

SERIAL

FOREST RESEARCH LABORATORY
LIBRARY
OREGON STATE UNIVERSITY

Supersedes 1280

FIRE-RETARDANT TREATMENTS FOR WOOD

Original report dated April 1957

Information Reviewed and Reaffirmed 1963

NO. 2081



FOREST PRODUCTS LABORATORY
MADISON 5 WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

In Cooperation with the University of Wisconsin

FIRE-RETARDANT TREATMENTS FOR WOOD¹

By

Forest Products Laboratory,² Forest Service
U. S. Department of Agriculture

From ancient times, man has associated wood with fire. He has become imbued with a wood-fire consciousness acquired by centuries of personal experience. It is, therefore, not surprising that mention of "fireproofing" treatments for wood should be received with enthusiasm by some and with skepticism by others. A better understanding of the facts should help to reconcile these widely divergent attitudes. Possibly the first step in reaching this understanding would be to avoid the use of the all-inclusive term "fireproof" and select instead one which describes a specific performance resulting from the treatment. Even this is not simple to do.

The manner in which the spread of flames is retarded and that in which penetration of fire is resisted depends upon the nature, form, and arrangement of the materials involved in the fire and also on the character of the igniting fire. In a fire test in which the character of the igniting fire is controlled, distinction between the two phases of fire performance is possible and the terms "fire-retarding" or "fire retardant" may be applied to treatments which limit flaming performance, and the term "fire resistance" to the property of the structure which resists penetration by fire. With this brief explanatory background, a description of the fire-retarding treatments may be more intelligible.

Two general methods are available for reducing the flaming characteristics of wood by the use of fire-retarding chemicals. One method consists of

¹This report was originally published in the Quarterly of the National Fire Protection Association in January 1943 as written by the late G. C. McNaughton, Forest Products Laboratory research engineer. It is presented here in slightly revised form.

²Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

an impregnation treatment which deposits water-borne chemicals within the wood. Many chemicals exhibit fire-retarding properties, but because of cost or other objectionable characteristics, comparatively few are considered generally practical. These are usually combined in various proportions in treating formulas, and often include mono and dibasic ammonium phosphates, ammonium sulphate, borax, boric acid, and zinc chloride. Penetration of the treating solution into the wood is usually obtained by the vacuum-pressure methods used in the wood preserving industry, and the operation is controlled to secure a predetermined retention of solution. The important considerations are the depth of penetration and the amount of chemical deposited in the wood, rather than the details of the treating method. Subsequent to treatment, the material must usually be dried before use.

The other method of controlling flaming characteristics of wood is the application of suitable paints to the wood surfaces. The paints may be of the nature of oil-, resin-, or latex-base preparations in which fire-retarding chemicals have been incorporated, or they may be of compositions the effectiveness of which depends mainly on their ability to froth and swell at fire temperatures and insulate the wood from the fire. A benefit that can be derived from these treatments is a reduction in the flammability of the wood, so that it will contribute little fuel to a fire already started. If the spread of flame from an incipient fire can be retarded or prevented, if flaming can be made to decrease and cease after the igniting source has been removed, and if the progress of the char into the wood can be delayed or held in check, the main purposes of the coating will have been achieved.

Impregnation with fire-retardant chemical has a less pronounced effect on the fire resistance of wood than it has on surface flammability. Nevertheless, the treatment can be used to improve fire resistance, probably by increasing the depth to which the layer of insulating charcoal builds up, sometimes importantly. The time of failure of wood walls has been increased from 20 to 33 percent by chemical treatment.

Comparison of Fire-Retarding Paints and Impregnation Treatments

Effectiveness

Under sustained, severe fire exposure, there are no impregnation treatments or fire-retarding paints that will give complete protection. Good impregnation treatments are more generally dependable than paint coatings, but for controlling the spread of fires of short duration a good fire-retarding paint can be as effective as an impregnation treatment.

