

**COMMITTEE
D07 ANSWERS
THE ALARM**

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The use of fire retardant chemicals has expanded the use of wood in construction and provided significant safety to occupants of wooden buildings. Since the dominant interests in fire retardants are allied with the wood industry, it is only natural that ASTM Committee D07 would have a subcommittee addressing the needs of fire retardants for wood. From 1991 to 2002, D07.07 on Fire Performance of Wood developed four ASTM standards to specifically test fire retardant lumber and plywood and use the resulting data to generate design adjustment factors. The factors are applicable to the entire United States and these responsive actions have restored market stability.

HISTORY OF FIRE RETARDANTS

Generally, **FIRST NAME** Gay-Lussac is credited with the development of fire retardants for wood when in 1820 he proposed treatments with ammonium phosphates and borax. The full impact of this invention can be gauged by the realization that systems similar to his are still in use today. Many other inorganic chemicals have also been utilized as fire retardants in the intervening years. In the early 1900s, formulations based on silicates, sulfates, borates, phosphates, zinc, tin and calcium were used for wood.

In a definitive series of reports from 1930 to 1935, researchers at the USDA Forest Products Laboratory (FPL) investigated about 130 different inorganic fire retardant formulations. They found that diammonium phosphate was the most effective for reducing flame spread while monoammonium phosphate, ammonium chloride, ammonium sulfate, borax and zinc chloride were also active. However, many of the tested chemicals were later found to also have associated problems of high cost, corrosion, hygroscopicity, strength reduction or glow promotion. Therefore, other approaches were needed.

By the 1950s, there were several formulations in commercial use for pressure treating wood. (Fire retardant coatings were also being investigated, but their acceptance and regulation lagged behind that of pressure-treated products.) All of these formulations were inorganic combinations blended to achieve a reasonable compromise of cost and acceptable performance. By the 1960s, three formulations became dominant and were used extensively for interior purposes for the next 20 years.

Exterior formulations were introduced in the late 1960s for protection of products such as shingles, **shakes**, siding or scaffold planking that are exposed to the elements. These systems were based on a different chemistry in that polymers were formed within the wood. The polymers encapsulated the other fire retardant ingredients and rendered them leach resistant.

The use of fire retardants climbed very slowly in the United States until the 1960s (Figure 1). Then from 1960 to 1970, the use quadrupled as there was an increased awareness of the considerable safety benefits of fire retardants. However, the emergence of corrosion, hygroscopicity and strength problems began to plague the industry and the market grew

US CONSUMPTION OF FIRE RETARDANTS FOR WOOD

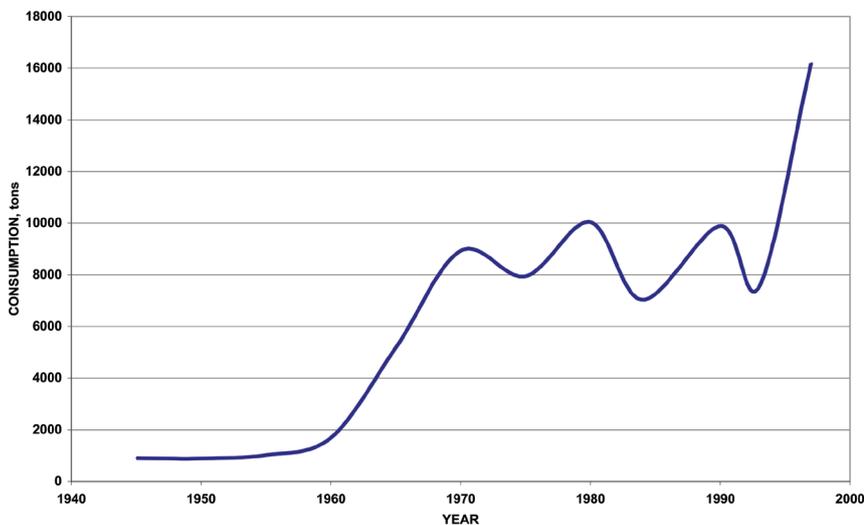


FIGURE 1. U.S. Consumption of Fire Retardants for Wood (American Wood-Preservers' Association Statistical Reports)

only slightly until 1980. The market suffered a downturn through the early 1980s even though building code changes were being implemented that opened up new uses for fire retardant treated wood.

