Fire Retardant Coatings

An evaluation of fire retardant coatings as a means of protecting wood panels

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Fraser Perry Goldsmith

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Executive Summary

The protection of residential buildings from the effects of fire is becoming increasingly important. For example, Alberta has altered its fire codes to make fire protection of wood sheathing, including plywood and OSB, compulsory in the design of residential buildings in close proximity to each other. Two of the approved methods of protection are through the use of fire retardant coatings or sheathing the OSB or plywood with exterior gypsum panels. There are divided opinions on which method of fire protection is superior in terms of performance, convenience, and cost effectiveness. In this essay I conclude that fire retardant coatings, when properly applied, perform well and are a convenient method for protecting wood sheathing from fire. However, their poor resistance to weathering and increased cost make them a less cost effective solution than durable gypsum sheathing systems. Coating systems may be effective when used to compliment a gypsum sheathing system to protect areas of buildings that are difficult to sheath.

List of Key words: Intumescent, oriented strand board, Alberta Fire code, gypsum sheathing, pressure treatment, flame spread rating, smoke developed index, flame retardant, exposure, leaching, weather resistance, wear resistance.

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1.0 Introduction

1.1 Fire in Buildings

Residential fires have always been a cause for concern for designers, specifiers and the general public. The destructive force of fires in residential buildings results in serious injuries, death, and the loss of millions of dollars worth of property. The choice of materials that are used in buildings can have a large impact on their susceptibility to fire and the rate at which the fire is spreads through the structure. Wood and wood composites are combustible materials and will naturally support a flame. Hence, fire is able to spread across the surface of wood and affect areas and structures beyond the origin of the fire. The flame spread over structural wood panels such as plywood and oriented strand board (OSB) is of particular concern to end-users.

Many different systems have been used to reduce the combustibility of wood. For example, in the past, lumber and plywood boards were pressure treated with fire-retardant chemicals to reduce their combustibility. Fire-retardant treatments are applied in basically the same way as preservative treatments (CWC, 2000). More recently, intumescent[1] fire-retardant coatings have been developed to protect wood and to slow the spread of flames.

Specific guidelines for the use of fire retardant coatings have been developed to minimize the impact of fires. Alberta, in particular, has taken steps to minimize the damage and area affected by residential fires by introducing strict rules in their fire and building codes. The need for increased fire protection can be attributed to the occurrence of 6300 fires each year, which kill around 35 people and cost approximately $190 million in property losses in Alberta (HIRF, 2008). In May of 2009, the Alberta Fire Code (AFC) was altered with the intent of minimizing the impact of residential fires (Markusoff, 2009). One of the main objectives of the fire codes is to minimize the spread of fire and to protect adjacent buildings if fire does occur. If buildings are within certain proximity of each other then the structural wood panels must be protected from fire by an approved fire retardant system.

[1] A substance that swells with exposure to heat (Price, 2001).

The Alberta Fire Code states that the allowable methods of fire protection are fire retardant coatings and fireproof gypsum sheathing. These methods of protection must be applied when the construction of the building exceeds exterior grade level[2] (FPB, 2010). There is no consensus as to which fire retardant system is the most suitable for use in Alberta or in other areas. To adhere to the new fire codes builders in Edmonton are choosing to use fire retardant coatings whereas builders in Calgary are using fireproof gypsum sheathing (Gratton, 2010). The benefits and potential drawbacks of using fire retardant wood coatings will be discussed in this essay and a balanced conclusion will be reached as to whether fire retardant coatings are an effective system for protecting residential buildings from fire.

1.2 Flame Spread Rating

Coatings used to protect wood panels must be approved by the Underwriter's Laboratories of Canada (ULC) with a class "A" flame spread rating and be applied by a certified professional. Flame spread rating (FSR) refers to the rate at which fire is able to travel along a building material's surface. The FSRs of a few building materials and the relationship between the FSR and the flame spread classification of materials are illustrated in Table 1.

