PU Europe FIRE SAFETY HANDBOOK

EUROPEAN FIRE STANDARDS AND NATIONAL LEGISLATION

INTRODUCTION

CURRENT TESTING AND STANDARDS

In the past, manufacturers, designers and specifiers operating in the European single market had to cope with a lack of pan-European standardisation for the assessment of the fire performance of construction products. Countries had each developed their own national standards [1], new products continuously arrived on the market, and there was the further complication of the range of applications; for example is a test assessing the behaviour of a product in a house fire equally applicable to how a product in a large warehouse fire might behave?

The European reaction to fire classification system was introduced in support of the Construction Products Directive (CPD) with the aim of achieving harmonisation and eventually replacing the different national standard tests and classifications. Some correlations could indeed be drawn between the 7 Euroclasses and elements of the pre-existing standards. Although the CPD is now replaced by the CPR, the European harmonised test methods and classifications remain the same.

Harmonising test standards in the Europe Union is meaningful whilst aiming for simplification and standardisation. However, the intended use, as described in the CPR, translates into different fields of application. Consequently, the test results have to be interpreted and assessed in order to confirm a fire classification, including the boundary conditions. These currently fall into two categories: the direct field of application (DIAP) and the extended field of application (EXAP).

Both DIAP and EXAP rules exist more widely for resistance to fire test standards than for reaction to fire test standards. Whereas DIAP rules are limited to the particular design tested, with only minor variations permissible, EXAP rules allow for greater variations, within the parameters of accepted knowledge and experience. Discussions continue in Europe on EXAP rules to develop new and revise existing EXAP standards. In many Member States national EXAP rules also exist e.g. for external fire performance. Various EXAP standards are now published e.g. CEN TS 15117 "Guidance on direct and extended application" and EN 15725 "Extended Application reports on the fire performance of construction products and building elements". Further specific EXAP standards also exist for various applications.

Essentially, the harmonised tests and standards are in place, but it is still a matter for each Member State to decide for itself what level of classification for fire safety is considered acceptable for each type of application.

[1] E.g. UK – BS 476; France – NF P 92-50x; Germany – DIN 4102

FIRE STANDARD CATEGORIES

Fire regulations historically refer to three basic categories of fire standards: Reaction to fire, resistance to fire and external fire performance of roofs. A fourth category is used in a number of countries and currently research is going on for setting a European approach to "external fire on façades". This was triggered by the introduction of new façade systems in buildings and their growing importance.

Each of these categories is expanded upon in the following sections.

REACTION TO FIRE

A reaction to fire test assesses how easily a product can be ignited and contribute to fire growth. It relates mostly to the early stages of a fire development and is arguably mostly relevant to those products directly exposed to the fire source i.e. wall linings, ceiling linings and external wall surfaces. It is also relevant for assessing the performance of construction products during construction or during building maintenance, e.g. welding of the building elements.

EURO-CLASSIFICATION

Under the European classification system for reaction to fire as defined in the standard EN 13501 part 1, construction products are tested for reaction to fire and divided into seven Euroclasses:

- A1 and A2;
- B, C, D, E;
- F for materials which fail Euroclass E criteria.

No performance determined (NPD) exists where no test has been performed. The classification of PU insulation can range from B to F depending on a variety of factors, including types of facings, the formulation used and the end-use condition.

Further classifications are used to indicate smoke production (s1, s2 and s3), and burning droplets (d0, d1 and d2). PU can achieve any class between s1 and s3 for smoke development, again depending on formulation, facings and end-use condition, but as a thermo-set material it does not produce droplets and therefore always achieves d0.

Alongside the Euroclass system there is now a European test to assess the smouldering or continuous glowing potential of a product (EN 16733). Smouldering or continuous glowing represent slow, internal combustion processes that can lead to fires breaking out some distance and time away from the original source of ignition. This characteristic is considered a risk, regarding hidden spread of fire and persistence of ignition sources after fire brigades have assumed that a fire is completely extinguished. PU insulation products do not need to be tested against European or national tests as they have not been shown to smoulder and so are not included in the smouldering product list (see the section on Combustibility behaviour of insulation products).

