COATINGS FOR THE PREVENTION OF END CHECKS IN LOGS AND LUMBER

Information Reviewed and Reaffirmed 1961

No. 1435
Because of a number of factors, the freshly cut ends of green or partially seasoned wood are apt to check and split unless end drying is retarded or prevented. Though such defects develop more or less in all types of logging and milling operations, they generally do not constitute a serious problem in the production of ordinary lumber. End checking may be expected, however, in logs stored in the woods, in log yards, or elsewhere for long periods of time; in timbers, specialty items of large cross-sectional dimensions, and some items of lumber while being air seasoned or kiln dried; and in the cross cutting of partially seasoned material.

Where end checking and splitting may be a problem, they can be materially reduced or eliminated by retarding the drying of moisture from the end grain. Many methods for retarding end drying have been used, such as shading or covering the ends of the piles, covering the ends of the pieces with blocks or waterproof paper, or applying coatings. End coatings, which were originally developed by the Forest Products Laboratory, offer more protection and have a wider range of usefulness than do the other methods. Although the primary purpose of end coatings is the prevention of end checking, they are also very necessary to prevent moisture loss from the ends of kiln samples used to determine the current moisture content of stock being kiln dried. Toxic chemicals can be mixed with them to help control stain and decay in logs.

1—Maintained at Madison 5, Wis., in cooperation with the University of Wisconsin.

Report No. 1435 (Original report dated Oct. 1943)
The Forest Products Laboratory has done no extensive research on end coatings recently. However, some manufacturers and users have developed new and better coatings. Because improved log and lumber values have made the use of end coatings more attractive, valuable timber is being conserved and users are making more money. This report presents the general background and some of the Laboratory's past research on end coatings and new information on commercial coatings.

Information on the early developments in the end coating field is on file at the Laboratory.  

General Considerations

As wood dries, the surface fibers dry first and tend to shrink, but are restrained by the wet interior of the wood. Thus, drying stresses develop which tend to cause mechanical failures. Such mechanical failures are termed checks. The tendency to check is greater at the end-grain surfaces of the wood because drying proceeds much more rapidly at end-grain surfaces than at side-grain surfaces. Checks are at first fine and shallow, but become coarser and deeper as drying progresses. They sometimes extend deeply into the piece, destroying its potential value. Various stages in the development of end checking in a sugar maple bolt are shown in figure 1.

Wood shrinks a considerably greater amount tangentially around the pith than it does radially. The formation of large V-shaped checks in round items and boxed-heart timbers that contain the pith center of the tree is inevitable during the last stages of seasoning except in cases where the differential in shrinkage is not great and the stress can be distributed and relieved. The large check shown in figure 1, D, developed because tangential shrinkage exceeded the radial shrinkage. This type of check may result entirely from loss of moisture from the sides of the piece. End coatings cannot prevent such checking. End coatings can, however, prevent the formation of numerous small end checks during the early stages of seasoning, retarding formation of the large checks. End coatings may thus, for example, reduce the severity of V-shaped checking in boxed-heart timbers that are not used in excessively dry locations. When logs are cut

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2"End coatings for logs and lumber - Status April 1943," by W. K. Loughborough and J. M. McMillen, unpublished report U. S. Forest Products Laboratory, May 17, 1945. (Also previous editions of this report.)
into items of small cross-sectional dimensions, the stresses due to differences in tangential and radial shrinkage do not develop or are relieved by distortions of shape.

When the end grain of wood is exposed more than the side grain, the tendency to end check is accentuated. Bark largely prevents loss of moisture from the side grain of logs, but the end grain is fully exposed. In lumber piles, the ends of the boards are more exposed than the sides. The drying conditions to which logs and lumber are exposed control to a certain extent the amount of checking developed by uncoated material. Checking is, of course, likely to be severe in hot, dry climates. Hot, humid weather may also be conducive to end checking in some items. Direct exposure of end-grain surfaces to the sun's rays or to the wind in dry climates is a severe condition. If a combination of high temperature and low relative humidity is used in the kiln drying of lumber, serious end checking is likely to occur.

End coatings should be applied as soon as possible to freshly cut end surfaces, for end coatings applied after checking has begun usually do not prevent deepening of the checks. To prevent stain and decay, it is necessary to apply a toxic to the logs within 24 hours of cutting.

