AN INTRODUCTION

CURRENT TESTING AND STANDARDS

In the past, manufacturers, designers and specifiers in the Internal Market had to cope with a lack of meaningful European/International standardisation for the assessment of the fire performance of construction products. Countries had developed their own 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 standards and tests. Some correlations could indeed be drawn between the 7 Euroclasses and elements of the pre-existing standards. However, it has been difficult to translate national reaction-to-fire classes into equivalent Euroclasses. For example, the results from the Dutch national smoke test are very different from results in the SBI smoke test, which is used in Euroclassification.

Harmonising test standards in Europe is meaningful whilst aiming for simplification and standardisation. However, the intended use, as described in the CPD, translates into 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).

Particularly for resistance-to-fire test standards both DIAP and EXAP rules are derived. But 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. There are still discussions ongoing in Europe on EXAP rules, but in many Member States national EXAP rules exist e.g. for external fire.

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

---

E.g. UK – BS 476; France – NF P 92-50; Germany – DIN 4102
Fire regulations refer to three basic categories of fire standards:

- Reaction to fire
- Resistance to fire
- External fire on roofs

Each of these is expanded upon in the following three chapters.

A fourth category is under development: the external fire on façades. This was triggered by the introduction of new façade systems and their growing importance.

**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 EN13501 part 1, building products are tested for reaction to fire and divided into seven Euroclasses:

- A1 and A2
- B, C, D, E
- F for materials for which performance has not yet been determined or failing Euroclass E criteria

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 anything between s1 and s3 for smoke development, again dependent on formulation, facings and end-use condition, but as a thermo-set material it does not produce droplets and therefore always achieves d0.

The Euroclass system does not yet consider the smouldering or continuous glowing potential of a product. As this is considered a risk, the European Commission mandated the European Standardisation Committee CEN to develop a test method. 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.

Other parts of EN13501 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  Small flame ignitibility test  

The first stage of testing is EN ISO 11925-2, which simulates a small flame ignition such as a cigarette lighter 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, or it is a prerequisite for the SBI test (30 instead of 15 seconds exposure), when the aim is to achieve classes B, C or D.

In the SBI test method according to EN ISO 13823, a specimen is exposed to a gas flame of 30 kW, simulating a single burning item in 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 in addition lateral flame spread is taken into account.

In the exhaust duct, also smoke obscuration is 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.

Smouldering will become a criterion in the reaction to fire classification on request of some national regulators. A new test is under development. As this test is not yet available as a harmonised method, EU Member States are allowed to have additional national tests and rules for CE marked products.
For floor coverings, an existing horizontal flame spread test, EN ISO 9239-1, has been adopted for the classes A2fl to Dfl, 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 has not been considered acceptable, for example for linear products. For cables, pipe insulation and pipes, a different classification system for reaction to fire has been developed and adopted.

The reaction-to-fire classification of a product should not be confused with fire safety performance in a building. It should not be interpreted in a way that with an A2 product, a building will always be fire-safe or that with an E product the building is less fire-safe. Fire safety in a building strongly depends on how the products have been applied. For other than wall and ceiling lining products, 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, EN13501 part 1, that testing is supposed to be in relation to the end-use condition 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 clearly the boundary conditions of the declared Euroclass. Therefore product specifications (harmonised product standards and ETAGs) may contain additional mounting and fixing rules.

The first version of insulation product standards did not have additional mounting and fixing rules. In addition, it became clear that the classification of the insulation product as such does not reflect the behaviour of the product in its real end-use condition. A mounting and fixing standard (EN15715) was developed and adopted to be used with the product standards, which allows the manufacturer to classify his product tested in the SBI in a number of specific set-ups simulating end-use conditions, in addition to the product as such classification. 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.” [2]

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.

Two tests that are widely used to classify resistance to fire are the (R)EI methods EN1365-2 (for load-bearing systems) or EN1364-2 (for non-load-bearing systems):

- **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 for 30 minutes would be classified as REI 30. The classification for resistance to fire is described in EN13501-2, 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.

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 emerging 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 examples 3 and 4 in the chapter Performance in application-related tests.

### EXTERNAL FIRE ON ROOFS

Statistically speaking, there is very little evidence of fire originating from an external fire source. Nevertheless, there is 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 EN13501-5. The testing is based on the Technical Specification TS1187, 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, 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 [3] rules, the interpretation and results are variable. The usefulness of any comparisons between Member States is therefore questionable.
TS 1187 is a system test, where all the components are taken into account. These are normally the supporting 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. These rules will soon be published.

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 has taken a decision to allow ‘classification without further testing’ (CWFT) for a number of roof coverings. This includes not only products like stone, fibre cement and steel, but also steel faced sandwich panels with PUR or PIR core material which are CWFT classified B roof (T1, T2 or T3), if certain conditions are met (thickness of covering layer, etc.).

Towards a single harmonised test scenario? A single burning roof test (SBR) has been proposed in order to harmonise test set-ups and standardise results. The different viewpoints of Members States make this discussion complex, leading to a high number of parameters to consider in the test set-up. In view of the rarity of external fire hazards, the testing could be ‘overdesigned’. In the meantime, most producers have done testing and classification according to the existing standard, so that it is questionable, whether it makes sense to develop another new test. In addition, no financing has been found for the development and validation of such a test. So work has
been stopped in the European standardisation group for external fire exposure of roofs.

REACTIoN tO FIRE oF FAçADES

With increasing requirements for energy savings, more and more houses are insulated, 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 construction in a real fire.

WHAT ARE thE RELEVANt FIRE SOURCES AND how DoES A FIRE DEVELOp ALONG A FAçADE?

A fire at 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 case, after some time the window brakes, and then flames are soon so high, that they reach the window of the floor above the initial fire. After some time, this window is also destroyed and the fire ignites the items in this room. When flashover is then reached in the room at the next floor, the same process starts again. Such a fire will always spread upwards, but that takes some time. If façade insulation is present, it is important to avoid that this process is accelerated, and that the façade insulation system contributes to a fast fire spread upwards.

FIRE tEStS FoR FAçADES

In the past, most countries have 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 them are based on
the scenario of a fire from a room and 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, as well as burning droplets and parts 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)
- Height of test rig

The different tests are also used in a different way for regulation. In
the UK for example, an extremely high fire load is applied in the test,
but if a façade insulation system passes this test, it can be applied
to every building without limitations. Germany is an example for a
different approach. There, the fire load during the test is lower, but a
general limitation for the use of combustible insulation products like
PU within a façade insulation system has been set: above a height
of 22 m (highest occupied floor) only non-combustible insulation
products are allowed.

Currently, a European test method is being developed within EOTA
(European Organisation for Technical Approvals). This will be a two
stage method (two sizes of fire load and two heights of test rig).
Based on that all the regulatory requirements of the different European
countries can be taken into account. The work has been started, but it
will still take at least two more years until a European test method can
be available.
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 System) is produced, the quality and stability of the outer covering (reinforcement layers and mortar) are 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, as the fire will be able to spread upwards through the gap, if appropriate fire barriers have not been applied. This is also valid, if non-combustible insulation products have been applied.

So from a point of view of fire safety, PUR and PIR products can be applied in all façade systems, wherever national regulations do not ask for non-combustible insulation products, if the necessary precautions are taken.