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# FIREPROOFING OF WOOD AND TEXTILE COMBUSTIBLE MATERIALS USED IN CONSTRUCTIONS

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***Abstract*:** *This paper details aspects related to increasing the fire resistance of combustible materials made of wood and textiles, through the chemical protection process known as fireproofing. This process is of major importance in ensuring prolonged fire resistance for building elements based on combustible materials, as it is necessary for both the protection of the building itself and the protection of material goods and people inside. The contribution of the paper consists of an experimental study on the effectiveness of fireproofing, through a series of laboratory investigations carried out on wood and wood-based products, with various thicknesses, fireproofed with simple and complete protection fireproofing products available on the market, with mentions regarding the fire reaction class of wood after fireproofing.*
***Keywords****: wood, textiles, natural durability, conferred durability, wood protection, fireproofing, fireproofing effectiveness, wood preservatives.*

## I. INTRODUCTION

*Fireproofing* is part of the group of special protections applied to prevent degradation and collapse caused by the presence of aggressive agents inside and outside a building, such as ignition sources, biological, chemical, geo-climatic elements, pollutants, etc., without neglecting the important contribution of the *anthropogenic* factor.

*Fire resistance performance* represents the ability of fireproofing products to form a protection against wood inflammability, by means of its compounds, under the action of oxygen in the air and a heating source, which are able to decompose and release incombustible mineral salts and water or to eliminate inert gases that reduce the combustible gas mixture on the wood surface or to form mechanical barriers

As the main means of increasing wood's fire resistance, fireproofing is mandatory (with some exceptions) and represents a criterion for in the form of glassy melts or thermal insulation foams.

The main substances used for the preparation of *fireproofing products* are water-soluble salts of silicates, phosphates and polyphosphates, boric acid, borax, polyurethane resins, etc. [1,2,3,4,5,6].

*Wood* and *protective products* (fireproofing, antiseptics against mold, bluing and rot, insecticides, hydrophobic agents) are construction materials that require technical agreements in order to be marketed, according to national and European legislation, under Regulation 305 EU [7]. In addition, the quality of biocide-based preservatives in the composition of some protective products (fire retardants, impregnants, primers, varnishes and paints) must be approved for market placement as per Regulation 528 EU [8].

establishing the fire reaction class of wood after fireproofing. The effectiveness of fireproofing is checked by a specific method in a fire testing

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laboratory, according to SR 652:2009 [9], provided for in the national technical regulations for constructions: C 58-1996, ST 049-2014, NP-069:2014 [10,11,12].

## II. GENERALITIES AND SCOPE OF FIREPROOFING

The use of wood in building structures, as a combustible (flammable), perishable and hygroscopic material, takes into account the fundamental requirements applicable to constructions, functionality and user requirements and it calls for sustainable measures to prevent the risk of fire, to protect the inhabited and surrounding environment, to ensure the phyto-sanitary conditions of the building and the health of people, by applying protective products with reduced toxicity and increased efficacy against biodegradation, burning and the action of other aggressive agents from inside and outside the building. The washability of fireproofing products, the hygroscopicity of wood and the variation of climatic conditions inside the constructions can limit the effectiveness of fireproofing in time. Depending on the warranty period of the fireproofing product and the execution of the work, periodic re-fireproofing is necessary.

Fireproofing is the activity by which the fire resistance performance of combustible materials in constructions is increased, by applying products capable of reducing ignition and fire propagation. Fireproofing is a passive measure of fire fighting, carried out with chemical products, accompanied by valid technical agreements and authorizations [13], executed by licensed operators [14], according to O.M.A.I. no. 87/2010. Fireproofing is not a process used during firefighting operations, but only a means of fire prevention, with a significant role in delaying ignition and fire propagation.

Fireproofing is a chemical process of protecting wood in constructions, by standardized methods of application, both on the surface and in-depth of the combustible material, depending on the fireproofing product, the process and the duration of application. The properties of wood regarding geometric characteristics, density, impregnability, chemical composition and structure are factors that directly influence the quality of fireproofing. Being a chemical protection process, it should be taken into account that, during burning, combustion compounds (environmental pollutants) will be released, and after the useful period of the treated wood, toxic waste for humans and the surrounding environment will result, making it necessary to provide specific measures for their evacuation and storage.

