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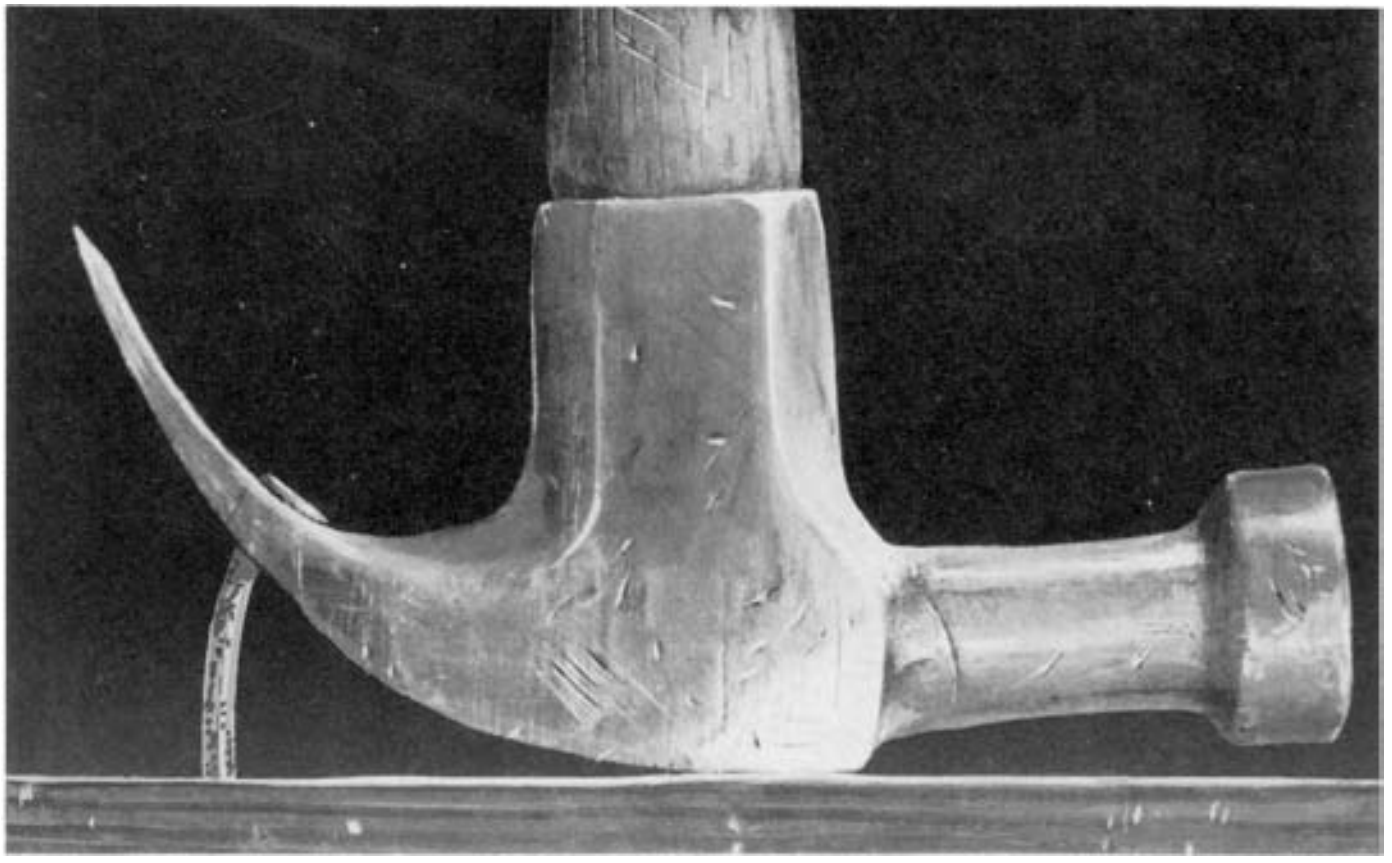
# EFFECTS OF VARIOUS PRESERVATIVE TREATMENTS OF FIELD BOXES ON NAIL HOLDING



U. S. DEPARTMENT OF AGRICULTURE ● FOREST SERVICE ● FOREST PRODUCTS LABORATORY

# SUMMARY

This research study was conducted to investigate the effects of 17 different types of preservative treatment for ponderosa pine on the withdrawal resistance of sixpenny, cement-coated nails. The specimens were obtained from field boxes subjected to 5 years of outdoor exposure and subsequent indoor conditioning.

The withdrawal resistance was affected by corrosion of the nails and the values were generally higher in exposed specimens than in nonexposed specimens. There was not a large difference in the withdrawal resistance of nails from specimens treated with various types of preservatives, except that specimens treated with a preservative containing a water repellant developed considerably lower withdrawal resistance than those treated with other types of preservatives.

