

## ISPITIVANJE GRAĐEVINSKIH MATERIJALA – REAKCIJA NA POŽAR

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**Rezime:** Kako bismo se što efikasnije borili sa pojavom nastanka požara u objektima, prilikom gradnje je neophodno uzeti u obzir aktivne i pasivne mere zaštite od požara. U radu će biti više reči o pasivnim merama zaštite od požara koje se odnose na izbor adekvatnog materijala koji će se koristiti prilikom gradnje, čime se doprinosi lokalizovanju vatre i sprečavanje širenja na druge prostorije i objekte.

Svi materijali, čija se ugradnja planira projektom, moraju da imaju adekvatne ateste da ne doprinosu razvoju požara, kao i da zadovolje klasu otpornosti prema požaru. U Republici Srbiji, jedino se Laboratorija za toplotnu tehniku i zaštitu od požara, u okviru Instituta IMS, bavi ovom vrstom ispitivanja i izdavanja izveštaja.

U radu će biti predstavljene ispitne metode kojima se dobija klasa reakcije na požar. Nakon izvršenih ispitivanja, prema standardu SRPS EN 13501-1, se izdaje Klasifikacioni izveštaj u kome se daje konačna klasa reakcije na požar za ispitani proizvod čije važenje traje 5 godina.

**Ključne reči:** reakcija na požar, klasifikacija građevinskih materijala, negorivost, gornja toplotna moć, gorenje malim plamenom, SBI test, ispitivanje podova

## TESTING OF BUILDING MATERIALS - REACTION TO FIRE

**Abstract:** To reduce occurrence of fires in buildings as efficiently as possible, it is necessary to take into account active and passive fire protection measures during construction of building. This paper will show more about passive fire protection measures related to the selection of adequate material to be used during construction, which contributes to the localization of fire and prevents it from spreading to other rooms and facilities.

All products, which are planned by project, must have adequate certificates not to contribute to the development of fire, as well as to meet the class of fire resistance. In the Republic of Serbia, only the Laboratory for Thermal Engineering and Fire Protection, within the IMS Institute, deals with this type of testing and issuing reports.

This paper will present test methods for obtaining a fire reaction class. After the tests, according to the standard SRPS EN 13501-1, a Classification Report is issued in which the final fire reaction class is given for the tested product whose validity lasts for 5 years.

**Key words:** reaction to fire, classification, non-combustibility, heat of combustion, ignitability, SBI test, flooring test

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## 1. INTRODUCTION

The duration of fire depends of several factors, such as the fire load, the size of the fire compartments and the amount of combustible materials in building. For this reason, it is necessary to pay special attention when choosing the materials that will be used during the construction of the building.

Reaction to fire is passive fire protection discipline which deals with response of a product in heat contribution by its decomposition to a fire to which it is exposed, under specified conditions. [1] For this reason, the material have to be little or non-combustible or less flammable so that the fire can be extinguished with the active fire protection systems (sprinkler systems, fire extinguishers). The main goal, which is taken into account when choosing the material, is primarily the protection of people who were inside the building at the occurrence of the fire, providing them enough time to evacuate safely.

To determine the performance of materials, it is necessary to test them according to the standards defined by national rules and guides. In the Republic of Serbia, a rulebook is being drafted which defines the testing of construction materials according to European standards, which provide a class of reaction to fire. Standard SRPS EN 13501-1 prescribes 7 classes of reaction to fire (A, A2, B, C, D, E, and F). The paper will present the methods that are necessary to use when obtaining a class for fire reaction.

## 2. FIRE LOAD

Fire load is the amount of heat of all materials that are in one room and have the property of burning, reduced to a unit of the surface area of the room, expressed in GJ / m<sup>2</sup>. It can be calculated for: a room, a sector, or for the whole building. According to the standard SRPS U.J1.030 [2], fire load is divided into three groups:

- low fire load - up to 1 GJ/m<sup>2</sup> (residential buildings, schools, kindergartens, hotels),
- medium fire load - 1 GJ/m<sup>2</sup> to 2 GJ / m<sup>2</sup> (shops, industrial facilities),
- high fire load - over 2 GJ/m<sup>2</sup> (wood industry, fuel storage).