Increasing the useful life of wood in the exposure environment, as defined by the exploitation classes [15] and utilization classes [16], is achieved by conservation with antiseptics and insecticides, which confer extended durability compared to natural durability [17] or by eliminating major risks in exploitation that influence the quality of wood elements in constructions, by ensuring the requirements of durability, phyto-sanitary conditions, moisture, resistance classes, environmental conditions, etc., and acting periodically, systematically and preventively, through check up and maintenance activities, taking measures for emergency repairs.

Fireproofing products give wood a fire reaction class superior to the fire reaction class it had before fireproofing. By fireproofing, combustible materials modify their ability to ignite and burn, in the sense of decreasing it, which leads to an improvement in their behavior in case of fire. As a result of fireproofing treatments, non-fireproofed combustible products classified in combustibility classes C3 and C4 (moderately and easily flammable) reduce their *combustibility*, mostly moving down into class C2 (difficult to ignite).

The classification of combustible (flammable) materials was updated starting with 2008, by Order M.L.P.L. no. 269/2008 [18], which establishes the replacement of *combustibility classes* - defined by the P118-1999 Normative - with *fire reaction classes*, as shown in the table below:

Table no. 1.

| Combustibility class | Fire reaction class | | |
|---|---|---|---|
| | | Performance level | |
| | Class | Burning drops / particles | Smoke emission |

| | | | |
|---|---|---|---|
| C0 (CA1) *in*combustible | A1 | - | - |
| | A2 | s1 | d0 |
| C1 (CA2a) practically *non*-flammable | A2 | s1- s3 | d0- d1 |
| | B | s1- s3 | d0- d1 |
| C2 (CA2b) difficult to ignite | C | s1- s3 | d0- d1 |
| C3 (CA2c) moderately flammable | D | s1- s3 | d0- d1 |
| C4 (CA2d) easily flammable | A2 | s1- s3 | d2 |
| | B | s1- s3 | d2 |
| | C | s1- s3 | d2 |
| | D | s1- s3 | d2 |
| | E | - | d2 |
| | F | - | - |

The obligation to fireproof combustible building materials is established in accordance with the provisions of Article 90 of O.M.A.I. no. 163/2007 [19]:

(1) Treatment or protection of combustible construction materials and/or elements and structures in buildings or installations with fire-resistant or fire-retardant substances shall be carried out in accordance with specific technical regulations.

(2) Fireproofing works shall be carried out only by certified personnel, in accordance with specific technical standards.

(3) The quality of the fireproofing work shall be certified by test reports issued by authorized laboratories, in accordance with the law, technical standards and measures regarding the design and construction of buildings, depending on the importance of the objective, the fire vulnerability of the construction, the value and the fire hazard of the goods inside.

The fireproofing process is necessary in certain situations.

a) it is obligatory, in the following cases:
   - for new constructions, modification or change of the destination of existing ones, as well as periodically for old constructions, in order to meet the specified requirements;
   - for the construction of certain elements, such as ceilings, wall passages, floors, enclosures or masking of fittings and equipment, finishing on evacuation routes, and others;
   - for special treatments (soundproofing, thermal) and finishings used in tall buildings, crowded buildings and electronic data centers;
   - for theaters, museums, exhibitions;
   - for interior decorative elements and finishings in crowded halls;
   - for temporary constructions, such as workshops, sheds, warehouses, storage areas, etc., where combustible substances or open flames are used;
   - for shelves and racks in warehouses and storage areas that house high-value or difficult-to-replace materials, such as unique imported parts.

For buildings with monumental value, historical monuments, as well as other buildings of special importance, the need to fireproof combustible materials shall be determined, on a case-by-case basis, by the designer and the supervisory authority.

The hidden parts of interior finishings or other construction elements that are accessible only by dismantling or disassembling the respective fireproofed construction elements shall be re-fireproofed during the repairs of the respective elements (regardless of the warranty period of the fireproofing product).

b) it is *not* obligatory, in the following cases:
   - when combustible materials are in constant contact with humid air (over 70%);
   - when the visible parts of the wood material are polished, painted or plastered; the whitewashed wood material will be fireproofed on a case-by-case basis, analyzing the opportunity of this operation;
   - when wooden warehouses are intended for storing cereals;

- when there are doors, windows, floors, as well as fences, furniture, etc.