Table 1: Flame Spread Ratings of Building Materials (Williamson, 2002)

Material	Flame Spread Rating*
Gypsum Sheathing	0
Red Oak Lumber	100
Douglas fir	70-100
Structural Wood panels	76-200

*Class A = 0 – 25
Class B = 26 – 75
Class C = 76 – 200

[2] Any construction above the foundation of a building (Gratton, 2010).

FSR is a measure of the area that a flame is able to spread over during a defined period of time. The FSR of building materials is calculated in the lab by exposing a test piece to a gas flame at one end and measuring the area that the flame spreads over. The area of flame spread for the test material is then divided by the area of a standard material and then multiplied by 100. Red oak is, in most cases, the standard material that test materials are compared to.

2.0 Advantages of Fire Retardant Coatings

2.1 Performance Characteristics

Fire retardant coatings are good at improving the performance of structural wood panels. First of all, they slow down the spread of fire. When intumescent coatings are exposed to high temperatures, the coating expands and insulates the material with a layer of char[3]. In this process, the coating can expand from anywhere from 50 to 200 times its original thickness (Pryzbylak & Kozlowski, 1999). This thick char layer is able to perfectly insulate the substrate below and greatly decrease the rate at which the fire spreads across the surface. Even when fire temperatures exceed 800^{o}C in extremely intense fires, the insulating layer will remain for about an hour (Fire Retardants Inc, 2010). Hence the structural integrity of the wood is maintained allowing people more time to evacuate the building and for authorities to try to control the blaze.

Most commercially available fire retardant coatings are able to achieve a flame spread index of less than 25 or an "A" classification when applied to plywood and OSB. **SafeCoat®**, one of the leaders in the fire retardant coating industry, manufactures a latex intumescent coating that is able to get a flame spread rating of 10 when applied to OSB (Quantum Chemical, 2011). This is well within the range of a class A fire retardant. The FSR of **SafeCoat** latex intumescent coating on different wood substrates is shown in Table 2.

[3] The solid material left over after the initial stage of combustion (Pryzbylak & Kozlowski, 1999).

Table 2: FSR and FDI for Coated Wood Building Materials (Quantum Chemical, 2011)

Material	Coating	FSR	SDI[4]
Douglas fir lumber	Single coat	5	0
SPF Plywood	Single coat and top coat	5	0
OSB (11mm)	Single coat	10	20

Many fire retardant coatings also have the ability to suppress the production of gases by wood when it combusts. The gases that are produced during the combustion of wood and especially wood-composites can be extremely dangerous. Approximately 70% of deaths in residential fires are attributed to gas inhalation (Markusoff, 2009).

Suppressing gases is also important for reducing flash over. Toxic gases and superheated air can reach a critical point during a fire causing the gas mixture ignite resulting in an explosion called flashover (Garrison, 2002). Flashover is a dangerous time in house fires and it is also a mechanism that enables the fire to spread at an increased rate. Fire retardant coatings also decrease smoke development which delays the build-up of toxic gases and thus helps reduce or at least delay flashover. Smoke development index (SDI) is used to quantify the amount of gases that are released when a building material is exposed to fire. Wood panels have an SDI anywhere from 25-270, but when coated with an intumescent coating the SDI can be reduced to 20 (Quantum Chemical, 2011). The SDI scale is similar to that of FSR with solid red oak having a value of 100 (Williamson, 2002).

[4] SDI is a measure of the concentration of smoke a material emits as it burns (Williamson, 2002).

2.2 Convenience of Coatings

Fire retardant coatings are also convenient to use. Fire retardant coatings can be applied in the factory, on the jobsite, or on panels that are already in use unlike fire retardant pressure treatments. Coatings can be applied using the same methods as most paints; using a sprayer, roller or brush (CWC, 2000).

Fire retardant coatings can be added to existing buildings to upgrade the fire retardant properties of panels to comply with modern codes and regulations. Having the ability to apply the fire retardant coatings in the field allows end users to coat highly customized projects. Hence, fire retardant coatings can be applied to key areas of importance instead of being applied to full sheets of fire sheathing. The AFC does not state that all of the structural wood panels have to be fully coated. Instead only the inside face of the wood panels and the outer rim of the wood-flooring panels must be coated. So, by applying the coatings in the field, the fire retardant is only applied to those areas which need it most and thus minimizing the amount of fire retardant materials that are required.

