



Compilation of International Building Regulations (Fire) Relevant for EPS/XPS

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SP Technical Research Institute of Sweden

Fire Technology

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(revised 2011-11-30)

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Abstract

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A compilation of international building regulations has been attempted. An undertaking of this kind is, by its very nature, nebulous and difficult to say the least due to the minutiae of differences in interpretation of seemingly similar regulations in their individual application. We have attempted to approach the topic in a systematic manner that has at times posed questions which have defied a single answer. This is particularly true in the EU where the CPD and associated harmonized Euroclass system seems straightforward at first glance, at least for those products where product standards exist (which is true for insulation materials). As the project has proceeded it has become painfully clear that the devil is in the detail, with application of the harmonized European approach differing significantly in the different member states, e.g. from essentially no material requirements in Sweden to stringent material requirements in Germany.

Nonetheless, it is clear from the compilation that the use of flame retardants in EPS/XPS is widespread, both in cases where this is a strict regulatory requirement (e.g., Germany) and in those where it is not (e.g., Australia).

The report is presented divided into European countries and non-European countries for the simple reason that the European countries have an overriding system (the CPD and Euroclass system) upon which they base their national regulations while those outside of Europe each have national codes.

The regulations themselves are summarized in Chapter 3 while their implications for European countries and non-European countries are summarized in Chapters 4 and 5, respectively.

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Key words: Polystyrene, EPS, XPS, flame retardant (FR), building regulations, fire requirements

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1 Introduction

Hexabromocyclododecane (HBCDD) was nominated for inclusion in the POP protocol by Norway in 2008. The Task Force on POPs (UN ECE) finished the Track A review at its 7th meeting, and at the 26th session of the Executive Body the Parties to the POP Protocol it was determined that HBCDD should be considered as a POP as defined under the Protocol. The Task Force on POPs was requested to continue its work, to proceed with the review of the substance, explore management options for HBCDD and complete the Track B review. As part of this work it is clear that an understanding of building regulations and their impact on the use of HBCDD is an important factor.

In September 2010, Swerea IVF received a commission to investigate whether building fire regulations have an impact on the use of HBCDD in EPS/XPS in building applications in UN ECE lands. As part of this project, SP Fire Technology was commissioned to collate international fire regulations with a focus on Europe, North America, Australia, and Japan.

The time available for this compilation has been short and the data presented in this report while not exhaustive does give an overview of the fire regulations as a basis for discussion of their impact on the use of HBCDD in EPS/XPS. The data compiled in this report is based both on in-house expertise at SP Fire Technology, in particular in relation to European Building legislation, and on replies to a questionnaire distributed to a selected group of colleagues internationally, and subsequent discussions with these colleagues. The subjects and the question posed in the questionnaire are given in Appendix 4. As part of the questionnaire, subjects have been asked to comment on whether existing regulations have an impact on the use of EPS/XPS in building applications in their country/countries of expertise. This information has been included where available. If not available, no additional investigation has been possible to ascertain this within the scope of this project.

It is important to state that all non-referenced information and conclusions given in this report is ultimately based on the knowledge and judgement of the authors.

2 Building applications of EPS/XPS

Expanded polystyrene (EPS) is a rigid and tough, closed-cell foam. It is usually white and made of pre-expanded polystyrene beads. Familiar uses include molded sheets for building insulation and packing material for cushioning fragile items inside boxes.

Extruded polystyrene foam (XPS) is a similar rigid, closed-cell foam which offers improved surface roughness due to higher stiffness and reduced thermal conductivity. Due to the extrusion manufacturing process, XPS does not require facers to maintain its thermal or physical property performance. Styrofoam is a trademarked name for XPS.

In building applications EPS/XPS can generally be used interchangeably, although XPS has better mechanical properties and higher moisture resistance which makes it suitable for demanding underground applications. Building and construction applications are the largest outlet for EPS accounting for around two-thirds of demand [1]. Common building applications include: insulation underground (tunnel linings, under road surfaces, as insulation between surrounding ground and a cellar structure), floors, walls and ceilings. In many cases the EPS/XPS is found as part of a complex structure, e.g. a facade system (as insulation) or sandwich panel.

This project will not specifically consider underground uses of EPS/XPS (which generally have less stringent, or no, fire performance requirements) but will focus on uses of EPS/XPS as building insulation and sandwich panels.

3 International Codes and Standards

3.1 Overview and Scope

Building fire regulations relate both to *Fire Resistance* and *Reaction-to-Fire*. Fire Resistance relates to the integrity of a fire compartment under the influence of a given fire. Fire Resistance testing assesses integrity, insulation and stability of the construction under well defined conditions. Regulations on fire resistance are put on construction products and building elements with a fire separating function. These type of construction do not normally contain EPS/XPS as polystyrene would not contribute positively to the integrity or the insulation properties of the construction during a fully developed fire. In this project we have interpreted the scope of the project to exclude a full compilation of regulations for fire resistance as this has no clear bearing on the use of flame retardants in EPS/XPS.

The Reaction-to-Fire of a product deals with characteristics such as ignition, flame spread, heat release rate, smoke and gas production, the occurrence of burning droplets and parts. This project will focus on the building fire regulations related to Reaction-to-Fire classification of EPS/XPS.

3.2 European Fire Regulations

3.2.1 Construction Products Directive (CPD)

The European Commission published the building products directive (89/106/EEG) in 1989, to promote free trade of building products within the European Union (and those countries outside the EU having an agreement with the EU to abide by the CPD, e.g. Norway). The directive contains six essential requirements that apply to the building itself:

- Mechanical resistance and stability
- **Safety in the case of fire**
- Hygiene, health and the environment
- Safety in use
- Protection against noise
- Energy economy and heat retention

Indeed, the entirety of the European activities concerning fire classification and fire standardization for building products rests on the single essential requirement of “safety in the case of fire”.

In order to determine whether a building product complies with the CPD, European classification standards are devised and referred to in Product Standards. Classification documents are developed within CEN, the European Committee for Standardisation, which call on standards also developed within CEN (or in some cases through ISO according to the Vienna Agreement).

The implication of the CPD is that building products must have a fire classification based on the same standards throughout Europe. The important issue is then how the classification standard is applied in each member country, i.e., the system itself is performance neutral. The European Classification Standards identify product performance but make no comment on what the performance should be for any given application. The level of safety a product must have in a building application in any member state is then the prerogative of building regulations in the specific member state.

A member state that regulates for a certain safety level will be able to identify the fire properties of a building product corresponding to that level according to the European classification standards. Products complying with the essential requirements of the directive are labelled **CE**. An overview of the system is given in Figure 1.

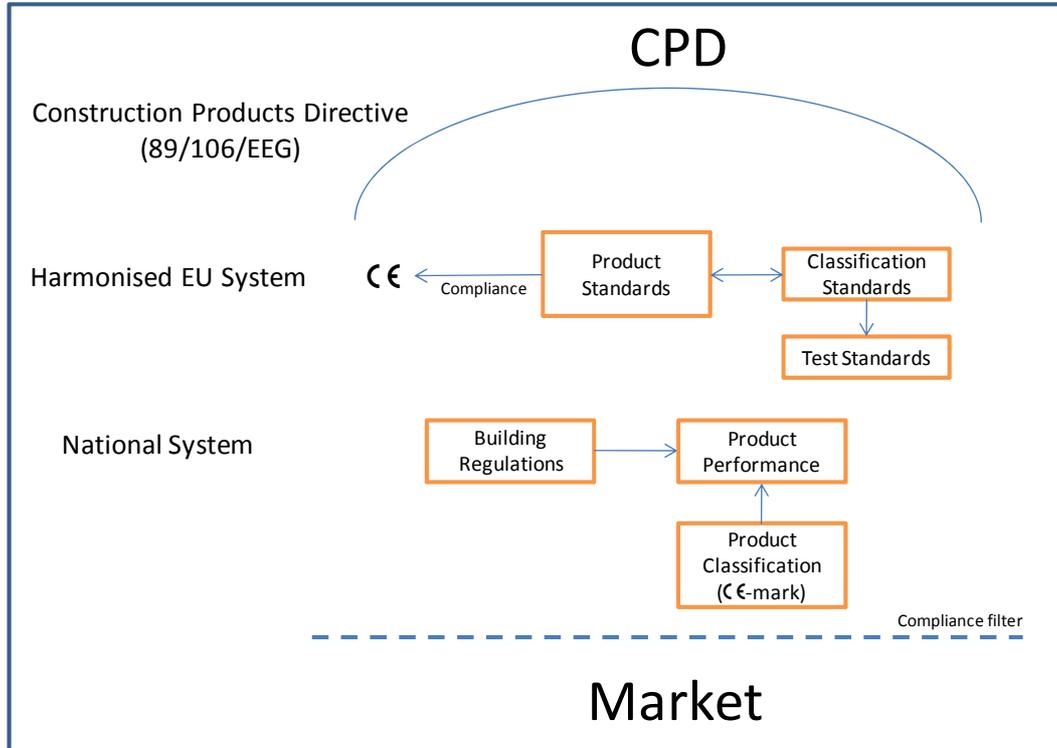


Figure 1: Schematic showing relationship between the CPD and the Market place for building products.

Once a product standard has been developed there is a continuous need for quality assurance associated with that standard. This can include interpretation of test procedures, extended application (EXAP) of test data, technical co-operation between test laboratories, agreements of praxis between certification bodies etc. The Fire Sector Group, consisting of notified bodiesⁱ for testing and certification throughout Europe, is responsible for discussing these issues and defining solutions if problems arise. Technical work such as the development of good technical practice in testing relies heavily on EGOLF, the European Group of Official Fire Laboratories, and various European industrial or trade organisations.

3.2.2 The Euroclass System

The European Commission published the Euroclasses in 2000 as a basis for classification of building products. The standard for Reaction-to-Fire classification of buildings products is EN 13501-1 [2]. Specific adaptations of the Euroclass system for different products have been developed and are given in the relevant product standards. The specifics can deal with the methodology for testing and determination of the Euroclass for any given product, not the definition of the Euroclass itself.

ⁱ A notified body is a body, for example a test laboratory or a certification organisation, which a member state has *notified* to the European Commission as suitable for performing testing/certification under the European system.

Seven main classes have been included in EN 13501-1: A1, A2, B, C, D, E and F. Additional classes apply to smoke development and the occurrence of burning droplets. Appendix 1 shows an example of the various Euroclasses for the reaction-to-fire performance of construction products excluding floorings and linear pipe thermal insulation products.

In many cases the test methods used are developed within ISO, the International Standardisation Organisation and later adopted within CEN through the Vienna Agreement. These standards are well known and some of them have been in use in various countries throughout the world for many years. ISO/TC92/SC1 has, in liaison with the CEN, actively been involved in the development of European standards. These standards are called EN ISO to indicate that they are both global and specifically European. The test methods included in EN 13501-1 are described in Appendix 2.

The test requirements for the classes included in EN 13501-1 have been designed based on the large-scale reaction-to-fire performance of products from a number of product groups. In particular, correlation has been made between EN 13823 (SBI) [3], the main test method in EN 13501-1, and ISO 9705 [4]/EN 14390 [5] which is a room scale test for surface lining products.

Class B in EN 13501-1 represents materials that do not give flashover in the reference room test, whereas Class C - Class E do give flashover after a certain time in the reference room test. Classes A1 and A2 are the highest classes and are not explicitly correlated to the reference room but represent instead different degrees of limited combustibility of a product. Class F signifies that no Reaction-to-Fire performance has been determined.

3.2.3 Product Standards relevant for EPS/XPS

3.2.3.1 European product standard for sandwich panels EN 14509

A specific European product standard for sandwich panels, EN 14509 Self-supporting double skin metal faced insulating panels - Factory made products – Specifications, was published in December 2008. Since January 2009, sandwich panel manufacturers can chose to **CE** - mark their products accordingly. From October 2010, CE marking will be compulsory for all sandwich panels sold in the EU.

The Reaction-to-Fire classification derived from the provisions in this standard provide regulators and other users with an essential parameter concerning fire performance of sandwich panels. Exclusively based on fire safety needs and with explicit justification, regulators may, for specific intended uses, set additional requirements to ensure that the fire safety of the construction is indeed in accordance with EN 13501-1. Other classifications, such as fire resistance, may also be required to achieve the intended fire safety objectives. In exceptional cases, other instruments such as fire safety engineering, may be used to assess the fire safety of the building.