Favorable experience in uncontrolled fires has been built up with impregnated material used for interior trim and scaffolding. There may have been similar favorable experiences with fire-retardant coatings, without available records.

The lack of a satisfactory background of use experience, extravagant claims by irresponsible promoters, lack of permanence, the uncertainty of proper application after the paint leaves the manufacturer, and failure of the user to take into account construction features that contribute to fire hazard may be among the reasons why authorities have not always reacted favorably to fire-retarding paints in the past.

The ultimate fire performance of a specific wood structure is more likely to be affected by details of design when a fire-retarding paint is used than when the structure is made of impregnated wood. One reason for this is that the paint is ordinarily applied to but one surface of the wood. Glowing, once it is established by the fire, is more apt to persist in the untreated wood beneath painted surfaces than in well-impregnated wood. Even though the spread of fire is prevented on the painted surface, ignition of an opposite unpainted side by transmitted heat may permit the fire to get out of control. This condition would occur when an incendiary bomb of the magnesium-thermit type comes to rest on spaced boards of an attic floor so that the molten metal can run through the cracks between the boards (fig. 1). If all surfaces have been penetrated by fire-retarding chemicals to an appreciable extent, some of the objections that apply to surface coatings disappear.

The shattering, by a demolition bomb or otherwise, of painted wood or a large partially impregnated timber would expose unprotected surfaces that would contribute to any fire that might be started. The amount of untreated wood exposed in a large impregnated timber would be less, however, than with coated timbers. It would be still less with impregnated timber and lumber of smaller sizes, because the amount of unpenetrated wood in the interior of impregnated material decreases with size and complete penetration may be obtained with thin lumber.

When there is a reasonable expectancy that integrity of surfaces will be maintained, and the fire can be expected to be of limited duration, coatings may offer worthwhile protection. Good coatings can greatly retard the spread of fire from small incendiary bombs or other sources of fire and thus increase the time for the discovery of the fire and for bringing suppression apparatus into action (compare figs. 2 and 3). Superior coatings or impregnated wood may even permit small fires to burn out unattended (figs. 4 and 5), while the same fire in untreated wood would spread rapidly (fig. 2).

The fire-test performance of lumber impregnated with fire-retarding solutions is related to the amount of dry fire-retarding chemical retained in the wood. Fire-retardant lumber is usually purchased on the basis of the pounds of chemical retained per cubic foot of wood.

The fire-test performance of wood coated with a good fire-retarding paint is related to the amount or thickness of application. Usually a greater thickness is required than is customary with ordinary decorative paint coatings. There are no generally accepted specifications for the composition of fire-retarding paints; and, while various ranges in effectiveness have been reported, there are no generally accepted standards of test performance.

Application

Pressure impregnation treatments are obviously unsuited for structures already erected. For best results in structures to be built, the lumber and timbers should be cut to finished dimensions before treatment and should not be cut or surfaced after treatment. Easily treated lumber of small cross section, however, may be so completely impregnated that cutting after treatment is permissible. The retentions and penetrations obtainable vary considerably with species of wood and between sapwood and heartwood of the same species. Some species are exceedingly difficult to treat, and considerable skill and careful supervision are required to insure an acceptable product.

Fire-retarding paints may be applied to completed structures by brushing or spraying, and to all species of wood with equal facility. The application of coatings is simple and requires only moderate equipment and skill. Inadequate application can be corrected, and the coatings usually can be renewed as often as required.

Both impregnation and paints may be applied to plywood and other forms of cellulosic material. With plywood, it is possible to impregnate the veneers before gluing, but such procedure requires the use of a glue that will not be affected adversely by the fire-retarding chemicals in the veneers.

Cost

Besides the actual cost of the fire-retardant chemicals, impregnated wood must bear the overhead of a treating plant, technical control and

inspection costs, rehandling and redrying costs, and sometimes additional transportation charges. The cost of impregnation will vary with the kind of wood, the quantity treated, the thoroughness of impregnation, the chemicals used, and the weight of chemical absorbed per unit of wood. Actual cost figures are likely to be between \$70 and \$80 per thousand board feet over the cost of the untreated wood, and sometimes higher. The fact that lumber impregnated with fire-retarding salts is hard on ordinary machine tools is another item of increased cost when the wood must be machined. Special alloy steel tools prove an economy if machine work on fire-retardant-treated wood is extensive.

