Fire Retardants and Standards - Today and Tomorrow

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Last February, during the subcommittee meeting of the National Forest Products Association on Fire Performance of Wood, a one day discussion was held concerning the various research requirements of the forest products industries as they relate to fire. It was the unanimous view of everyone in attendance that day, that the biggest problem we face is the general lack of awareness and understanding by other segments of the forest industries about fire, fire code requirements, fire test standards, fire retardant treatments and, most importantly, how these impact on present and future markets for wood products.

Therefore, when Dr. Smith asked if I might participate in this year's annual CWPA meeting by giving a short talk, I viewed it as an excellent opportunity to ensure that our wood treating industry was informed about this subject. I am not presenting data from any research that we have carried out, nor am I introducing any new products or processes. This paper is intended simply to provide you with an overview of the general situation that wood products face throughout Canada and the U.S.A. in respect to fire. Finally, I hope to provide some indication about how these questions will affect you, the wood treating industry.

For at least thirty years, two terms have been used, almost exclusively, to categorize the burning properties of most building materials. Although their wording is almost identical, each one has acquired very different meanings. Flame spread resistance is the ability of a material or building assembly to limit the rate and distance that burning, usually in the form of flaming combustion, progresses along a surface. Fire resistance sometimes called fire endurance, is the ability of a material or construction assembly to confine a fire by withstanding the passage of fire and heat through it, while it continues to perform its intended structural function.

While you may know of it by the name of Steiner tunnel, twenty-five foot fire tunnel, 7.6 m tunnel, ASTM E-84 tunnel or just the big tunnel, the device is the same and it is used to measure the flame spread resistance of a material. The test method as adopted by the fire test committee of Underwriters Laboratories of Canada is recognized as a National Standard of Canada, number CAN 4-S102 (1), and is referenced in all building codes

in this country for the specification of flame spread resistance. Although it was originally established by definition, that the flame spread co-efficients of red-oak lumber and asbestos board were to be 100 and 0 respectively (2), recent modifications to mathematical calculation of FSC values have resulted in some slippage of these numbers. Even so, good fire retardant treated wood still should demonstrate a flame spread co-efficient of less than twenty-five.

The fire endurance or fire resistance tests are a number of similar tests which are used to evaluate the ability of materials to confine fire when incorporated into construction assemblies simulating those used in normal building practices. There are separate versions of these tests for walls, floors, doors, columns or beams, etc. but in each one, the test specimen or assembly is incorporated into the construction of a membrane, that is at least one hundred square feet in size, and that membrane is then used as one face of a large furnace. The fire resistance rating is the length of time that the entire membrane, whether it includes a door, window, damper or even an entire wall or floor-ceiling assembly, can confine the heat, hot gases and fire to the furnace when it is heated according to a specific time-temperature rate. Temperatures reach 538°C (1000°F) in just five minutes, 927°C (1700°F) in one hour and 1093°C (2000°F) in four hours. All building code authorities in this country reference these tests, which are also National Standards of Canada, for the specification of fire resistance of separations (3, 4, 5).

There are a few other special fire tests in general use today that have been developed for evaluation of specific products. The only test that might interest wood treaters, is the standard for fire resistance of roof covering materials - shingles and shakes. This test which has been developed for ASTM standard E-108 (6, 7), subjects wood roof covering materials to a series of tests which simulate the affects of a fire from neighbouring sources on the roof covering and determine the ability of that covering to restrict penetration of fire downwards through the roof membrane and into the house. In addition, there are tests to measure the ability of the roof covering, once burning, to minimize the spread of fires to other neighbouring buildings. Although this test standard is seldom used in Canadian building codes, it is widely referenced in building codes used in the southern and western parts of the U.S.A.

That summarizes most of the fire tests presently applicable to wood products in North America. However, in less than five years the flame spread test and probably even the fire resistance test could be replaced for evaluation of the fire performance of most products used for interior applications. In an attempt to more closely simulate real fire situations and more accurately evaluate the propensity of the materials used in buildings to contribute to fire, ASTM committee E-05 on Fire Standards, the grandfather organization responsible for the development of most of the fire test standards used in North America, will soon adopt full size room test. Although the test is presently only designated a standard guide for study of room tests (8), the concept has many influential advocates and its adoption as a full standard can be expected within three years. Then, if past history is an accurate indicator, reference to this test by Canadian authorities can be anticipated within an additional two years.