3.0 Disadvantages of Fire Retardant Coatings

3.1 Exposure Problems

There are some issues which make fire retardant coatings them less suitable for their purpose. First of all, not all fire retardant coatings can be used outdoors without losing their fire retarding capabilities. Fire retardant chemicals can leach from the underlying wood substrate when exposed to high humidity or rain, rendering the materials unprotected from fire (CWC, 2000). Some coatings are “exterior rated” and can stand up to the elements, however, these are typically more expensive. Other coatings, such as **SafeCoat** latex intumescent coating, can have a water resistant coating applied on top of them to make them suitable for use outdoors (Quantum Chemical, 2011).

In most cases the wood sheathing will not be exposed to the elements in its final application. Siding material made from wood, composite, or plastic will most likely be on the outer face. However, in the construction phase of the building, the wood sheathing material will be

exposed to moisture. The duration of exposure to moisture is difficult to predict. It can take days, weeks, or even months for the building envelope to be closed. Before such closure the sheathing can be exposed to sun, wind, rain, and snow without any protection. Hence, if interior rated fire retardant coatings are used, the fire retardant may be leached, reducing the performance of the coating.

To be classified as an exterior rated fire retardant coating by the National Fire Protection Agency (NFPA), the coating has to be subjected to a laboratory test. Coatings that will be exposed to the weather or conditions of 80% humidity or higher must pass the "Standard Rain Test" (NFPA, 2009). The test involves exposing samples to 12 one-week conditioning cycles with extreme water exposure and drying cycles. The amount of water exposure is the equivalent of over 2000cm of rain over the 12 week period (WWPI, 2005). This test ensures that the FSR of the coated material does not change when it has been exposed to extreme conditions.

The Alberta Fire Code does not specify whether exterior or interior coatings must be used. It only states that the fire retardant coating must have a class "A" FSR (Markusoff, 2009). The fire code assumes that the wood sheathing will be used in an interior application, but it does not take into account that the sheathing may be exposed to the elements in the construction stage. If an interior fire retardant coating is used, much of its ability to retard fire could be lost, as mentioned above (CWC, 2000).

Fire retardant coatings may also be subject to mechanical wear and damage when they are used to coat panels. Building materials are not usually treated with the utmost care and can be damaged by accident or carelessness. Fire retardant coatings are not capable of withstanding much wear and damage which can greatly diminish their effectiveness (Price, 2001).

3.2 Application Issues

To comply with the Alberta Fire Code, a fire retardant coating with a class "A" FSR approved by the Underwriter's Laboratories of Canada must be applied to panels. To maintain this designation, the fire retardant coating must be applied by a trained professional or a representative from the company that manufactures the product (Schwarz, 2003). This ensures

that the coating is applied evenly, and at the specified thickness. The lather is important to the coating's ability to achieve the desired fire retardant properties (Fire Retardants Inc, 2010). The requirement of having an expert apply the coating increases the cost and the time involved in coating panels.

There are also many issues with onsite application. The surface of the wood sheathing needs to be dry, clean, and relatively smooth (No-Burn, 2008). On a construction site, conditions are less than ideal. Keeping a wood panel clean and dry can be difficult. Also, the low temperatures at the jobsites can increase the time required for coatings to cure. Some latex intumescent coatings have a curing time of about 48 hours. In this time the ambient temperature must exceed 10^{o}C for the coating to cure properly (Quantum Chemical, 2011). During the winter, such temperatures rarely occur, particularly in Alberta.

