. Strength graded structural timber with rectangular cross section General requirements* [12]
- *BS EN 14342 Wood flooring. Characteristics, evaluation of conformity and marking* [13]
- *BS EN 14915 Solid wood panelling and cladding. Characteristics, evaluation of conformity and marking* [14].

If a non-FR product being placed on the market falls under any of the above standards a CE mark must be applied and a Declaration of Performance produced for the product.

With the addition of a fire retardant the product will fall within the description of 'products/materials for which a clearly identifiable stage in the production process results in an improvement of the reaction to fire classification (for example, an addition of fire retardants or a limiting of organic material)'. For this reason the product will be at Assessment and Verification of Constancy of Performance (AVCP) system 1. This requires that the fire testing must be undertaken by a Notified Body, sampling prior to testing may also be required. A Notified Body will review all relevant test evidence, conduct an initial audit at the factory and then issue a Certificate of Conformity for the product. This allows the persons placing the product on the market to draw up a Declaration of Performance and then CE mark the product. However, at the time of writing, *BS EN 14080* and *BS EN 14081-1* do not cover the addition of fire retardants and, for this reason, products that are covered by these standards but have an FR added are not mandated to be CE marked.

Often with third party treatments, the products already have a CE mark applied prior to treatment, as a non-fire-retardant product. It must be understood that the treatment process will make this CE mark void even though in many cases it can still be seen. The product will need to be re-evaluated by a Notified Body after treatment to ensure there has been no change to the declared values for non-fire characteristics (structural).

Further information is available in *TRADA's WIS 2/3-56: CE marking: implications for timber products* [15].

Acknowledgements

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To provide members with the highest quality information on timber and wood products to enable them to maximise the benefits that timber can provide.

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Research is largely driven by the desire to update and improve our information so that it continues to meet our members' needs in the future.

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