For sandwich panels there are additional instructions regarding both reaction-to-fire and fire resistance tests in Annex C of EN 14509. The testing procedure of the tests required in EN 13501-1 is described in more detail in this annex.

Note that the specific class required for the use of a sandwich panel in Europe is the prerogative of regulators in the specific country of use within the EU.

3.2.3.2 European product standard for EPS EN 13163

This European Standard specifies the requirements for factory made products of expanded polystyrene (EPS), with or without facings or coatings, which are used for the thermal insulation of buildings. The products are manufactured in the form of boards or rolls or other preformed ware.

The Standard specifies product characteristics and includes procedures for testing, evaluation of conformity, marking and labeling. In the case of Reaction-to-Fire performance of the products EN13163 refers to EN 13501-1 with information on required testing frequencies but with no additional testing instructions.

3.2.3.3 European product standard for XPS EN 13164

This European Standard specifies the requirements for factory made products of extruded polystyrene (XPS), with or without facings or coatings, which are used for the thermal insulation of buildings. The products are manufactured in the form of boards, which are also available with special edge and surface treatment.

The Standard specifies product characteristics and includes procedures for testing, evaluation of conformity, marking and labeling. In the case of Reaction-to-Fire performance of the products EN13164 refers to EN 13501-1 with information on required testing frequencies but with no additional testing instructions.

3.2.4 Euroclass testing of EPS/XPS

Products including EPS/XPS cannot pass the requirements of the classes A1 and A2 in EN 13501-1, even with flame retardant treatment. The inherent energy in the polymer excludes passing the criteria of non-combustibility in EN ISO 1182 [6] and/or the criteria concerning heat of combustion in EN ISO 1716 [7].

Therefore the two test methods in EN 13501-1 that are relevant for EPS/XPS products are EN 13823 (SBI) and ISO EN 11925-1 [8]. EN 13823 is an intermediate scale test where two vertically oriented sheets of the product are placed in a corner arrangement and a burner is applied to the base of the corner. ISO EN 11925-1 is a small-scale test where a small flame is applied to a vertically oriented test specimen. More details of these methods are given in Appendix 2.

The applications of the Euroclass tests for the main type of EPS/XPS product categories are summarized in Table 1. The expected ranges of classification results for non-flame retarded (non-FR) and flame retarded (FR) EPS/XPS, respectively, are indicated in the table.

Table 1: Euroclass test requirements for EPS/XPS products and estimates of classification results.

| Product | Application of Euroclass tests | Non-FR product Estimate of Euroclass | FR product Estimate of Euroclass |
|--|---|--|--|
| EPS/XPS (EN 13163, EN 13164) | EN 13823 EN ISO 11925-2 <i>Resulting classification:</i> | < D < E <i>Euroclass F</i> | (B*)-D B-E <i>Euroclass (B*)-E</i> |
| Building elements including EPS/XPS | Surface: EN 13823, EN ISO 11925-2 Cut edge: EN ISO 11925-2 Covered edge: EN ISO 11925-2 <i>Resulting classification:</i> | B - D B - E < E B - E <i>Euroclass B-F</i> | B - D B - E B - E B - E <i>Euroclass B-E</i> |
| Sandwich panels, EPS/XPS core (EN 14509) | Surface: EN 13823, EN ISO 11925-2 Cut edge: EN ISO 11925-2 Covered edge: EN ISO 11925-2 <i>Resulting classification:</i> | B - D B - E < E B - E <i>Euroclass B-F</i> | B - D B - E B - E B - E <i>Euroclass B-E</i> |

* An exposed FR-EPS/XPS sample specimen would only in rare cases pass the Euroclass B requirements in EN 13823.

The interpretation of the indicative classification results in Table 1 is that Class B and C can only be obtained for EPS/XPS that has been treated with flame retardants in some way. In building elements or sandwich panels where the EPS/XPS is not exposed during the fire test, high fire performance can be obtained (corresponding to Class B and C) if the EPS/XPS insulation is sufficiently well protected from the fire. This may be true independent of whether the EPS/XPS has been flame retarded.

The relevance of testing sandwich panel products using EN 13823 (SBI) and the link to the reference room test has been discussed previously [9], as sandwich panel products are often used as self supporting building elements or mounted on a supporting frame. This has led to the development of special large-scale tests for sandwich panels [10-11]. These tests are not part of the European system but can have a role as demonstration tests in performance based fire safety engineering.

3.2.5 Compliance with the CPD and the Euroclass system

Compliance with the CPD requires that products, where a product standard exists, are tested and CE-marked to allow access to the European market. This does not, however, define what level of performance any given product must have to be approved for use in any specific country. In other words, the CE-mark is a prerequisite for access to the European market for EPS/XPS in building applications but the fire performance cited in the CE-mark may be as low as F (no testing required). Thus, potentially non-flame retardant products can be CE-marked and sold within the EU. Indeed, this is the case for

many building applications in Sweden where, provided the insulation material is not exposed in the final product, no further fire testing of the product is required.

The specific classification requirements in each country determine what performance is needed in order for the product to be marketed in the country of choice. This is discussed in more detail in Chapter 4.

The CPD has been in existence since 1989 as a *Directive* that is non-mandatory. There is a move in recent years to change the Construction Products Directive into the Construction Products Regulation which would essentially be mandatory in all EU-member states. The present projection for the implementation of this Regulation is 2013.

3.2.6 Additional informal requirements

In addition to the Directive and the associated Euroclass system there are numerous informal national systems in effect. In Sweden the “Pitch Fork”-markⁱⁱ (⚡) is a national mark indicating type approval. In Sweden the Pitch Fork is largely disappearing as it is not legally allowed in Sweden once a product standard allows the implementation of the CE-mark.

In Germany, the “Ü-mark” is widely used to signify acceptable performance of building material for use on the German market. This symbol signifies that not only are the EU-requirements met but also the specific German requirements which allow use of the product in German construction. This mark is very strong in the building market in Germany and while non-mandatory, is so well established that it is to all intents and purposes mandatory.

3.3 North American Fire Regulations

3.3.1 US

Building codes in the United States have developed over the years principally by locality and region. Local municipalities can choose to adopt their own building code version. Three different Model Building Codes have, however, been in effect since about 1940. Their use has been preferred in the following regions:

- The West: The Uniform Building Code (CBC) issued by the International Conference of Building Officials (ICBO).
- The Midwest and Northeast: The BOCA National Building Code issued by Building Officials and Code Administrators International, Inc.
- The South: The Standard Building Code issued by the Southern Building Code Congress International, Inc. (SBCCI).

These model building codes are favoured in the areas where they originated and are adopted in full or in part in state or city building regulations, although this is not mandatory. Local or regional variations in building code acceptance deal with issues and concerns peculiar to that specific area. Localities can adopt a model building code but with specific changes or provisions needed in their particular location.

ⁱⁱ This mark is regulated by The National Board of Housing, Building and Planning (Boverket) in Sweden.

Fire precautions are dealt with comprehensively in these model building codes. Many of the fire standards referenced in the codes are issued by the American Society for Testing and Materials (ASTM). Many building authorities also use the nationally available NFPA 101 Life Safety Code of the National Fire Protection Association (NFPA) [12], which also covers fire precautions. In addition, certain building regulations issued by the federal agencies apply nationwide. Minimum property standards have also been established by the Department of Housing and Urban Development (HUD) and the Department of Health and Human Services (HHS).

On December 9, 1994, the **International Code Council (ICC)** was established as a non-profit organization dedicated to developing a single set of comprehensive and coordinated national codes to promote code uniformity throughout the country. The ICC founders BOCA, ICBO, and SBCCI created the ICC in response to technical disparities between the three sets of model codes in use within the United States. This single family of codes has received widespread public support from leaders in the building community in the United States. The ICC issued their first **International Building Code (IBC)**, in 2000.

The IBC is not mandatory but it does appear to have met fairly broad acceptance across the US. This means that while the IBC may not be formally adopted, a particular state will have something similar in force. Further, if it is adopted it is often adopted with specific modifications for the state or municipality in question. The code, like the other three model codes has one primary chapter on expanded foam plastics, which includes most of the flammability regulations. It was agreed that standards adopted by the code would be based on consensus processes, for example, ASTM or NFPA.

The IBC essentially defines that expanded foam plastics used in building applications must be tested according to ASTM E84 (the Steiner Tunnel) for Reaction-to-Fire (for details, see Section 5.1).

In 2000, the **International Residential Code (IRC)** replaced the International One- and Two-Family Dwelling Codes (formerly CABO). Designed as a companion to the IBC and other International Codes, the IRC concentrates on one- and two-family dwellings, as well as townhouses up to three stories high. Flammability resistance of plastics in residential housing is no more stringent than in other constructions.

3.3.2 Canada

The regulation of buildings in Canada is the responsibility of provincial and territorial governments. Each of the 10 Provinces and 3 Territories have their own building code. All of the provincial and territorial building codes, however, are based on a single model code, the National Building Code of Canada (NBC). Although the NBC is intended to establish a minimum standard of fire safety for the construction of new buildings or the renovation of existing buildings, several provinces make amendments to the NBC that render their codes somewhat more demanding.

There are requirements both on material level and on the finished product. The test methods relevant for EPS/XPS insulation are: CAN/ULC-S124, "Test for the Evaluation of Protective Coverings for Foamed Plastic" and CAN/ULC-S101, "Fire Endurance Tests of Building Construction and Materials".

3.4 Other regions

3.4.1 Japan

In 1998, a revision of the main parts of the BSL (Building Standard Law), including the fire safety design systems, was published and came into effect in 2000. This revision has started a process of changing from a specification-based (i.e. prescriptive) to a performance-oriented design regulation.

The new version of the BSL places *Basic Requirements* and *Performance criteria* on building parts and materials. These are divided into fireproof, fire preventative construction, non-combustible materials, quasi-combustible materials and fire retardant materials. Based on the performance of tested materials, a “performance evaluation report” is issued and can be used to obtain approval for use.

Non-combustible materials are classified based either on ISO 1182 [6] where a temperature rise of no more than 20 °C is allowed, or using the Cone Calorimeter (ISO 5660-1[13]) at 50 kW external heat flux, where the total heat release is not allowed to exceed 8 MJ and the maximum heat release must be less than 200 kW/m² during the whole 20 minute test period. Clearly EPS/XPS cannot meet these test requirements even when treated with flame retardants.

Quasi-combustible materials are classified either based on ISO 5660-1 or in the Box Heat Test, ISO 17431 [14]. The classification requirements are the same in ISO 5660-1 with the exception that the test period is only 10 minutes. In the Box Test a total heat release of 30 MJ is allowed with a maximum heat release rate of 140 kW. Further, no burn-through is allowed.

Flame retardant materials are also classified using the Cone Calorimeter or the Box Test. In this case the test period is only 5 minutes and the same classification criteria apply.

3.4.2 Australia

The Commonwealth of Australia consists of six states - New South Wales, Queensland, South Australia, Tasmania, Victoria, and Western Australia - and two Territories – the Australian Capital Territory where the capital, Canberra, is situated, and the Northern Territory. Building regulations are the responsibility of the states and territories. All the State and Territory Building Regulations call up the Building Code of Australia (BCA).

The BCA is published by the Australian Building Codes Board (ABCB). The BCA is performance based. It contains Objectives, Functional Statements, and Performance Requirements. The Performance Requirement for materials is that they must resist the spread of fire and limit the generation of smoke, heat, and toxic gases to a degree appropriate to the building type. The BCA also contains prescriptive Building Solutions that are “deemed-to-satisfy” the Performance Requirements without further testing.

Controls on buildings are based on building classification. Broadly speaking, the classes are:

1. Single detached houses
2. Apartments
3. Hotels and boarding houses
4. Caretaker cottages on other buildings
5. Offices
6. Shops

7. Carparks and warehouses
8. Factories
9. Health care and assembly buildings
10. Outbuildings

The scope of the requirements for Classes 1 and 10 differs from those for Classes 2 to 9. (Class 4 is treated as a special case of Class 1).

