THE TESTING OF SURFACE FIRE RETARDANTS

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Research article

Abstract: The article deals with the importance of testing and using of application of fire retardants for the needs of fire protection in practice. The experiment present the testing of test specimens by means of experimental scientific method of test of limited flame spread in the test bench under laboratory conditions. Based on the measured data are exactly and precisely evaluated different types of surface fire retardants. On test specimens made by wood were applied the tested fire retardants, which were directly exposed to open flame. The results of the experiment represents and expressed fire-technical characteristics that describe the behavior of wood specimens during the process of combustion: weight loss, time of ignition, time of spontaneous combustion and time of smolder. The acquired information reflects the effectiveness of fire retardants in protection against the fire.

Keywords: Fire protection, combustion, fire retardants, experiment, testing.

Introduction

The value and importance of testing and using protective materials for fire protection in practice among others is in consequence of data and information from fires statistics be doing by the Presidium of Fire and Rescue Services. In 2012 was in the Slovak Republic more than 14 000 fires, exactly 14 413. In compare with the previous year is an increase of more than 5 %. As a result of these fires 44 people were killed, 232 people were injured and direct damages of materials was estimated at 41 394 490 €. Firefighters and other members of the Fire and Rescue Service made together 56 952 actions, actions to fires represent 44.29 % (FTEI, 2013). The target of fire-technical engineering and fire science is also the improvement and development of test methods for the examination and evaluation of materials. It also helps to make the pressure for scientist, academics and people from practice to trying to find different ways and opportunities for fire protection and complete fire prevention. In the field of fire science is the way how to make the combustible materials noncombustible the ambitious and challenging destination. One possible proceeding of the wide and various spectrums of possibilities of fire prevention measures against fires and combustion is the correct application of fire retardants.

Materials and methods

Surface fire retardants are chemical impregnating substances which in their chemical, physical or combined way to protect and prevent ignition, slowing down the process of burning of combustible materials and eliminate undesirable causes of fire and conflagration.

The principle of process of retardation is continuation of the specific retardation element to the flammable element to prevent reaction of the process of combustion. Most retardants works by preventing the access of oxidizing agent (for example air), but they are also able to affect the ratio of flammability or to upgrade flammability parameters and characteristics of impregnated material which is protected. Fire retardants have the ability to protect impregnated treated material from direct contact of flame, flameless combustion (smoldering) and before higher temperatures of fire. Retardation of process of combustion is a complicated process that depends on several synergistically contingent factors. Process of retardation of new materials (e.g. plastics) is relatively easier compared with natural materials (e.g. wood), where the process of retardation is considerably more complicated (Drysdale, 1999, Osvaldová, 2005).

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In current engineering technical practice already exists a number of different types of fire retardants and retarder modifications, which are used primarily to achieve a reduction of the flammability of most and commonly used substances. They can be applied to finished products or added during the technological process of materials processing. Application methods and mechanism of action of fire retardants depends on the characteristics of the fire retardant and the properties of the treated material that we want to protect against the negative effects of fire. Fire retardants can be applied to various types of surfaces and materials: the construction and design elements, coverings of wall and ceilings, flooring, insulation materials, electrical appliances, electronic equipment, cable bundles, wood, furniture, plastics, metals, indoor and outdoor paints, textiles, toys and more.

Classification of surface fire retardants depending on the principle of retardation (Osvald, 1997):

1. Fire retardants that release and emit inflammable gases in the heat interval, when the combustible gases generated by thermal decomposition of the flammable material, which leads to dilution of flammable gases and difficult to ignite them.
2. Fire retardants that accumulate heat from the heat source and make the source cooler.
3. Intumescing (foaming) fire retardants that have two levels of effectiveness (physical and chemical), first level create a few centimeters layer of foam that separated flammable material surface from the heat source, then the material is slowly heated, and consequently the chemical reaction which means the second level and even slow the process of burning.
4. Fire retardants that represent mechanical type for example film and various cladding of non-flammable materials.

Classification of fire retardants depending on the way of application:

a) Application of coating - e.g. coatings on metals.
b) Application of soaking - e.g. additives in plastics (PVC).
c) Application by impregnation - e.g. impregnation of wood and wood products.

The correct choice of fire retarder, the option of application and the professional assessment of conditions where the retarded component or material is exposed and which will act on it, represents functional unit retardation. Quality and functional system of retardation consists of correct selection of fire retardant, proper application and of professional evaluation of environmental conditions in which the material which we want to protect and what external factors will be applied to this material. Currently the wood becomes popular material for houses, buildings and similar constructions. However in Slovakia, nobody tested such as wood constructions and not detect whether they have the necessary criteria and standards for constructions. The risk of fires in residential timber construction cannot be completely ruled out, therefore there is a need for proper and correct implementing preventive measures and application of fire retardants, which may reduce the risk of fire as far as possible, to slow down the combustion process, to protect the life of people, animals and also the building itself until arrival members of the Fire and Rescue Services.