## III. FIREPROOFING OF WOOD AND WOOD-BASED MATERIALS

1. Preparation conditions for fireproofing:

- cleaning the wood and wood-based materials (bark removing, carving, cutting, planing, etc.);
- sealing cracks, gaps and joints with fireproof putty, according to the manufacturer's instructions or, as appropriate, according to the provisions of standard C 58;
- reducing the moisture content of the wood to a maximum of 18% for surface protection and a maximum of 25% for impregnation fireproofing;
- homogenizing the fireproofing products before application and, where appropriate, diluting them with water, in accordance with the technical specifications, application instructions and technical approval provided by the manufacturer;
- the choice of the fireproofing product and method of work should take into account the wood species and impregnation characteristics, the place of application and the intended use of the fireproofed wood (enclosed and dry spaces or exterior ones), the role of the wooden elements (resistance, invisible, visible, roof structure, decorative elements, etc.); the fireproofing product should be indicated in the specifications book and execution project;
- carrying out fireproofing work at a temperature of at least 5-10°C;
- eliminating the risk of reduced effectiveness of fireproofing, by considering the composition and washability of the fireproofing product: fireproofing products fall into the category of highly washable products, forming films with reduced stability to the indoor air moisture or to water infiltrated through roof leaks or defective installations.

2. Products to be used and application technologies [20]:

A. For *surface treatments*, according to 9302/4, by brushing or by spraying;

- fireproofing products are applied in 2-3 coats, until the consumption of the product indicated in the technical data sheet is achieved, after drying (2-4 h) or (24-48 h) between coats, depending on the nature and moisture content of the wood, the composition of the fireproofing product, environmental conditions, etc.;
- surface fireproofing is applied to healthy wood with a maximum moisture content of 15-18%, both on wood with a previously applied insect-fungicide treatment and on *un*treated wood;
- the previous biological protection treatment before fireproofing or the subsequent finishing treatment are applied only if the application instructions are followed, if there are technical requirements for application in the object of fireproofing, if the products are mutually compatible and if the effectiveness of fireproofing is not affected;
- short immersion is also a surface treatment, through which specific consumptions equivalent to the application methods by brushing or spraying are achieved and the penetration depth of the product is shallow, about 1-2 mm;
- the appropriate application method is chosen depending on the type of wood, whether it is old or new, already set up or not;
- the treated wood is not exposed directly to solar radiation or precipitation, as there is a risk of unwanted drying phenomena, with changes in the geometric shape and appearance of structural defects (cracks, splits);
- some characteristics of the wood, such as the wood species, density or sawing zone (sapwood or heartwood) can affect the

quality of fireproofing; each wood species has a specific impregnability, meaning it can be easily treated with protective products, in the sense that they can retain active substances on the surface or in depth (i.e. it has good retention properties). Density and the nature of the fireproofing product also contribute to this: there are *fluid* watery solutions (called *impregnants*) or *viscous* watery solutions (called *film*-forming solutions).

B. For *in-depth treatments*, industrial impregnation methods are used in special installations, using simple and double (hot-cold) bath procedures or vacuum-pressure, vacuum-pressure atmosphere and vacuum-pressure atmosphere-vacuum procedures, according to STAS 9302/1,2,3. Fire-retardant wood materials are used after drying.
C. Fire-retardant surfaces can be covered with varnishes and paints, by observing the criteria and requirements for the protection of wooden elements in constructions, see ST 049-2014, p. 5
D. For fire-retardant elements, before they are put into operation, any surface damage is rectified after the installation of the materials.
E. For the fire-retardant treatment of wood and wood-based materials, the following are used:

a) colorless products that do not change the natural appearance of wood, based on polyphosphates and boric acid, etc.:
- Floro Fire Proof
- Bios Wood Ignifug
- Magma Fire Stop SBP 10
- Primosal Burn Protector WP P 4171
- Lider STI-01
- Bochemit
- Tytan 4F
- other equivalent products
- insect-fungicide products for complete protection, available on the market.

b) film-forming products, slightly opalescent or pigmented, based on silicates, boric acid, fillers, etc.:
- Setistop S
- Florosting
- Ifignil 1.98
- Ignisol
- Igniprof 4c
- Slatisol
- Combat Total Protect
- Ignis AP
- other equivalent products.

c) fire-retardant and finishing products in the form of varnishes, for parquet, paneling, stairs, etc., with a content of moisture and traffic-resistant resins.