Classes 2-9

The test methods used to ascertain whether building materials or components meet the deemed-to-satisfy provisions of the ABCB are described in AS 1530.1 (the combustibility test), AS 1530.2 (the flammability test), AS 1530.4, (the fire resistance test), AS ISO 9705 (the room corner test), AS/NZS 3837 (the cone calorimeter test), AS ISO 9239 (the flooring radiant panel test) and AS/NZS 1530.3 (the Early Fire Hazard Test).

Controls on wall and ceiling linings are based on testing in AS ISO 9705, and in some cases, AS/NZS 3837. Controls on flooring are based on testing in AS ISO 9239. AS/NZS 1530-3 (the Early Fire Hazard Test) applies to all other building materials and components other than thin flexible materials.

Where EPS/XPS are incorporated in a building system, such as sandwich panels, the system usually requires testing in AS ISO 9705. Where EPS/XPS are installed as in-ceiling or in-wall insulation, testing to AS/NZS 1530.3 may be required.

Classes 1 and 10

There are very few requirements for fire properties of building materials in Classes 1 and 10. There are, however, consumer regulations relating to the use of insulation in houses. These vary with the nature of the insulation. For instance, there are specific requirements for shredded paper. There are, however, no specific requirements for EPS/XPS.

Two other standards are commonly used to assess the fire performance of plastic materials in buildings but as these standards are not referenced in the ABCB they are not mandatory. The first, AS 2122-1 assesses the flame propagation properties of rigid and flexible cellular plastics in the form of bars and is similar to ASTM D 3014. The second, AS 2122-2 assesses the minimum oxygen concentration required for flame propagation on small specimens and is not relevant for EPS/XPS.

3.5 Fire Safety Engineering (FSE)

Fire Safety Engineering is the application of science and engineering principles to protect people and their environments from the destructive effects of fire and smoke. *Prescriptive* fire safety regulations are regulations which in detail specify the design and classification of building components. These will, for some applications, exclude the use of products containing combustible materials which do not conform to the required fire rating. A performance based approach to comply with the overall fire safety level of the building can be a valid alternative for such applications.

Fire safety regulations are basically prescriptive in many countries. However, a performance based approach is allowed in several countries. A few European countries have their regulations based on a performance based approach and some countries allows

performance based solutions in specific applications. FORUMⁱⁱⁱ have reported [15] that the European countries that can be classified as performance based are: the United Kingdom, Sweden, and Norway. Other European countries allowing performance based alternatives include: Belgium, France, Italy, Luxembourg, Netherlands, Germany, Denmark, Ireland, Greece, Portugal, Spain, Austria, Finland, and Switzerland.

Internationally, New Zealand and Australia have performance based codes. Japan generally allows performance based alternatives and both the US and Canada allows performance based alternatives in their regulations to a certain degree.

Generally, *performance based* regulations allow the building contractor to choose an appropriate design method to accomplish fire protection in accordance with the safety level defined in the regulations.

For most buildings there are two alternative methods that can be used in performance based fire safety work:

- prescriptive design or
- analytical design.

Prescriptive design is, in principle, the same method as was used prior to the introduction of performance based requirements. Prescriptive design assumes that all the requirements and general recommendations for the object in question are set out to be fully met. When using prescriptive design it is not possible to make any technical exchanges in addition to those already given in the published regulations. If any other technical exchanges are made the design is considered to be an analytical one.

One reason to abandon prescriptive design is that a more cost effective design might be possible using analytical design through a technical exchange. An even more common reason to use analytical design is that fire safety according to prescriptive standards places limitations on the design regarding, for example, architectural objectives or building activity.

A comprehensive requirement when using analytic design is that the fire safety accomplished in a building should be as good as or better than if all the prescriptive requirements were set out to be met. A disadvantage when using analytic design is that this method requires a more knowledgeable designer than prescriptive design.

When using prescriptive design the requirements to verify the results are low. This design method is simple, well known and in most cases results in a conservative fire safety solution.

When using analytical design, however, the need to verify the results is higher. This is due to the fact that the need to verify the results is high when the starting point for the design is the prescribed risk level. The verification of an analytical design solution concerns the choice of method, the acceptance criteria and the way the uncertainties are managed. Figure 2 illustrated the different sources of data when using Fire Safety Engineering to design a building.

The extent of changes made compared to prescriptive design and the complexity of the building, determines the need for verification. When the deviations from a prescriptive design are small, it is not reasonable to require a complete safety evaluation, considering

ⁱⁱⁱ The International Forum of Fire Research Directors (FORUM) is a group of the Directors of fire research organizations throughout the world which aim to reduce the burden of fire through international cooperation on fire research.

the time and resources that would be needed to make one. It is, however, necessary to study all the relevant cases that will be affected by the deviations from the prescribed requirements in order to prove that the fire protection accomplished through the analytic design is equivalent to or better than that which would have been defined using prescriptive design.

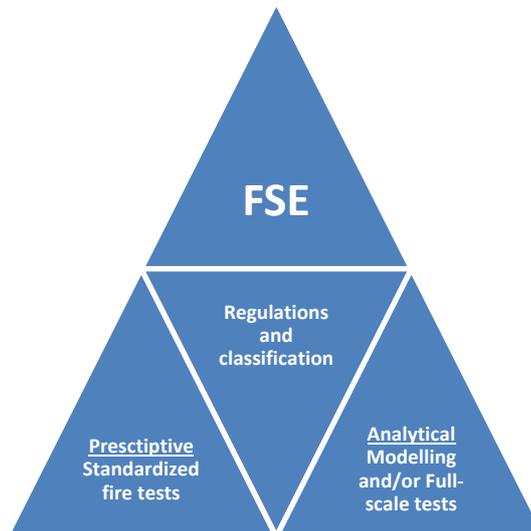


Figure 2: Pyramid diagram illustrating different sources of input used in Fire Safety Engineering (FSE).

The application of analytical design is typically used for fire safety design of large complex buildings and is not the preferred methodology for simple applications. For EPS/XPS products one could imagine analytical design to be used for larger building where sandwich panels are used and in some cases have a load bearing function.

However, it is not possible to quantify the extent of application of analytical design specifically to EPS/XPS products. Further, it is unclear whether the application of analytical design would necessarily change the fire performance requirements of these products in any given application as the fire safety design in an analytical design must be equivalent to or better than that using a prescriptive design.

4 Requirements in Europe

4.1 The Nordic countries

On a Nordic basis the NKB (Nordic Committee for Building Regulations) previously had the task of harmonising the Nordic Building Regulations. Since the Construction Products Directive came into practical use, the NKB Product Rules have increasingly been replaced by the new European system for testing and classification. The level of harmonization of the Nordic Building Regulations has been described and analysed in a SP-report [16].

The general principles and levels of regulatory tools concerning fire safety are described in Figure 3. The highest level defines the overall objective: safety in the case of fire. The next level includes two possible routes: Pre-accepted Design using fire classes and numerical values (prescriptive rules) or Performance Based Design utilising fire safety engineering (FSE). Finally, at the third level, either European test and classification methods or engineering methods can be used to define the required classes or performance of materials, products and building elements.

Only the test and classification methods and essential requirements in the case of fire are harmonised. On the design level there are a lot of differences between the Nordic countries [16]. For Reaction-to-Fire classification, EN 13501-1 is the basic classification document in all Nordic countries in accordance with the Euroclass system.

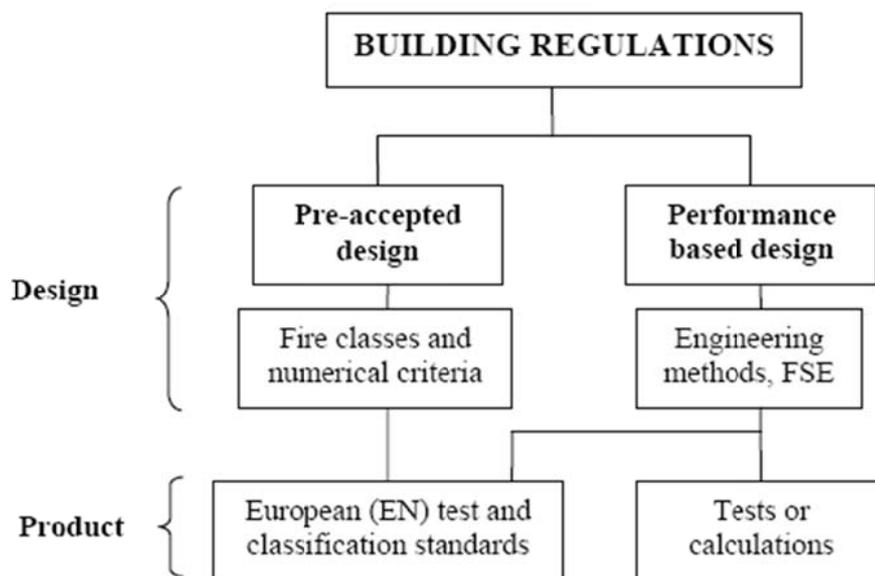


Figure 3: Schematic presentation of regulatory tools in the Nordic countries [16].

4.1.1 Sweden

The Euroclass system is fully implemented in Sweden and the Swedish building code (BBR) [17] sets requirements using the Euroclasses. BBR further sets requirement on façades for multi storey buildings according to SP FIRE 105 [18] (see A5.1). There is presently no large scale European fire test method for façades; but, a national large scale test method is used in Sweden. No other Nordic country requires such large scale façade testing at present, although Denmark and Norway are considering its introduction in the future. Sweden will continue to use the national test while there is a regulatory need to

assess fire spread along facade systems in multi-storey buildings and no European equivalent is available.

Sweden has a performance based building code which implies that analytical fire safety design can be used for certain types of buildings. There are no informal requirements that restrict the use of EPS/XPS products.

The test requirements for EPS/XPS products in Sweden are summarized in Table 2. The classification requirements according to BBR are summarized in a simplified manner in Table 3. For full detail see BBR [17]. The more stringent requirements given for Br2 and Br1 buildings in Table 3 are for evacuation routes. Further, there are special requirements for escape routes in hotels etc. and for places of assembly and premises which present a fire hazard.

Table 2: Test requirements in Sweden for common applications of EPS/XPS products.

| Product | Euroclass tests (see Table 1) | National tests |
|-------------------------------------|----------------------------------|---|
| EPS/XPS sheets etc. | Yes | No |
| Building elements including EPS/XPS | Yes | SP FIRE 105 (façade systems on BR1 buildings) |
| Sandwich panels | Yes | Full scale test in certain cases |

Table 3: Requirements of fire safety classes for various applications in Sweden.

| Application | Br3 building 1- and 2- storey no special circumstances | Br2 building 1- and 2- storey incl. institutional and places of assembly | Br1 building 3- storey and more, and 2- storey for disabled etc. |
|-------------|--|--|--|
| Wall | D-s2,d0 | C-s2,d0 – B-s1,d0* | C-s2,d0 – B-s1,d0* |
| Ceiling | D-s2,d0 | C-s2,d0* – B-s1,d0* | B-s1,d0* |
| Floor | - | Dfl-s1 | Cfl-s1 (escape route) |
| Façade | D-s2,d0 | D-s2,d0 | Pass SP FIRE 105 |

* Surface lining shall be mounted on A2-s1,d0 product.

There are no reaction-to-fire requirements on testing that exclude the use of non-flame retarded EPS/XPS products in buildings in Sweden, except as exposed surface linings.

The requirement of SP FIRE 105 for facades of multi storey buildings does not exclude the use of non-flame retarded EPS in e.g. plaster-on-insulation wall systems.

4.1.2 Denmark

The Danish rules as summarised in the “Collection of examples for fire protection of buildings” [19] imply reaction-to-fire requirements on a material level generally for materials, coverings and building elements. Therefore when the Danish regulations prescribe a certain Euroclass this implies, simplified, that each of the components in the product must fulfil the stated reaction-to-fire requirements on a material level.

DBI Method FIRE01:2007 [20] give specifications for testing and classification for the reaction-to-fire properties on a material level in relation to the Euroclass tests, i.e. by a characterization testing and classification procedures giving results which are independent of the concept “end use application”.

However, the use of insulation materials in buildings is specially specified in section 3.2 of the above mentioned regulation [19]. The general requirement for insulation materials is D-s2, d2 but products with lower performance are allowed in several applications if certain conditions are fulfilled. Applications for specific constructions where EPS insulation of Euroclass F is allowed are given in [19].