The system of retardation and fire retardants are in present considered by the methods of testing, which for the purposes of fire protection assess used flammable materials, their surface modifications and comparison of effects of retardation on the materials and environs.

Convenient and using test methods in present (Horrocks, 2001):

- Tests of flammability.
- Test for limited flame spread.
- Determination of limited oxygen index.
- Determination of scorched heat value and heat generation (heat release tests).
- Thermal analysis.
- Determination of the optical density of smoke (smoke tests).

The experiment presented experimental and scientific testing method of fire retardants through the test for limited flame spread on the test specimens in the test bench under laboratory conditions. This laboratory method consists of direct exposure to the gas burner to test specimens for a period of time.

The test bench for the experiment was compound from these equipments: propane gas cylinder with technical propane, flow meter, gas burner, test specimen and the holder for test specimen. Schematic of test bench is shown in Fig. 1. The test specimen was placed in to the holder device at angle 45° and it was exposed to impact of flame for 5 minutes. For each individual measurement was accurately defined distance from the center of the test specimen to the mouth of the gas burner 50 mm (± 1 mm) and also the defined height of flame 40 mm

(± 2 mm). In every single testing was followed the united technological testing procedure.

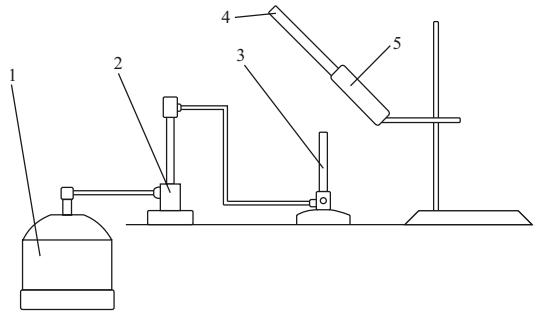

Fig. 1 Schematic of test bench: 1 - propane gas cylinder, 2 - flow meter, 3 - gas burner, 4 - test specimen, 5 - holder for test specimen (Osvald et. al., 2009)

The test specimens represented boards of spruce wood with dimensions 200 x 95 x 10 mm (± 1 mm), which were conditioned 24 hours at temperature 20 °C (± 2 °C) and relative air humidity 65 % (± 5 %) before the fire retardation. For each set of test specimens, quantity of 5 pieces, were applied different types of fire retardants which were subsequently tested and evaluated by characteristic of the process of combustion. Fire retardants used in experiment are initiated in Tab. 1. The simulation of testing of test specimens impregnated with fire retardants is shown in Fig. 2 - 4.

Tab. 1 Tested types of fire retardants

Tested fire retardant	
Abbreviated term	**Complete term**
FR	FaluRed commercial
PS STD	Plamostop Standard
R 01	PLS 75 - PKH 4 - Nanopol 1264
R 02	OLS 75 - alkyd - PKH 4 - Nanopol 1264 - AcA
R 03	OLS 75 - PKH 12 - Nanopol 1264
HD 01	Hydrospol D-01 alkyd breakup
R 04	OLS 75 - PKH 16 - Nanopol 1264 - alkyd 5
R 05	Hydrospol 01 - PKH 5 - FaluRed 5
R 06	OLS 75 - PKH 26 - FaluRed 5 - Nanopol 1264 9
R 07	OLS 70 - Cloisite 30B/2 - PKH 13

Fig. 2 The simulation of testing of fire retardant Plamostop Standard

Fig. 3 The simulation of testing of fire retardant Falured - Nanopol

Fig. 4 The simulation of testing of fire retardant Cloisite

The tested fire retardants were assessed by these evaluation criteria: weight loss of test specimens and physical parameters specific to the process of combustion of wood: time of ignition, time of spontaneous combustion and time of smolder. All characteristics times of the combustion process were measured in seconds. Weight loss was measured in grams.

Results

The results of experiment are initiated in following table 2 in form of average values of evaluation criteria for each set of test specimens of tested fire retardants. In figures 5 - 8 are processed graphs with the results individual for each evaluation criteria acquired from the experiment.

