

## Semi-natural test methods to evaluate fire safety of wall claddings

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**Abstract.** External walls and their components are subjected to a number of fire safety requirements. Fire resistance and reaction to fire are the harmonised requirements in the EU. These cover two fire scenarios: contribution of internal wall linings to an intermediate-size developing fire inside a fire compartment, and resistance of external walls to post-flashover fire inside a fire compartment (resistance to an external fire may also be required). The spread of fire along the external surface is not part of this European evaluation system and remains subjected to national fire safety codes and regulations. A number of test methods covering this scenario exist in Europe and North America at national levels as well as at the international level (ISO). These test methods and associated criteria differ in fire size, test duration, test specimen size and configuration. This paper presents principles of major existing test methods and comparison of test results on comparable test specimens where they are available.

### INTRODUCTION: IMPORTANCE OF FIRE SPREAD

The Construction Products Regulation (CPR) [1] provides the regulatory framework for the performance of construction products in Europe. In the CPR, the Basic requirement for construction works no. 2 “Safety in case of fire” requires that the construction works must be designed and built in such a way that in the event of an outbreak of fire:

- the load-bearing capacity of the construction can be assumed for a specific period of time;
- the generation and spread of fire and smoke within the construction works are limited;
- the spread of fire to neighbouring construction works is limited;
- occupants can leave the construction works or be rescued by other means;
- the safety of rescue teams is taken into consideration.

External wall cladding may become a contributing factor in a fire incident in all these aspects!

Yet the practical way of evaluating the safety of external wall claddings in case of fire differs a lot from this definition – at least at the level of harmonised approach to construction products in EU. External wall claddings and their components are evaluated for reaction to fire as standalone products and assemblies to EN 13501-1 [2] in a room fire scenario; fire resistance requirements to EN 13501-2 [3] may comprise wall claddings as part of the structure; and spread of fire along the external surface is currently not part of this harmonised system at all. Consequently European member states, which presently regulate for this characteristic, have to rely on national test methods.

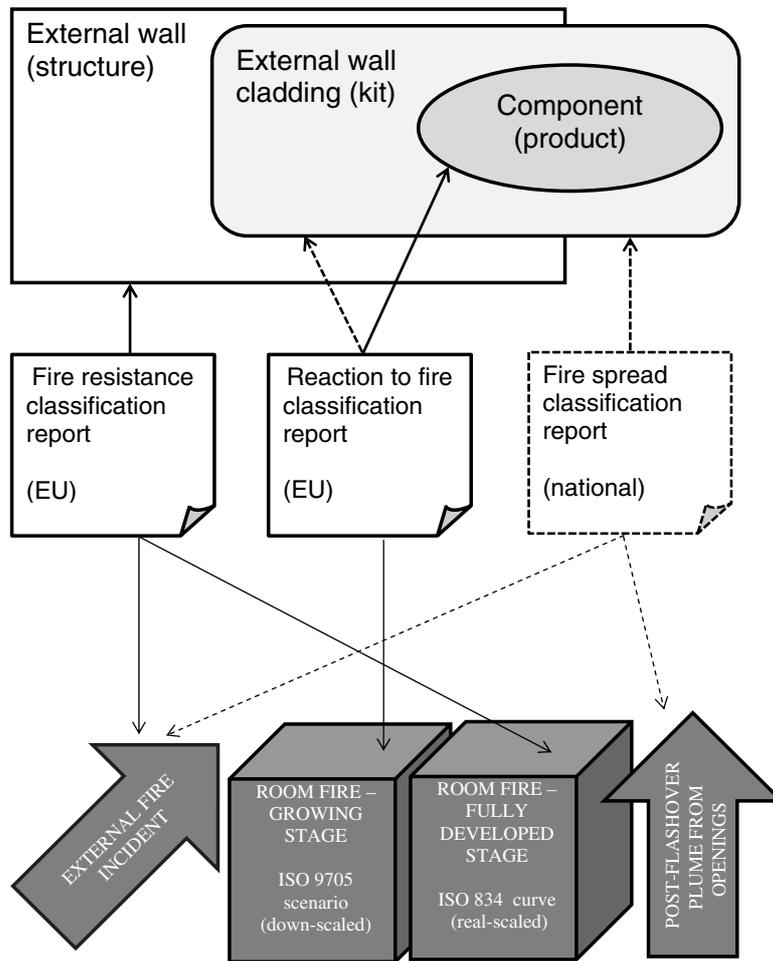
Therefore it is worthwhile to look at the approaches used in European Member States and overseas. The methods for evaluating the fire spread over external wall claddings are diverse although some similarities can be identified.