The Danish Plastic Industry Association (Plastindustrien) has provided the information that the majority of the EPS that is used for constructions in Denmark is of Euroclass F and thus without fire retardant.

4.1.3 Finland

EN 13501-1 is the test method used to assess fire performance for most applications in Finland and there are generally few requirements on a material level. There are, however, some exceptions where material type requirements are related to minimum performance levels in some applications or to certain conditions or materials used. Examples relevant to the application of EPS/XPS products include:

- The framework of external walls of buildings of class P2 with 3-4 storeys may be made of building materials of class D-s2,d2. The insulation material and other filling material shall in this case be of at least class A2-s1,d0.

This requirement essentially prohibits the use of EPS/XPS in this case.

- Building materials used in external walls in buildings of class P1 shall be mainly of at least class B-s1,d0.

This requirement essentially prohibits the use of non-flame retarded EPS/XPS in this case.

- Thermal insulation which is inferior to class B-s1, d0 shall be protected and positioned in such a manner that the spread of fire into the insulation, from one fire compartment to another and from one building to another building is prevented.

This requirement essentially means that non-flame retarded EPS/XPS can be used provided it is properly protected against being involved in the spread-of-fire.

- Internal wall and ceiling surfaces in buildings of class P2 shall be provided with a protective covering made of building materials of class A2-s1,d0 if the construction is made of materials of class C-s2,d1 or worse.

This requirement allows the use of non-flame retarded EPS/XPS in this case.

4.1.4 Norway

EN 13501-1 is the classification standard used to assess fire performance for most applications in Norway and there are generally few requirements on a material level.

There are specific classification requirements for sandwich panels in Norway. The Euroclasses required in this case are B-s1,d0 or D-s2,d0, depending on application. It is not clear whether it would be possible for a sandwich panel containing EPS/XPS to pass this classification, even if it were flame retarded. It would definitely not be possible for a non-flame retarded EPS/XPS material to obtain such a classification.

There are no reaction-to-fire requirements on testing that exclude the use of non-flame retarded EPS/XPS products in buildings in Norway, except if these are used as exposed surface linings. Therefore non-flame retarded EPS/XPS is allowed as insulation material in buildings in Norway.

4.1.5 Iceland

Reaction-to-fire classification is based on EN 13501-1, but in the Icelandic building regulation there are a number of examples for fire protection in buildings which imply reaction-to-fire requirements on a material level for materials, coverings and building elements.

There are specific classification requirements for sandwich panels in Iceland. The Euroclasses required in this case are A2-s1,d0 or B-s2,d0, depending on application. It is not clear whether it would be possible for a sandwich panel containing EPS/XPS to pass this classification, even if it were flame retarded. It would definitely not be possible for a non-flame retarded EPS/XPS material to obtain such a classification.

4.2 Germany

Germany has traditionally applied a system with reaction-to-fire requirements on a material level. The national requirements are still used in parallel with the Euroclass system. There is further an informal product certification system, the “Ü-mark”, which is required for insulation products on the German market. The “Ü-mark” sets requirements on materials and products that refer to the old National fire safety classification.

DIN 4102-1 (see Annex 3.2) is equivalent to EN ISO 11925-2, the small flame test in EN 13501-1. The German requirements for application of the small flame test to cut-edges of EPS/XPS for any building product results in the application of these requirements on a material level when testing according to the Euroclass system

The minimum requirement for EPS/XPS is class E or DIN 4102 B2. However, in practice all EPS/XPS sold in Germany today meets DIN 4102 B1. Flame retarded EPS/XPS is therefore needed in all applications, at present and most likely in the future.

Table 4: Actual test requirements for common applications of EPS/XPS products.

| Product | Euroclass tests (see Table 1) | National tests | Informal requirements |
|-------------------------------------|---|--|-----------------------|
| EPS/XPS sheets etc. | Yes | DIN 4102, part 15/16 DIN 4102, part 1 | Ü-mark |
| Building elements including EPS/XPS | Yes, but cut-edges for all applications | DIN 4102, part 15/16 DIN 4102, part 1 | Ü-mark |
| Sandwich panels | Yes, but cut-edges for all applications | DIN 4102, part 15/16 DIN 4102, part 1 | Ü-mark |

Table 5: Requirements of fire safety classes for various applications.

| Application | Current requirements | Future requirements |
|------------------|----------------------|----------------------------|
| EPS/XPS | German B2 | Euroclass E |
| Complete product | German B2 – B1 | Euroclass E – higher class |

4.3 Poland

The European classifications have been introduced in Poland meaning that the test methods for reaction-to-fire as required in EN 1351-1 are applied. Euroclass E is the general requirement for EPS/XPS in Poland.

Two basic documents regulate the fire safety of buildings: the “Decree of the Minister of the Interior on the fire safety of buildings, other building structures and sites”, and the “Decree of the Urban Planning and Building Minister on the technical requirements for buildings”. In multiple dwellings and public buildings, where over 50 persons are present, fixed finished materials must be made of at least hardly ignitable materials. Hardly ignitable would be at least Euroclass E. Ceiling covering and suspended ceilings must be made of non-combustible or non-ignitable materials (Euroclass A1, A2 or B), which will not fall down in case of fire (not valid for dwellings).

There are special requirements involving classification based on the national test method PN-90/B-02867 for fire spread on external walls of buildings. There are three classes: 1. Non-spreading fire, 2. Low spreading fire, and 3. Easy spreading fire. Additionally, if the core material of the wall is of EPS/XPS the material must be of Euroclass E or better.

Also for sandwich panels there is a requirement of Euroclass E for the core material.

In summary for Poland, flame retarded EPS/XPS foam grades are used in most applications.

4.4 France

In France, building products are tested for reaction-to-fire performance following EN 13501-1. There are no material-related requirements specific for EPS/XPS. In addition to prescriptive rules, performance-based building solutions are used in some cases which can be relevant for EPS/XPS products.

4.4.1 Public buildings

Insulation materials - internal applications:

There are specific requirements for the fire attack from the inside of a building on insulation materials for public buildings, which are given in article AM8 of the public buildings safety regulation [21][22][23]. These requirements are summarised in Table 7. The regulations further allow performance based solutions including a risk analysis as an alternative.

Table 6: Requirements on insulation materials for public buildings in France.

| Euroclass of protective material (minimum) | Requirements on building component |
|---|--|
| No protection | A2-s2, d0 for walls, ceilings and roofs A2 _{FL} -s1 for floors |
| A2-s2, d0 Protection thickness is defined according to the temperature providing less than 5% of mass loss of the insulation in a TGA test | EN 1365-1 / ISO 834-1, EI15* (wall & floors) EN 1365-2 / ISO 834-1, EI30* (ceiling) No degradation of the insulation |
| No pre-defined protection | Risk-based approach (FSE study) to ensure that the construction system do not affect tenability conditions inside the building during evacuation |

* Fire resistance classification according to EN 13501-2 [24].

If the risk-based approach is used, the study has to be accepted by the central fire safety authority (Official commissions: CECMI, then CCS). By now (2010), only one construction system containing XPS has passed by this approach. That was a construction system based on wood-framed metallic-faced sandwich panels.

Insulation materials - external applications:

The requirements for the fire attack from the outside of a building on insulation materials are given in references [25] and [26] of the Public buildings safety regulation [21], and detailed in an additional text (IT249) modified recently to consider an increase of insulation thicknesses from 120 mm to 300 mm [27].

The CO20 article [25] specifies that all façade elements have to be classified as, at least, **D-s3, d0**. However, there are additional rules called “C+D”, described in reference [27] related to vertical and horizontal distances between windows of the façade, and a limitation of calorific value of the façade limited to 130 MJ/m² (CO21 article, ref [26]). If these requirements are not fulfilled, all materials have to be classified as **C-s3;d0**.

In reference [27], there are different requirements to prove that safety exigencies are fulfilled, depending on insulation thickness, constructive system, substrate, etc. The following list tries to summarize these rules:

- 1) Insulation thickness can be increased from 120 mm to 300 mm without considering calorific load when fire stops are present horizontally every 2 storeys

(no sleeping places in the building) or 1 storey (sleeping places in the building).

- 2) All materials shall conform to requirements cited previously and respect pre-accepted constructive assemblies (solutions P1 to P6 for various cases).
- 3) The façade system passes a façade test called LEPIR II , detailed in reference [28]. This can be used in replacement of rule 2).
- 4) Performance-based construction solutions are further allowed in replacement of rules 2) and 3). The aim of the regulation is that fire penetration into the building from a façade fire is not accepted, according to a fire risk analysis based on tests and modelling. Ad-hoc tests or façade tests coming from other countries are required for a such study.

If the system is based on a EPS/XPS insulation, it has to be protected by a A2-s3; d0 surface material reinforced with fibreglasses, and respecting solution P1 of the text. EPS and XPS insulations have to be CE-marked and of **Euroclass E**. Producer of raw material has to prove flame retardancy to reach **Euroclass D** level for raw XPS in 60 mm and for raw EPS in 40 mm. This applies also to sandwich panels made of B-s1; d0 wood-wool skins and EPS/XPS core. The facade test will not restrict the use of EPS/XPS if the constructive system protects it enough from the fire.

4.4.2 Other buildings

For domestic applications [29], there is no specific requirement for reaction-to-fire in individual houses and small collective buildings limited to 3 storeys (1st and 2nd families). However, for buildings of more than 3 storeys (3rd and 4th family, under 50m), rules applicable for common parts of the building (corridors, etc) and façade are close to those for public buildings. IT249 [27] is not applicable, and the current version of the safety regulation [29] does not take into account an increase of insulation thickness.

For high-rise buildings (both domestic and public usages), specific drastic regulation applies [30] [31][32], including control of calorific load inside the building (except for privative part of domestic high-rise buildings, type IGHA). The AM8 article is not applicable and insulation materials requires classification as, at least, **A2-s2,d0**. Façades have to respect additional restrictive rules as stated in [27].

4.5 Belgium

Requirements are on products in their end use application, i.e. on finished products, although local fire brigades sometimes require classes for individual components.

The Euroclass system is gradually replacing the former national classes based on NF P92-501 and/or B 476 Part 7. There is no specific classification for EPS/XPS other than for all other construction products. No direct requirement that they are flame retarded, although the reaction-to-fire requirements result in the use of flame retardants where reaction-to-fire requirements are imposed. For XPS sold to the construction market this means that 100% is FR-retarded. The use of non-FR EPS is less than 10% in the construction sector.

4.6 Italy

The building regulations in Italy has adapted the European CPD and there are no National requirements in addition to the Euroclass testing of reaction-to-fire performance

according to EN 13501-1. There are, however, special requirements for insulation materials.

The requirements for EPS/XPS are ruled by the application and if the EPS/XPS material is uncovered or covered with a material with a better reaction-to-fire performance. Classification requirements for different applications are given in Table 7.

Table 7: Requirements on Insulation materials in Italy.

| Euroclass of protective material (minimum) | Euroclass of EPS/XPS |
|--|---|
| No protective covering | B-s2,d0 or B-s1,d1 |
| A2-s3,d0 or A2fl-s2 (floor) | C-s2,d1 (wall) / Cfl-s2 (floor) / C-s2,d0 (ceiling) |
| A1 or A1fl (floor) | D-s2,d1 (wall) / Dfl-s2 (floor) / D-s2,d0 (ceiling) |
| EI 30* | E |

* Fire resistance classification according to EN 13501-2.

The information that we have received is that EPS/XPS for the Italian market is normally flame retarded, except for the use in Euroclass E applications. However, our experience is that also Euroclass E products requires flame retardant treatment.

4.7 Spain

The building regulations in Spain has adopted the European CPD and all requirements involves finished products and systems. It is unclear if old national tests are still required or alternatively used. National tests relevant for EPS/XPS products include UNE 23727, UNE 23724 and UNE 23725.

In most application Euroclass E is required. For sandwich panels containing EPS/XPS the requirements are Euroclass B-s2, d0 or C-s2, d0, depending on application. It is unclear if non-flame retarded products are actually used in some applications, but for applications where Euroclass E or higher classes are required the EPS/XPS would be flame retarded.