The retail cost of a gallon of fire-retarding paint can be expected to vary, depending largely upon the paint base. The necessity for thick films limits the coverage per gallon and increases the cost per unit area as compared with ordinary paint. The ultimate cost of a suitable fire-retarding coating for a unit of area, however, is usually less than the cost of impregnating the wood.

Strength of Wood

Paints are not harmful to wood and do not penetrate it appreciably, hence there is no reason to expect that they would have an adverse effect upon the strength of the wood to which they are applied.

Little authentic information is available concerning the effect of the various fire-retardant chemicals and treating conditions upon the strength of the impregnated product. Zinc chloride is known to hydrolyze cellulosic material when used in high concentrations and at elevated temperatures, and the concentration of zinc chloride solutions required to impart high fire retardance to treated wood is likely to be harmful to strength. The effect may not be apparent immediately after treatment, but may increase with the age of the treated wood, particularly if the wood is used under conditions of low humidity and high temperature. Similarly, observations in reworking pine lumber impregnated with borax suggest that large amounts of this salt may make the wood brittle. Other chemicals may have a corrosive effect upon metal fastenings used in constructions and require the addition of a corrosion inhibitor to the treating solution. There is also a probability that, in wood treated with certain chemicals, high kiln-drying temperatures may produce injurious effects, but more research is needed to relate more definitely the extent of the injury with the particular chemical and the time and temperature of heating.

There have been few adverse reports concerning strength reduction in fire-retardant-treated wood in use, but on the other hand there is no assurance that reduction in strength has not occurred in some cases. For these reasons, the purchaser of impregnated lumber should be cautious in using high concentrations of fire-retardant chemicals in timber that is to be subjected to high working stresses or whose failure would have serious consequences. In timbers whose weakening would create undue hazards, protection may be obtained by leaving the load bearing members untreated or lightly treated for decay prevention and then covering them with 1-inch lumber heavily impregnated with fire-retarding chemicals.

General Durability

On account of the water-soluble nature of the fire-retarding chemicals, neither impregnations nor coatings containing the water-soluble chemicals are well adapted to damp or wet conditions or to weather exposure, but, under similar exposures to moisture, wood impregnated with fire-retarding chemicals should retain its effectiveness somewhat longer than the painted wood.

The fire-retardant properties of wood impregnated with fire-retardant chemicals should remain permanent if the material is not subjected to water exposure. On the other hand, fire-retardant paints, like ordinary paints, would need renewing at intervals, according to the amount of wear or other damage to which they are exposed in use.

In some instances where impregnated structural wood has been used in outdoor exposures, outside house paint has been applied to retard the leaching of the chemicals by rain or other water. There is little information as to how well the paint performs such service. There are indications, however, that once the paint film has become thoroughly dry and freed of combustible volatiles, it does not detract from the fire-retarding properties of the treated lumber.

The application of a suitable "waterproof" material over fire-retarding paints has been suggested as a means of adapting the latter to damp exposures, but no evidence has been made available that the scheme would be successful.

In a general way, a comparison of the two methods for improving the fire performance of wood may be summarized as follows:

<u>Property</u>	<u>Coatings</u>	<u>Impregnation Treatments</u>
Fire-retardant effectiveness	Moderately to very effective	Usually more effective and dependable than coatings
Suitability for application	To structures already erected	To building lumber or timbers before erection
Cost	Ordinarily less than impregnations	Relatively high
Adverse effect on strength of wood	Probably none	Possible in some cases
Conservation of critical materials	Small amounts used	Substantial retentions required
Durability	Not permanent, but renewable	More lasting than coatings, but not renewable
Limitations	Usually not durable outdoors	Fire-retardant leaches away in rain and ground water



Figure 1.--Performance of a borax-linseed oil base fire-retarding paint in a conventional wood attic section, when exposed to a training-type 1-lb. magnesium bomb placed in the extreme corner. Spread of flame was delayed, but the cracks between floor-boards allowed molten metal to run through and ignite the unpainted surfaces below. Left to right, at 1, 6, and 20 minutes.