Tab. 2 The values of evaluation criteria of tested fire retardants

Tested fire retardant	Weight loss [g]	Time of ignition [s]	Time of spontaneous combustion [s]	Time of smolder [s]
FR	13,26	18,40	0,00	32,40
PS STD	5,35	99,80	0,60	1,20
R 01	15,14	21,00	0,60	39,20
R 02	12,25	12,80	0,60	38,00
R 03	15,66	13,20	9,80	12,40
HD 01	16,90	20,60	35,60	15,60
R 04	16,61	19,60	0,20	1,20
R 05	12,01	25,20	11,00	29,80
R 06	9,67	24,40	0,00	23,80
R 07	13,16	22,00	0,20	14,20

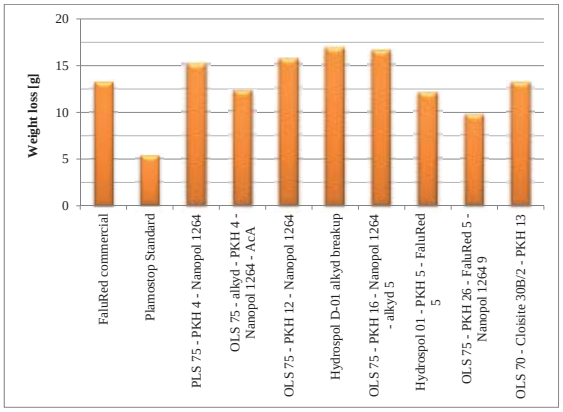

Fig. 5 The values of weight loss

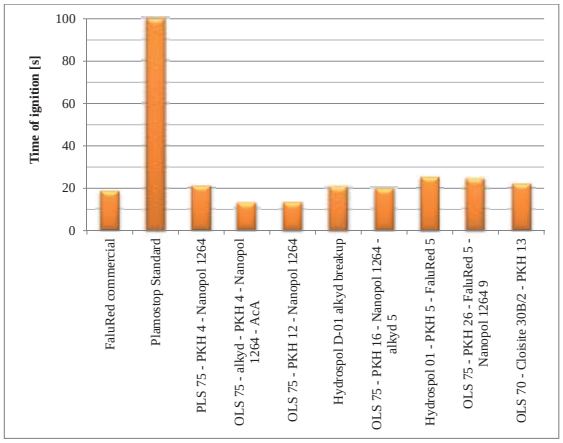

Fig. 6 The values of time of ignition

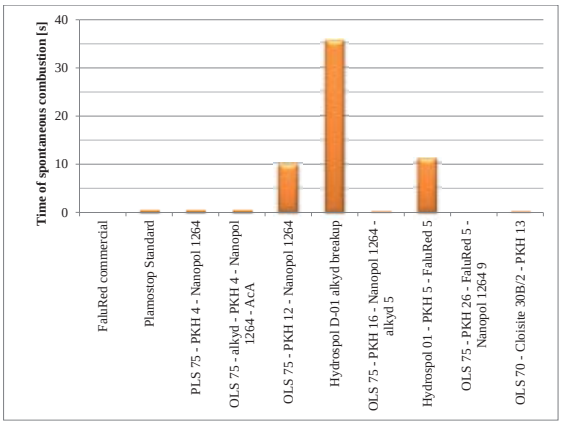

Fig. 7 The values of time of spontaneous combustion

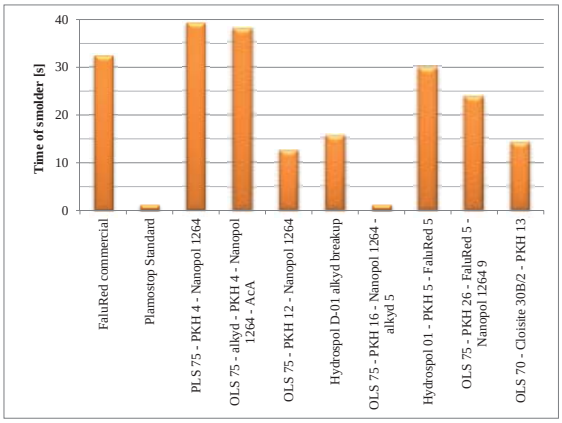

Fig. 8 The values of time of smolder

Discussion

The experiment tested different types of fire retardants by test method for limited flame spread test in laboratory conditions. Each of the tested fire retardants worked on a different principle in chemical-physical reaction flame attack, thanks why we have interesting results. From the acquired values of the individual evaluation criteria characteristic to the process of combustion of wood we can deduce from all tested types the most effective fire retardants: Plamostop Standard (PS STD), OLS 75 - PKH 26 - FaluRed 5 - 9 Nanopol 1264 (R 06) and OLS 70 - Cloisite 30B/2 - PKH 13 (R 07). The best results achieved Plamostop Standard. Plamostop had the lowest value of weight loss and was able to withstand initiation of the combustion process longer than the other tested retarders in compare. This fire retardant is opaque, white color and use in application of coating. Among the tested types of fire retardants is one, which belongs to the group of intumescent fire retardants that works on the principle of creating an insulating layer in the form

of foam during testing prevented the transfer of heat to the wood as the material of test specimens.

Conclusion

The active interaction with fire-fighting equipment, signaling and alarming equipment, material and other tools and fire prevention inspections, which be in the service of fire protection and to protect against fire, fire retardants are one of the most affordable and effective system to protect the life and health of people, animals, property and components of the environment from potential fire hazard. Various statistical studies and scientific research has repeatedly demonstrated the importance of fire retardants for the whole society.

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