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REACTION TO FIRE TESTS FOR BUILDING PRODUCTS – DETERMINATION OF THE HEAT OF COMBUSTION ACCORDING TO STN EN ISO 1716: 2003

Streszczenie

Artykuł przedstawia wyniki testów ogniowych, jakim poddano materiały budowlane w związku z normami STN EN ISO 1716:2003

Summary

The article describes our experience with determination of the heat of combustion of building products according to STN EN ISO 1716: 2003, in continuity with fire classification of construction products and building elements, Part 1: Classification using test data from reaction to fire tests according to STN EN 13501 – 1: 2004. The aim of this article is to focus on possible problems that may occur during tests of homogeneous or non-homogeneous materials.

Introduction

Testing Laboratory for the Product Assessment (TLPA), as a part of Fire and Research Institute Ministry of Interior of the Slovak Republic (FRI) is accreditated laboratory for testing of combustibility of liquids, solid substances, plastics, textile materials, building products, interiors of automobiles and toys as well as for determination of characteristics of technical and personal tools, which are used by firefighters and rescue teams in Slovak Republic. The testis are performed according to standard methods, in the frame of accreditation of Slovak National Accreditation Service (SNAS), in agreement with requirements of the Standard STN EN ISO/IEC 17025: 2005.

Since 2004, TLPA as the authorized subject of Ministry of Construction and Regional Development of the Slovak Republic (registration No. SK 53), performs accreditated tests in the frame the Part 1 of STN EN 13501-1: 2004 that serves to classify construction products

and building elements to new classes according to their reaction to fire, using results of tests of reaction to fire.

Following standards, together with standards listed in Tables 1 and 2, replaced old classification of materials according to standard STN 73 0862: 1980 Determination of flammability degree of building products, which was used in Slovak Republic:

- STN EN ISO 1716: 2003(2) Reaction to fire tests for building products – Determination of the heat of combustion;
- STN EN ISO 1182: 2003 Reaction to fire tests for building products – Non-combustibility test;
- STN EN ISO 11925 - 2: 2003 Reaction to fire tests – Ignibility of building products subjected to direct impingement of flame – Part 2: Single flame source test.

The following terms and definition are needed to understand the test procedures as well as to interpretate correctly the results of the heat of combustion:

- homogeneous product: product considering of a single material having uniform density and composition throughout the product
- non-homogeneous product: product that does not satisfy requirements of a homogeneous product and which is composed of one or more than one component, substantial and/or non-substantial
- substantial component: material that constitutes a significant part of a non-homogeneous product, a layer of which having a mass/unit area $\geq$ 1,0 $kg.m^{-2}$ or a thickness $\geq$ 1,0 mm
- non-substantial component: material that does not constitute a significant part of a non-homogeneous product. A layer with a mass/unit area < 1,0 $kg.m^{-2}$ and thickness < 1,0 mm. Two or more non-substantial layers that are adjacent to each other (i.e. with no substantial component(s) in between the layers) are regarded as one non-substantial component when they collectively comply with requirements for a layer being a non-substantial component.
- internal non-substantial component: non-substantial component that is covered on both sides by at least one substantial component
- external non-substantial component: non-substantial component that is not covered on one side by a substantial component

Methods

Test methods, classification criteria and additional classification of test methods performed by TLPA are listed in Tables 1 and 2. In case that testing according to following test methods does not meet requirements for A1 or A2 classification of materials, it is needed to perform additional tests according to requirements of the standard
STN EN 13501 – 1: 2004.

Table 1

Classes of reaction to fire performance for construction products excluding floorings

Class	Test method (s)	Classification criteria	Additional classification
A1	STN EN ISO 1182: 2003 ([1]) and	$\Delta T \leq 30°C$; and $\Delta m \leq 50$ %; and $t_f = 0$ (i.e. no sustained flaming)	-
	STN EN ISO 1716: 2003	PCS $\leq 2{,}0$ MJ.kg^{-1} ([1]) and PCS $\leq 2{,}0$ MJ.kg^{-1} ([2]) ([2a]) and PCS $\leq 1{,}4$ MJ.m^{-2} ([3]) and PCS $\leq 2{,}0$ MJ.kg^{-1} ([4])	-
A2	STN EN ISO 1182: 2003 ([1]) or	$\Delta T \leq 50°C$; and $\Delta m \leq 50$ %; and $t_f \leq 20$ s	-
	STN EN ISO 1716 and	PCS $\leq 3{,}0$ MJ.kg^{-1} ([1]) and PCS $\leq 4{,}0$ MJ.m^{-2} ([2]) ([2a]) and PCS $\leq 4{,}0$ MJ.m^{-2} ([3]) and PCS $\leq 3{,}0$ MJ.kg^{-1} ([4])	-
	STN EN 13823 ([7])	FIGRA ≤ 120 W.s^{-1} and LFS < edge of specimen and $THR_{600s} \leq 7{,}5$ MJ	Smoke production ([5]) and Flaming droplets/particles([6])