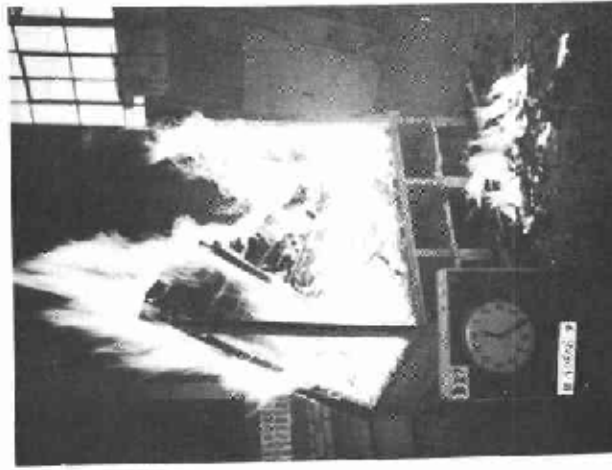
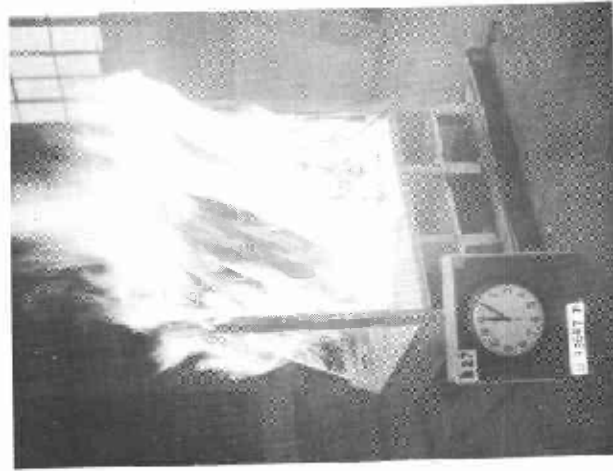
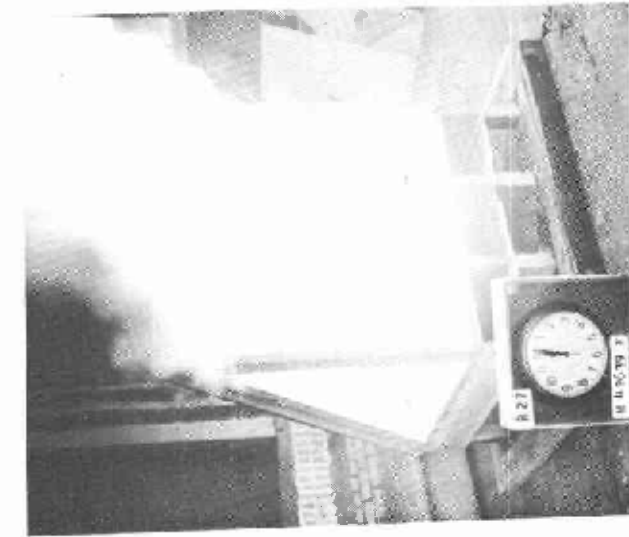


Figure 2. --Performance of an untreated wood attic section exposed to a 3.25 lb. magnesium bomb placed in the extreme corner. A double thickness of 3/4-inch flooring prevented the molten metal from igniting surfaces beneath the floor. Untreated surfaces above the floor contributed fuel readily. Left to right, at 1, 5, and 25 minutes.