4.8 UK

The United Kingdom is comprised of England, Wales, Scotland and Northern Ireland. The Building provisions required in the various parts of the UK may differ slightly but are largely the same despite the fact that it is the prerogative of each part to define autonomously which Building Regulations they will adopt.

Technical provisions for the use and fire performance of building materials and components are given in the supporting documents to the Building Regulations, e.g. Approved Document B for England and Wales. The technical provisions for England/Wales and Northern Ireland are virtually identical. Those for Scotland differ in minor aspects only.

The provisions in Approved Document B are given as guidance only and provide one method of showing compliance with the Regulations. There is no obligation to follow that method provided compliance with the Regulations can be satisfactorily demonstrated.

National test standards for surface linings in buildings includes BS 476, part 6 and part 7. However, as the Harmonised European Fire Testing System has been established corresponding UK standards have been removed and the Euroclass system adopted.

There are generally no requirements on material level in UK. Regarding reaction-to-fire properties the provisions in the regulations are related to surfaces of walls and ceilings so when the thermal insulation is covered there is no requirement. There are, however, specific applications where only non-combustible insulation is allowed. In these applications PS foam would not be used. However, safety requirements from insurance companies regulates the use of EPS/XPS in the construction phase which has resulted in that most EPS and all XPS for the UK market is flame retarded. When flame retarded the PS foam is meeting **Euroclass E** according to EN 13501-1.

4.9 Summary Europe

Although the European countries are progressing towards harmonized classification systems and testing standards, e.g. the EN 13501-1 standard for reaction-to-fire classification of surface linings in buildings, there are differences in applications and requirements in the individual countries. There can further exist requirements concerning fire performance for specific areas of applications such as insulation materials and sandwich panels in some countries. Table 8 gives a summary of those applications where EPS/XPS products are affected and if there are special regulations in the individual European countries. The table also contains information concerning whether the majority of EPS/XPS used in each country in building applications is flame retarded (FR) or not. A “Yes” or “No” in Table 8 signifies that information has been available as confirmation, this may be based on formal (mandatory) or informal (voluntary) requirements. In cases when information have not been available an assessment based on test requirements has been made and is written in italics.

Table 8: Summary of the requirement areas for fire performance in European countries and information on the practice of usage of FR EPS/XPS in each country where available.

| Country | General requirements for materials | Specific requirements for insulation materials | Specific requirements for sandwich panels | Specific requirements for facades | Usage of FR-treated EPS/XPS |
|---------|------------------------------------|--|---|-----------------------------------|-----------------------------|
| Sweden | No | No | No | Yes | No |
| Denmark | Yes | Yes | <i>n.i.</i> | <i>n.i.</i> | No |
| Finland | No | Yes | No | No | <i>Likely</i> |
| Norway | No | No | Yes | No | <i>Not likely</i> |
| Iceland | Yes | <i>n.i.</i> | <i>n.i.</i> | No | <i>Likely</i> |
| Germany | Yes | Yes | Yes | <i>n.i.</i> | Yes |
| Poland | No | Yes | Yes | Yes | Yes |
| France | No | Yes | <i>n.i.</i> | Yes | <i>Likely</i> |
| Belgium | No | <i>n.i.</i> | <i>n.i.</i> | <i>n.i.</i> | Yes |
| Italy | No | Yes | <i>n.i.</i> | <i>n.i.</i> | Yes |
| Spain | No | <i>n.i.</i> | Yes | <i>n.i.</i> | Yes |
| UK | No | Yes | <i>n.i.</i> | <i>n.i.</i> | Yes |

n.i. = No specific information available.

The European fire classification system for construction products and material does not set requirements on individual material in a building product, but on the fire performance of the complete product in its intended mode of use. There are, however, a few European countries that have national requirements that specify the fire performance on an individual **material level** in a building product. These countries include Germany, and to a certain extent, Iceland. The implication for the use of EPS/XPS in such products is that flame retardant products are required.

It is more common to have specific national regulations for the fire performance of **insulation materials**. The European countries with such regulations are: Finland, Denmark, Germany, Poland, France, Italy and UK. We have no direct information on this from Iceland, Belgium and Spain. Requirements on insulation materials can exclude the use of EPS/XPS in many applications, especially for public buildings and other buildings with a high safety class, as e.g. high-rise buildings. For most applications in these countries flame retarded EPS/XPS should be required. There could be exceptions, e.g. for applications of insulation materials in buildings with a lower safety level, such as single family dwellings. Although it is unclear whether these exceptions actually mean that a small portion of the market is non-flame retarded or whether all the market in these countries uses flame retarded EPS/XPS by default. However, in Denmark the national regulations for insulation materials allows non-fire retarded EPS insulation in several applications if certain conditions are fulfilled.

There are special requirements for **sandwich panels** in Norway, Germany, Poland and Spain. The requirements in Germany, Poland and Spain exclude the use of non-flame retarded EPS/XPS. The Norwegian requirements would exclude non-flame retarded EPS/XPS for some applications.

Sweden, Poland and France have special requirements for **facades**. To our knowledge it is possible to pass the Swedish test with a wall construction containing protected non-flame retarded EPS. Indeed, it appears that the majority of EPS/XPS that is used in Sweden is non-flame retarded.

In UK there are no formal regulations that would exclude the use of non-flame retarded EPS/XPS, however, according to the UK plastic industry, almost the entire market share for EPS/XPS in UK is flame retarded products due to requirement from the insurance sector.

5 Requirements in Non-European countries

5.1 USA

The general requirements in US apply to finished building products and not on the separate materials in a product. There are fire resistance requirements on construction assemblies and reaction-to-fire requirement on exposed materials. The rating or classification required is dependent on application and given in relevant NFPA standards.

Table 9: General test requirements on products and surface linings in US.

| Material application | Test method |
|------------------------|--|
| Exposed surface lining | ASTM E84 (flame spread etc, see Annex 3.3) |
| Construction assembly | ASTM119 (fire resistance) |

The International Building Code (IBC) has regulations for foam plastic insulation in chapter 26, section 2603 [33]. The general requirements are that foam plastic insulation and foam plastic cores of manufactured assemblies shall have a flame spread index of not more than 75 and a smoke-developed index of not more than 450 where tested in the maximum thickness intended for use in accordance with ASTM E 84. For complete listing of requirements and exceptions see [33].

Table 10: Requirements in ASTM E84 testing of foam plastic insulation and core materials according to IBC.

| Parameter | Requirement (index) |
|--------------|---------------------|
| Flame spread | < 75 |
| Smoke | < 450 |

The IBC contains additional requirements and alternatives for applications of foam plastic insulation:

- Foam plastic shall be separated from the interior of a building by an approved thermal barrier. There are some exceptions from this requirement, e.g. for masonry and concrete construction where the insulation is covered.
- Exterior walls of buildings have requirements on fire resistance (ASTM E 119) and ignition (NFPA 268). Exterior walls of cold storage buildings required to be constructed of non-combustible materials.
- Foam plastic insulation meeting the flame spread and barrier requirements are permitted as part of a roof-covering assembly, provided the assembly with the foam plastic insulation is a Class A, B or C roofing assembly where tested in accordance with ASTM E 108 or UL 790.
- Foam plastic insulation shall not be used as interior wall or ceiling finish in plenums except when complying with special requirements or when protected by a thermal barrier.
- Special approval can be based on large-scale tests such as, but not limited to, NFPA 286 FM 4880, UL 1040 or UL 1715. Such testing shall be related to the actual end-use configuration and be performed on the finished manufactured

foam plastic assembly in the maximum thickness intended for use. Foam plastics that are used as interior finish on the basis of special tests shall also conform to the flame spread requirements.

The consequence of the IBC regulation for EPS/XPS insulation in building products is that the ASTM E84 reaction-to-fire test is required in all applications, which must exclude the use of non-fire retarded EPS/XPS. The information that we have received is that EPS/XPS for the US market is normally flame retarded.

5.2 Canada

The general requirement for foamed plastics is that they must be protected. Special requirements depend on application and how they are protected.

There are requirements both on material level and on the finished product. The test methods relevant for EPS/XPS insulation are: CAN/ULC-S124, "Test for the Evaluation of Protective Coverings for Foamed Plastic" and CAN/ULC-S101, "Fire Endurance Tests of Building Construction and Materials".

The requirements are depending on applications and how the foam plastic is protected. The flame spread rating can range from below 25 up to 500. In small buildings, such as single family houses, there is no limit on flame spread rating for foam plastic insulation as long as it is protected (such as by interior finish).

The code does not explicitly require the use of flame retardant but applications that require a flame spread rating of 25 obviously warrant the use. The information that we have received is that EPS/XPS for the Canadian market is normally flame retarded.

5.3 Australia

For most building types, the controls on wall and ceiling linings are based on testing in AS ISO 9705, and in some cases, AS/NZS 3837. Controls on flooring are based on testing in AS ISO 9239. AS/NZS 1530-3 (the Early Fire Hazard Test) applies to all other building materials and components other than thin flexible materials. Where EPS/XPS are incorporated in a building system, such as sandwich panels, the system usually requires testing in AS ISO 9705. Where EPS/XPS are installed as in-ceiling or in-wall insulation, testing to AS/NZS 1530-3 may be required.

There are very few requirements for fire properties of building materials for single detached houses and outbuildings. There are, however, consumer regulations relating to the use of insulation in houses. These vary with the nature of the insulation. For instance, there are specific requirements for shredded paper. There are, however, no specific requirements for EPS/XPS.

Although the test requirements, generally, would not require that EPS/XPS for building applications be flame retarded to obtain an acceptable classification it seems that EPS/XPS in building applications in Australia is generally flame retarded voluntarily by industry as this is deemed necessary for safety.

5.4 Japan

The Japanese system of test methods was recently changed and one of the major test methods is the cone calorimeter as described in ISO 5660. In addition ISO DTS 17431, an intermediate test, and ISO 1182 are used as described below.

Non-combustible materials are classified based either on ISO 1182 (Furnace Test) where a temperature rise of no more than 20 °C is allowed or using the Cone Calorimeter (ISO 5660-1) at 50 kW external heat flux, where the total heat release is not allowed to exceed 8 MJ and the maximum heat release must be less than 200 kW/m² during the whole 20 minute test period. Clearly EPS/XPS cannot meet these test requirements even when treated with flame retardants.

Quasi-combustible materials are classified either based on ISO 5660-1 or in the Box Heat Test ISO 17341. The classification requirements are the same in ISO 5660-1 with the exception that the test period is only 10 minutes. In the Box Test a total heat release of 30 MJ is allowed with a maximum heat release rate of 140 kW. Further, no burn-through is allowed.

Flame retardant materials are also classified using the Cone Calorimeter or the Box Test. In this case the test period is only 5 minutes and the same classification criteria apply.

EPS/XPS in building applications could potentially pass as quasi-combustible with flame retardants but would in that case need to be classified as flame retardant materials where additional toxicity testing is required over and above the fire performance testing. This implies that EPS/XPS in building applications is probably flame retarded, and it has been confirmed that this is the case.

5.5 Korea

The building law of Korea is issued by the Land, Transportation and Sea Ministry of Korea. Korean standards are prepared by KATS, the Korean Agency of Technology and Standards. There are evaluation criteria (classification requirements) for interior materials in building in the Building Law of Korea, the 52th directive. There are no specific criteria for e.g. sandwich panels at present. The criteria for interior materials are based on reaction-to-fire tests and toxicity tests and are divided in the following classes:

- Non-combustible material, KS F ISO 1182 and “mouse test, 9 min”.
- Semi-combustible material, KS F ISO 5660-1 (10 min) and “mouse test, 9 min”.
- Flame retardant material, KS F ISO 5660-1 (5 min) and “mouse test, 9 min”

For sandwich panels the Product standard KS F 4724 applies and relevant test methods includes KS F ISO 5660-1, KS F ISO 13784-1 (specific reaction-to-fire test for sandwich panels) and KS F ISO 9705 (room-corner test). Of these tests is only KS F ISO 5660-1 adapted in the Building law presently.

The requirements in the Korean building law reminds of that in Japan. It has not been confirmed, but it seems reasonable that EPS/XPS on the Korean market should be flame retarded.