As it is presently proposed, rooms 3m square (ten feet) and 2.4m high (eight feet) would be constructed within an insulated non-combustible shell. The actual materials used in the construction of the rooms would incorporate all of the materials used in the walls, ceiling and floors of the building design that they are intended to simulate. An opening, to simulate an open door, is built into one wall of the room and then a fire is created next to the wall lining on the opposite wall. Although the magnitude of the initiating fire is still being debated, one source under consideration is a wood crib made from 72.6 kg (160 pounds) of douglas fir lumber. It is anticipated that a gas fueled fire producing from 40 to 160 kw of radiant energy in a series of ascending steps will ultimately be accepted for this standard. In any case, the smallest sized fire under consideration for the room creates such a tremendous build-up of heat that even in rooms lined with gypsum board wall panels, flash-over occurs within five minutes. Walls covered with untreated plywood can flash-over in less than two minutes. Flash-over, for those not familiar with the term, is the occurrence which results when radiant energy is so great that every combustible material present spontaneously bursts into flames. In room tests, flash-over is usually indicated by the spontaneous ignition of balls of crumpled newspaper that are scattered on the room floor - and by a huge ball of fire that almost explodes out the door opening. In addition to flash-over, oxygen consumption, visible smoke production, rate of heat build-up, production of toxic combustion gases and fire resistance of the room's membrane can also be measured. What is of concern to the wood industry is that all combustible material can contribute to flash-over in room tests and that can encompass doors and door frames, window frames, trim, hardwood flooring, decorative wall panels and wood furnishings. Even in rooms lined entirely with non-combustible materials, wood studs and joists can ultimately be ignited if very large initiating fires are used for the test.

There is one other concept that must also be considered when viewing the future of room tests: that is mathematical and computer modelling. Because both the geometry of the room and the magnitude of the heat source are known values, it is possible to mathematically predict the heat build-up and the time of flash-over in the room if the thermal-chemical properties of materials used in the construction of the room are also identified. Presently, eight major institutions throughout North America are studying various mathematical models (9) and in each of them, rate of heat release of each component used in construction of the room is one part of their equations. Although there are at least three different tests being developed to measure rate of heat release (10), the one that will finally achieve prominence will ultimately depend upon which of the models receives greatest acceptance by code authorities. Therefore, it is probable, that in the future, all building materials will be evaluated for fire performance using only a small laboratory test for measurement of rate of heat release.

There is one other new performance test that will be introduced in the very near future and it is an important one for wood treaters. It is a test to evaluate the toxicity of combustion gases produced when materials burn. At present, there is provision in the fire tunnel test to evaluate smoke development by measuring the opacity of smoke produced during flame spread tests but this new concept involves the evaluation of physiological

reactions of mice and rats exposed to the smoke. Several groups have been working through the ASTM Fire Test Committee to develop suitable smoke toxicity tests;(11) but it is possible that all of their efforts may be pre-empted by the imposition of test standards by several American State authorities. Wood materials, and especially some of the treated wood materials, can produce substantial amounts of chemicals such as carbon monoxide, hydrogen cyanide and acrolein when they are burned under unfavorable conditions.

The title of this paper includes a discussion of fire retardants - the wood treatment that wood treaters seldom ever think about, let alone use.

Quite truthfully, there are very few circumstances specified in our Canadian building codes that demand use of fire retardant treated wood (FRT wood), so I am not surprised that such a small amount of it is produced in this country. There are some treaters that have searched out and found small markets for a limited number of their specialty FRT wood products, but their numbers are few. There simply is not a significant sized market in Canada today for FRT wood. Conversely, in the U.S.A. there is a very good market for these products, and because of the very activist nature of their code writing authorities, that market is expanding.