3. Reception, control and effectiveness of fireproofing

– The reception of fireproofing works is based on the results obtained from the tests carried out in accredited laboratories by RENAR (CNSIPC-IGSU, INCD-INCERC Cluj, QUALITY CERT, OMNITEST, ICECON), in accordance with the provisions of SR 652:2009, and test reports are issued.
– The preparation of test specimens is carried out under the supervision of the works beneficiary, simultaneously and under the same conditions as those used in the construction object called the fireproofed objective, their number being determined according to the area of fireproofing and the time interval for verification tests. The specimens are kept under the same conditions as the fireproofed work.
– The rectangular specimens (400x150 mm) sent to the laboratory (at least 3) are packed, sealed and labeled, specifying the fireproof product, quantity, specific consumption per unit of surface or volume of application, application method, number of layers and the workshop that carried out the work; the specimens are accompanied by the provisional acceptance report.
– Data on the conditioning of the specimens for testing, in accordance with the requirements of SR EN 13238 [21]: temperature 23±2°C, relative humidity 50±5%;

– The test results contain information on:

3.1 Data on the equipment, test parameters, observations and specifications:

– balance with an accuracy of 0.1 g; balance with an accuracy of 5g
– timer with an accuracy of 1s in 1h
– flow meter, with an accuracy of 0.01 l/min
– combustible gas, liquefied petroleum gas, minimum 90% butane, according to SR 66
– gas flow rate [l/minute] and burning duration [min., sec.];
– during and after gas supply interruption: smoke, cracks and smacks, residual flame
– average wood moisture content [%]
– measurement *un*certainty

3.2 Data on the environmental conditions during testing

3.3 Test result (table no. 2)

3.4 Calculation formula, according to SR 652:2009:

$$M.L.\ (\%) = \frac{(iW - fW) \times 100}{iW}$$

- ✓ M.L. - mass loss (loss of mass)
- ✓ iW - initial weight, before the specimen's burning
- ✓ fW - final weight, after the specimen's burning

3.5 The trial results are detailed in Table no. 2.

The trial results are detailed in Table no. 2.

| Set no. | Thickness of specimens (mm) | Values of mass loss (%) | | |
|---|---|---|---|---|
| | | Specified (max.) | Calculated (average) | Determined (individual) |
| 1 | | | | |

3.6 The schematic diagram of the burning device (Figure 1), used for determining the effectiveness of fireproofing (SR 652:2009):

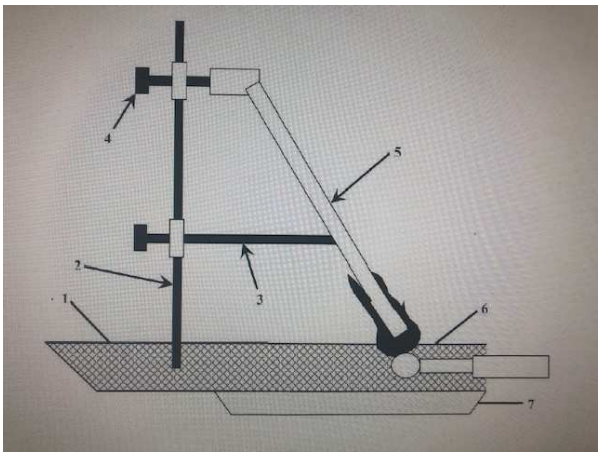


Figure no. 1 - Schematic diagram of the burning device:

Legend:
1. Flat support
2. Vertical stand
3. Horizontal arm
4. Clamps for securing the specimen holder
5. Specimen holder
6. Burner
7. Residue collection tray

3.7 The effectiveness of fireproofing in the laboratory is assessed through the criteria of acceptability, which consist of:

- the maximum mass loss is 30-35%, depending on the nature and thickness of the material.

3.8 The actual effectiveness of wood and wood-based construction materials is as follows:

- approximately 3 years, for surface fireproofing, depending on exterior / weather conditions.
- approximately 15 years, for impregnation fireproofing, depending on the conditions of use.