Although almost all woods will end check under severe drying conditions, the tendency to check is more pronounced in the denser hardwoods than in the lighter hardwoods or the softwoods. The severe checking and splitting of a southern swamp oak butt log is illustrated in figure 2. End checking in a sweetgum log and the control of such checking by an end coating are shown in figure 3.

Types of material to which end coatings may be applied are (1) logs; (2) piles, poles, and posts; (3) timbers and ties; (4) yard lumber; (5) dimension stock and specialty items, such as gunstock blanks and crossarms; (6) kiln samples and test material.

Logs check least when the time between logging and milling is short or when they are stored in log ponds. If hardwood logs are to be stored more than a few weeks, some provision should be made to control checking. Softwood logs can be stored for longer periods of time without serious damage from checking because the checks are usually of a shallow nature and can be removed in the usual trimming operations. Stains caused by fungi, however, can progress deeply into logs in very short storage periods, and decay can become a serious problem if the storage period is prolonged. Usually, no attempt is made to prevent checking in piles, poles, and posts.
The tendency of boards, planks, timbers, and specialty items to end check during seasoning increases with increasing cross-sectional dimensions of the wood. Figure 4 shows end checking in Douglas-fir timbers. The checks not only follow the rays of the wood structure but also the annual rings. Such checking sometimes contributes to early deterioration of the material by providing places where decay can start. Extensive end checking of thick oak wagon stock is shown in figure 5. If checks do occur in ordinary pine boards under severe drying conditions, they are usually of a fine, shallow type shown in figure 6.

The means by which most end coatings prevent checking is by providing a moisture barrier. Other coatings maintain moisture hygroscopically at the surface of the wood or combine the two means of check prevention. To prevent stain and decay, toxics are included in the coatings. Pentachlorophenol, a cheap and readily available preservative has been incorporated in a cold coating with some success for control of stain and decay. Other toxic chemicals probably could be included with the cold coatings to afford some control, but the Forest Products Laboratory does not have any information on their use in this manner. Another recommended means of controlling stain is to spray the ends and barked areas with toxic chemicals before applying the end coating. (5).

The principal requirement of a water-resistant end coating is adequate resistance to water movement under all conditions of temperature and humidity to which it may be subjected during the drying of the wood. None of the coatings tested at the Laboratory completely prevented passage of water. Fortunately, complete prevention of moisture movement is not necessary, because, if the loss of water through the coating is small, the stresses set up are not sufficient to cause checking. The degree of water resistance required depends upon the species and size of the wood. Greater water resistance is required for species of wood and types of material most susceptible to checking. In general, the moisture resistance required of a coating to protect logs during comparatively short storage periods is not as great as that needed to protect stock of large dimensions during air seasoning or kiln drying. To prevent loss of moisture from the ends of short kiln samples and test pieces, the most highly water-resistant coatings are advisable.

In general, the research on end coatings at the Forest Products Laboratory has indicated that, to be effective in a single coat, a thick application is required. To remain on the surface, such a coating must have a high viscosity and must adhere to the wet surface of the wood. For satisfactory use in kiln drying, a coating must be tough enough to withstand rough handling, strong enough to resist blistering caused by the expansion of the water vapor.
and air within the wood, and flexible enough to adjust itself to dimension changes as the wood dries. It is desirable that an end coating be solid when set and not messy to handle.

In order to be satisfactory for large scale use, the cost to cover a given amount of end area should be low. The labor cost involved may prevent wide use of coatings that require more than one coat to be effective. A material that must be used as a thick coating to be effective should cost about $2.00 per gallon or less. Materials that are effective in thin coats can be economical at a higher price per gallon.

End coatings can be classified in a number of ways. In this report they are classified as hot coatings and cold coatings. Hot coatings are solid at ordinary temperatures and must be heated above their softening points for application. The use of hot coatings is generally limited to material of short length that can be manipulated by hand, although one manufacturer of paraffin has devised an apparatus to spray it on large freshly-sawn logs. Cold coatings are suitable for application at ordinary temperature and can be applied readily to logs and lumber as well as to kiln samples and dimension stock.

**Hot Coatings**

The Forest Products Laboratory has been instrumental in the development of various hot coatings for end check prevention. Past studies have shown, in general, that the best hot coatings are more effective than a single coat of any of the cold coatings.