### LIMITS TO HARMONISATION

#### Reaction to fire: EN 13501-1 [2]

Declaring the reaction to fire class of products as they are placed on the market is a basic requirement for any construction product. If these products are placed on the market as a kit, it may be required to

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**Figure 1.** Fire safety characteristics in legal evaluation systems in EU. Although the spread of fire is an important part of the CPR [1] definition (BWR 2), it has not been harmonized. The picture also shows which fire scenarios are normally represented by classification reports. External wall may comprise the cladding system. Fire spread may be considered part of the national reaction to fire classification and/or represent a benchmark – not a real-scale – testing in some Member States.

declare the class for the assembled kit. It is important to realise the purpose and assumptions of this information (Fig. 1).

Reaction to fire classification system in the EU is based on a scenario of internal room fire during the growing stage and ISO 9705 [4] alias EN 14390 [5] is the only available large-scale reference test. Classification reports to EN 13501-1 [2] for external wall cladding systems need to be seen from the perspective of this logic. The principal of the harmonised system is that the result from the SBI test [6] is correlated to that of the large-scale reference test.

Generation of smoke as part of the EN 13501-1 [2] criteria is solely based on the SBI [6] test exposure of 30,75 kW. As the response of products (and especially laminated kits e.g. ETICS [7]) to a growing fire is not linear, this information is related to this level of fire exposure only.

Generation of droplets is another supplementary class contained in the EN 13501-1 [2] classification system. It is tested on products and kits installed vertically with fire source impinging on a flat side of

the wall where no additional installation details are tested. Any combustible core components covered by a protective surface layer will normally not produce droplets in the SBI [6] test. For external wall cladding system however, important details like the fire-exposed vertical window edge and especially the bottom edge (lintel and system base) need to be tested; these details are not part of the test specimen. It is also here that a semi-natural fire test provides valuable information.

### **Fire resistance: EN 13501-2 [3]**

External wall claddings may be considered to be part of the external wall assembly, as far as fire resistance of external wall is considered. This is especially important in drywall systems like timber-frame; it is with these types of external walls that the external cladding may have an impact on load-bearing capacity of the external wall.

For typical masonry and concrete external walls, fire resistance of the loadbearing part of the wall is more than sufficient to meet standard fire resistance criteria. The presence of a combustible or non-combustible external cladding system does not impact the loadbearing capacity of the original wall to a significant degree.

### **External fire spread**

Although mentioned several times in the CPR definition of the Basic work requirement “Fire safety”, spread of fire along the external wall surface has not become part of the European legal system for evaluating construction products’ fire safety. For some reason, it is part of the evaluation of roof coverings and roof assemblies, however. EN 13501-5 [8] is hopefully a unique example of failed harmonisation process where one classification standard referring to a CEN/TS document [9] containing 4 different test methods results in 4 different classification criteria.

## **EXTERNAL FIRE SPREAD FROM INTERNATIONAL PERSPECTIVE**

In the absence of harmonisation, safety against fire spreading along external is handled by individual Member States – differently almost in each of them. Fire spread tests are not part of regulatory systems everywhere; and where they are present, they may serve as supplementary information to other approaches, like calculation of calorific potential of wall claddings, normative requirements on structural details, safe distances, provisions against falling droplets, etc.

The variety of approaches, differences, and similarities is illustrated by the list of major test methods shown in Tables 1 and 2.

### **European test methods**

In the absence of harmonised approach, 1/3 of EU countries use their own methods for defining safety levels of fire spread on external walls. As shown below, these safety levels differ. Apart from the Polish standard, all the test methods simulate a fire attack on the wall external face in a post-flashover window fire plume scenario, and are used as an alternative route to prove an equal level of safety to the one defined by prescriptive requirements. More than test configuration, the use of test results is defined by safety criteria which are quite different.

### **International test methods**

A large-scale test method has been developed by ISO, but this is not used for approvals in any country. A couple of diverse methods are in use in North America, and one method exists in Russia and some other former USSR countries.

**Table 1.** Main parameters of major international and national test methods for fire spread on external wall cladding. European tests.