# EFFECTS OF VARIOUS PRESERVATIVE TREATMENTS OF FIELD BOXES ON NAIL HOLDING

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## INTRODUCTION

This study of the withdrawal resistance of nails from treated wood specimens cut from field boxes is supplemental to an evaluation made on the entire boxes. The initial investigation was made with wood field boxes to obtain information on the relative effectiveness of 17 different treatments, under continuous field conditions, in controlling mold and decay of wood. In addition to evaluations of the progress of decay, condition of the nails, and the relative effectiveness of the different treatments after a 5-year-outdoor exposure period, the boxes were subjected to a diagonal compression test to obtain information on their relative strength. The results of these evaluations have been previously reported.[2]

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Kurtenacker, R. S., Scheffer, T. C., and Blew, J. O. Condition of preservative treated field boxes after 5 years of outdoor exposure. Forest Products Lab. Rpt. 2054, 15 pp., illus. 1956.

## MATERIALS AND METHODS

The material for this study was obtained from 200 boxes of the field or picking-box type, which previously had been exposed to the weather. The boxes had been made from ponderosa pine shooks and assembled with sixpenny, cement-coated box nails. Inside dimensions of the boxes were 20 by 14 by 7 inches.

### Exposure of Boxes

The boxes were divided into 20 lots of 10 each. Fifteen lots were preservative treated by a 1-minute dip process after assembly. The material for two lots was treated by the pressure method in shook form, then kiln dried and assembled into boxes. The remaining three lots were assembled from untreated material to be used as controls, two of which were exposed along with the treated boxes and one was stored under cover. The various types of preservative treatments used are detailed in table 1.

The boxes were placed on an outdoor exposure site at Madison, Wis., for a period of 5 years. Of the 10 boxes in each lot, 5 were placed on the ground and the other 5 placed directly on top as shown in figure 1. After removal from the site, the boxes were placed in a storage shed and subsequently tested in diagonal compression (fig. 2).