It is also difficult to apply coatings to OSB. All fire retardant coatings require that the surface of the substrate be somewhat smooth and free of surface imperfections. OSB usually has a rough surface (Evans & Cullis, 2008). Furthermore, the surface is often contaminated by resin, wax, and various chemicals (Quantum Chemical, 2008). These components can reduce the adhesion of a coating to the surface of the OSB and thus reduce the performance of the coating. Hence, prior to application of fire retardant coatings, oils, waxes, and resins must be removed from the surface of OSB. The removal of the substances is difficult. Sanding the surface of OSB can remove such contaminants but sanding of OSB reduces its resistance to fire (Evans & Cullins, 2008). To deal with the contamination of the surface of OSB, a basecoat of primer should be applied. Fore example, a basecoat of latex primer is highly recommended when a **SafeCoat** latex intumescent coating is applied to OSB (Quantum Chemical, 2011). This requirement is costly and time consuming.

3.3 Cost of Coating Systems

Fire retardant coatings can be an expensive way to improve the fire retardant abilities of wood products. The coatings themselves are quite expensive. Product prices are on average around $90-100 per gallon. Prices of coatings vary depending on their quality, performance characteristics, whether they are exterior rated, and whether they have the ability to inhibit the

growth of fungi or mold. **Ceasefire**™ latex intumescent coating, another "class A" fire retardant product, retails for approximately $100 per gallon (Ceasefire Technologies, 2011). Two (low and high) estimates of using a Ceasefire coating system are shown in Figure 1.

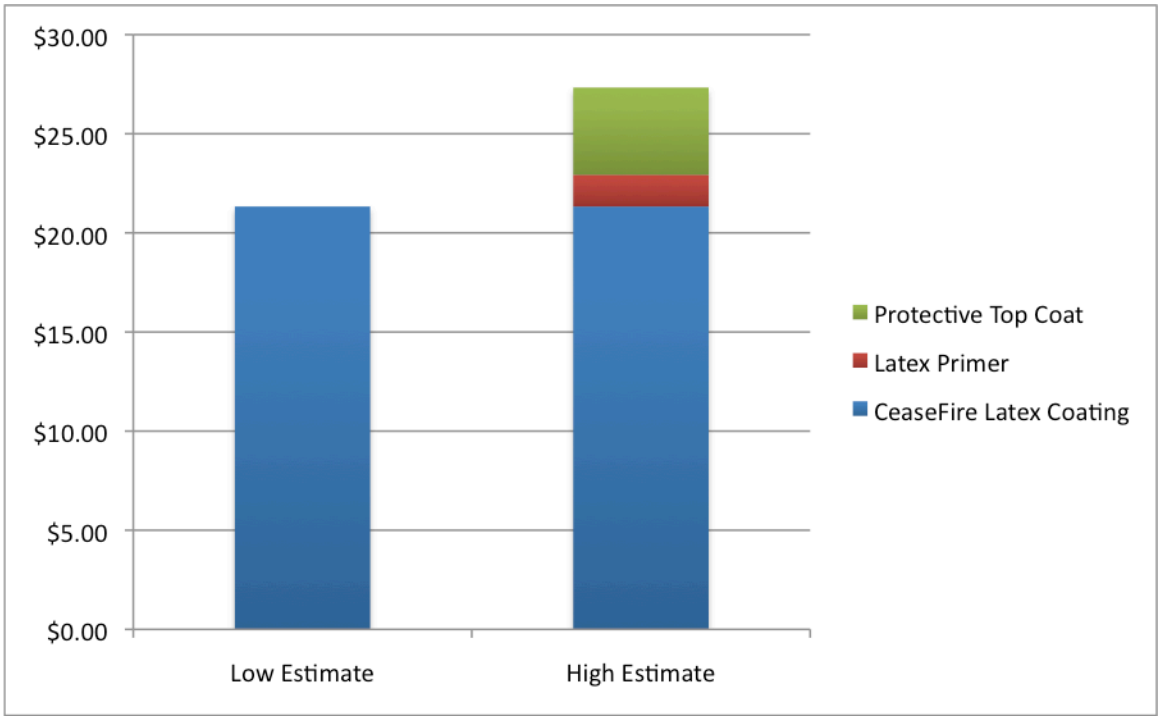

Figure 1: Estimated Costs of Coating a 4' x 8' OSB Panel (Ceasefire Technologies, 2011)