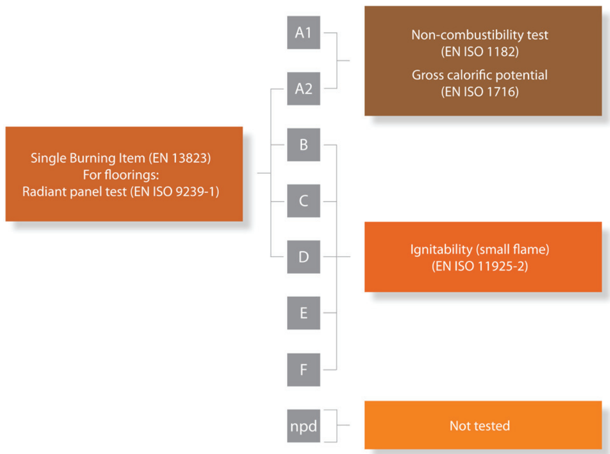
Other parts of EN 13501 cover classification for resistance to fire (parts 2, 3 and 4), external fire performance of roofs (part 5) and cables (part 6).

EUROPEAN FIRE STANDARDS TO DETERMINE EUROCLASS

The following tests are used to determine the Euroclass for all construction products except floor coverings and cables:

EN ISO 1182	Non-combustibility test
EN ISO 1716	Determination of the heat of combustion
EN ISO 13823	Single Burning Item (SBI)
EN ISO 11925-2	Ignitability of products subjected to direct impingement of a small flame

The first stage of testing for combustible products is EN ISO 11925-2, which simulates a small flame ignition such as a cigarette lighter



Reaction to fire classes (Euroclasses) CEN standards

Contribution to fire	Smoke production	Burning droplets
A1	Not applicable	Not applicable
A2	s1, s2, s3	d0, d1, d2
B	s1, s2, s3	d0, d1, d2
C	s1, s2, s3	d0, d1, d2
D	s1, s2, s3	d0, d1, d2
E	Not tested	None or d2
F	Not tested	Not tested

Left – Figure 1: Tests needed for classification of reaction to fire

Right – Table 1: Possibilities for reaction to fire classes

being applied for a short time (15 seconds) to the edge or surface of the product being tested. This can result in an E or F classification. A 30 s exposure is a prerequisite for the SBI test, when the aim is to achieve classes B, C or D.

In the SBI test method according to EN 13823, a specimen is exposed to a gas flame of 30 kW, simulating a single burning item in a corner (i.e. waste paper basket).

The exhaust gases are analysed. From the amount of oxygen consumed and the amount of CO released, the heat released by the burning specimen can be calculated. The main classification is based on the criteria FIGRA (Fire Growth Rate) and THR (Total Heat Release within 10 minutes), and for the higher classes lateral flame spread is also taken into account.

In the exhaust duct, smoke obscuration is also measured resulting in the criteria SMOGRA (Smoke Growth Rate) and TSP (Total Smoke Production – measured over 10 minutes) which form the basis for the smoke classification of the product.

The third parameter for classification is based on the visual observation whether burning droplets (outside the burner area) are observed during the test.

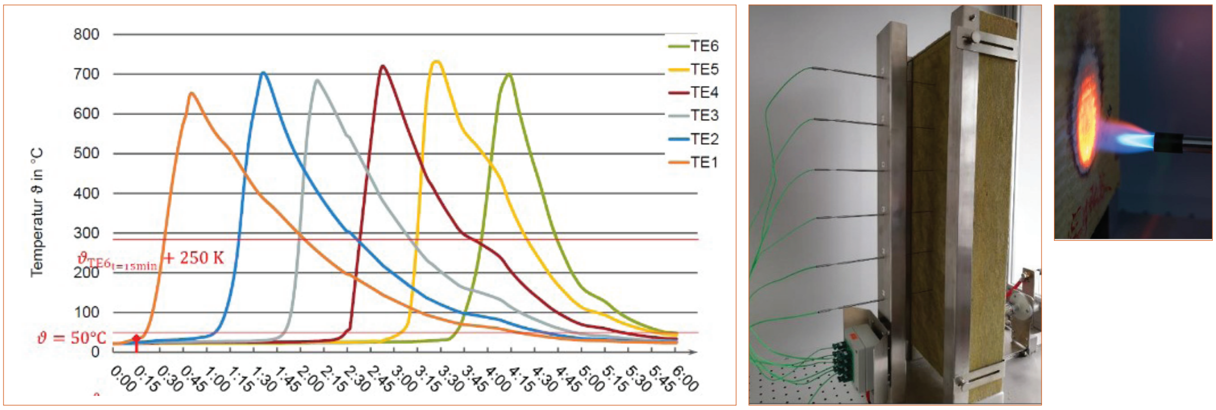


Figure 2: Additional Classification: Glowing combustion – Test apparatus and example for temperature development in glowing sample

Smouldering is now a criterion alongside the reaction to fire classification on request of some national regulators. PU products do not need to be tested for smouldering, as PU rigid foam is generally considered as a product which cannot undergo smouldering combustion (see Figure 2).