The softening temperature and the viscosity-temperature relationships of hot coatings are important from two standpoints, the temperature necessary for application of the coating to the wood, and the temperature conditions encountered during the drying. The vapor pressure of the water in the wood increases as the temperature increases. The vaporization of water tends to cause blistering and lack of adhesion when the coating is applied at too high a temperature. Hot coatings with lower softening temperatures may be easily applied, but are not suitable for use at high kiln temperatures. In general, a coating with the lowest softening point that will safely withstand all drying temperatures contemplated should be applied. In kiln-drying practice, the softening point of the coating, determined by the ring-and-ball method E28-51T (1), should be at least 30° F. above the highest kiln temperature to be used.
The thickness of hot coating applications depends on several variables, such as temperature of coating material and length of application time. Experience has shown that pitch-asphalt coatings are effective if applied uniformly with a thickness of 1/20 to 1/16 inch.

Types of Hot Coatings

Paraffin. -- Paraffin has long been used to coat specialty items that are to be air seasoned. It is effective in one thick coat, can be applied at low temperatures (135° - 150° F.) and adheres well to wood. Its low softening temperature (115° - 125° F.) makes it unsuitable for use in kiln drying. Some of the specially prepared paraffins have higher softening points and thus can have limited use in kiln drying. One dimension stock manufacturer uses paraffin to protect hardwood squares from the time of cutting to entrance into the kiln, then uses mild conditions to control checking during the first stages of kiln drying.

Rosin and lampblack. -- A mixture of seven parts (by weight) of lampblack per 100 parts of rosin has been used as an end coating. Even though the drying temperatures are as high as 170° F., rosin and lampblack mixtures rank high in water resistance. See figure 7. The temperature of application is approximately 300° F. The coating is brittle and chips off easily when handled roughly.

Pitch and asphalt. -- A number of experiments conducted at the Laboratory have shown that coal-tar pitches with suitable softening temperatures form highly water-resistant coatings if they remain intact. Some of the asphalts are nearly as water-resistant. A series of Forest Products Laboratory experiments developed comparative information on a number of different hot coatings. In these experiments, the amount of moisture lost through the coatings was determined with small blocks of green wood completely covered with the test coatings and exposed to regulated temperatures and relative humidities in an experimental kiln. The coatings tested, the conditions of the test, and the results, expressed as the percentage of evaporable moisture remaining in the wood, are shown in figures 7 and 8.

The softening points of a number of hot coating materials included in the tests, as determined by the ring-and-ball method (1), were:
<table>
<thead>
<tr>
<th>Material</th>
<th>Softening Point °F</th>
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<tbody>
<tr>
<td>155° coal-tar pitch</td>
<td>134</td>
</tr>
<tr>
<td>213° coal-tar pitch</td>
<td>204</td>
</tr>
<tr>
<td>225° - 235° petroleum asphalt</td>
<td>235</td>
</tr>
<tr>
<td>Rosin</td>
<td>180</td>
</tr>
<tr>
<td>155° coal-tar pitch (70 percent)</td>
<td></td>
</tr>
<tr>
<td>rosin (30 percent)</td>
<td>147</td>
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</tbody>
</table>

Moisture resistance, however, is not the sole criterion of the effectiveness of a coating for prevention of end checking. Experience has shown that the 213° pitch is brittle and does not adhere well to wet wood. The 155° pitch is flexible, but even at 130° F. it softens and runs off the wood. The loss of coating from the ends of kiln samples is particularly disconcerting. It was formerly a common practice to modify pitch coatings by mixture with rosin. The mixture of rosin and 155° pitch used in the experiments mentioned above partially sloughed off the wood at the test temperatures. Rosin tends to make the coating more adhesive to wet wood, but does not decrease the brittleness.

Blends of 155° and 213° coal-tar pitch were found to be more flexible, more adhesive, and tougher than 213° pitch alone and their moisture resistance almost as high. Likewise, the 225°-235° petroleum asphalt was shown to be flexible, tough, and highly water-resistant, although a higher temperature of application was necessary for this coating. On the basis of these test results, the following blend of the pitches and asphalt was developed:

- 60 percent 213° coal-tar pitch
- 25 percent 155° coal-tar pitch
- 15 percent 225°-235° petroleum asphalt

The softening point of this coating, as determined by the ring-and-ball method, was 210° F. This coating was used extensively at the Laboratory in a number of kiln-drying experiments and to some extent commercially, and it has been effective in preventing end checking of black walnut. Its adhesiveness is better than that of the 213° pitch but still not as great as could be desired. A proprietary asphalt or pitch coating has been used extensively for walnut gunstock blanks since World War II. The Laboratory does not know whether this is a blend or a single type of material.

