CHARRING RATE OF INTUMESCENT FIRE PROTECTIVE COATED NORWAY SPRUCE (PICEA ABIES L.)

Wilfried Beikircher¹, Paul Hartmann², Josef Kögl³

ABSTRACT: The objective of this study was to determine the combustion properties of Norway spruce (Picea abies L.) wood specimens coated with intumescent fire protective coatings of four commercial products in comparison to the uncoated reference material. Two of the products were transparent coatings and two coloured non transparent coatings. The tests were performed with an adapted cone calorimeter by using the heat flux of 25kW/m², 50kW/m² and the ISO 834 test curve. The test duration was 30 min. Results indicate that the intumescent coatings reduce the charring rate at significant in comparison to the uncoated reference material. The temperature profile for all fire retardant coated test samples show quite similar results with an insulating effect.

KEYWORDS: Cone calorimeter, fire retardant wood, intumescent coatings, mass loss rate, temperature profile, charring rate

1 INTRODUCTION

Due to the composition of wood, which mainly consists of cellulose, lignin and hemicellulose, it burns if exposed to severe fire conditions. As wood is used for structural building elements it will be essential to make wood flame retardant. Basic studies of intumescent fire protective coated wood are necessary to determine the combustion properties of protected structural timber elements. It is well known that materials made of wood can be treated with compounds containing nitrogen, phosphorus, halogens, and baron such as ammonium phosphate and other to improve flame retardance and accelerate the formation of a carbonized layer on the materials. Wood coatings for structural timber elements more often are designed to retard ignition and rate of burn rather than to provide the fire-resistive barrier which is more typical of steel coatings. In the recent years more and more intumescent fire protective coatings for wood are available on the market. For most of the products information on the increased reaction to fire class are available but quite no information regarding the performance of the fire-resistive barrier as required for structural calculations are available. This study was aimed to determine some combustion properties of Norway spruce coated with intumescent fire protective coatings.

2 MATERIALS AND METHODS

2.1 MATERIAL

One uncoated reference series and four coated test series made of defect free Norway spruce (Picea abies L.) was cut into 100 mm by 100 mm squares and at 30 mm thickness. For each test series three replications were performed (s.Table 1). The underlying wood was selected in that way to have twin samples and the influence on the natural wood properties is minimized. The samples were prepared for testing perpendicular to the grain orientation in the tangential direction.

Commercial intumescent fire retardant coatings were chosen instead of model formulations so that the effects of single chemicals and other additives are included in the fire performance results. The products were selected in the way that all fulfil the reaction to fire class B according to the European standard EN 13501-1. The formulations were provided by different manufacturers. The coatings were applied by spraying the required amount of 350 g/m² on the surface.

After the coating the samples were conditioned at laboratory conditions at 65 % RH and 20 °C for at least for weeks prior to testing to meet equilibrium moisture content (EMC). Before testing the moisture content and the density were determined according to the ISO 3130 and the ISO 3131 standard. For the cone test the specimen were placed in an aluminium foil with a lip 5 mm above the top surface of the sample.

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### Table 1: Test series

<table>
<thead>
<tr>
<th>Test series</th>
<th>Coating</th>
<th>Test duration (min)</th>
<th>25 kW/m²</th>
<th>50 kW/m²</th>
<th>ISO 834 test curve</th>
</tr>
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<tbody>
<tr>
<td>A1</td>
<td>transp.</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>A2</td>
<td>transp.</td>
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<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>B1</td>
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<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>B2</td>
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<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Ref.</td>
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<td>30</td>
<td>15</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

#### 2.2 METHODS

The tests were performed using the adapted Conical Heater from FTT (Fire Testing Technology) with respect of the requirements on the Cone Calorimeter Test as described in accordance to the guidance in ISO 5660-1 on choosing a heat flux for cone calorimeter experimentation. The cone calorimeter brings quantitative analysis to materials flammability research by investigating parameters such as heat release rate (HRR), time to ignition ($t_{ig}$), total heat release (THR) and mass loss rate (MLR) and by adequate test durations also on the charring rates.

In this study the tests were performed in the horizontal orientation, with the conical radiant electric heater located above the specimen and the retainer frame over the test specimen. The electric spark igniter has not been used in these investigations. The time measured for ignition is the time until the auto-ignition is observed. Heat flux levels of 25 kW/m² and 50 kW/m² and the standard ISO 834 test curve are used to test the wood products. The real standard ISO 834 test curve was not possible to regulate with the available equipment and therefore a simplified regulation by using target temperatures was used s. Figure 1.

The duration of the tests was 1800 s in general with exception of the reference material at 50 kW/m² for which series the test has to be stopped at 900 s due to the limited material thickness.

#### 3 RESULTS AND CONCLUSION

Several samples with intumescent fire retardant coating have undergone tests in order to investigate their combustion behaviour. From the tests executed so far it can be concluded that:

- The four investigated intumescent fire protective coatings showed similar fire protection properties in comparison to the uncoated reference material.
- The charring rate of the wood coated with intumescent fire protective coatings is reduced at about 35-55% in comparison to uncoated wood for the testing time of 30 min and the heat flux of 50 kW/m² and the ISO 834 test curve.
- For the heat flux of 25 kW/m² the charring rate of coated samples show a reduction of about 90%.
- The temperature measurements show an protective effect from the intumescent coating in the range of 5-15 minutes dependent on the irradiance level.
- The mass loss rate of the coated sample converge after about 15 min to the reference material by expose at 50 kW/m² and after 25 min by the irradiance level acc. to the ISO 834 test curve.

By using intumescent fire protective coatings some protection time regarding the charring/decomposition of wood could be demonstrated. Further investigation should focus on the start of char and the charring rates at different time windows and under real fire scenarios for generating data, which could be used for model calculation of the protection time.

![Figure 1: Regulation steps for the standard ISO 834 test curve](Image)