For floor coverings, an existing horizontal flame spread test, EN ISO 9239-1, has been adopted for the classes $A2_{fl}$ to D_{fl}, instead of the SBI.

BACKGROUND TO THE REACTION TO FIRE CLASSIFICATION OF PRODUCTS

The Euroclass is determined via small & medium scale test methods.

In some cases and for some products, the Euroclassification system was not considered acceptable. This was the case for linear products. For cables, pipe insulation and pipes, a different classification system for reaction to fire has been developed and adopted and included in EN 13501-1 (linear products) and EN 13501-6 (cables).

The reaction to fire classification of a product should not be confused with fire safety performance in a building. It should not be assumed that by using an A2 rated product a building will always be fire-safe or that with an E rated product the building will be less fire-safe. Fire safety in a building strongly depends on how the products have been installed/applied. For other than wall and ceiling lining products,

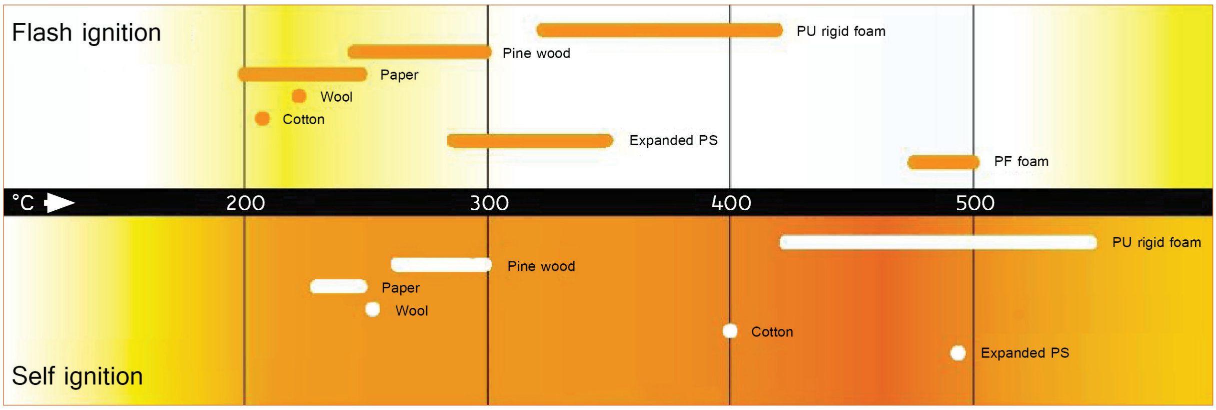


Figure 3: Ignition temperatures of materials according to ISO 871, 2006. A range is given for versatile product families [2]

there may not be an easy link between the reaction to fire class of the product and its real performance in the building.

The interpretation of the safe use of construction products is made via the national (Member State) building fire regulations.

REACTION TO FIRE CLASSIFICATION IN END-USE

Testing insulation boards as such does not take into account the context in which they are used i.e. behind a covering such as plasterboard or bricks.

It is written in the scope of the classification standard for reaction to fire, EN 13501 part 1, that testing is supposed to be in relation to the end-use conditions of the construction product. The SBI standard gives some basic rules for mounting and fixing, but that may not be enough. Specific mounting and fixing conditions can be used provided the manufacturer communicates the boundary conditions of the declared Euroclass clearly. Therefore product specifications (harmonised product standards and EADs) may contain additional mounting and fixing rules.

The first version of the insulation product standards did not have additional mounting and fixing rules. It soon became clear that the classification of the insulation product as such does not reflect the behaviour of the product in its real end-use application. A mounting

[2] *Polyurethane and Fire*, Franz H. Prager and Helmut Rosteck, Wiley-VHC Verlag, 2006

Figure 4: PU board with gypsum (plasterboard) cover achieving class B in SBI test according to EN 13823

and fixing standard (EN 15715) was developed and adopted to be used with the product standards. This allows the manufacturer to classify their product tested in the SBI in a number of specific set-ups simulating end-use conditions, as well as the product as placed on the market. In some Member States, an end-use classification is needed for the interpretation of the national regulations.