Any blend of coal-tar pitches and asphalts that would give suitable temperature, flexibility, toughness, and adhesion characteristics should produce
an effective end coating. An application temperature of 375° to 425° F. has been found generally suitable for all pitch and asphalt coatings.

Proprietary Hot Coatings

For an up-to-date list of manufacturers and distributors of end coatings, see Forest Products Laboratory Report No. 1954. Several of the manufacturers of petroleum and coal-tar products listed make paraffinic, asphaltic, or pitch-type hot coatings. At least one manufacturer has a special type hot-melt coating that has proved economical to one manufacturer of kitchen cutlery, although it is high in price. The Forest Products Laboratory does not have any comparative data on the effectiveness of such proprietary coatings.

Methods of Application of Hot Coatings

Hot coatings can be applied by dipping the ends of the pieces to a depth of one-half inch in the molten coating. The temperature should be high enough to give good flow characteristics to the coating, but should be as low as possible to minimize steam formation. The dipping time should be short to avoid blistering. Adhesion is likely to be poor when the dipping method is used. If the wood surface is very wet, better adhesion can be obtained by drying it slightly before dipping, but not enough to start checking.

The best method to apply hot coatings is to use a power-driven roller that revolves in a bath of molten coating, as illustrated in figure 9. The end of the piece should be held firmly against the roller and moved against the rotation of the roller. The whole operation should be completed in about a second. With this method, a smooth, uniform coating is applied, and adhesion is better than that obtained by dipping. One manufacturer of a paraffin coating has developed portable equipment to heat it and spray it on logs and large timbers.

Cold Coatings

The use of paints, drying oils, and asphalt varnishes as end coatings, sometimes with little regard to their effectiveness, has long been practiced by the lumber industry. A recent development has been the adaptation of wax emulsions to end coatings. Ordinary paints and varnishes are too thin for
end coatings unless several coats are applied. On the other hand, because of the highly water-resistant properties of wax, thin coatings of wax emulsions have proved highly beneficial for some purposes.

Information on different types of cold coatings is discussed in the following paragraphs.

Types of Cold Coatings

Pigment and oil pastes. --One of the simplest effective end coatings is a heavy paste of white lead or a similar pigment in linseed oil or a similar vehicle. Test results on this type of coating are limited but indicate good moisture resistance. The water resistance of these coatings is due primarily to the large proportion of pigment they contain and the thick film formed. The paste should be prepared with only enough oil to allow its application with a trowel or stiff brush. Although this coating is too expensive for large-scale use, the ingredients are usually readily available, and the coating is suitable for use on small lots of material.

Filled-varnish coatings. --About 1920, the Forest Products Laboratory developed a coating called filled hardened gloss oil from barytes, magnesium silicate, and an extra heavy gloss oil varnish made by a special formula. This coating was highly water resistant and adhered well to wet wood. Its fillers were abrasive to wood-working knives, however, and it tended to pick up dirt that made it more abrasive. It has fallen into disuse for purposes where turning, planing, or shaping operations are involved.

Other coatings have been developed for logs and timbers, so no further details of the manufacture or properties of the filled hardened gloss oil coating are needed here. It is still available from some commercial manufacturers listed in Report No. 1954, and the Laboratory will gladly furnish the names of these suppliers or the formula for the coating.

Some of the proprietary coatings are of the filled-varnish type. As with the coating described above, a heavy consistency is needed to give a highly effective coating. Presumably many new types of varnishes are more water resistant than gloss oil and would make coatings that would be more effective with thinner applications.

Aluminum paints. --Properly-made aluminum paint end coatings are among the most effective coatings and thus can be used for kiln samples and for comparative tests with other coatings of unknown quality. The effectiveness
of aluminum paints as moisture-retardant coatings is due to the leafing that occurs when the flat particles come to the surface and pack themselves closely together in the outer layers of the vehicle. The amount of aluminum that can be used effectively in making a satisfactory paint varies from 1.75 pounds to 2.25 pounds per gallon of vehicle, depending upon the grade of paste or powder used. If larger amounts are used, the particles do not pack together well, and the moisture-retarding properties are impaired. For the same reason, an aluminum coating should not be excessively brushed.