3.9. Specifications regarding the values of burning parameters, depending on the type and nature of the wood material, specimen thickness, burning duration, gas flow rate and

maximum allowable value of mass loss, as shown in Table no. 3:

Table no. 3

| Type and nature of the wood material | Thickness [mm] | Gas flow rate [l/min.] | Duration min. [sec.] | Loss of mass max.[%] |
|---|---|---|---|---|
| fir, spruce, alder, poplar | 12 | 1,50 | 10 | 30 |
| | 18 | 2,00 | 15 | 30 |
| | 20 | 2,08 | 17 | 30 |
| | 22 | 2,17 | 18'30" | 30 |
| | 24 | 2,25 | 20 | 30 |
| | 25 | 2,30 | 21 | 31,5 |
| | 30 | 2,56 | 28 | 35 |
| | 40 | 2,80 | 40'30" | 35 |
| | 48 | 3,00 | 45 | 35 |
| beech, hornbeam, birch, ash | 20 | 2,00 | 30 | 35 |
| | 25 | 2,25 | 30 | 35 |
| | 30 | 2,75 | 30 | 35 |
| | 40 | 3,00 | 40 | 35 |
| | 60 | 3,00 | 40 | 35 |
| oak, acacia | 20 | 2,50 | 30 | 30 |
| | 25 | 2,75 | 30 | 30 |
| | 30 | 3,00 | 30 | 30 |
| | 40 | 3,50 | 40 | 30 |
| | 50 | 3,50 | 50 | 30 |
| plywood | 3 | 0,75 | 10 | 30 |
| | 4 | 0,75 | 10 | 30 |
| | 5 | 0,75 | 10 | 30 |
| | 6 | 0,75 | 12 | 30 |
| | 8 | 0,75 | 12 | 30 |
| chipboard (LDF), OSB (**O**riented **S**trand **B**oard) | 8 | 1,25 | 10 | 30 |
| | 10 | 1,50 | 10 | 30 |
| | 12 | 1,75 | 15 | 30 |
| | 16 | 2,00 | 20 | 30 |
| MDF (**M**edium **D**ensity **F**iberboard) | 4 | 0,50 | 10 | 30 |
| | 5 | 0,50 | 10 | 30 |
| | 6 | 0,50 | 10 | 30 |
| Fiberboard | 8 | 0,75 | 10 | 30 |
| | 10 | 0,75 | 10 | 30 |
| | 12 | 1,00 | 10 | 35 |
| | 16 | 1,25 | 15 | 35 |
| | 20 | 1,50 | 15 | 35 |

3.10 The effectiveness of fireproofing in the laboratory is assessed based on admissibility conditions, consisting of:

- maximum weight loss of 30-35%, depending on the nature and thickness of the material;

3.11 the actual effectiveness of wood and wood-based materials used in construction is:

- approximately 3 years, for *surface fireproofing*, depending on environmental conditions;
- approximately 15 years, for *impregnation fireproofing*, depending on the conditions of use of materials.

4. Specifications regarding fireproofing warranty:

- from a technical and commercial perspective, the warranty is provided in the technical documents related to the fireproofing product and the application works and it is a provision with legal and technical implications for the relationship between producer/executor/beneficiary;
- the warranty for the execution of the works may be equal to or different from the product warranty provided by the producer, for several reasons:

a) the producer guarantees the fireproofing product kept in its original packaging, for a limited or *un*limited period of time, with specifications regarding the integrity and seal of the packaging, temperature and humidity of the storage environment and other specifications, as the case may be;

b) the executor, by removing the product from its original packaging, offers their own warranty, usually shorter than the producer's warranty, because the product applied on wood is subject to the action of aggressive environmental agents, from the inside/outside of the building (ST 049-2014);

c) the fireproofing product is "for interior use" - a specification provided by the producer indicating that the product is used in specific interior conditions, defined by classes 1 and 2 of use (SR EN 335) equivalent to classes 1 and 2 of exploitation (*Eurocode* 5).

This indication is a precautionary measure (to prevent product degradation) under the action of environmental factors (decomposition under the influence of temperature or washing/laundering/dissolution/dilution under the influence of environmental humidity).

d) the fireproofing product is water-dilutable and therefore falls into the group of "easily dilutable/washable" wood protection products,

meaning it can be easily washed with water, according to STAS 9302/1.

In terms of washability, chemical protection products are classified according to their field of use (interior/exterior/without contact with the ground/covered/*un*covered/in direct contact with the ground/in direct contact with water) into: washable products, hard-to-wash products and non-washable products. Any source of moisture on the treated wood surface (from air, condensation, infiltration, etc.) may reduce the active substance content and hence decrease the fireproofing efficacy, which is conditioned by maintaining the initial concentration of the applied product, established at the product launch through the specific product consumption, in the instructions, technical specifications sheet, technical approval.