RESISTANCE TO FIRE

One definition of fire resistance is "the ability of a structural element to sustain the performance of its structural duty, whilst being exposed to the temperatures likely to be encountered in a developed fire for specified periods of time." [3]

Consequently, resistance to fire relates to the structure, which mostly is a combination of products including fixing methods. However it could consist of a single or composite product. Accreditation is therefore awarded to that particular construction as a whole, and not to the individual products it is made of.

With this kind of testing, there are many possible different combinations of products and fixings making up the overall structure, and it is impractical to test every permutation. Because of the huge variations that are possible, harmonised standards are accompanied by direct and extended field of application rules.

The most relevant test standards are EN 1363, EN 1364, EN 1365 and EN 1366. The main parameters are:

R = the load bearing capacity of the element, looking at strength and stability

E = the integrity of the element, the ability of the element to contain flames

I = insulation; the ability of the element to contain the heat

The results are expressed as the number of minutes all three aspects resist the effects of a fire, so an element fulfilling all of these criteria

[3] PU Europe Factsheet nº 1: *Fire resistance of different insulation materials in pitched roofs and timber frame walls*

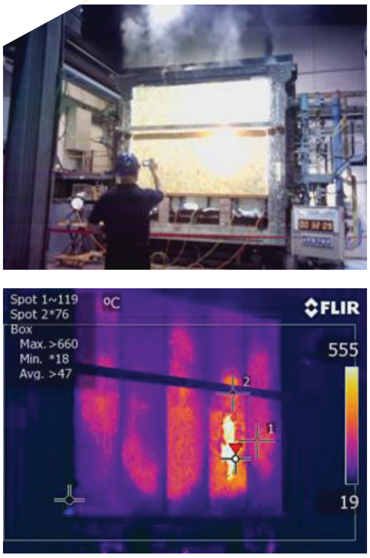


Figure 5: Test build-up according to EN 1365-1: the unexposed face of the specimen and thermographic image during test

for 30 minutes would be classified as REI 30. The classifications for resistance to fire are described in EN 13501-2, 3 and 4.

Because the test sample has to represent the complete element, roof or wall, etc. determining REI requires testing in large scale and is expensive. For example, a flat roof test would need to include the supporting roof deck, the waterproofing layer as well as the insulation respecting the method of fixing intended in the building.

Naturally, the degree to which the insulation has an opportunity to play a role in fire resistance depends on the construction. For instance, if a flat roof with a concrete slab base were being tested, it would give several hours of fire resistance, regardless of what other products were placed on top, and when it does fail, the performance of the effect of the other products would be irrelevant as the structure itself would already be compromised.

Regarding the insulation resistance criterion (I), experience and testing have shown that structures insulated with rigid polyurethane insulation (PU) products show excellent fire performance in real fire scenarios due to their thermosetting character and high thermal stability. This is especially so with PIR insulation, which is formulated for improved fire resistance. The char generated on the surface of the insulation protects the core from decomposition, so the integrity of the structure is maintained for a long time even if heavily attacked by the fire. Structures insulated with PUR/PIR insulation can perform better than or give performance equivalent to structures insulated with other mainstream insulation materials. PUR/PIR insulation performs better than the Euroclassification system for 'reaction to fire' might indicate. PU insulation does not melt or drip when heated. Evidence is provided through the tests described in the examples in the section Combustibility behaviour of insulation products (Performance in application-related tests).

EXTERNAL FIRE PERFORMANCE OF ROOFS

In some countries this aspect originated from burning debris or brands from one building fire catching alight a neighbouring

EXAMPLE OF DIFFERENT COUNTRIES APPROACHES TO TS 1187

Scenario	Origin	Criteria
1187-1	Germany	Burning brands (droplets), burn through incl. glowing
1187-2	Nordic	Burning brands, wind
1187-3	France	Burning brand, wind and radiation
1187-4	UK	Gas flame, wind and radiation (as in BS 476 part 3)

Table 2: Example of different countries approaches to CEN/TS 1187

building. Nevertheless, there are a large range of existing test methods with a wide variation in approach and interpretation of test results in Europe.

Classification of roofs for external fire performance is described in EN 13501-5. The testing is based on the Technical Specification CEN/TS 1187, which is split into four different test scenarios (1187-1 to 1187-4). EU Member States have not been able to agree on one single test and countries tend to stick to their historic testing and related criteria. Even within a cluster of countries using one type of testing, there are different approaches. For example, CEN/TS 1187-1 is used differently in the Netherlands than it is in Belgium or Germany.