The effectiveness of aluminum paints is also influenced by the vehicle used. With ordinary bronzing liquids, the effectiveness is not very great. One of the best vehicles is a phenolic-resin, tung-oil varnish. Even with the latter vehicle, one coat does not produce an effective coating. In one experiment at the Forest Products Laboratory, green blocks completely covered with one, two, and three coats retained 20 percent, 64 percent, and 75 percent, respectively, of the evaporable moisture when exposed to rather severe drying conditions for 74 hours. In another experiment, a moisture-retaining efficiency of 82 percent was found for a 2-coat application of an aluminum-phenolic resin coating compared with an efficiency of 65 percent for the pitch-asphalt hot coating previously described. In this experiment the coatings tested were applied to the end grain of test blocks, the sides of which were covered with two coats of a highly water-resistant material. A maximum temperature of 165° F. was used. Efficiency was determined according to the following equation:

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\text{Percentage efficiency} = 100 \left(1 - \frac{\text{Moisture loss through coating}}{\text{Moisture loss from control with uncoated ends}}\right)
\]

For end coating purposes, a two-coat application is generally satisfactory, but a three-coat job may be better for comparative tests. A paint consisting of 2 pounds of aluminum powder or paste in a gallon of 100 percent phenolic resin marine spar varnish slightly thinned with xylol makes a good coating that can be sprayed or brushed. These paints have better properties if they are freshly made.

Unfilled varnishes. --Some of the resins now available for varnishes are so highly water resistant that they can be used in end coating varnishes without abrasive fillers. These coatings are much heavier in consistency than ordinary varnishes. They also must have a great deal of tack to cling to wet wood. This type of coating remains flexible and effective during the early stages of kiln drying, but becomes brittle during the final stages. Thus it can be turned easily without damaging machine knives.
Such coatings have come into general use in the bowling pin and shoe last industries.

Asphaltic coatings. -- Two types of asphaltic coatings have been developed and used for cold coatings. One is the asphalt-emulsion type, containing water; the other is the asphalt cut-back type, containing a petroleum solvent or dispersant. At least one commercial firm has produced an emulsified asphalt that stands up well under the weather; it has prevented checking, helping to retard decay penetration in field tests (4, 5). Presumably other firms have asphalt emulsions that would be as satisfactory.

Not all emulsions of this type are weather resistant, however. All water emulsions are subject to breakdown upon freezing or exposure to heavy rain immediately after application. Cold asphaltic coatings are generally applied with a trowel or stiff brush, but could be sprayed with proper equipment.

Wax emulsions. -- One of the most interesting end coating developments in the last 10 years is the emergence of wax emulsions. The basic ingredients are microcrystalline waxes from petroleum. The coating is usually sprayed on as a milky liquid but dries to a thin clear film. Colors can be mixed with the emulsion for identification, branding, or visual evidence of treatment. At least 3 commercial firms produce this type of end coating.

The redwood industry (3) has found that a coating of wax emulsion sprayed on the ends and flat surfaces of protruding boards in their seasoning piles at a cost of about 50 cents per thousand board feet resulted in net savings of $3.50 to $11.50 per thousand. Used on 2 by 4's, the coating not only helps make properly dried material more suitable for construction use but also provides an attractive sales appeal to purchasers. As with asphalt emulsions, the wax emulsions must be protected from freezing and heavy rain after application.

Hygroscopic coatings. -- The use of hygroscopic pastes (2) to prevent end checking has been proposed. This type of coating has not come into large scale commercial use.

Proprietary Cold Coatings

The Forest Products Laboratory has not made comprehensive tests of proprietary cold coatings. However, a test on oak tight cooperage bolts showed that 3 proprietary coatings are better than filled hardened gloss
Manufacturers of such coatings are listed in Report No. 1954. Potential users of end coatings are advised to write to several of the manufacturers who could conveniently supply them and request information as to type of coating, properties, and price. Samples of 3 or 4 could be obtained and tried in simple tests such as those described above to see which coating is the best for any particular use.

Method of Application of Cold Coatings

Cold coatings are applied by brush or sprayed, with proper equipment. Dipping does not usually result in good adhesion to wet wood, but a power driven roller can be used. Cold coatings should be allowed to set for a few hours before being subjected to kiln conditions.