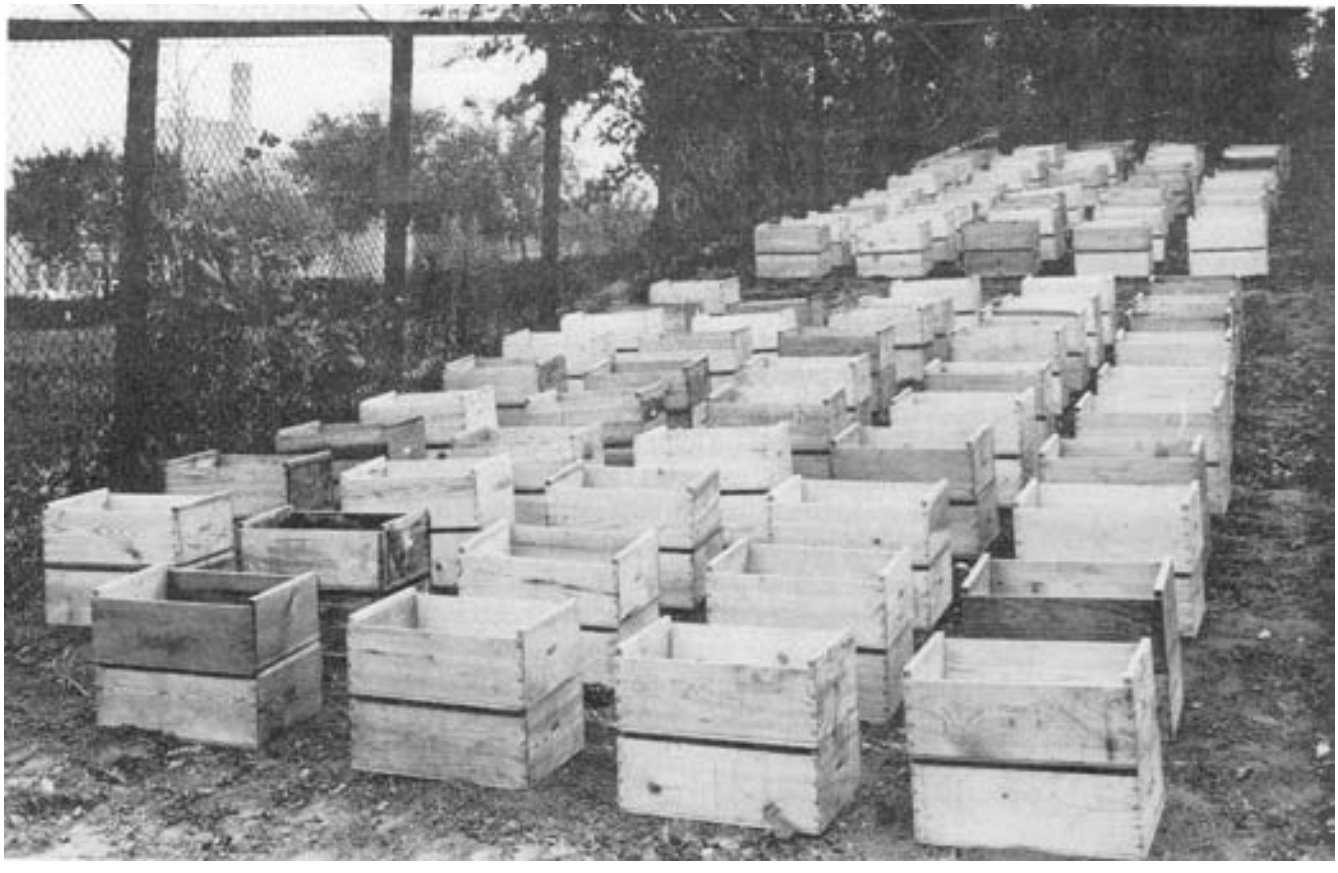

Figure 1.--Test plot at Madison, Wis., showing arrangement of treated boxes during outdoor exposure period. M 83260F

Table 1.--Withdrawal resistance of sixpenny, cement-coated box nales in preservative-treated, ponderosa pine specimens after outdoor and indoor exposure

| Treatment number | Treatment[1] | Preservative | Average retention[2] | Box position[3] | Specimens: Moisture content | Specimens: Specific gravity[4] | Nail-withdrawal load: Immediate[5] | Nail-withdrawal load: Delayed[6] | Nail-withdrawal load: Ratio delayed/immediate | Number of nails broken[7] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pounds per cubic foot | | Percent | | Pounds | Pounds | | |
| 1 | Dip | Pentachlorophenol, 5 percent and ester gum, 5 percent, in commercial aromatic solvent. | 2.4 | B | 12.0 | 0.41 | 140 | 150 | 1.07 | 6 |
| | | | | T | 11.9 | .42 | 130 | 120 | .92 | 0 |
| 2 | Dip | Copper naphthenate, 1 percent metallic copper, in commercial aromatic solvent | 4.9 | B | 12.4 | .38 | 150 | 140 | .93 | 0 |
| | | | | T | 12.3 | .41 | 140 | 110 | .79 | 0 |
| 3 | Dip | Zinc dimethyldithiocarbamate, 5 percent, 0.25 percent metallic zinc, in commercial aromatic solvent | 2.0 | B | 12.5 | .40 | 135 | 165 | 1.22 | 7 |
| | | | | T | 12.3 | .40 | 145 | 115 | .79 | 0 |
| 4 | Dip | Copper 8-quinolinolate, 5 percent, in coal-tar creosote. | 4.5 | B | 12.3 | .41 | 145 | 145 | 1.00 | 2 |
| | | | | T | 12.4 | .41 | 135 | 125 | .93 | 0 |
| 5 | Dip | 2-Nitrophenol, 5 percent, in commercial aromatic solvent. | 4.7 | B | 12.1 | .43 | 155 | 130 | .84 | 8 |
| | | | | T | 11.8 | .39 | 130 | 110 | .85 | 0 |
| 6 | Dip | Sodium 2-benzylchlorophenolate, 5 percent, in commercial aromatic solvent | 7.0 | B | 11.9 | .41 | 155 | 125 | .81 | 1 |
| | | | | T | 11.8 | .37 | 125 | 95 | .76 | 0 |
| 8 | Dip | Ethanolamine salt of 2-benzylchlorophenol, 0.94 percent, and water repellant, 25 percent, in mineral spirits | 4.8 | B | 12.0 | .42 | 135 | 150 | 1.11 | 5 |
| | | | | T | 11.4 | .41 | 140 | 30 | .29 | 0 |
| 9 | Dip | Copper-8-quinolinolate, 1.1 percent, in Stoddard solvent and proprietary solvent | 4.7 | B | 12.2 | .43 | 145 | 65 | .45 | 0 |
| | | | | T | 11.9 | .45 | 135 | 40 | .30 | 0 |
| 10 | Dip | Pentachlorophenol, 5 percent, and water repellant, 15 percent, in commercial aromatic solvent | 4.6 | B | 12.1 | .41 | 150 | 150 | 1.00 | 1 |
| | | | | T | 11.6 | .42 | 135 | 55 | .41 | 0 |
| 11 | Dip | Water repellant, 15 percent, in commercial aromatic solvent | 4.5 | B | 11.8 | .42 | 140 | 105 | .75 | 3 |
| | | | | T | 11.6 | .41 | 150 | 65 | .43 | 0 |
| 12 | Dip | 2-Phenylphenol, 5 percent, and water repellant, 15 percent, in commercial aromatic solvent | 4.7 | B | 12.5 | .33 | 140 | 70 | .50 | 0 |
| | | | | T | 11.5 | .47 | 140 | 45 | .32 | 0 |
| 13 | Dip | Sodium orthophenylphenate, 5 percent in water | 2.2 | B | 12.2 | .42 | 140 | 120 | .86 | 6 |
| | | | | T | 11.9 | .42 | 145 | 110 | .76 | 1 |
| 14 | Dip | Sodium pentachlorophenate, 2 percent, and borax, 1 percent, in water | 4.9 | B | 12.2 | .42 | 135 | 145 | 1.07 | 3 |
| | | | | T | 11.8 | .43 | 145 | 105 | .72 | 2 |
| 15 | Dip | Ammoniacal copper arsenite,[8] 1.1 percent solution | 7.3 | B | 11.4 | .42 | 150 | 170 | 1.13 | 3 |
| | | | | T | 12.0 | .47 | 180 | 115 | 1.09 | 4 |
| 16 | Pressure | Nickel sulfate, 3.5 parts, sodium arsenate, 4.0 parts, arsenic acid, 1.5 parts, and sodium dichromate, 3.0 parts (by weight). | .21 | B | 11.3 | .42 | 140 | 140 | 1.00 | 8 |
| | | | | T | 11.5 | .46 | 170 | 100 | .59 | 4 |
| 17 | Pressure | Ammoniacal copper arsenite.[9] | .21 | B | 11.3 | .41 | 115 | 160 | 1.39 | 7 |
| | | | | T | 11.3 | .45 | 145 | 140 | .97 | 4 |
| 18 | Dip | Salicylanilide, 2.5 percent in commercial aromatic solvent | 3.8 | B | 12.1 | .41 | 135 | 145 | 1.07 | 6 |
| | | | | T | 12.1 | .39 | 145 | 125 | .86 | 0 |
| | | AVERAGES | | | | | | | | |
| | | Treated (exposed) | | B | 12.0 | .41 | 140 | 135 | .96 | 3 |
| | | | | T | 11.8 | .42 | 140 | 105 | .75 | 4 |
| | | Nos. 7 and 20 untreated (exposed) | | B | 12.7 | .42 | 155 | 150 | .97 | 5 |
| | | | | T | 12.6 | .41 | 140 | 145 | 1.04 | 0 |
| | | No. 21 untreated (stored in doors) | ---- | | 11.4 | .40 | 130 | 40 | .31 | 0 |