The low estimate does not include a primer basecoat or a weather-protecting top coat. To achieve the best fire retardant results on OSB, a primer basecoat is required. Also, if the panel is to be exposed to excessive humidity or rain, a topcoat of weather and wear resistant finish is required (Ceasefire Technologies, 2011). Both the basecoat and the topcoat will greatly increase the cost of the fire retardant coating system, as the graph above shows. Also, the graph above does not include the costs of applying the coating. Since the individual applying the coating must be certified by the Underwriter's Laboratories, the cost of using the coating will increase. Labour cost will be almost tripled if a basecoat or topcoat are required. Furthermore it is time consuming to apply the three coatings and wait for them to fully cure. The costs associated with fire retardant coatings decrease their appeal as fire retardant systems.

4.0 Comparison of Coatings to Other Systems

4.1 Coating Versus Treatment

Fire retardant treatments were once the primary way of making wood products more fire resistant. However, fire retardant coatings have many advantages over fire retardant treatments. First and most importantly, fire retardant treatments can only be applied to solid wood and plywood and not to OSB or most other engineered wood products (Williamson, 2002). This is a problem because OSB is a widely used for sheathing in residential construction. The second drawback of fire retardant treatments is that the treatment cannot be applied to the building material in the field. Pressure-treatment must be done at a special treatment facility. Hence, the fire retardant panels cannot be customized to their purpose. Fire retardant treatments require large loadings of chemicals compared to coatings with retentions of 10-20% by weight (Plotnikova, Egorov, & Khaliullin, 2003). Such high retentions increase the total cost of fire retardant chemicals. Furthermore, many of the fire retardant treatments can have the adverse effects on the wood's strength, hygroscopicity, stability, toxicity, adhesion, and receptivity to paints (Price, 2001). The drawbacks of fire retardant treatments and the inability to apply them to OSB make them unsuitable for a fire protection system for the Alberta Fire Code.

4.2 Coatings Versus Gypsum Sheathing

Exterior gypsum sheathing can be used instead of the application of OSB coated with fire retardant paint to comply with the Alberta Fire Code (FPB, 2010). Gypsum sheathing is a cementitious material that can simply be nailed or screwed to the exterior face of OSB panels to protect them from fire. The main advantage that fire retardant systems have over gypsum sheathing is the ability to apply the coatings to irregular or custom areas. Coatings can be applied to walls without having to measure or cut any pieces to specific dimensions.

Gypsum sheathing has many advantages which make it, in many cases, a more suitable system for improving the fire retardancy of OSB or plywood sheathing. Firstly, gypsum sheathing performs better than coated panels in fire. Gypsum is a completely incombustible material and

thus its fire retardant abilities are excellent. Since gypsum is incombustible, the FSR and SDI of gypsum sheathing are both zero (Williamson, 2002). Hence, fire will not spread across the surface of gypsum and the emission of toxic gases and the risk of flashover are eliminated. Gypsum sheathing will thus be a better system for reducing intensity and the spread of residential fires which are the primary goals of the AFC.

Gypsum sheathing conforming to the AFC must be exterior rated and able to stand up to exposure to weather and mechanical wear. Exterior gypsum, unlike many fire retardant coatings, does not lose its fire retardant abilities when it has been exposed to the elements (ToolBase, 2003). This is a key advantage considering that panels may be exposed to the elements and mechanical wear during building construction as mentioned above. Hence, fire retardant systems using gypsum sheathing will retain their fire retardant ability better than coatings and will be more effective in buildings.

Unlike fire retardant coating systems, the installation of gypsum sheathing does not require a high quality surface. Gypsum sheathing can be directly installed onto the wood panel without having to worry about the condition of the surface. This is particularly advantageous when OSB is the sheathing material that requires fire protection.