The decrease in fireproofing efficacy requires its restoration, sometimes even at a shorter interval than guaranteed. Therefore, monitoring works of the storage conditions (monitoring of the construction over time) and interventions for repairs and/or special protection restoration are necessary.

e) regarding quality in constructions, it must be related to the quality of wood and treated wood, for which there are product standards and testing methods and harmonized conformity assessment and CE marking standards.

Wood is a biological material, with environmentally friendly properties, but it is hygroscopic, perishable and combustible (flammable). Good conservation state is evidence of appropriate use and exploitation conditions. The natural durability of wood is limited after cutting, primary processing and fitting (setting-up), by losing the vital function, under the action of humidity, temperature, xylo-phagous insects and fungi or ignition sources. Considering that wood used in constructions degrades even after treatments, due to the properties of fireproofing products, chemical and structured characteristics of wood and the existence of destructive environmental agents in the built environment, it is necessary to check the quality of the construction throughout the warranty period. The warranty is a result of experience and good practices and covers risks of bio-degradation and fire.

## IV. FIREPROOFING OF TEXTILE MATERIALS

A. Products to be used and their preparation for application:

1. Products for textile material fireproofing are made based on water and mineral or organic salts that do not modify the nature or color of the textile material, ready for application or dilutable with water in various concentrations.
2. Before use, the product is homogenized by stirring or mixing with a stick and its compatibility with the fireproof material is checked.
3. If the product contains impurities, they are filtered before application.
4. For fireproofing preparations, the appearance, density, pH, according to the product's technical specifications, are all checked.
5. Fireproofing products are applied by immersion or spraying, under the conditions specified in the product's instructions.
6. For fireproofing textile materials, colorless products based on polyphosphates and boric acid, etc., the following are used:

- Floro FireProof
- Bios FireProof Wood
- Magma Fire Stop SBP 10
- Primosal Burn Protector WP P 4171
- other equivalent products.

B. Application technologies for fireproofing textile materials:

1. Padding (impregnation with the stretched fabric), squeezing by rolls and drying are the most effective procedures.
2. Spraying using devices such as *Vermorel*, *Calimax* or mobile installations powered by air compressors and slow drying in the open air (24-48 hours), for fabrics that cannot be removed to be padded.

3. Immersion (only for products with specifications in the technical sheet).

C. Impregnation conditions:

- *pre*-washing of fabrics and dust cleaning;
- plush and velvet fabrics treated by spraying should not have their non-velvet/non-plush side starched;
- homogenization of fireproof product solutions before use;
- rapid penetration of fireproof products into materials;
- observance of established specific consumption;
- uniform treatment (both on surface and in-depth);
- no change in the appearance of fireproofed materials.

Receiving, control and efficiency of textile material fireproofing:

- The reception of fireproofing work is carried out by the beneficiary through technical bodies, based on the results of tests performed in RENAR-accredited laboratories (CNSIPC-IGSU, INCD-INCERC Cluj, QUALITY CERT, OMNITEST, ICECON), under the conditions provided by SR EN ISO 6941 [22] and test reports are issued.
- Tests carried out: Procedure **A** - *surface* ignition; Procedure **B** - *bottom edge* ignition
- Dimensions of test specimens: Length (L) = 560 mm; Width (w) = 170 mm
- Quantity of specimens for each procedure:
  3 yarns (1,2,3) cut along the *length* of the material (*warp* direction - *longitudinal* direction)
  3 yarns (4,5,6) cut along the *width* of the material (*weft* direction - *transverse* direction)

Procedure **A** - Surface Ignition

- Flame size: (25±2) mm measured as the distance from the tip of the burner to the outermost end of the yellow part
- Distance between the tip of the horizontally positioned burner and the specimen surface: (17±1) mm
- Test results (according to Table no. 4) :