Because of this variation between countries and the application of EXAP/DIAP [4] rules, the interpretation and results are variable. The usefulness of any comparisons between Member States is therefore questionable.

CEN/TS 1187 is a system test, where all the components are taken into account. These are normally the supporting roof deck, insulation layers, vapour barriers and waterproofing layers on top. More layers may be present. If every variation of one of these components would have to be tested, costs would be extremely high. Based on the experience with national tests, rules for direct and extended application of test results for the different tests have been developed in CEN/TS 16459. For a number of roof systems, experience shows that the covering layer is able to protect the layers below from any impact of a fire from outside. This is why the European Commission

[4] See also the introduction to this section

has taken a decision in 2000 to allow a deemed to satisfy list for a number of roof coverings. This includes products like stone, fibre cement and steel, and covers also steel faced sandwich panels with PUR or PIR core material which are CWFT (Classified Without Further Testing) classified B_{ROOF}(t1, t2 or t3) if certain conditions are met (thickness of covering layer, etc.).

Towards a single harmonised test scenario? There was some discussion at the European level to only get one test, however this was very difficult and complex due to a high number of parameters. As a result, this has stalled and is currently no longer in discussion.

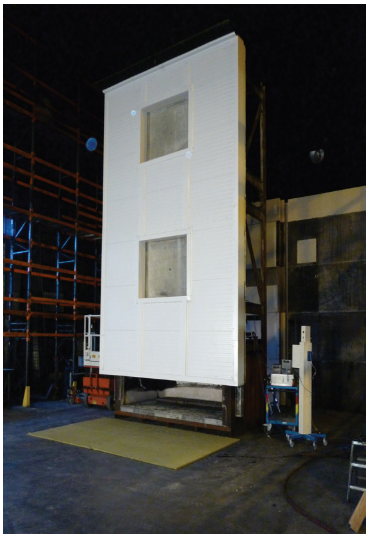


Figure 6: Façade fire test set up according to NFPA 285

FIRE PERFORMANCE OF FAÇADES

With increasing requirements for energy saving, more and more houses are insulated, notably by applying thermal insulation systems on the outside of the building walls. During recent years, regulations regarding fire safety of these insulation systems have been introduced in most European countries. For other applications in buildings, these requirements are mainly based on the results of laboratory tests, but for façades, full scale tests have been developed, to show the behaviour of the whole façade including insulation and cladding.

WHAT ARE THE RELEVANT FIRE SOURCES AND HOW DOES A FIRE DEVELOP ALONG A FAÇADE?

A fire on a façade can be initiated either by a burning house near the façade, or by a burning item close to a façade (burning car or waste container). The most frequent and in many cases the most severe fire source for a façade is a fire resulting from a flashover situation in a room. In this situation a fire starts in a room and after some time the window breaks and then flames are soon so high on the façade that they reach the window of the floor above the initial fire. After some further time, this window is also destroyed and the fire ignites the items in this room. When flashover is then reached in the room on the next floor, the same process starts again. Such a fire will always spread upwards, but that takes some time. If the façade is insulated it is important that the façade insulation system does not contribute to a fast fire spread upwards.

As there have been some fires in recent years where, for example, burning waste containers or vehicles in front of buildings have caused serious façade fires, some countries (i.e. Germany) are now considering additional tests and requirements regarding the performance of façade systems when exposed to a severe external fire source.

FIRE TESTS FOR FAÇADES

In the past, most countries set requirements for outer façade insulation based on the classifications obtained from the usual laboratory tests. Experience has shown that, in some cases, these tests do not give sufficient information about the performance of the complete insulation system in a real fire. So full scale tests have been developed in several European countries. Most of these tests are based on the scenario of a fire in a room breaking through a window. In most cases, the parameters measured include the observation of flame spread (visual observation and temperature measurements), the assessment of damage on the outside of and within the insulation system after the test, and burning droplets and parts or debris falling down.