Gypsum sheathing is a more cost effective method for improving the fire retardancy of panels than intumescent coating systems. This may be the most important advantage of choosing gypsum sheathing as a fire retardant system. The cost of a gypsum sheathing system includes the material cost of the gypsum sheathing, and the labour cost associated with installation. Exterior gypsum sheathing that meets the Alberta Fire Code can be bought in a variety of sizes. Sheets 8’ by 4’ and a thickness of 0.5” can be purchased for approximately $16 compared to $21.50 or $27.50 for the cost of coating an 8’ by 4’ sheet with fire retardant finishes. This material cost can also be converted into a price per square foot and compared to the price per square foot of a fire retardant coating (Table 3).

Table 3: Cost of Coating System Compared to a Gypsum System (Ceasefire Technologies, 2011, ToolBase, 2003)

Fire Protection System	Cost ($/ft^2)
Low Estimate for Coating System	0.67
High Estimate for Coating System	0.85
Exterior Gypsum Sheathing	0.50

The price per square foot of gypsum sheathing is 0.5 $/ft^2 which is 0.35 $/ft^2 less than the high price of a fire retardant coating system, and 0.17 $/ft^2 less than the low price for the coating system. The former saving is probably more accurate since gypsum sheathing should be able to match the performance of the full fire retardant coating system. Table 4 shows the approximate costs of different fire retardant systems used in a small house.

Table 4: Costs of Using Fire Retardant Systems to Protect a House* (Building a Home Info, 2010)

Fire Protection System	Cost ($)
Coating System (fire retardant coat only)	1,951
Coating System (basecoat, fire retardant coat, topcoat)	2,475
Gypsum Sheathing System	1,456

*1500ft^2 three bedroom house with attached garage

The cost of the coating systems for the house mentioned above are significantly more than using a gypsum sheathing. The less expensive coating system is about 34% more than gypsum sheathing and the more expensive (exterior-rated) coating system is about 70% more than the gypsum system. A significant amount of money can be saved using a gypsum system over a coating system, especially in larger residential buildings.

The prices and costs listed in Tables 3 and 4 only show the cost of the raw materials. The use of gypsum sheathing also has the advantage of lower labour costs. Gypsum sheathing can be installed by the construction personnel onsite, unlike fire retardant coatings, as mentioned above. This means that the installation can be done at the discretion of the builders and there is no need to hire a certified individual, which lowers the cost of the gypsum sheathing system versus fire retardant coatings. The lower material and labour costs make gypsum sheathing a much more cost effective solution than the use of fire retardant coatings.

5.0 Conclusion and Recommendations

The use of fire retardant coatings can be an effective way of protecting structural wood panels in residential buildings. However, they have some limitations that affect their suitability for certain applications. The lack of weather and wear resistance of fire retardant coatings limits their use in exterior applications. The AFC considers fire retardant coatings as an acceptable means of protecting wood panels for new construction projects, but the exposure of the coatings to the elements is not considered.

If fire codes are to accept the use of fire retardant coatings then they should specify that the coatings must be protected, almost immediately, from the elements and potential sources of damage and wear during construction. The AFC should also specify whether exterior rated fire retardant coatings are required in cases of prolonged exposure to the elements during construction. Also, research must be done to ensure that panels coated with interior rated coatings retain their fire retardant ability when construction of the building is complete.

Another issue with coating OSB that will continue to inhibit the role of fire retardant wood coatings is the need to carefully prepare the surface and apply a basecoat of primer. This increases the costs and the time required to coat panels. Unless coating companies are able to develop cheaper products that work better with OSB, their usefulness will be limited.

The lower material and labour costs associated with installing a gypsum sheathing system makes it a much more cost effective solution. Than fire retardant coatings. Gypsum will maintain its cost advantage unless cheaper coatings become available. The considerable

performance and cost advantage of gypsum sheathing makes it more economical and effective than fire retardant coatings as a means of inhibiting the spread and impact of residential fires and satisfying the Alberta Fire Code.

Fire retardant coatings may have a role when used in combination with gypsum sheathing. Gypsum could be used to protect as much of the paneling as possible but certain areas of the building that are difficult to sheath with gypsum, could be coated with a fire retardant spray. This would ensure that the building is protected better than by an entirely gypsum system and it would be a much more cost effective solution than applying a fire retardant coating to the entire building.

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