[1] Dipping time was 1 minute. Dipped boxes were completely assembled when treated. Pressure treatment was done on the shook.

[2] Average volume of wood per box was 0.233 cubic feet.

[3] B designate, lower boxes (on ground) and T designates upper boxes.

[4] Based on ovendry weight and volume at test.

[5] Each value is the average for 15 nails for each type of treatment except No. 21, which is for 21 nails. Depth Of nail penetration Was 1.14 inches.

[6] Tests conducted after 5-years'-outdoor exposure and subsequent conditioning at 75° F. and 64 percent relative humidity. Each value shown is the average for 20 nails for each type of treatment except No. 21, which is for 28 naills. Depth of nail penetration was 1.08 inches.

[7] The number that failed when pulled, as related to the 70 tested after exposure

[8] The nonproprietary water repellant consisted of the following ingredients and amounts by weight in the treating solution: ester gum, 6.5 percent; raw linseed oil. 6.5 percent, and paraffin wax. 2 percent.

[9] Federal specification TT-W-549a.

## Preparation of Specimens

When the evaluation of the entire boxes was completed, one end of each box was removed and used for the nail-withdrawal tests after an extended period of conditioning in an atmosphere maintained at 75° F. and 64 percent relative humidity. During the manufacture of the boxes, a 3/4- by 3/4-inch cleat was nailed along the top edge of each end of the boxes with four sixpenny, cement-coated box nails, 1-7/8 inches in length and 0.0865 inch in diameter (fig. 3). During the diagonal compression test, a load was applied to the cleat at one end of the box as shown in figure 2, but the nails holding the cleat in place on the opposite end (lower end in figure 2) were not subjected to any distortion and, therefore, were used for the withdrawal tests.

## Test Procedure

The box ends, which were 14 inches in length and 7 inches in height, were cut so that the upper 3 inches of height, which contained no visible decay, provided the specimen. The cleat was cut near the nails and removed as illustrated in figure 4 and the length of nail extending above the block or box end measured. This measurement subtracted from the nail length provided a measure of the nail penetration.

Load was applied to the head of the nail in the testing machine with the movable head of the machine driven at a rate of 0.078 inch per minute until maximum load was obtained. The maximum load, condition of the nail, and type of failure were noted and recorded.

When the nail-withdrawal tests on the exposed specimens were completed, an additional series of tests was conducted on the same specimens with new nails driven just prior to withdrawal. To insure that the test specimens would conform in quality and treatment as closely as possible to the original specimens, a 3/4-inch cleat was cut from the bottom of the block and nailed to the top of the block, as shown in figure 5. The cleat was attached to the block with three sixpenny, cement-coated box nails obtained from the same batch used in assembling the boxes. The nails were driven midway between the nailholes remaining from the original tests. The method of cutting and removing the cleat, so that each nail could be pulled individually, was similar to that used in the original tests.