In the early 1980s, second-generation fire retardants were introduced to address the corrosion and hygroscopicity problems of the first generation inorganic formulations. These second-generation products were of two types. One formulation blended a nitrogen-phosphorus organic compound with boric acid. The other second-generation formulations were based on ammonium polyphosphates with or without various additives in small quantities. The additives included boric acid, borax, moldicides and others that augmented fire resistant properties.

STRENGTH ISSUES

With the introduction of the second-generation products, there was concern on the part of designers and specifiers that the generic strength reductions used for the previous fire retardants would no longer be applicable to the new products. Accordingly, in 1984, the National Design Specification for lumber was revised to require that the fire retardant producers supply design reduction factors and in 1986, a testing protocol for matched treated and untreated lumber was issued to determine NDS values. In 1987, the Plywood Design Specification was similarly revised to require design values from the producers but no testing protocol was specified.

In the course of development of the NDS test protocol, it was suggested that elevated temperature testing be included but the protocol did not require such testing. Thus, in the late 1980s, there was no accepted protocol for testing either lumber or plywood at elevated temperatures. In the 1950s and '60s, FPL researchers had shown that elevated temperatures and humidities can impact wood strength but their work was generally done at temperatures that seemed far above those occurring in structures.

However, in the late 1980s, reports began to surface that some of the second-generation formulations were experiencing strength loss in high temperature applications such as roof sheathing. After the initial concern that all second-generation products were involved, it was found that prob-

lems were occurring with only some formulations. Litigation ensued and further investigations revealed that high humidity conditions frequently existed in problem installations. Numerous causes were alleged for the strength problems and the end result was that the overall market for fire retardants was severely impacted.

Prior to encountering these problems, the market had accepted the second generation products, and growth in treated panels had matched that of untreated panels (Figure 2). With the threat of litigation, there was a steep decline in volume in the early 1990s. Most of the ammonium polyphosphate-containing products were withdrawn or replaced with new formulations by that time.

At the onset of the heat problem, the then-National Forest Products Association (now the American Forest and Paper Association) convened a task group to investigate the issue. The author chaired this task group and the membership covered all parties interested in the issue in that government, academic and industrial researchers made up the group. First, a regime of high temperature and high humidity exposure conditions was developed under the task group auspices. Then a complete series of strength tests was done with treated and untreated plywood exposed to high heat and humidity conditions. This research was summarized in a report¹ issued by the FPL in 1991 and this report was the genesis of standards developed by ASTM.

ASTM INVOLVEMENT

An ASTM task force quickly developed a test protocol based on the FPL report and submitted it to D07 for consideration as an emergency standard. In late 1991, the test protocol was accepted as ES 20, Test Method for Calibration of Upright Cylindrical Tanks Using Optical Reference Line Method. In general, the test method calls for matched samples of treated and untreated plywood to be strength tested after exposure for more than 60 days at 170°F (77°C) and greater than 50 percent relative humidity. Samples are taken at approximately two-week intervals during the exposure so that a strength loss rate can be reasonably determined compared with the unexposed controls. This protocol eventually became D 5516, Test Method for Evaluating the Flexural Properties of Fire-Retardant Treated Softwood Plywood