While all of the chemical and physical reactions that permit certain chemicals to retard the burning of wood are still not fully understood, the group of chemicals that function as fire retardants were first identified several centuries ago and have not changed greatly since then. If anyone is seriously interested in studying more about them, I recommend some of the articles written by George Bramhall (12), Herb Eickner (13), Carleton Holmes (14), Subhash Juneja (15) and John Lyons (16) in the late sixties and early seventies. These gentlemen covered the entire subject thoroughly. I will only summarize their findings by saying that certain phosphates, sulfates, borates, silicates and halides are key ingredients in most fire retardant treatments. Todays modern fire retardants are only refinements of those same old chemical formulations refinements that have been necessitated by our contemporary requirements for additional properties such as leach resistance and reduced corrosivity and low hygroscopicity.

Figure 1. Common Inorganic Salts Used in Fire Retardants

Ammonium:	Phosphates, halides, sulfate, sulfanate
Boron:	Boric acid, borates
Zinc:	Chlorides, sulfates, arsenates

Until the early seventies, almost all fire retardants were simply aqueous solutions of water soluble salts such as ammonium sulfate, ammonium phosphates, borax, boric acid, zinc chloride and a few other chemicals. They were very effective in retarding the combustion of wood, but because they were so soluble in water, the treated wood could only be used for interior applications. Then, at about the same time, researchers at Koppers Company in the U.S.A. (17) and the Canadian Forestry Service in Ottawa - now Forintek (18) - developed new fire retardant treatments that were sufficiently leach resistant for the treated wood to be used in applications directly exposed to the weather. Although each organization had used somewhat different chemicals and processes, each had arrived at the same answer. That was encapsulation and chemically binding the actual fire retarding agent into the matrix of water resistant polymeric resin compounds. Since that time both Koppers and the various licensees of Forintek's formulations have modified their products several times to further improve them. In addition, several other companies copied this same concept and developed exterior fire retardant treatments of their own. They are all effective fire retardants and have repeatedly demonstrated their leach resistance during numerous certification tests.

The only other major change in fire retardant treatments which has occurred in just the last few years, is in the treatment of FRT wood being used for interior applications. Treatment of wood with some of the inorganic salts most frequently incorporated into fire retardants had left the wood unacceptably corrosive to metalic hardware and fasteners and very hygroscopic. Modern construction practices could no longer tolerate these properties in building materials; and as a result, a number of new fire retardant formulations have been developed which alleviated this problem. Since most fire retardant formulations are proprietary, I can only speculate about their composition, but it is logical to believe that the use of chemicals such as ammonium sulfate has been severely reduced in these new formulations while the use of borax, boric acid and some phosphates has increased.

In the future, three aspects of fire retardants will need to be studied extensively to further inprove FRT wood. The first is cost, and unfortunately, I cannot foresee much success. The chemicals used in the manufacture of fire retardants are not decreasing in price and the wood treatments require retention of much more chemical, 45-100 kg/m^3 (3-7 pcf) as compared to preservative treatments that cost reductions will be minimal at best.

The second area of fire retardants that needs improving is their preservative properties. Exterior FRT wood is simply too valuable of a commodity to have its service life impaired by wood rot fungi. Present FRT materials such as wood roof coverings and wood siding materials, need the improved durability that could be provided by inclusion of a preservative in their fire retardant treatment. Materials used in preserved wood foundations will also have to demonstrate a significant degree of fire retardancy in future years. Finally, it is economically feasible to incorporate preservative properties into exterior FRT wood and technically, it should be possible to accomplish.

The third area of fire retardant treatments that requires even more improvement is leach resistance. While all of the modern exterior FRT wood is leach resistant, it is not leach-proof. Some chemicals are slowly leached away by rain and as a result, the wood must be impregnated with

excess amounts of fire retardant in order to assure that sufficient quantities remain in the wood after exposure to weather. Solving this problem will permit a reduction in the amount of chemicals which must be used and should bring about an important cost saving for the treaters.