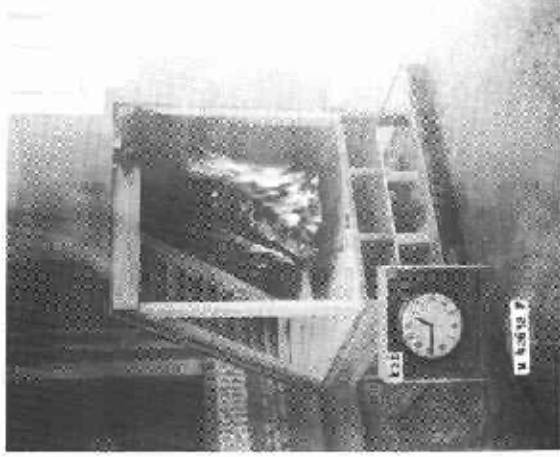
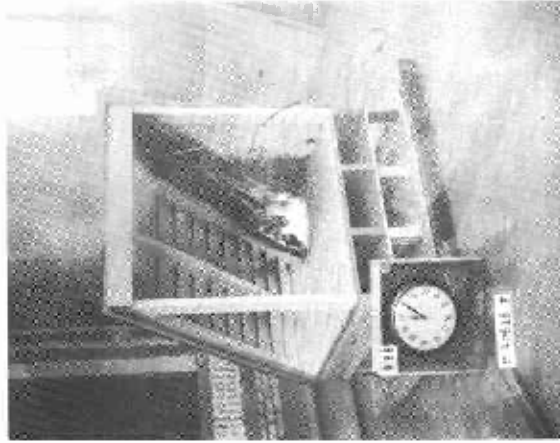
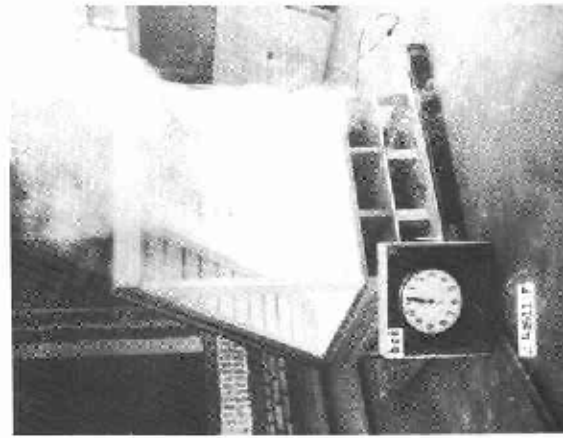


Figure 3. --A wood attic section painted with a moderate application of a water-base alginate paint and exposed to the same test conditions shown in figure 2. The coating greatly retarded, but was not heavy enough to prevent the spread of fire from a 3.25 lb. magnesium bomb. Left to right, at 1, 5, and 45 minutes.

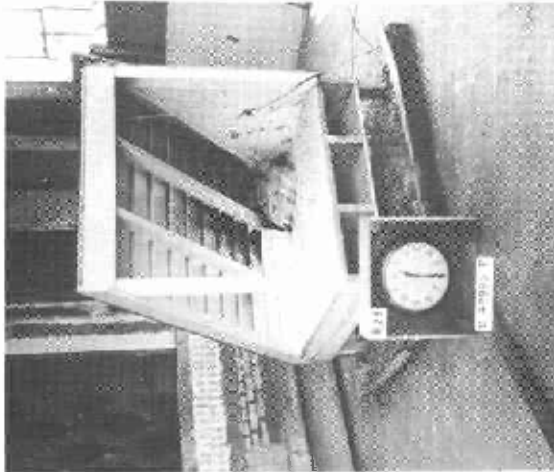
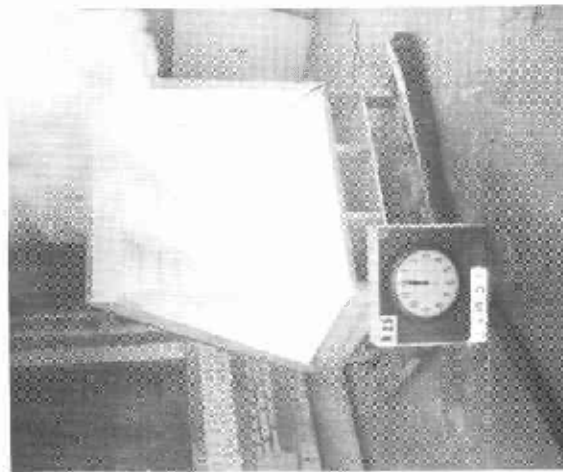