Table no. 4

| Specimen conditioning: min. 24h<br>Temperature (°C): (20±2)°C<br>Relative humidity (%): (65±5)% RH | | Testing conditions<br>Temperature (°C): (10-30)°C<br>Relative humidity (%): (35-65)% RH | | | | | | |
|---|---|---|---|---|---|---|---|---|
| No. | Measured Characteristic | M.U. | Measured Values | | | | | |
| | | | specimens (warp) | | | specimens (weft) | | |
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| 1. | Surface ignition time (Procedure **A**) | sec. | 10 | 10 | 10 | 10 | 10 | 10 |
| 1.1 | Time 1 to the 1st marking yarn (220 mm) | sec. | | | | | | |
| 1.2 | Time 2 to the 2nd marking yarn (370 mm) | sec. | | | | | | |
| 1.3 | Time 3 to the 3rd marking yarn (520 mm) | sec. | | | | | | |
| 1.4 | Time elapsed till the burning stopped | sec. | | | | | | |
| 1.5 | Burning stopped before the marking yarn no. … | yarn no. | | | | | | |
| 1.6 | Combustion phenomena: fumes, melting, charring | F,M,C | | | | | | |

Procedure **B** – Bottom edge ignition

- Flame size: (40±2) mm measured as the distance from the tip of the burner to the extreme end of the yellow part
- Test results (according to Table 5):
- Distance between the tip of the burner (tilted at 30º) and the lower vertical edge of the specimen: (20±1) mm

Table no. 5.

| Specimen conditioning: min. 24h<br>Temperature (°C): (20±2)°C<br>Relative humidity (%): (65±5)% RH | Testing conditions<br>Temperature (°C): (10-30)°C<br>Relative humidity (%): (35-65)% RH |
|---|---|

| No. | Measured Characteristic | M.U. | Measured Values | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | specimens (warp) | | | specimens (weft) | | |
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| 1. | Bottom edge ignition time (Procedure **B**) | sec. | 10 | 10 | 10 | 10 | 10 | 10 |
| 1.1 | Time 1 to the 1st marking yarn (220 mm) | sec. | | | | | | |
| 1.2 | Time 2 to the 2nd marking yarn (370 mm) | sec. | | | | | | |
| 1.3 | Time 3 to the 3rd marking yarn (520 mm) | sec. | | | | | | |
| 1.4 | Time elapsed till the burning stopped | sec. | | | | | | |
| 1.5 | Burning stopped before the marking yarn no. … | yarn no. | | | | | | |
| 1.6 | Combustion phenomena: fumes, melting, charring | F,M,C | | | | | | |

## V. EXPERIMENTAL SYNTHESIS STUDY ON FIREPROOFING EFFECTIVENESS

In this chapter, we did a synthesis study on the values obtained by fire tests conducted in accredited laboratories for various fireproofing products, prior to their market release. The study includes specifications regarding the fire reaction class and characteristics of wood protection as a result of fireproofing.

The experimental values are to be found in the Technical Approvals (TA) and are shown in Table no. 6.

Table no. 6

| No | Name of fireproofing product; TA no.; type of wood material | Loss of mass (%) | Fire reaction class | Biological protection (fungi, insects) |
|---|---|---|---|---|
| 1 | FLOROSTING<br>021-03/023-2022<br>fir, spruce, beech, oak, chipboard, MDF, OSB, plywood, panel | max. 30-35 % | B-s1,d0 | fungi,<br>STAS 8022<br>insects,<br>SR EN 117 |
| 2 | FLORO FIRE PROOF<br>021-03/024-2022<br>fir, spruce, beech, oak, chipboard, MDF, OSB, plywood | max. 30-35 % | C-s1,d0 | - |
| 3 | IFIGNIL 1.98<br>021-03/020-2022<br>fir | max. 30 %<br>fir 18 mm: 17,05 %<br>fir 22 mm: 20,84 % | C-s1,d0 | fungi,<br>STAS 8022<br>insects,<br>SR EN 117 |
| 4 | COMBAT TOTAL PROTECT<br>001SB-03/967-2021<br>wood materials and derivatives | max. 30 %<br>fir 23 mm: 16,8-22,4 % | B-s1,d0 | - |
| 5 | BIOS WOOD IGNIFUG<br>001SB-03/999-2022<br>wood materials and derivatives | max. 30 %<br>fir 18 mm: 17,05 %<br>fir 22 mm: 20,84 % | B-s1,d0 | +BIOS WOOD 224<br>fungi and insects |
| 6 | IGNICON<br>021-03/019-2022<br>wood, chipboard, MDF, plywood | max. 30-35 % | B-s1,d0 | mold and decay fungi, insects |
| 7 | IGNIPROF 4C<br>021-03/021-2022<br>fir | max. 30-35 % | B-s1,d0 | - |
| 8 | IGNISOL<br>021-03/017-2022<br>fir, chipboard | max. 30-35 %<br>fir 22 mm: 20,91 % | C-s2,d0 | fungi,<br>STAS 8022<br>insects, |