In recent years, great advancements have been made in the quality of fire retardant coatings. Spurred on by the need to provide fire protection to the steel and concrete products used for certain military and industrial applications, coatings have been developed which their manufacturers claim, will offer protection against anything smaller than an "Exocet missile". At this time, these coatings are much too expensive to be used on wood intended for most construction purposes and so, with the exception of factory finished panel products, they are not competing with pressure treated materials. It is important to note though, that this technology already exists and could become a major competitive product for your industry at some future time.

Although this may not greatly interest you, it will certainly affect all wood treaters in the future, because the wood treating industry is the only industry presently capable of improving the fire performance of wood. Adoption of room tests and toxicity tests and many others, which were not described, will significantly challenge the traditional use of wood products. Each revision to our building codes brings more requirements for the fire performance of building materials and assemblies. In time, these changes will leave wood an obsolete material if the wood industry is not prepared for them with suitable wood treatments.

While the future will bring many more markets for FRT wood than are presently available, wood treaters do not need to await tomorrow. A study of the various building codes used throughout North America will illustrate the fact that there are very few times that specific generic materials such as wood are proscribed. Usually, it is only the performance properties that are prescribed. That means there are many situations, especially in non-residential construction, that FRT wood can already be used instead of alternatives such as steel, concrete or gypsum materials. If FRT wood is not being used it is because no one is actively pursuing these markets.

The Dominion Fire Commissioner reported (19), that in 1980 there were 85530 fires in Canada and these caused over one billion dollars in lost property and killed 833 people. Of those fires, forty thousand occurred in residential housing and accounted for 661 of the deaths and another 2200 personal injuries. American statistics for 1981 (20) listed 2.9 million fire incidents which claimed 6700 lives and seven billion dollars worth of destroyed property. Neither the public nor our various levels of government are accepting statistics such as these as inevitable. They are actively pursuing measures to reduce this carnage (21). The wood treating industry can provide part of the answer.

Table 2. Fires

1980 CANADA (Dominion Fire Commissioner)

85530 fires
$1 billion property loss
833 deaths
3409 injuries

Canadian residential

40 thousand fires
2200 injuries
661 deaths
$340 million property loss

1981 U.S.A. (National Fire Prevention Association)

2.9 million fires
$6.7 billion property loss
6700 deaths
31000 injuries

American residential

733 thousand fires
20 thousand injuries
5540 deaths
$3.3 billion property loss.

Figure 3. International Comparison of Fire Deaths

	Fire deaths per million people	Building fires per thousand people
Netherlands	5	1.0
Austria	9	2.4
Germany	9	<<<1.0
Australia	12	1.2
France		1.5
United Kingdom	15	1.7
Japan		0.3
Canada	32	3.2
U.S.A.	34	4.8

Fire Technology - World Health Organization

Fifteen years ago the general public had never heard of Wolmanized or All-Weather Wood or whatever you call your own brand of CCA treated lumber. Today, every lumber company stocks these products and they have become a major consumer product and a financially important part of your industry. FRT wood could be just as successful a commodity if knowledge of its advantages were advanced to the public and if it was just as readily available to them.

There is one final point I would like to present and it is this - the principles developed for nearly every fire standard used in this country originated in ASTM Committee E-05 on fire standards. Canada's own fire standards writing organization, which is Underwriters Laboratories of Canada, almost always adopts established ASTM standards to our Canadian situation. If you as wood treaters do not like some of our present standards or feel that your products are unfairly judged by them, there is a way to influence those standards before they ever come to Canada. Membership on committee E-05 is balanced between producers on one side and consumers and users on the other. The problem faced by our wood industry is that its members are only a very small minority of all of the producer members and so people representing the interests of steel, concrete, gypsum and plastics products greatly out number them. The result has been standards that do not always evaluate wood fairly. Membership on this ASTM committee does not require attendance at their semi-annual meetings but it does require active participation in their society ballots. The cost is minimal ($50 per year), but the advantages of membership by more wood treaters could be substantial on key ballots of some of the more controversial proposals. The voting numbers involved simply do not permit a few association members to adequately represent the interests of the wood treating industry. Therefore, I strongly urge all wood treaters to apply for membership on this fire test committee. It could be critically important for your industry.

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