Standard	BS 8414-1	LEPIR II	MSZ 14800-6	SP FIRE 105	Önorm B 3800-5	DIN E 4102-20	PN-90/B-02867
Country	UK	F	H	S	A	D	PL
Fire exposure	Wood crib, peak heat 3,5 MW, 4500 MJ	600 kg wood crib	380 kg wood crib/10 kg Diesel oil	601 heptane	25 kg wood / 320 kW propane	25 kg wood / 320 kW propane	20 kg wood crib + wind towards the wall (2 m/s)
Max. heat flux on surface	70 kW/m <sup>2</sup> at 1 m height	Not specified	Not specified	15 or 80 kW/m <sup>2</sup>	Not specified	70–95 kW/m <sup>2</sup> at 1 m height	Not specified
Max. temperature on surface	600 °C / 20 min	Average 500 °C, peak 800 °C	600 °C 0,5 m high / 50 min	450 °C / 12 min	Not specified	Not specified	800 °C peak
Test duration	30 min	Min. 30 min	40 min	Min. 12 min	30 min	21 min gas, 30 min wood	30 min
Test specimen	Corner 2,5 m × 8,0 m + 1,5 m × 8,0 m	Flat wall 3,0 m × 5,5 m	Flat wall 6,0 m × 7,0 m	Flat wall 4,0 m × 6,7 m	Corner 3,0 m × 6,0 m + 1,5 m × 6,0 m	Corner 3,0 m × 5,2 m + 2,0 m × 5,2 m	Flat wall 2,3 m high
Substrate	Masonry or light frame	Any	Masonry	Aerated concrete	Aerated concrete	Aerated concrete	Masonry
Criteria <sup>a</sup>	Temp. limits	Flame on 2 <sup>nd</sup> floor	Temp. rise, fire spread, falling parts <sup>b</sup>	Flames 2 floors above; Falling parts	Temp. rise, fire spread, falling parts <sup>b</sup>	Temp. rise, fire spread, falling parts <sup>b</sup>	Temp. limits; Burning particles

<sup>a</sup>) Additional criteria may be contained in other standards or regulations.

<sup>b</sup>) Temperature rise, vertical and/or horizontal flame spread, burning droplets and particles, falling parts of certain size or mass.

A few notes on the existing European and international test methods:

*BS 8414-1* [10]: A real-size test to simulate post-flashover plume from an opening in external wall. Passing this test results in unlimited application of the external wall cladding product. Different criteria exist in basic regulation [11] and in insurance approval schemes [12, 13].

*LEPIR II* [14]: This test is not part of French regulatory requirement; it is used for development purposes. No approval criteria are linked to this method in French regulations.

*MSZ 14800-6* [15]: A real-sized approval test originated from LEPIR. A revision is on-going; adding a lateral wing to the flat wall is under consideration.

*SP FIRE 105* [16]: A draft method used as an alternative route for approval in Sweden, and for research and development purposes. Under consideration in Denmark and Norway.

*DIN E 4102-20* [17]: A benchmark draft test method used for national approval of external wall cladding systems for mid-height buildings. This test does not represent an external fire attack other than the window-plume situation.

*Önorm B 3800-5* [18]: A variation of the draft DIN method that can be used for product approvals in Austria.

*ISO 13785-2* [19]: A real-scale test representing both a post-flashover window plume scenario, and an external fire attack. Similar in nature to the BS 8414-1 [10] test.

**Table 2.** Main parameters of major international and national test methods for fire spread on external wall cladding. International and overseas tests.

Standard	ISO 13785-2	ISO 13785-1	GOST 31251	NFPA 285	NFPA 268	CAN/ULC-S134	CAN/ULC-S101 + CAN/ULC-S114
Country	none	CZ	AZ, AM, KG, KZ, MD, RU, TJ, UZ, UA	USA	USA	CAN	CAN
Fire exposure	Propane set by calibration	Propane 100 kW	Soft wood 700 MJ/m <sup>2</sup>	Gas burner	Radiant panel 12,5 kW/m <sup>2</sup>	Propane set by calibration	Defined time/temp curve
Max. heat flux on surface	55 kW/m <sup>2</sup> at 0,6 m height	Not specified	12,5 kW/m <sup>2</sup> at 2 m height	38–40 kW/m <sup>2</sup> at 0,6-1,2 m height	12,5 kW/m <sup>2</sup>	45 kW/m <sup>2</sup> at 0,5 m height	Not specified
Max. temperature on surface	Min. 800 °C	Max. 150 °C at 0,5 m height	750 °C at lintel	712 °C at 0,9 m height	Not specified	Approx. 415 °C	Not specified
Test duration	23–27 min	30 min	35 min	30+10 min	20 min	25 min	Min. 15 min
Test specimen	Corner 3,0 m × 5,7 m + 1,2 m × 5,7 m	Corner 1,2 m × 2,4 m + 0,6 m × 2,4 m	Flat wall 3,0 m × 5,1 m	Flat wall 4,1 m × 5,3 m	Flat wall 1,2 m × 2,4 m	Flat wall 10 m high	Flat wall min. 2,8 m × 2,8 m
Substrate	Any	12 mm Ca-Si board	Masonry concrete	150 mm th. floor slabs	Steel tube	Concrete	None
Criteria <sup>a</sup>	Not included	Not included	Not included	Flame spread, temp. rise <sup>b</sup>	Ignition	Vertical flame spread, heat flux	Integrity of top layer <sup>c</sup>

<sup>a)</sup> Additional criteria may be contained in other standards or regulations.