When the nail-withdrawal tests were completed, a section was cut from each specimen for specific gravity and moisture content determination.

The volume of these sections was obtained from measurements made immediately after removal from the specimens. The sections were then oven-dried to obtain the specific gravity based on all ovendry weight and volume at test. This procedure was followed for all sections to provide a common basis for specific gravity determinations without regard to treatment.

Figure 2.--Treated box positioned for the diagonal compression test, after 5 years of outdoor exposure. M 97943F

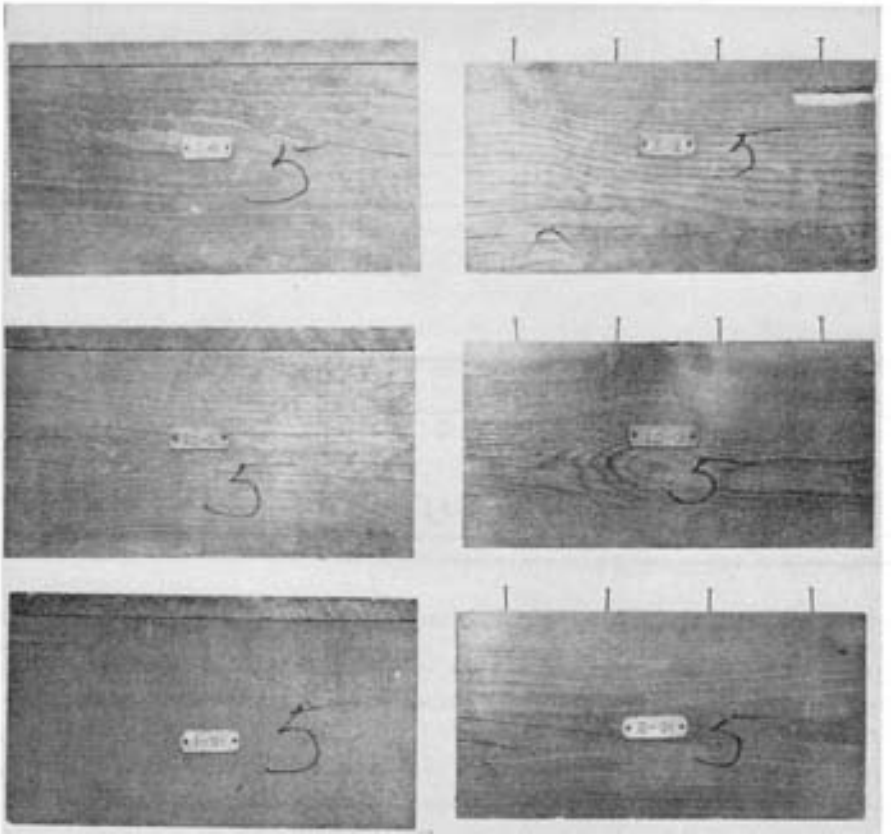

Figure 3.--Typical box ends before test, showing; (left), spedcimens with cleats in place; (right), specimens with cleats removed just prior to withdrawal of nails.