Fire load can be: movable and immovable. The movable fire load includes all the contents of the building, such as furniture, appliances, curtains, carpets, ... The immovable fire load includes the building itself (wall, ceiling, and floor coverings, doors, windows, wall partitions).

The total fire load of a building, or its part, is the thermal energy that can be released in a fire during its complete combustion and represents the sum of moving and stationary load, expressed in GJ. Specific fire load is the quotient of the total fire load and the area of the area for which it is calculated and represents the average value of the total fire load calculated per area, expressed in GJ / m<sup>2</sup>. The calculation of the specific fire load is calculated according to the standard SRPS U.J1.030, whereby its use is obliged by the "Rulebook on technical and other requirements for determining the fire load and the degree of fire resistance".

$$P = \sum_i \frac{V_i \cdot H_i \cdot \rho_i}{S}$$

where:

P - specific fire load [MJ / m<sup>2</sup>]  
V<sub>i</sub> - material volume [m<sup>3</sup>]  
H<sub>i</sub> - lower thermal power of the material [MJ / kg]  
ρ<sub>i</sub> - material density [kg / m<sup>3</sup>]  
S - base area [m<sup>2</sup>].

### 3. TEST METHODS USED IN TESTING BUILDING MATERIALS

To obtain a class of reaction to fire, it is necessary to test the construction material according to the standards prescribed by the new rulebook which will replace the "Rulebook on mandatory attestation of elements of standard building structures to fire resistance product". The procedure for obtaining a reaction to fire class is specified in SRPS EN 13501-1. The standard distinguishes 7 classes:

- A1 – products will not contribute in any stage of the fire including the fully developed fire; for that reason, they are assumed to be capable of satisfying automatically all requirements of all lower classes (stone, brick, metals, glass, inorganic materials with less than one percent organic matter),
- A2 – products will not significantly contribute to the fire load and fire growth (gypsum boards, sandwich panels with mineral wool),
- B – as class C, but satisfying more stringent requirements (wood-cement boards, sandwich panels with polyurethane foam),
- C – additionally under the thermal attack by a single burning item they have a limited lateral spread of flame (sandwich panels with polyurethane foam, phenolic foam),
- D – products satisfying criteria for class E and EL and capable of resisting, for a longer period, a small flame attack without substantial flame spread; in addition, they are also capable of undergoing thermal attack by a single burning item with sufficiently delayed and limited heat release (wood products),
- E – products capable of resisting, for a short period, a small flame attack without substantial flame spread (expanded polystyrene, polyurethane),
- F – products that cannot be classified in one of the classes A1, A2, B, C, D, E.

Depending on the type of product, there are five, standardized methods to determine the class for reaction to fire:

- non-combustibility test (SRPS EN 1182),
- the heat of combustion test (SRPS EN 1716),
- ignitability test (SRPS EN 11925-2),
- single burning item test (SRPS EN 13823),
- determination of the burning behavior of floorings, using a radiant heat source (SRPS EN 9239-1).

In addition to the basic, there are additional classifications based on the amount of smoke released by the material, as well as the production of flammable droplets/particles. Smoke emissions are denoted by the letter s and are divided into 3 subgroups:

- s1 – no smoke,
- s2 – the average level of smoke emissions,

- s3 – high level of smoke emissions.

The formation of flammable droplets/particles is also monitored during the test, where we can distinguish three subgroups:

- d0 - if no flaming droplets/particles occur within 600 s when tested in accordance with EN 13823,
- d1 - if no flaming droplets/particles, persisting longer than 10 s, occur within 600 s when tested in accordance with EN 13823,
- d2 - if no performance is declared, or if the product.

Depending on the required class of fire reaction for certain construction material, tests are performed in accordance with the request of the customer. Tables 1, 2, and 3 lists the test methods that need to be performed to obtain a fire reaction class according to SRPS EN 13501-1.