<sup>b)</sup> Temperature rise, vertical and horizontal flame spread.

<sup>c)</sup> Protection of foam plastics on external facade – protective layer must remain in place, no openings developed, does not disintegrate. S114 is additional non-combustibility requirement.

*ISO 13785-1* [20]: A screening method for ISO 13785-2 [16]. Despite the limitation in its scope, the test is currently used in Czech Republic as an alternative route for product approvals.

*GOST 31251* [21]: A semi-natural test similar to the MSZ14800-6 [15] method. Similarly, the application of test results is linked to classes depending on measured values.

*NFPA 285* [22]: A benchmark test comprising 2 burners: one in the combustion chamber, and an additional one simulating a fire attack on the lintel.

*NFPA 268* [23]: A radiant panel test used to determine ignition resistance of claddings i.e. another building on fire.

*CAN/ULC-S134* [24]: A real-scale semi-natural test similar to BS 8414-1 [10] but not containing a lateral wing.

*CAN/ULC-S101* [25] + *CAN/ULC-S114* [26]: A combination of a fire resistance and combustibility tests applied specifically to protection of foamed plastics.



**Figure 2.** ETICS system with organic rendering containing 200 mm high fire-stopping strip made of stone wool installed within EPS insulation layer, tested in ISO BS 8414-1 [10] configuration (3 MW heat source).



**Figure 3.** ETICS system with organic rendering containing 200 mm high fire-stopping strip made of stone wool installed within EPS insulation layer, tested in DIN E 4102-20 [17] configuration (320 kW heat source).

### TEST RESULTS FOR COMPARISON OF TEST METHODS

Although some of the methods depicted above show certain similarities, the diversity of measured values and evaluation criteria make it impossible to provide correlation between various test methods. Any test programmes providing data for comparison are of high value.

An example of a project of this type has been carried out recently by and results are publicly available [27, 28]. These results point to some interesting conclusions:

- The test specimens were ETICS systems with different types of renders and combinations of insulating core made of expanded polystyrene with stone wool fire-stopping strips of various sizes included at different positions relative to the lintel. Response of this type of laminated kit containing non-homogeneous insulation core to fire differs not only in relation to the fire size, but also to different types of render materials.
- The fire-stopping strips made of stone wool proved effective in some test configurations and specimen types, while ineffective in others.



**Figure 4.** ETICS system with organic rendering containing 200 mm high fire-stopping strip made of stone wool installed within EPS insulation layer, tested in ISO 13785-1 [20] configuration (100 kW heat source).

Comparison of test results [27] have been done based on different pass/fail criteria linked to each standard. However, no correlations between the tests were possible regarding burning behaviour of the tested kits, measured temperatures, or heat flux.

The response of an almost identical specimen to different fire sources varied, and is shown on figures 2 to 4: 100 kW propane burner of ISO 13785-1 [20] (Fig. 2); 320 kW propane burner of DIN E 4102-20 [17] (Fig. 3); and 3 MW output from a timber crib of BS 8414-1 [10] (Fig. 4).

## CONCLUSION

It is not only different test methods used worldwide, but also principally different criteria linked to these methods that result in different external wall cladding kits being approved to be safe in one region but maybe not in another. Despite that fire spread is an integral part of the CPR [1] definition of the basic work requirement “Safety in case of fire”, this product characteristic is not part of existing mandates from the Commission or published European Technical Approval Guidelines. In Europe, evaluation of safety of external wall cladding kits is still based on reaction to fire, which is inadequate. Existing declarations used for CE-marking provide a very elementary safety net and a benchmark – not relevant information to evaluate safety against fire spread.

As the example of roofing products show, creating European standards just by collecting mutually incompatible different test methods is not a route for real harmonisation. The purpose of CE-marking

is to provide a relevant product characteristics linked to the CPR [1] definitions that can be used by member states to define safety levels as they find appropriate, based on proper understanding of product performance and real risks.

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