M 127 902

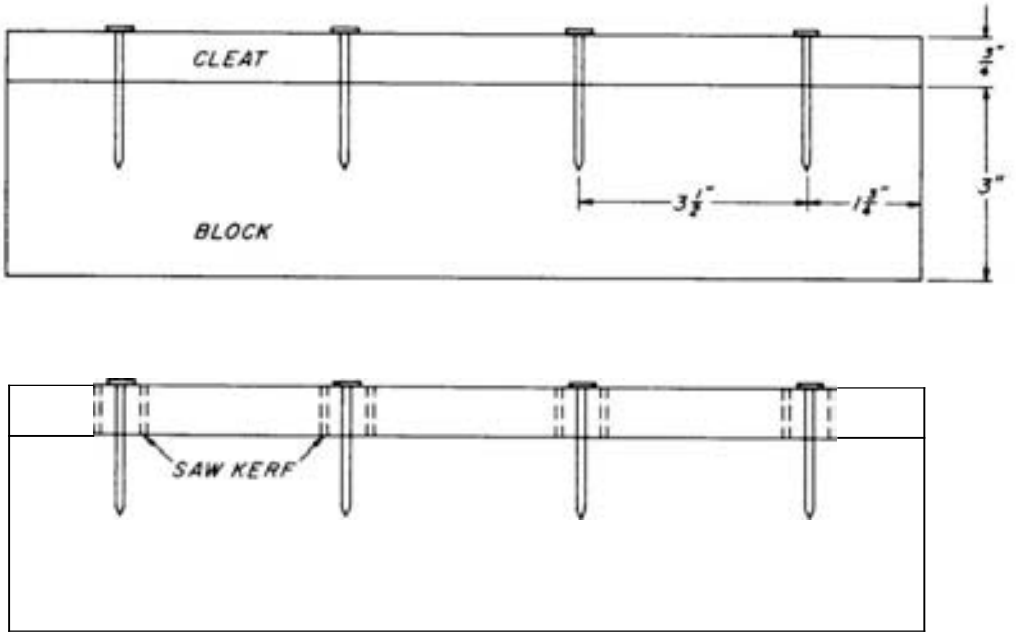


Figure 4.--Method of preparing specimens for the nail-withdrawal tests. (Top), specimen as cut from box ends; (bottom), cleat was cut near the nails and split off without disturbing nails in bloxk.

M 129 020

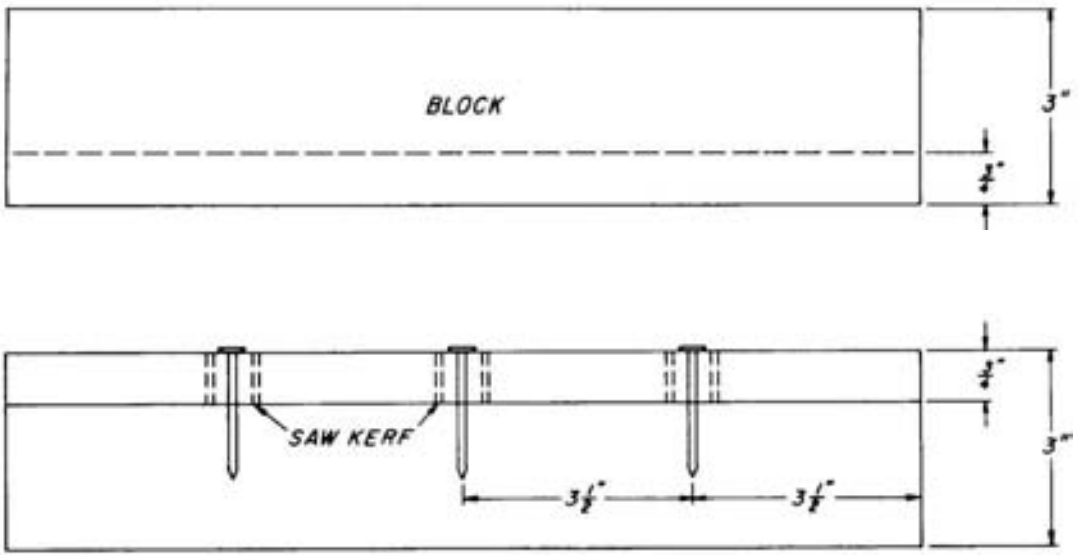


Figure 5.--Method of preparing control specimens. (Top), a 3/4-inch strip was cut from the bottom of the block and used for the cleat of the control specimen; (bottom), cleat was attached to the top of the block with three new sixpenny, cement-coated box nails and then cut as shown and split off without disturbing the nails in the block. M 129 019

## DISCUSSION OF RESULTS

The results of this study are summarized in table 1 and in figure 6. The withdrawal loads are for sixpenny, cement-coated box nails of 13-1/2-gage wire (0.0865-inch diameter) and 1-7/8 inches in length, driven into the side grain of ponderosa pine. Since the cleats attached to the box ends varied from 0.73 to 0.80 inch in thickness, the actual average depth of penetration of the nails in the specimens was 1.14 inches for the immediate tests and 1.08 inches in the specimens that were tested after several years' exposure.

The specific gravity based on ovendry weight and volume at test averaged 0.42 for all the specimens and the moisture content averaged 11.9 percent. While there were minor variations in specific gravity and moisture content of the specimens, the properties for each lot of boxes did not vary appreciably from the average; therefore, no adjustments were made for quality of material or for slight variations in depth of penetration. Comparisons are based on the actual test values.

In table 1, the withdrawal loads for nails pulled from the ends of the boxes placed on the ground (B) and those placed on top (T) are listed separately, because the results for some types of treatment varied considerably with the position of the boxes. The average withdrawal load for the nails pulled from treated specimens taken from boxes that had been placed on the ground was 135 pounds and from those taken from boxes that had been placed on the top was 105 pounds. The average load for nails driven into the same specimens and pulled immediately was 140 pounds.

The withdrawal loads for nails in the untreated specimens that were subjected to the same outdoor exposure were about the same after exposure (145 pounds) as when pulled immediately (150 pounds). The withdrawal load for nails in untreated specimens that were stored under cover, however, where no corrosion occurred, was only 40 pounds as compared to 130 pounds for nails driven and pulled immediately from the same specimens.