Summary and Conclusions

The information available at the Forest Products Laboratory on end coatings for preventing end checking of logs and lumber during storage, handling, and drying may be summarized as follows:

1. End coatings must be inherently of high water resistance and generally must be applied in a thick film to eliminate checking. Hygroscopic coatings must maintain enough moisture in the surface fibers to keep the wood swollen. For practical use, a coating must adhere to the wood, remain intact during handling, and be flexible enough to adjust to changing wood dimensions, yet not too messy to handle. Economically, the reduction of the losses due to checking must be greater than the cost of using the coating. It is generally not economical to end coat softwood lumber of small cross-sectional dimensions. End coatings, however, reduce the severity of checking in large timbers, and it is imperative to apply them to thick hardwood items to avoid excessive damage.

2. Hot coatings must be heated above their melting point when applied. Among the hot coatings, paraffin, rosin and lampblack, coal-tar pitches, and asphalt are highly effective when applied in a single coat. Paraffin is generally suitable only for air seasoning, rosin and lampblack are suitable for kiln temperatures up to 150° F., and pitches and asphalts can be selected for use at any ordinary kiln temperature. Blends of coal-tar pitches and petroleum asphalts of suitable softening points form effective coatings that are tougher and more adhesive than the pitch alone. The coating with
the lowest softening point that will safely withstand the drying temperatures used is recommended. Hot coatings can be applied by dipping the ends of the pieces in the molten coating, or more satisfactorily by means of a power-driven roller device.

3. Cold coatings can be applied at ordinary temperatures by brushing or spraying but should be allowed to set before being subjected to kiln conditions. Among the cold coatings, pigment and oil pastes are effective when applied in a single heavy coat. The available data on hygroscopic coatings are insufficient to allow conclusions on their effectiveness. Aluminum coatings must be made with water-resistant vehicles to be effective as end coatings, but even then 2 or more coats are required. There are many proprietary cold coatings such as filled or unfilled varnishes, asphalt emulsions or cutbacks, and wax emulsions, that are effective in reducing end checking losses.

Literature Cited


(5) Scheffer, T. C., and Jones, T. W. 1953. Control of decay in bolts and logs of northern hardwoods during storage. Northeastern Forest Experiment Station, Station Paper No. 63.
Beginning of seasoning; no checks.

Early stage of seasoning; numerous small checks.

Later stage of seasoning; size of some checks increased with closing of others.

Final stage of seasoning; almost complete closing of most checks when major stress is relieved by large V-shaped check.

Figure 1.--Four views of an uncoated end of a sugar maple bolt showing progressive changes in end checking during various stages of air seasoning.

ZM 49512 F
Figure 2. -- Severely checked southern swamp oak butt log.

ZM 49513 F

Figure 3. -- Sweetgum log, left uncoated, right half coated with a single coat of filled hardened gloss oil containing cresylic acid.
Figure 4. --End checking during air seasoning of Douglas-fir timbers.

Figure 5. --End checking during air seasoning of thick oak wagon stock.

Figure 6. --Minute end checks in southern pine.

ZM 49511 F
Figure 7. --Moisture resistance of different end coatings tested on small green shortleaf pine blocks subjected to accelerated drying conditions.
Figure 8. -- Moisture resistance of different end coatings tested on small green black walnut blocks subjected to accelerated drying conditions.

ZM 48438 F
Figure 9. -- Power-driven roller device for the application of hot coatings.

ZM 43112 F
The following lists of publications deal with investigative projects of the Forest Products Laboratory or relate to special interest groups and are available upon request:

- Box, Crate, and Packaging Data
- Chemistry of Wood
- Drying of Wood
- Fire Protection
- Fungus and Insect Defects in Forest Products
- Glue and Plywood
- Growth, Structure, and Identification of Wood
- Furniture Manufacturers, Woodworkers, and Teachers of Woodshop Practice
- Logging, Milling, and Utilization of Timber Products
- Mechanical Properties of Timber
- Pulp and Paper
- Structural Sandwich, Plastic Laminates, and Wood-Base Components
- Thermal Properties of Wood
- Wood Finishing Subjects
- Wood Preservation
- Architects, Builders, Engineers, and Retail Lumbermen

Note: Since Forest Products Laboratory publications are so varied in subject matter, no single catalog of titles is issued. Instead, a listing is made for each area of Laboratory research. Twice a year, December 31 and June 30, a list is compiled showing new reports for the previous 6 months. This is the only item sent regularly to the Laboratory's mailing roster, and it serves to keep current the various subject matter listings. Names may be added to the mailing roster upon request.
McMillen, John Milton

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