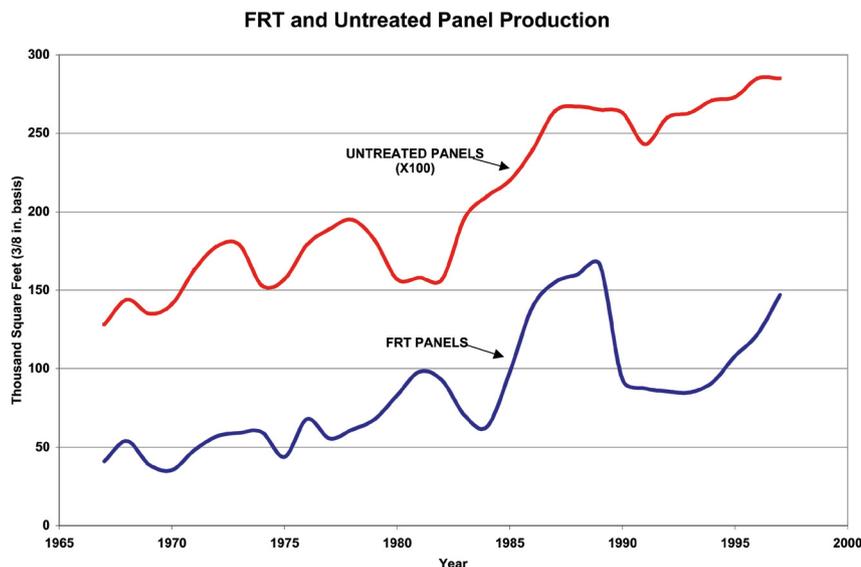


FIGURE 2. FRT and Untreated Panel Production (American Wood-Preservers' Association Statistical Reports and Forest Products Laboratory Statistical Reports)

Exposed to Elevated Temperatures.

However, there was a need to transform the D 5516 results into design adjustment factors that would be useful to specifiers, engineers and building code personnel. A second task force had already perceived this need and had begun work on synthesizing the D 5516 data into a different format. The idea was to transform the strength loss determined by the laboratory method into "real world" numbers by use of a computer model developed at FPL. This model predicts temperatures occurring in buildings using readily available meteorological data as input. It was found that the United States could be readily divided into different zones depending on the heat load and a design adjustment factor could be obtained for each zone. This calculation procedure was promulgated in 1998 as D 6305, Standard Practice for Calculating Bending Strength Design Adjustment Factors for Fire-Retardant-Treated Plywood Roof Sheathing. Thus, the design community now had standardized procedures available for establishing adjustment factors for plywood used in the various climates encountered in the United States.

But what about lumber? With their active role in strength testing, it was natural for FPL researchers² to take the lead in a third ASTM task group and propose a test regime for lumber. In this case though, the various strength properties of lumber required a large number of differently shaped specimens to be obtained from the matched treated and untreated lumber. Therefore it was too unwieldy to require the same frequency of tests as for plywood and it was proposed that lumber testing be done on three sets of samples taken during exposure at 150°F (66°C) and greater than 50 percent relative humidity for up to 108 days. Again, the data was used to compare the strength values of treated and untreated lumber compared to the original unexposed controls. This protocol was accepted in 1995 as D 5664, Test Method for Evaluating the Effects of Fire-Retardant Treatments and Elevated Temperatures of Strength Properties of Fire-Retardant Treated Lumber.

The same need existed for lumber as it had for plywood and a fourth ASTM group proposed similar methodology to address transforming the test results into design adjustment factors. In this case, the various strength properties

(tension, compression, bending, etc.) complicated the issue somewhat but again consensus was achieved. Basically, the data from D 5664 is used with the same computer model and various design adjustment factors for the lumber properties are generated. This was approved in 2002 as D 6841 Standard Practice for Calculating Design Value Treatment Adjustment Factors for Fire-Retardant-Lumber.

CONCLUSION

These standards have given specifiers the needed confidence to again use fire retardant treated wood. These tests were developed under the ASTM consensus process by government, academic and industry researchers and quickly adopted by building codes and other regulators. The result is that several products are currently available that give excellent strength performance. In fact, new fire retardants entering the market essentially undergo testing by the above methods prior to acceptance into the stream of commerce. The ASTM process helped restore market stability and substantial growth in fire retardants has occurred in the last decade. //

References

- 1 Winandy, J.E., S.L. Levan, R.J. Ross, S.P. Hoffman and C.R. McIntyre. 1991. "Thermal Degradation of Fire-Retardant-Treated Plywood: Development and Evaluation of a Test Protocol," Res. Pap. FPL-RP-501, U.S. Dept. of Agriculture, Forest Service, Forest Products Laboratory, p. 21.
- 2 Winandy, J. E. 2001. Thermal Degradation of Fire-Retardant-Treated Wood: Predicting Residual Service Life. *Forest Prod. J.* 51(2): 47-54. <http://www.fpl.fs.fed.us/documnts/pdf2001/winand1a.pdf>



With over 30 years of extensive experience with fire retardants and wood preservatives, **CRAIG R. MCINTYRE** started McIntyre Associates in 1992 to provide litigation support and development expertise. Previously, he managed R&D groups for multinational companies that spanned all wood treatment activities. See www.mcintyre-inc.com.