All of the nails except those driven into untreated material and stored under cover were corroded, as shown in figure 7. The extent of the corrosion affects the withdrawal loads considerably. A small amount of corrosion tends to increase the Withdrawal loads; however, in some boxes the corrosion had progressed to the stage where the nail broke off during test, The number

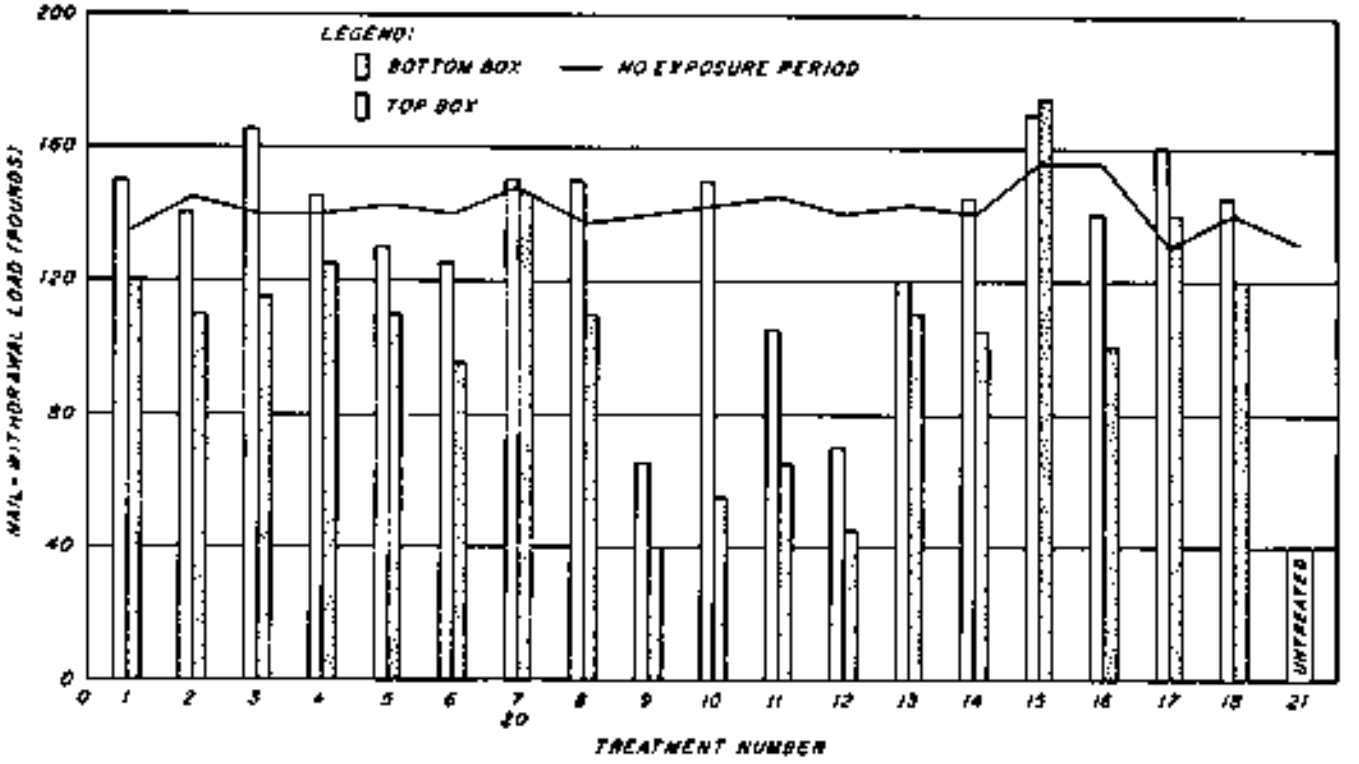


Figure 6.--Comparison of nail-withdrawal loads of sixpenny, cement-coated box nails embedded 1-1/8 inches in the side grain of treated and untreated ponderosa pine specimens. Specimens nos. 7 and 20 were from untreated boxes after 5 years' outdoor exposure. The specimens designated no. 21 were from untreated boxes that had been stored indoors. M 129 018

of nails that failed during test is given in table 1. This number, in relation to the 20 nails that were pulled from the ends of the 5 top and 5 bottom boxes for each treatment, gives an indication of the extent of the corrosion and its weakening effect on the nails. For the treated boxes that were placed on the ground, an average of 3 out of 20 nails failed during test. For the treated boxes placed on top, an average of 1 out of 20 nails failed during test. For the untreated boxes, however, an average of 5 out of 20 nails failed during test from boxes that were placed on the ground, while none failed from boxes that were on top or off the ground.

As illustrated in chart form in figure 6, the withdrawal loads of nails for a11 treatments except No. 15 were higher for specimens from the bottom boxes than from the top boxes. An examination of the nails showed that, in general, the nails in the bottom boxes had corroded more severely than those in the top boxes, because the boxes nearer the ground undoubtedly were subjected to a higher and more severe moisture condition. The difference in the extent of corrosion is reflected in the loads, since the withdrawal resistance of nails in the top treated boxes averaged about 75 percent of those in the bottom boxes.