5.6 Egypt

The building regulations regarding fire safety are currently under development in Egypt. The intent is to adopt the European testing standards, i.e. the Eurocodes.

Concern has recently been raised regarding the fire safety of construction with sandwich panels with a combustible core. US fire resistance standards have been applied for these products.

5.7 Summary for Non-European Countries

There are many countries internationally that have not been covered in the cursory summary of building regulations relevant to EPS/XPS use in building applications outside Europe. The countries that have been studied were selected either based on the significance of use of EPS/XPS or on the availability of information. Table 11 contains a summary of the findings and their implications for the use of flame retardants (FR) in each country. A “Yes” in the final column in Table 11 signifies that information has been available as confirmation. Note that the use of FRs may be based on formal (mandatory) or informal (voluntary) requirements. In cases when information has not been available an assessment based on test requirements have been made and is written in italics.

Table 11: Summary of the requirement areas for fire performance in selected non-European countries and information on the practice of the use of FR EPS/XPS in each country, where available.

| Country | General requirements for materials | Specific requirements for insulation materials | Specific requirements for sandwich panels | Specific requirements for facades | Usage of FR-treated EPS/XPS |
|-----------|------------------------------------|--|---|-----------------------------------|-----------------------------|
| USA | No | Yes | Yes | Yes | Yes |
| Canada | Yes | Yes | <i>n.i.</i> | <i>n.i.</i> | Yes |
| Australia | No | Yes* | <i>n.i.</i> | <i>n.i.</i> | Yes |
| Japan | Yes | Yes | <i>n.i.</i> | <i>n.i.</i> | Yes |
| Korea | Yes | <i>n.i.</i> | No | <i>n.i.</i> | <i>Likely</i> |
| Egypt | Unclear** | Yes | Yes | <i>n.i.</i> | <i>n.i.</i> |

n.i. = No specific information available

* = depending on the application, i.e., no requirements for detached houses or outbuildings

** = the country specific application of the Eurocodes will determine whether material performance will be required.

6 Summary and Conclusions

A compilation of international building regulations has been attempted. An undertaking of this kind is, by its very nature, nebulous and difficult to say the least, due to the minutiae of differences in interpretation of seemingly similar regulations in their individual application. We have attempted to approach the topic in a systematic manner that has at times posed questions which have defied a single answer. This is particularly true in the EU where the CPD and associated harmonized Euroclass system seems straightforward at first glance, at least for those products where product standards exist (which is true for insulation materials). As the project has proceeded it has become painfully clear that the devil is in the detail, with application of the harmonized European approach differing significantly in the different member states, e.g. from essentially no material requirements in Sweden to stringent material requirements in Germany.

In summary, the overlying regulations in Europe do unify the method for testing EPS/XPS products in building applications although the specific performance requirements differ significantly in the different member states. In particular, one can note that in those countries where only the performance of the final product is tested the use of EPS/XPS as insulation material does not result in a formal requirement that the EPS/XPS used is flame retarded. In those countries where material performance is required, e.g. Germany, EPS/XPS that is used must be flame retarded. UK is an example of a country where requirements from insurance companies has resulted in that the majority of EPS/XPS is flame retarded.

In North America (USA and Canada), it seems that there are material requirements for insulation materials which mean that flame retarded EPS/XPS would be most common in building applications. And the information that we have received is that EPS/XPS for the North American market is normally flame retarded.

In Australia there are very low formal requirements concerning fire performance of materials which would not necessarily require the use of flame retarded EPS/XPS but verbal information received by the authors indicates that EPS/XPS generally used in Australia in building applications is flame retarded voluntarily.

In Japan, it would appear that EPS/XPS would need to be classified as flame retardant material as it would not be able to attain any of the other classes without the use of flame retardants which would automatically mean that it would be included in this class. This implies also that the majority of EPS/XPS for use in Japan would be expected to be flame retarded. Korea appears to have a similar situation as that in Japan.

Finally, in Egypt it is unclear how the Eurocodes will be applied and therefore not possible to determine whether EPS/XPS in insulation is typically flame retarded or not. The reference to US codes (IBC) in the case of sandwich panels would, however, imply that at least in this application flame retarded products are used.

Despite the short time available and the difficulty in determining definitive answers to the interpretation of building regulations in some cases, it is clear from the compilation that the use of flame retardants in EPS/XPS is widespread, both in cases where this is a strict regulatory requirement (e.g., Germany) and in those where it is not (e.g., Australia).

Appendix 1: EN 13501-1 tables of Euroclasses

Table 12: Table for Euroclasses for fire performance for construction products excluding floorings and linear pipe thermal insulation products.

| Class | Test method(s) | Classification criteria | Additional classification |
|-----------|--|--|--|
| A1 | EN ISO 1182 (1); <i>and</i> | $\Delta T \leq 30^\circ\text{C}$; <i>and</i> $\Delta m \leq 50\%$; <i>and</i> $t_f = 0$ (i.e. no sustained flaming) | - |
| | EN ISO 1716 | $\text{PCS} \leq 2.0 \text{ MJ.kg}^{-1}$ (1); <i>and</i> $\text{PCS} \leq 2.0 \text{ MJ.kg}^{-1}$ (2) (2a); <i>and</i> $\text{PCS} \leq 1.4 \text{ MJ.m}^{-2}$ (3); <i>and</i> $\text{PCS} \leq 2.0 \text{ MJ.kg}^{-1}$ (4) | - |
| A2 | EN ISO 1182 (1); <i>or</i> | $\Delta T \leq 50^\circ\text{C}$; <i>and</i> $\Delta m \leq 50\%$; <i>and</i> $t_f \leq 20\text{s}$ | - |
| | EN ISO 1716; <i>and</i> | $\text{PCS} \leq 3.0 \text{ MJ.kg}^{-1}$ (1); <i>and</i> $\text{PCS} \leq 4.0 \text{ MJ.m}^{-2}$ (2); <i>and</i> $\text{PCS} \leq 4.0 \text{ MJ.m}^{-2}$ (3); <i>and</i> $\text{PCS} \leq 3.0 \text{ MJ.kg}^{-1}$ (4) | - |
| | EN 13823 (SBI) | $\text{FIGRA} \leq 120 \text{ W.s}^{-1}$; <i>and</i> $\text{LFS} < \text{edge of specimen}$; <i>and</i> $\text{THR}_{600\text{s}} \leq 7.5 \text{ MJ}$ | Smoke production(5); <i>and</i> Flaming droplets/ particles (6) |
| B | EN 13823 (SBI); <i>and</i> | $\text{FIGRA} \leq 120 \text{ W.s}^{-1}$; <i>and</i> $\text{LFS} < \text{edge of specimen}$; <i>and</i> $\text{THR}_{600\text{s}} \leq 7.5 \text{ MJ}$ | Smoke production(5); <i>and</i> Flaming droplets/ particles (6) |
| | EN ISO 11925-2 ⁽⁸⁾ : <i>Exposure = 30s</i> | $\text{Fs} \leq 150\text{mm}$ within 60s | |
| C | EN 13823 (SBI); <i>And</i> | $\text{FIGRA} \leq 250 \text{ W.s}^{-1}$; <i>and</i> $\text{LFS} < \text{edge of specimen}$; <i>and</i> $\text{THR}_{600\text{s}} \leq 15 \text{ MJ}$ | Smoke production(5); <i>and</i> Flaming droplets/ particles (6) |
| | EN ISO 11925-2 ⁽⁸⁾ : <i>Exposure = 30s</i> | $\text{Fs} \leq 150\text{mm}$ within 60s | |
| D | EN 13823 (SBI); <i>And</i> | $\text{FIGRA} \leq 750 \text{ W.s}^{-1}$ | Smoke production(5); <i>and</i> Flaming droplets/ particles (6) |
| | EN ISO 11925-2 ⁽⁸⁾ : <i>Exposure = 30s</i> | $\text{Fs} \leq 150\text{mm}$ within 60s | |
| E | EN ISO 11925-2 ⁽⁸⁾ : <i>Exposure = 15s</i> | $\text{Fs} \leq 150\text{mm}$ within 20s | Flaming droplets/ particles (7) |
| F | No performance determined | | |

(*) The treatment of some families of products, e.g. linear products (pipes, ducts, cables etc.), is still under review and may necessitate an amendment to this decision.

(1) For homogeneous products and substantial components of non-homogeneous products.

(2) For any external non-substantial component of non-homogeneous products.

(2a) Alternatively, any external non-substantial component having a $\text{PCS} \leq 2.0 \text{ MJ.m}^{-2}$, provided that the product satisfies the following criteria of EN 13823(SBI) : $\text{FIGRA} \leq 20 \text{ W.s}^{-1}$; *and* $\text{LFS} < \text{edge of specimen}$; *and* $\text{THR}_{600\text{s}} \leq 4.0 \text{ MJ}$; *and* s_1 ; *and* d_0 .

(3) For any internal non-substantial component of non-homogeneous products.

(4) For the product as a whole.

(5) $s_1 = \text{SMOGRA} \leq 30\text{m}^2.\text{s}^{-2}$ *and* $\text{TSP}_{600\text{s}} \leq 50\text{m}^2$; $s_2 = \text{SMOGRA} \leq 180\text{m}^2.\text{s}^{-2}$ *and* $\text{TSP}_{600\text{s}} \leq 200\text{m}^2$; $s_3 = \text{not } s_1 \text{ or } s_2$.

(6) d_0 = No flaming droplets/ particles in EN13823 (SBI) within 600s; d_1 = No flaming droplets/ particles persisting longer than 10s in EN13823 (SBI) within 600s; d_2 = not d_0 or d_1 ; Ignition of the paper in EN ISO 11925-2 results in a d_2 classification.

(7) Pass = no ignition of the paper (no classification); Fail = ignition of the paper (d_2 classification).

(8) Under conditions of surface flame attack and, if appropriate to end-use application of product, edge flame attack.

EN 13501-1 additionally includes a classification tables for floorings and thermal insulation products.

Appendix 2: Test methods referred to in EN 13501-1

A2.1 EN ISO 1716, Calorific potential

EN ISO 1716 [7] determines the potential maximum total heat release of a product when completely burning, regardless of its end use. The test is relevant for the classes A1, A2, A1_{fl} and A2_{fl}.

The calorific potential of a material is measured in a bomb calorimeter. The powdered material is completely burned under high pressure in a pure oxygen atmosphere.

A2.2 EN ISO 1182, Non-combustibility

EN ISO 1182 [6] identifies products that will not, or significantly not, contribute to a fire, regardless of their end use. The test is relevant for the classes A1, A2, A1_{fl} and A2_{fl}.

EN ISO 1182 is a pure material test and a product cannot be tested in end use conditions. Therefore only homogenous building products or homogenous components of a product are tested. The test apparatus is shown in Figure 4 and the test specifications are given in Table 13.

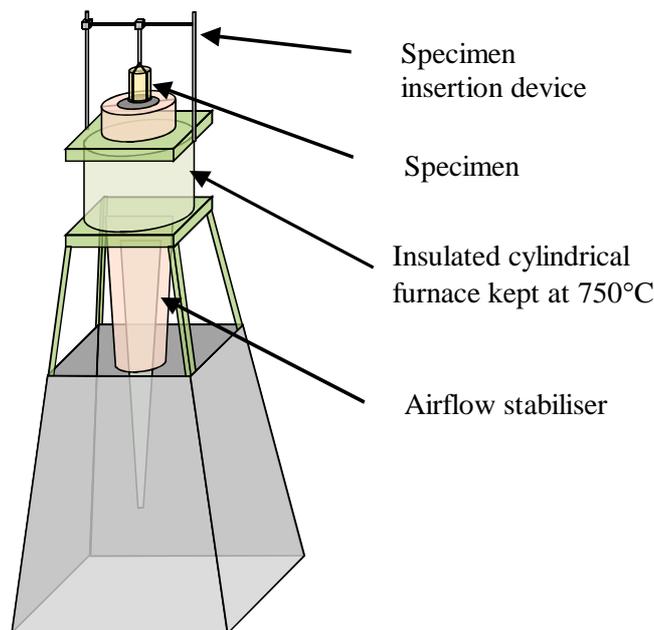


Figure 4: EN ISO 1182 test for Non-combustibility.