Figure 4. --A wood attic section similar to that shown in figure 3, but with a heavier application of the water-base alginate paint, and under a similar bomb exposure. In this case the heavier coating completely stopped the spread of fire. Left to right, at 1, 5, and 30 minutes.

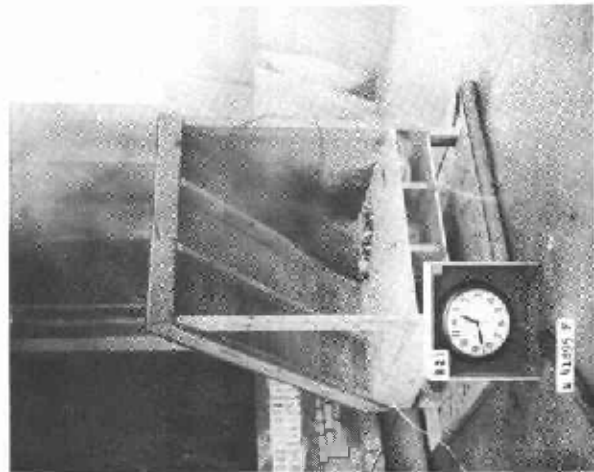
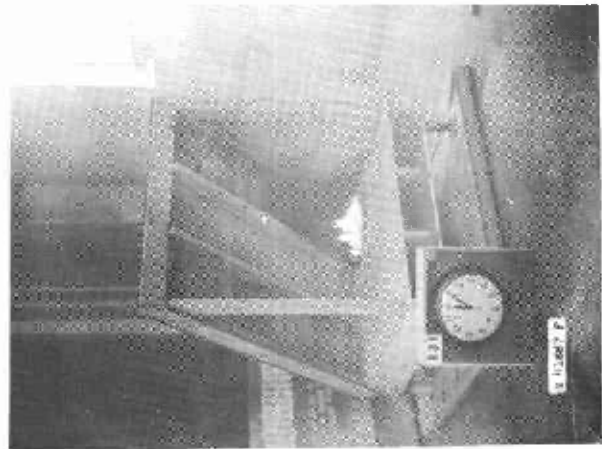
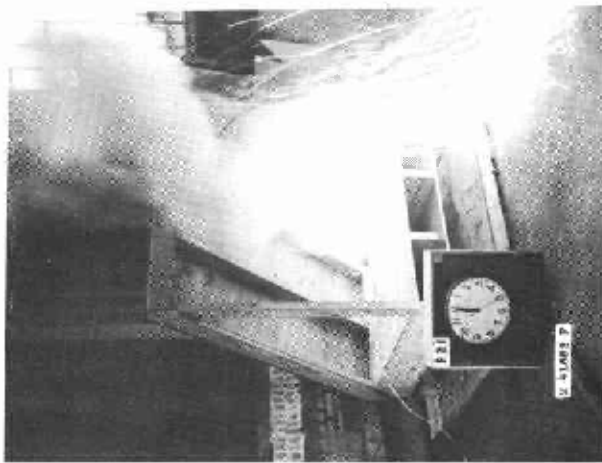


Figure 5. --An attic section in which the rafters, roof-boards, inside of end-wall, and top ply of flooring were impregnated for a moderate degree of fire-retardance, and exposed to a 3.25 lb. magnesium bomb. The treatment completely stopped the spread of fire on exposed surfaces, but the untreated subfloor became ignited by the excessive heat transmitted through the flooring. Left to right, at 1/2, 5, and 42 minutes.