However, there are big differences between the tests depending on the country. The main parameters, which are different, include the following:

- Type of fire source (some tests use wood cribs, others gas burners or liquid fuels)
- Size of fire source
- Specimen configuration (corner or flat wall, additional openings/windows)
- Height of test rig

Various tests are used for different height limitations in different countries. In the UK for example an extremely high fire load is applied in the BS 8414 test. The regulation was until 2018 that if a façade system passed this test, it could be applied to any building. Changes have been made to the use of tests in the different parts of the UK after the tragic fire of the Grenfell Tower (London, 14th June 2017) and at the time of issuing this section, for England and Wales high-rise buildings 18 m above ground level which contain one or more dwellings, an institution or a room for residential purposes, must only use A1 or A2-s1,d0 insulation and cladding products. For Scotland the height limit is now 11 m and while the A1 or A2-s1, d0 insulation and cladding systems are specified, the BS 8414 test is still allowed for façade system assessment to identify any other systems can be installed. For buildings lower than 18 m in England and Wales and 11 m in Scotland combustible insulation can be used as long as the system performance is reached.

In Germany the fire load during the test is lower, but a general limit for the use of combustible products within a façade cladding system has been set such that above a height of 22 m (highest occupied floor) independent from the use of the building combustible products are not allowed.

The European Commission started a new project in 2017 with the aim to develop a European approach to assessing the fire performance of facades and the definition of all relevant details and classifications to be used for harmonised products standards (in CEN) and for European Assessment Documents (in EOTA) for the relevant construction products (kits) within the framework of implementation of the Construction Products Regulation (CPR) 305/2011/EU. As a result of this project in 2018, a study [5] was published which still does not deliver a final solution. Two possibilities for the future European method were presented:

- Proposed method: the BS 8414 and DIN 4102-20 test rigs are kept as they are. If falling parts/burning debris is to be assessed the complete rig needs to be uplifted, or extended, at least 0.5 m to ensure that the radiation from

[5] *Development of a European approach to assess the fire performance of façades*

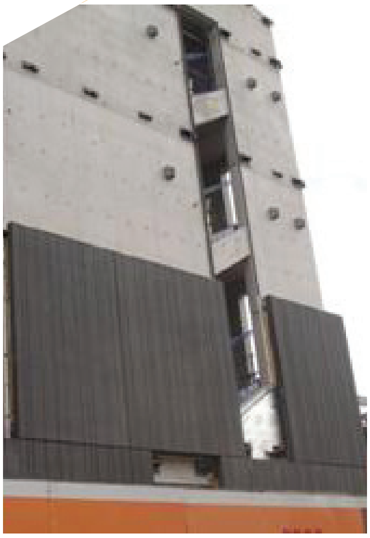


Figure 7: External cladding applied as soon as possible to insulated parts, stage by stage (Ventilated façade, Manchester, UK, August 2010)

the combustion chamber does not affect the material falling down during the test;

- Alternative test method: the width and height of the main face and the wing is 3.5 x 7 m and 1.5 x 7 m for the medium fire exposure and 3.5 x 8 m and 1.5 x 8 m for the large fire exposure. The height from the floor to the lintel of the combustion chamber is different in the two methods, 1 m for the medium fire exposure and 2 m for the large fire exposure. In addition, the complete rig needs to be uplifted, or extended, at least 0.5 m to ensure that the radiation from the combustion chamber does not affect the material falling down during the test.

The European Commission decided in Autumn 2019 to go forward with the "alternative approach". A study was started with the goal to finalize this assessment method, develop assessment criteria and classifications and verify repeatability and reproducibility of test results. The European Commission could introduce this new method for CE marking with a delegated act. The study is envisaged for a time period of 2 years and started in April 2020 [6].

It is not clear, how in the end member states will adopt this method for façade systems, as the European Commission can only decide how to deal with products and kits which are CE marked.

PUR AND PIR FOR FAÇADE INSULATION

Wherever combustible products are allowed, it is possible to pass the requirements for fire safety of façade insulation systems with PU. However, the insulant used is not the only factor deciding about fire safety. If an ETICS (External Thermal Insulation Composite System) is produced, the quality and stability of the outer covering (reinforcement layers and mortar) is also important for the performance of the insulation system in a fire. For curtain walls (wall covering systems with a ventilated gap between the outer cladding and the insulation layer or the wall) special precautions always have to be taken. The reaction to fire of the outer cladding is important

[6] *https://www.ri.se/en/what-we-do/projects/finalisation-of-the-european-approach-to-assess-the-fire-performance-of-facades*

and the fire will be able to spread upwards through the gap, if appropriate fire barriers have not been installed. This is the same even if non-combustible insulation products have been used.

Therefore, from a point of view of fire safety, PU products can be applied in all façade systems, whenever national regulations do not ask for non-combustible insulation products, provided they can fulfil the relevant full-scale testing requirements.