Table 13: EN ISO 1182 test specifications.

| | |
|-------------------|---|
| Specimens | 5 cylindrical samples, diameter 45 mm, height 50 mm |
| Specimen position | Vertical in specimen holder in the centre of the furnace |
| Heat source | Electrical cylindrical furnace at 750 °C (measured by the furnace thermocouple) |
| Test duration | Depends on temperature stabilisation |
| Conclusions | Classification is based on temperature rise as measured by the furnace |

| |
|---|
| thermocouple, duration of flaming and mass loss of the sample. Details are given in Table 12. |
|---|

A2.3 EN ISO 11925-2, Small flame test

EN ISO 11925-2 [8] evaluates the ignitability of a product under exposure to a small flame. The test is relevant for the classes B, C, D, E, B_{fl}, C_{fl}, D_{fl} and E_{fl}.

The small flame test is quite similar to the DIN test used for the German class B2. Variants of this procedure are also found in other EU member states regulations. The test rig is shown in Figure 5 and the test specifications are summarized in Table 14.

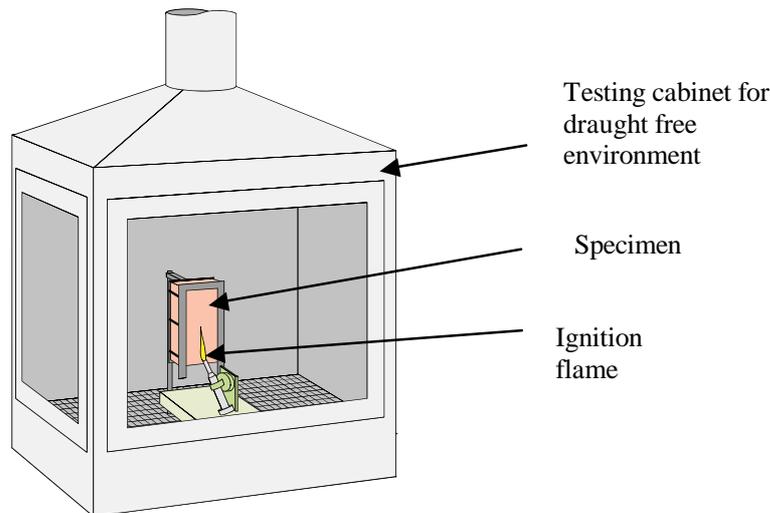


Figure 5: EN ISO 11925-2 Small flame test.

Table 14: EN ISO 11925-2 Small flame test specifications.

| | |
|-------------------|---|
| Specimens | 250 mm long, 90 mm wide, thickness 60 mm |
| Specimen position | Vertical |
| Ignition source | Small burner. Flame inclined 45° and impinging either on the edge or the surface of the specimen |
| Flame application | 30s for Euroclass B, C and D. 15s for Euroclass E |
| Conclusions | Classification is based on the time for flames to spread 150mm and occurrence of droplets/particles. Details are given in Table 12. |

A2.4 EN 13823, SBI

EN 13823 SBI [3] evaluates the potential contribution of a product to the development of a fire, under a fire situation simulating a single burning item in a room corner near to that product. The test is relevant for the classes A2, B, C and D. The SBI is the major test procedure for classification of linings.

The test rig is shown in Figure 6. Test specifications are summarised in Table 15.

The SBI is of intermediate scale size. Two test samples, 0,5 m x 1,5 m and 1,0 m x 1,5 m are mounted in a corner configuration where they are exposed to a gas flame ignition source. As for ISO 9705 a direct measure of fire growth (Heat Release Rate, HRR) and light obscuring smoke (Smoke Production Rate, SPR) are principal results from a test. Other properties such as the occurrence of burning droplets/particles and maximum flame spread are observed.

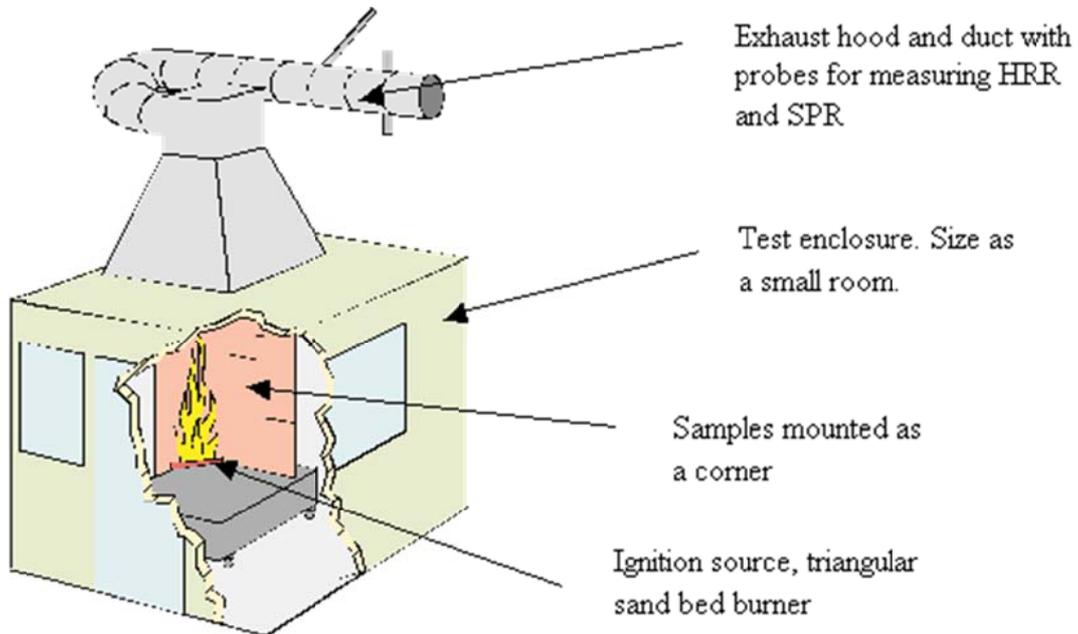


Figure 6: EN 13823, SBI, the Single Burning Item.

The index FIGRA, FIre Growth RAte, is used to determine the Euroclass. The concept is to classify the product based on its tendency to support fire growth. Thus FIGRA is a measure of the biggest growth rate of the fire during a SBI test as seen from the test start. FIGRA is calculated as the maximum value of the function (heat release rate)/(elapsed test time), units are W/s. A graphical presentation is shown in Figure 7.

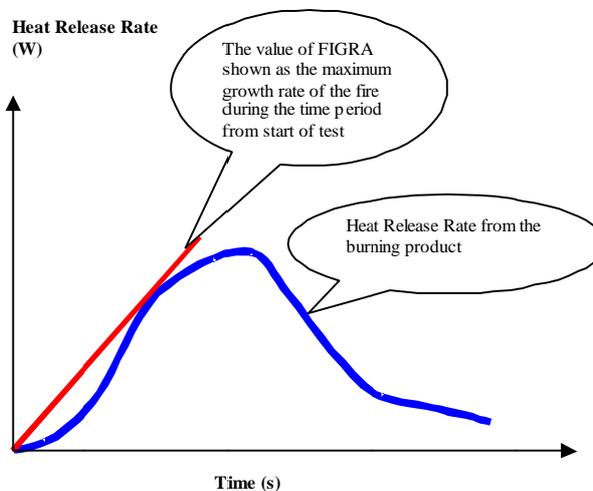


Figure 7: Graphical representation of the FIGRA index.

To minimise noise the HRR data is calculated as a 30s running average. In addition certain threshold values of HRR and the total heat release rate must first be reached before FIGRA is calculated.

The additional classification for smoke is based on the index SMOGRA, SMOke Growth RAte. This index is based on similar principles as FIGRA is. SMOGRA is calculated as the maximum value of the function (smoke production rate)/(elapsed test time) multiplied by 10 000. The data on smoke production rate, SPR, is calculated as a 60s running average to minimise noise. In addition certain threshold values of SPR and integral values of SPR must first be reached before SMOGRA is calculated.

The detailed definitions of FIGRA and SMOGRA can be found in EN 13823 (SBI).

Table 15: EN 13823 SBI test specifications.

| | |
|-------------------|--|
| Specimens | Samples for 3 tests. Each test requiring one sample of 0,5x1,5m and one sample of 1,0x1,5m |
| Specimen position | Forms a vertical corner |
| Ignition source | Gas burner of 30 kW heat output placed in corner |
| Test duration | 20 min |
| Conclusions | Classification is based on FIGRA, THR _{600s} and maximum flame spread. Additional classification is based on SMOGRA, TSP _{600s} and droplets/particles. Details are given in Table 17. |

A3.1 Sweden

SP FIRE 105, External wall assemblies and facade claddings – reaction to fire:

SP Fire 105 [18] specifies a procedure to determine the reaction to fire of materials and construction of external wall assemblies or facade claddings, when exposed to fire from a simulated apartment fire with flames emerging out through a window opening. The behaviour of the construction and material and the fire spread (flame spread) in the wall/cladding can be studied.

The test method is applicable to: - external wall assemblies - and facade claddings added to an existing external wall. The test method is only applicable to vertical constructions. The method is not applicable for determination of the structural strength of an external wall assembly or facade cladding construction when exposed to fire.

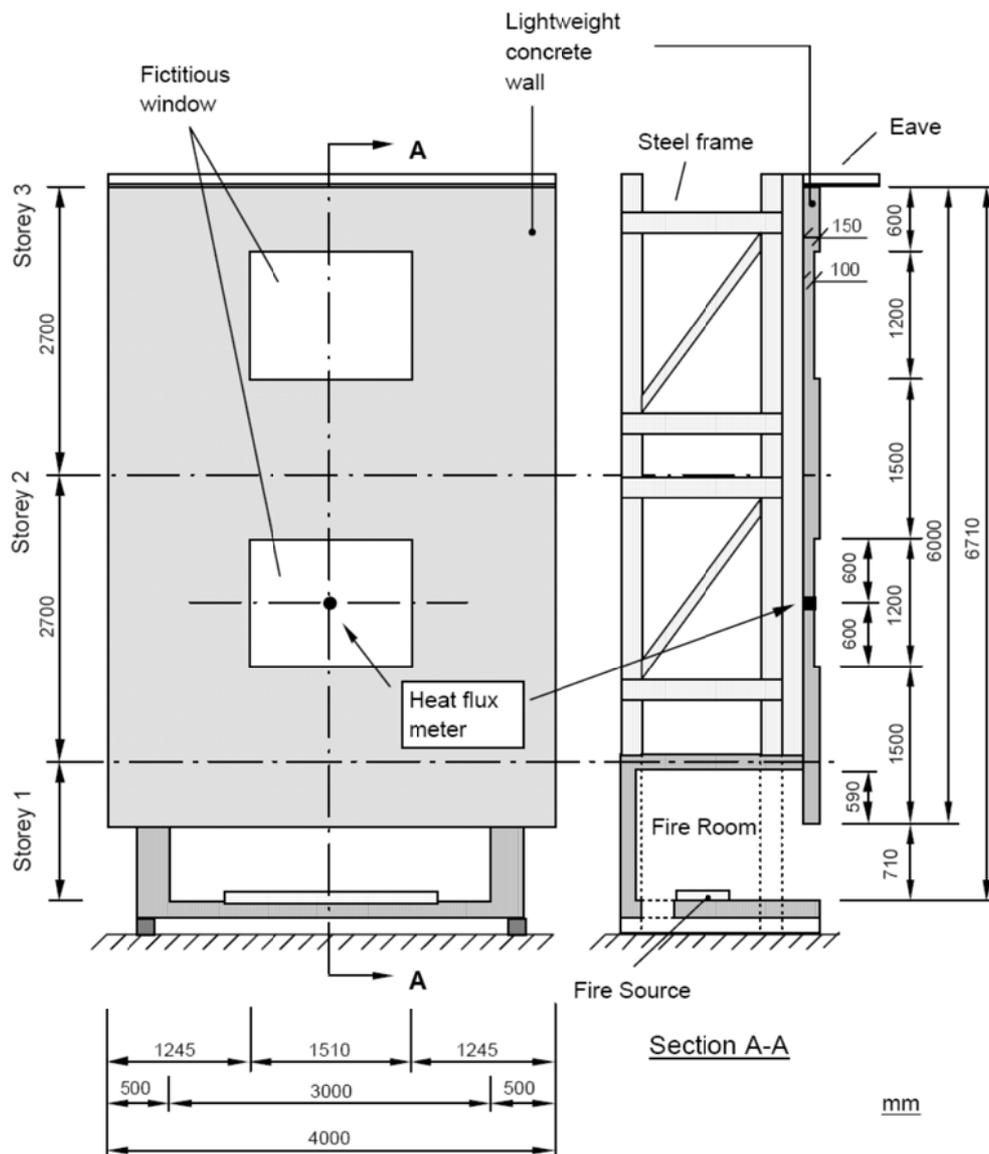


Figure 8: The test rig used in SP Method 105.