([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 PCS ≤ 2,0 $MJ.m^{-2}$, provided the following criteria of STN EN 13823: FIGRA ≤ 20 $W.s^{-1}$, and LFS < edge of specimen, and THR_{600s} ≤4,0 MJ, and s1, and d0.

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

([4]) For the product as a whole.

([5]) In the last phase of the development of the test procedure, modifications of the smoke measurement system have been introduced, the effect of which needs further investigation. This may result in a modification of the limit values and/or parameters for the evaluation of the smoke production.

s1 = SMOGRA ≤ 30 $m^2.s^{-2}$ and TSP_{600s} ≤ 50 m^2. s2 = SMOGRA ≤ 180 $m^2.s^{-2}$ and TSP_{600s} ≤ 200 m^2; s3 = not s1 or s2.

([6]) d0 = No flaming droplets/particles in STN EN 13823 within 600 s; d1 = no flaming droplets/particles persisting longer than 10 s in STN EN 13823 within 600 s; d2 = not d0 or s1.

([7]) This test method is not performed by TLPA.

Table 2

Classes of reaction to fire performance for floorings

Class	Test method(s)	Classification criteria	Additional classifications
$A1_{fl}$	STN EN ISO 1182: 2003 ([1]) and	ΔT ≤ 30°C; and Δm ≤ 50 %; and t_f = 0 (i.e. no susteined flaming)	-
	STN EN ISO 1716: 2003	PCS ≤ 2,0 $MJ.kg^{-1}$ ([1]) and PCS ≤ 2,0 $MJ.kg^{-1}$ ([2]) and PCS ≤ 1,4 $MJ.m^{-2}$ ([3]) and PCS ≤ 2,0 $MJ.kg^{-1}$ ([4])	-

$A2_{fl}$	STN EN ISO 1182: 2003 ([1]) or	$\Delta T \leq 50°C$; and $\Delta m \leq 50$ %; and $t_f \leq 20$ s	-
	STN EN ISO 1716 and	PCS $\leq 3{,}0$ MJ.kg^{-1} ([1]) and PCS $\leq 4{,}0$ MJ.m^{-2} ([2]) ([2a]) and PCS $\leq 4{,}0$ MJ.m^{-2} ([3]) and PCS $\leq 3{,}0$ MJ.kg^{-1} ([4])	-
	STN EN ISO 9239-1 ([5]) ([8])	Critical flux ([6]) $\geq 8{,}0$ kW.m^{-2}	Smoke production ([7])

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

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

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

([4]) For the product as a whole.

([5]) Test doration = 30 min.

([6]) Critical flux is defined as the radiant flux at which the flame extinguishes or the radiant flux after a test period of 30 min, whichever is the lower (i.e. the flux corresponding with the furthest extent of spread of flame).

([7]) s1 = Smoke ≤ 750 % minutes;

s2 = not s1.

([8]) This test method is not performed by TLPA.

Measurements of the heat of combustion are performed by the calorimeter IKA C5000 (Figure 1) and obtained results were calculated according to requirements of the standard for homogeneous or non-homogeneous products. Calorimeter is calibrated once per two months to ensure accuracy of results.

Figure 1. Calorimeter and accessories

a. Calorimeter with calorimetric bomb
b. Balance
c. Pressurized oxygen bomb with output pressure 3 MPa

Principle of the test is complete combustion of 0,5 g of disintegrated material with 0,5 g of benzoic acid in calorimetric bomb (Figure 2) under oxygen pressure of 3,0 MPa. Entire process of testing can be observed either on the display of the equipment (Figure 3) or it can be printed.