Table 1: Classification for construction products excluding floorings and linear pipe thermal insulation products

| Class | Test methods                                | Additional classification               |
|-------|---|---|
| A1    | EN ISO 1182 and EN ISO 1716                 | -                                       |
| A2    | EN ISO 1182 or EN ISO 1716,<br>and EN 13823 | s1, s2, s3<br>d0, d1, d2                |
| B     | EN 13823 or EN ISO 11925-2                  | s1, s2, s3<br>d0, d1, d2                |
| C     | EN 13823 or EN ISO 11925-2                  | s1, s2, s3<br>d0, d1, d2                |
| D     | EN 13823 or EN ISO 11925-2                  | s1, s2, s3<br>d0, d1, d2                |
| E     | EN ISO 11925-2                              | without additional<br>classification/d2 |
| F     | EN ISO 11925-2                              | -                                       |

Table 2: Classification for for linear pipe thermal insulation products

| Class           | Test methods                                | Additional classification               |
|-----------------|---|---|
| A <sub>1i</sub> | EN ISO 1182 and EN ISO 1716                 | -                                       |
| A <sub>2i</sub> | EN ISO 1182 or EN ISO 1716,<br>and EN 13823 | s1, s2, s3<br>d0, d1, d2                |
| B <sub>i</sub>  | EN 13823 or EN ISO 11925-2                  | s1, s2, s3<br>d0, d1, d2                |
| C <sub>i</sub>  | EN 13823 or EN ISO 11925-2                  | s1, s2, s3<br>d0, d1, d2                |
| D <sub>i</sub>  | EN 13823 or EN ISO 11925-2                  | s1, s2, s3<br>d0, d1, d2                |
| E <sub>i</sub>  | EN ISO 11925-2                              | without additional<br>classification/d2 |
| F <sub>i</sub>  | EN ISO 11925-2                              | -                                       |

Table 3: Classification for floorings

| Class            | Test methods                                 | Additional classification               |
|------------------|--|---|
| A1 <sub>fl</sub> | EN ISO 1182 and EN ISO 1716                  | -                                       |
| A2 <sub>fl</sub> | EN ISO 1182 or EN ISO 1716,<br>and EN 9239-1 | s1, s2, s3<br>d0, d1, d2                |
| B <sub>fl</sub>  | EN 9239-1 or EN ISO 11925-2                  | s1, s2, s3<br>d0, d1, d2                |
| C <sub>fl</sub>  | EN 9239-1 or EN ISO 11925-2                  | s1, s2, s3<br>d0, d1, d2                |
| D <sub>fl</sub>  | EN 9239-1 or EN ISO 11925-2                  | s1, s2, s3<br>d0, d1, d2                |
| E <sub>fl</sub>  | EN ISO 11925-2                               | without additional<br>classification/d2 |
| F <sub>fl</sub>  | EN ISO 11925-2                               | -                                       |

### 3.1. Non-combustibility test

Non-combustibility is testing according to standard SRPS EN ISO 1182. The non-combustibility of the material is the property of the material not to contribute to the further development of fire. This type of test applies to all materials classified as non-combustible materials - group A1 or A2. To classify the material as A1 in accordance with SRPS EN 13501-1, it is necessary to determine the heat of combustion of the product. When obtaining class A2, we can choose whether we test the product according to SRPS EN ISO 1182 or SRPS EN ISO 1716. For class A2, we need to make SBI test also.

Before starting the test, we need to make five test specimens. The test specimens shall be cylindrical and each shall have a volume of  $(76 \pm 8) \text{ cm}^3$ , a diameter of  $02 ( \quad 4 ) \text{ mm}$  and a height of  $(50 \pm 3) \text{ mm}$ . [3]



Figure 1: Non-combustibility testing apparatus

### 3.2. Heat of combustion test

The heat of combustion is tested according to standard SRPS EN 1716 and represents the energy released during the complete combustion of the material sample. The heat of combustion is calculated according to temperature rise, taking account of heat loss and the latent heat of vaporization water. This type of test applies to all materials classified as non-combustible materials - groups A1 and A2.