A3.2 Germany

The National German test standard for fire testing of building products is DIN 4102. This standard contains several parts of which Part 2 and Parts 15/16 are relevant for reaction-to-fire properties of EPS/XPS materials and products.

DIN 4102 Part 1 – “Kleinbrenner”

This is a small flame test and is essentially the same test method as EN ISO 11925-2 (see Annex 2). The test is used for determining the B2 requirement.

The test specimen is suspended vertically and a 20mm high flame is applied for 15 seconds to both the specimen surface and edge. Reference lines are marked on the specimen, which achieves B2 classification if the tip of the flame does not reach the reference marks within 20 seconds on any sample. 5 samples are tested with filter paper being placed below each to determine the production of flaming droplets.

DIN 4102 Parts 15/16 – “Brandschacht”

This is the main test method in DIN 4102 which measures reaction-to-fire. The term Brandschacht, refers to the testing apparatus which consists of a square-shaped vertical housing equipped with a gas burner. Four 1000 mm × 190 mm test samples are held vertically in a supporting frame and are subjected to flames for 10 minutes. A constant, uniform flow of air is blown into the Brandschacht from below during the test. The test apparatus is shown in Figure 9.

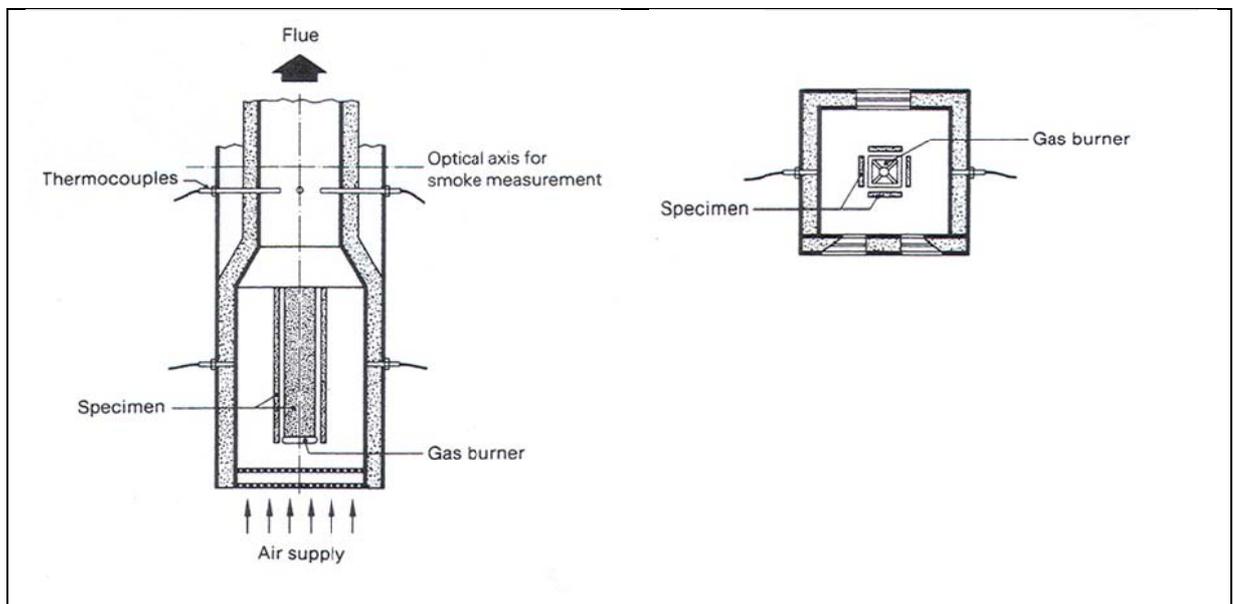


Figure 9: Schematics of test set-up of German "Brandschacht" (DIN 4102 Parts 15/16).

In evaluating the test, smoke gas temperature and the mean residual length of the sample are taken into account (residual length = the part of the specimen which has escaped burning). In order to be classified as B1, the tested product must show: 1) A mean residual length of not less than 150mm, with no specimen being burned away completely. 2) A mean smoke gas temperature of less than 200°C.

A3.3 US

Within the US the major test method for wall and ceiling linings is ASTM E84 which is an intermediate scale test for interior finishes. In a number of cases also a full scale test is required such as NFPA 286 and UL1715. These full-scale tests are rather similar. Besides this also requirements from the insurers are used. ASTM E84 is described below.

ASTM E 84-00a Surface Burning Characteristics of Building Materials

ASTM E 84 is probably the most used or referenced fire test standard and the generally most important in the US building codes to characterize flammability of plastics. The test fixture is known as the Steiner Tunnel and was developed by Underwriters Laboratories. The standard is used to assess the comparative surface burning behaviour of building materials and is applicable to exposed surfaces such as walls and ceilings, although building codes rely on data for most cellular product insulation materials, even if behind other barriers.

The test is conducted with the specimen in the ceiling position with the surface to be evaluated exposed face down to the ignition source. The material, product, or assembly must be capable of being mounted in the proper test position during the test. Thus, the specimen must either be self-supporting by its own structural quality, held in place by added supports along the test surface, or secured from the back side. The purpose of this test method is to determine the relative burning behaviour of the material by observing the flame spread along the specimen. Flame spread and smoke developed indices are reported.

Two preliminary tests are carried out after the apparatus is calibrated. A first run is made with a standard red oak specimen to obtain numerical values of 100 for flame spread and smoke density. In the second preliminary test, an inorganic reinforced cement board specimen is tested in order to obtain zero values for these same parameters. In the actual main test, the contribution of the material under test to smoke development and flame spread is measured and the material classified on the basis of the results. Test specifications are given in Table 16.

Table 16: ASTM E 84 test specifications.

| | |
|-------------------|--|
| Specimens | Sample size 0.51 m × 7.32 m x thickness of use up to a maximum |
| Specimen position | Horizontal |
| Ignition sources | Two gas burners, 5.3 MJ/min output located 190 mm below the specimen at a distance of 305 mm from and parallel to the fire end of the test chamber |
| Test duration | 10 min |
| Conclusions | Flame spread index and smoke-developed index (smoke density) |

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Appendix 4: Questionnaire

A4.1 Introduction

As described above, fire regulations internationally are often based on Model Codes. This term implies that a code has been developed for the classification of material but that the application of this code, i.e., which material is allowed in which building application, is then specific to the building codes in the individual state or country. This means that compilation of how building regulations impact on the use of a specific chemical or material is not just a matter of identifying the relevant Model Code but also how it is implemented into national or state regulations.

At SP Fire Technology there is detailed knowledge of the Model Codes for fire safety employed in Europe and to a certain degree in North America but only patchwork knowledge of how this is applied in each individual state or country. To add detailed knowledge of the application of the Model Code in the various states and countries included in this compilation, a number of colleagues were contacted with a small number of questions. This chapter contains a summary of those included in the questionnaire and the questions posed. The information provided through the questionnaire has been incorporated into both the chapter on Building Regulations and the chapter on Compliance.

A4.2 Subjects

The subjects for inclusion in the questionnaire were selected based on their experience of building fire regulations in their country of origin or (in some cases) across a number of different markets.

Some of the subjects were representatives of the building industry, others were research scientist working for organisations like SP internationally, yet others were consultants. Table 17 summarises the subjects included in the questionnaire and whether they provided and answer or not.

Table 17: Summary of participants in Questionnaire.

| Country | Employment | Relevant Expertise | Provided an answer |
|----------------|-------------------------------------|---|---------------------------|
| Germany | BASF | Building regulations, Standardisation | Yes |
| UK | DOW | Building regulations, Standardisation | Yes |
| UK | Exova Warringtonfire | Test Lab, Research Lab | Yes |
| France | LNE | Research Lab, Building regulations, Standardisation | Yes |
| Poland | ITB | Test Lab, Building regulations | Yes |
| Italy | LAPI | Test Lab, Building regulations, standardisation | Yes |
| Spain | Cidemco | Research Lab, Building regulations, standardisation | Yes |
| Belgium | Ghent University | Research Lab, Building regulations, standardisation | Yes |
| Canada | National Research Council | Research Lab, Building regulations, standardisation | Yes |
| USA | NASFM | Building Regulations | Yes |
| USA | NIST | Research Lab, Building regulations, standardisation | Yes |
| USA | SwRI | Research Lab, Building regulations, standardisation | Yes |
| Egypt | NIS | Research Lab, Building regulations, standardisation | Yes |
| Australia | Consultant (previously CSIRO) | Building regulations, standardisation | Yes |
| Japan | NMRI | Research Lab, Building regulations, standardisation | Yes |
| Korea | Fire Insurers Laboratories of Korea | Research Lab, Building regulations, standardisation | Yes |

A4.3 Questions posed

The following set of questions was sent to each of the identified subjects:

“1. Do your building regulations place requirements on individual materials (e.g. EPS) or on finished products (e.g. sandwich panels with EPS) or both?

2. Which test methods are used to assess compliance of insulation materials such as EPS/XPS or products containing these in your country?

3. Which classification must EPS/XPS attain to be used in different building applications?

4. Do these building regulations require that EPS/XPS used in construction is flame retarded?

Note that the Questions relate to reaction-to-fire rather than fire resistance.”

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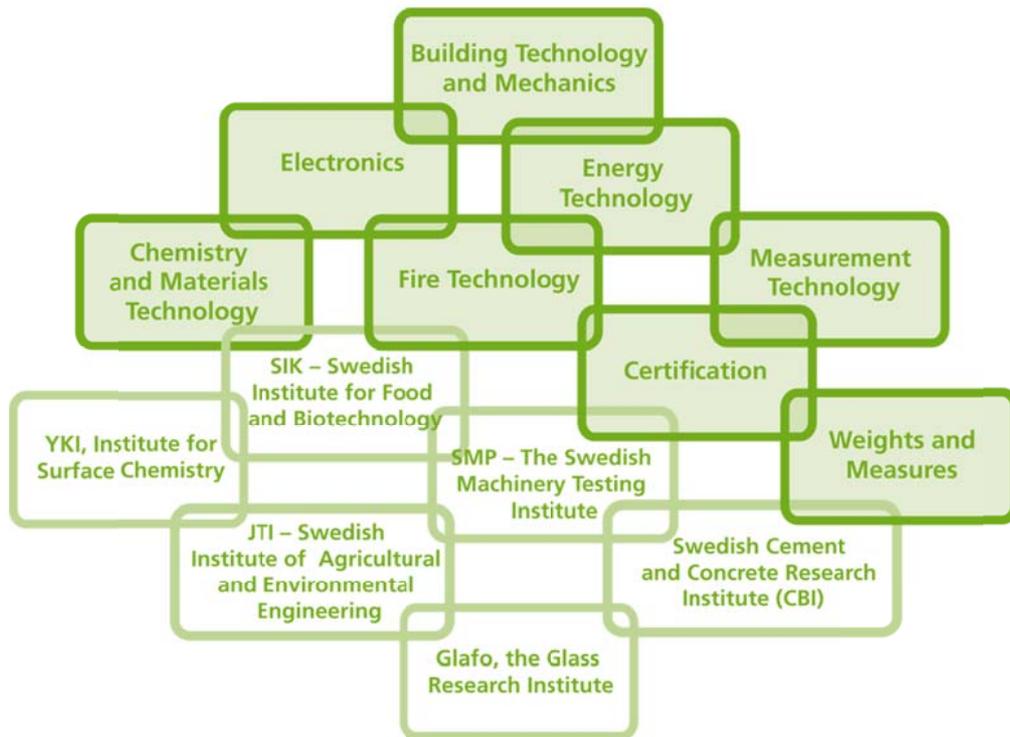
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