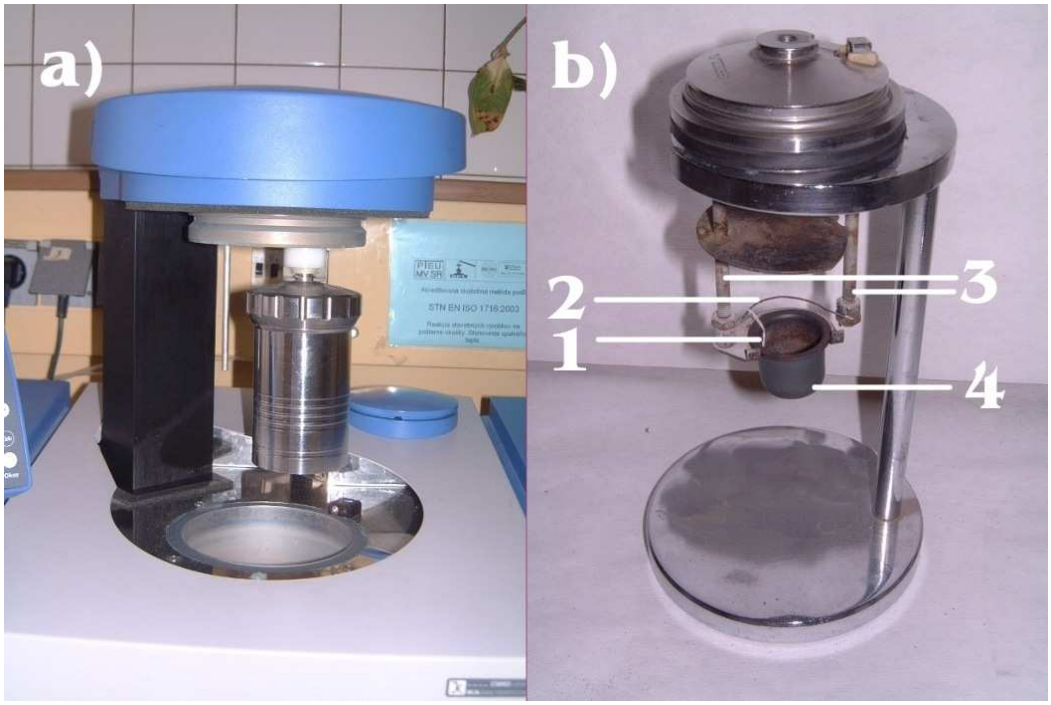

Figure 2. Calorimetric bomb

a. Calorimetric bomb before the test
b. Calorimetric bomb lid:
    1. Ignition cotton thread
    2. Ignition wire
    3. Ignition electrode
    4. Crucible holder and crucible with sample (crucible is usually made of metal, such as stainless steel, nickel or silica. Silica crucible is used in certain cases to avoid damage of crucible and/or ignition electrode).

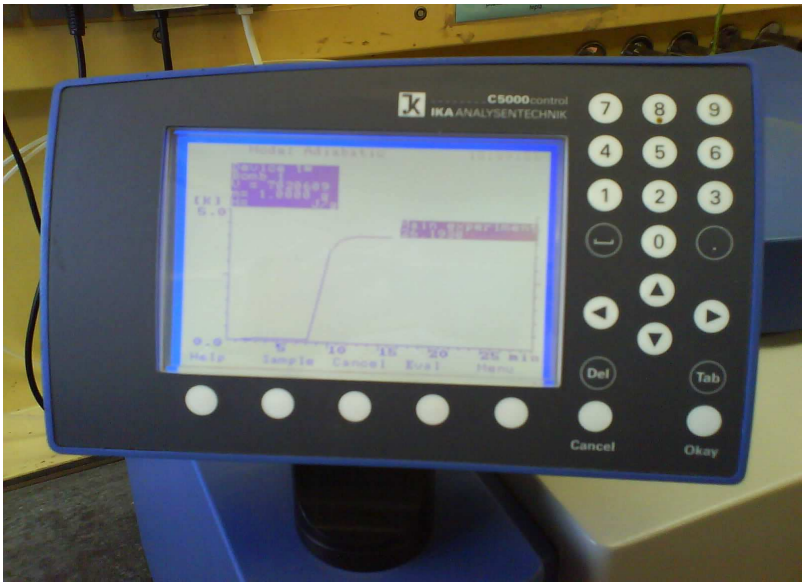

Figure 3. Detail of calorimeter display

After testing, results are calculated according to requirements of standard STN EN ISO 1716: 2003. To be validated, test results should include three replicated tests with the following criteria in the specified range of values (Table 3):