| | | | | |
|---|---|---|---|---|
| | | chipboard 22 mm: 19,97 % | | SR EN 117 |
| 9 | PRIMOSAL BURN PROTECTOR WP 4171<br>021-03/022-2022<br>wood, fir | max. 30 % | B-s2,d0 | + PRIMOSAL BURN PROTECTOR EC 10<br>fungi and insects |
| 10 | MAGMA FIRE STOP SBP 10<br>017-03/445-2022<br>wood | max. 30 %<br>fir 23 mm: 19,53 %<br>fir 23 mm: 20,03 %<br>fir 18 mm: 19,68 % | C-s3,d0 | + WOOD PROTECT 611<br>fungi and insects |
| 11 | 4F TYTAN<br>021-03/018-2022<br>fir | max. 30 % | B-s2,d0 | mold / decay / blue stain fungi, insects |
| 12 | SETISTOP S<br>001SC-03/388-2021<br>fir, chipboard, OSB, MDF | max. 30 %<br>fir: 25,43-26,8 %<br>OSB: 26,2-26,8 %<br>chipboard: 24,4 %<br>MDF: 23,4 % | C-s1,d0 - fir, 0,275 kg/m$^2$<br>C-s2,d0 - fir, 0,310 kg/m$^2$<br>C-s2,d0 - OSB, 0,340 kg/m$^2$<br>B-s2,d0 - fir, 0,660 kg/m$^2$<br>B-s1,d0 - OSB, 0,585 kg/m$^2$<br>B-s1,d0 - chipboard, 0,720 kg/m$^2$<br>B-s1,d0 - MDF, 0,630 kg/m$^2$ | fungi and insects |

## VI. CONCLUSIONS

1. Increasing the humidity of wood in constructions degrades the wood structure, favors the development of biological aggression and affects the quality of fire protection products by modifying the biochemical layer of protection and reducing the mechanical resistance of wood.
2. To ensure natural durability and extend it, as well as to maintain fire protection levels high, a complete preventive treatment is necessary, including both biological protection and fire prevention.
3. Fireproofing improves the behavior of fire-exposed wood in the load-bearing structures of the roof, playing an important role in reducing the risk of fire and maintaining the stability and mechanical resistance of wood (for a limited period of time) in the event of a fire.
4. A mass loss of at most 30-35% is a guaranteed behavior for fire-exposed wood, which must maintain minimum shape and resistance parameters to allow for the evacuation of material and human resources during firefighting interventions. However, the evolution of a fire cannot be accurately predicted, as it depends on several existing factors.
5. Any changes in the recipe of the fire protection product (because of market developments, technical progress and legal restrictions on certain components) shall require new tests to be carried out on the fire reaction class and fireproofing effectiveness. At the same time, efforts shall be made to obtain technical approval for a new product.
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## IGNIFUGAREA MATERIALELOR COMBUSTIBILE DIN LEMN SI TEXTILE UTILIZATE IN CONSTRUCTII

**Rezumat:** Această lucrare detaliază aspecte legate de creșterea rezistenței la foc a materialelor combustibile din lemn și textile, prin procesul de protecție chimică cunoscut sub numele de ignifugare. Acest proces are o importanță majoră în asigurarea rezistenței prelungite la foc pentru elementele de construcție pe bază de materiale combustibile, întrucât este necesar atât pentru protecția clădirii în sine, cât și pentru protecția bunurilor materiale și a persoanelor din interior. Contribuția lucrării constă într-un studiu experimental privind eficacitatea ignifugării, printr-o serie de investigații de laborator efectuate pe lemn și produse pe bază de lemn, cu grosimi variate, ignifugate cu produse ignifuge de protecție simplă și completă disponibile pe piață, cu mentiuni privind clasa de reactie la foc a lemnului dupa ignifugare.
**Cuvinte cheie:** lemn, textile, durabilitate naturală, durabilitate conferită, protecția lemnului, ignifugare, eficiență ignifugă, conservanți pentru lemn.

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