The withdrawal resistance of nails from different types of treated material did not vary appreciably, except that the values for treatment Nos. 9, 10, 11, and 12 were considerably lower than the average for the other treatments. These four treatments (9 through 12) contained a water repellant which included a small amount of wax that may have tended to lubricate the nail surface; or possibly some ingredient in the preservative may have tended to inhibit corrosion. For these four treatments, the average withdrawal resistance for nails from both top and bottom boxes was only slightly more than one-half the average withdrawal resistance of the other 13 treatments (75 pounds versus 130 pounds). Except for these four treatments, the withdrawal resistance of nails from the bottom boxes after more than 5-years' exposure was not greatly different from the immediate withdrawal resistance.

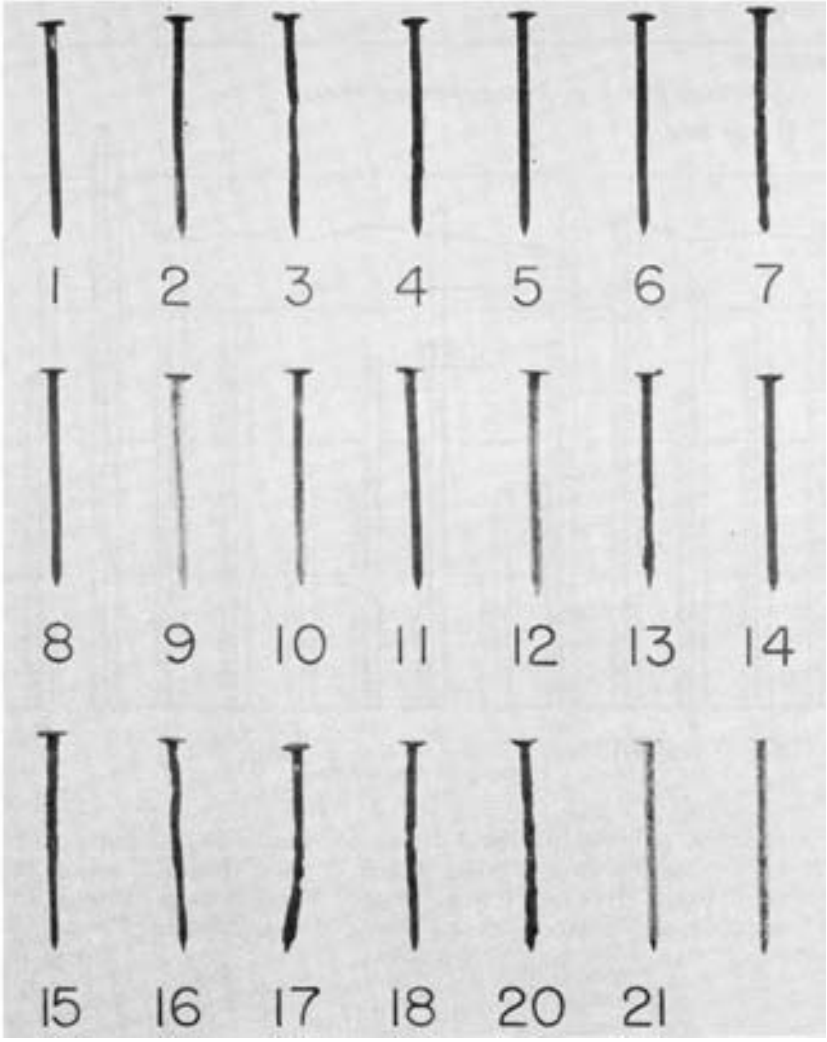


Figure 7.--Typical condition of nails from each set of treated boxes after 5 years' outdoor exposure. Numbers shown designate type of treatment. The unnumbered nail (lower right) is a new and unused sixpenny, cement-coated box nail. M 106 906

## SUMMARY OF RESULTS

The withdrawal resistance of nails after exposure did not vary appreciably for different types of treatment except for those treatments that contained a water repellant. The average value for the 13 treatments without a water repellant was 145 pounds in the bottom boxes and 120 pounds in the top boxes. The average value for the four treatments containing a water repellant was 95 pounds in the bottom boxes and 50 pounds in the top boxes.

When the values for the top and bottom boxes are combined, the values for only two types of treatments (170 pounds for No. 15 and 150 pounds for No. 17) were higher than the 145 pounds obtained for the untreated controls. The average of the top and bottom values for all treatments, however, was higher than the 40 pounds obtained for the untreated material from boxes that were stored inside and not exposed.

Nail corrosion in some treated specimens and in the untreated specimens had progressed to the stage where nail failure occurred during the withdrawal test.