Table 3

Criteria for the validity of test results

Gross heat of combustion	**Max – Min of the 3 replicated tests**
PCS ($MJ.kg^{-1}$)	$\leq 0{,}2\ MJ.kg^{-1}$
PCS ($MJ.m^{-2}$) [a)]	$\leq 0{,}1\ MJ.m^{-2}$
[a)] for non-substantial components only	

Results and discusion

Based on our experience, TLPA prefers to perform tests of the heat of combustion according to standard STN EN ISO 1716: 2003 because of shorter time needed to perform the test, accuracy of results and simplicity of sample preparation. In case that value of the heat of

combustion of the sample relates to A1 class, TLPA performs additional tests according to standard STN EN ISO 1182: 2003 to verify classification of tested material to A1 class.

In some cases, endothermic reaction may occur during the combustion of the sample. This may happen mostly during the combustion of the inorganic materials when a part of heat released by combustion of benzoic acid is absorbed by melting sample resulting in a negative value of calculated gross heat of combustion (PCS) of the tested product. Negative value of PCS does not mean an error of determination. According to the standard STN EN ISO 1716: 2003, the negative PCS for a homogeneous product are indicated by number sign minus. However, for a non-homogeneous products any negative PCS values of individual components are indicated by zero value.

Since 2004 TLPA tested at least 80 building products with the aim to determine the heat of combustion. Materials tested can be classified into two groups:

- Construction products excluding floorings
- Floorings

Taking into account the fact that only one sample of all materials tested by TLPA was flooring, this article is focused on evaluation of construction products excluding floorings. This group can be divided into two subgroups:

a) Homogeneous products

- Plastic catwalk (4 samples)
- Sealing materials (glass fibre fabric and alluminium foil) (13 samples)
- Wallpaper and sunblind materials (5 samples)
- Painting, plaster and mineral wool boards (47 samples)

b) non-homogeneous products

- Painting systems (3 samples)
- Sendwich and plaster boards (4 samples)
- Metal plates with surface finish treatment (4 samples)

Results of PCS of homogeneous and non-homogeneous are shown in the Table 4 and 5, respectively. Because of the composition of building products containing sand, gypsum, cement or glass fibres, it is not always possible to perform a complete combustion of tested sample. These materials are usually fused regardless of use of either crucible or cigarette method.

From the point of view of fire safety the best results were observed in materials composed of cement, sand, gypsum, glass fibres, mineral wool and metal plates. For metal plates, PCS is set to zero and thus the PCS of whole non-homogeneous product in $MJ.m^{-2}$ is very low.
On the other hand, the worst results were found in materials containing organic compounds as polystyrene beads, wooden chips, paintings etc. Although these inflammable components increase the thermoisolation characteristics of building products, they also increase the value of PCS of non-homogeneous products ($MJ.m^{-2}$) and homgeneous products ($MJ.kg^{-1}$). Thus they may accentuate the risk of fire. Significant differences in PCS were observed among various glass fibres due to different quality of their impregnation by various chemical additives.

Table 4

Homogeneous products

Type of product	**Gross heat of combustion ($MJ.kg^{-1}$)**					
	(0 – 2)	**(2 – 3)**	**(3 – 4)**	**(4 – 10)**	**(10 – 20)**	**More than 20**
Plastic catwalk					4	
Sealing materials	6		2	2		3
Wallpaper and sunblind materials					4	1
Painting, plaster and mineral wool boards	23	4		8	7	4
All together	30	4	2	10	15	8
	69					

Table 5

Non-homogeneous products

Type of product	Gross heat of combustion ($MJ.kg^{-1}$ / $MJ.m^{-2}$)					
	(0 – 2)	(2 – 3)	(3 – 4)	(4 – 10)	(10 – 20)	More than 20
Painting systems			1/0	1/0	1/0	0/3
Sendwich and plaster boards	4/0			0/2		0/2
Metal plates with surface finish treatment	4/4					
All together	8/4		1/0	1/2	1/0	0/5
	11/11					

Conclusion

Our experience proved that some materials originally classified to class A according to the old standard STN 73 0862: 1980 do not meet requirements of the new classification according to standard STN EN 13501-1: 2004 neither for A1 nor A2. Thus, new testing methods examine buiding products more complexly than old method, forcing manufacturers to produce not only high-quality functional materials but also safe materials that can lead in better fire safety of buildings.

References

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