In this test, a test specimen of specified mass is burned under standardized conditions, at constant volume, in an atmosphere of oxygen, in a bomb calorimeter calibrated by combustion of certified benzoic acid. [4]



Figure 2: Part of the apparatus for measuring heat of combustion test

### 3.3. Single-flame source test

The single-flame source test is carried out according to standard SRPS EN 11925-2. The method is performed to determine the ignitability of products by direct small-flame impingement under zero impressed irradiance using vertically oriented test specimens. This method is used when obtaining classes from B to E.

Before testing it is necessary to make a sample with dimensions given in the standard. Three specimens shall be cut lengthwise and three crosswise. The dimensions of the test specimens shall be  $(250 \pm 2)$  mm long by  $(90 \pm 2)$  mm wide. [5] The maximum specimen thickness shall be 60 mm and under.



Figure 3: Part of the apparatus for ignitability test

### 3.4. Single burning item test

We can test a single burning item according to the standard SRPS EN 13823. This type of test is the most sophisticated test in the field of fire reaction. As a result of the test, we can obtain the data of heat and smoke release from the tested specimen. The classes that can be achieved by this method are from A2 to D, where the SBI test is used to test all products except floor coverings. Based on the results of this test, an additional classification can be performed. The additional classification includes: classification according to smoke emission ( $s_1$ ,  $s_2$ ,  $s_3$ ) and the formation of flammable droplets/particles ( $d_0$ ,  $d_1$ ,  $d_2$ ).

The SBI test facility shall consist of a test room, the test apparatus (trolley, frame, burners, hood, collector, and ducting), the smoke exhaust system, and general measuring equipment. [6] The specimen, for this type of testing, should be made from two wings that are mounted like a corner. The dimensions of a short wing should be  $(495 \pm 5) \text{ mm} \times (1\,500 \pm 5) \text{ mm}$  and of a long wing  $(1\,000 \pm 5) \text{ mm} \times (1\,500 \pm 5) \text{ mm}$ . The maximum thickness should be 200 mm and under.



Figure 4: Apparatus used in SBI test

### 3.5. Determination of the burning behaviour of floorings, using a radiant heat source

Determination of the burning behavior of floorings, using a radiant heat source is tested according to standard SRPS EN 9239-1. During the test, the floors are exposed to the surface action of the burner and the radiant panel. Based on the test results, the classification of the tested substrates, in accordance with the standard SRPS EN 13501-1, can be performed. The classes that can be achieved with this test are from A2<sub>FL</sub> to D<sub>FL</sub>. Based on the results of this test, the additional classification of smoke emission is determined (s1, s2).

The test specimen is placed in a horizontal position below a gas-fired radiant panel inclined at 30° where it is exposed to a defined heat flux. [7] After starting the test it is needed to note any occurrence of flame and progression its progression in terms of the time. In the end, we have results of flame-spread distance versus time, the critical heat flux at extinguishment, and smoke density versus time.



Figure 5: Apparatus for testing floorings

## 4. CONCLUSION

End-use application of construction products determine a requirement of reaction to fire class. The demand for this type of testing has been increased with goals to determine combustibility of materials at the time of the fire. This brings us to the importance of choosing adequate materials. With these implementations, there is more time for the safe evacuations of people, localization of the fire in the part of building where it occurred, more time for the reaction of firefighters, as well as the possibility of extinguishing the fire with active fire protection measures. European countries are aware of the benefits of these tests, and for this reason, laws and rulebooks have been developed that guide designers and contractors when planning and building this type of facility. This paper presents the methods used in obtaining the class of reaction to fire and refers to the testing of building materials. After finishing all the necessary tests it is possible to determine the classification of the product according to the standard SRPS EN 13501-1. Only accredited bodies can give the class for tested materials. In the future, it is necessary for Serbia to pay more attention while obtaining a class of reaction to fire in order to fight the occurrence of fires inside the buildings as efficiently as possible.



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