Subject: Preservation of the Exterior Surfaces of Wooden Shipping Containers to Retain Identification Symbols In Long-Term Outdoor Storage--Final Report After 4 Years of Exposure

Ordnance Project No.: TB4-006I (Formerly TB5-1101F)

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Authors: V.P. Miniutti and E.A. Mraz

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FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

ABSTRACT

Wood shipping containers were stenciled, bound with steel bindings of round wire and flat strap, and exposed outdoors at Madison, Wis., Panama Canal Zone, Fort Churchill, Canada, and Yuma, Ariz. The boxes were positioned at the test sites in a way that exposed all surfaces except the bottoms to the full effects of the weather. Four marking materials were used with seven combinations of two undercoat and four topcoat treatments to stencil the north, south, and top sides of boxes made of red oak, Douglas-fir, and southern yellow pine.

All stencils made with 12 combinations of marking material and undercoat-topcoat treatment remained legible after 4 years of weathering only on the south side of one untreated southern yellow pine box in Canada.

After 4 years of exposure of the boxes pretreated with material A, a water-repellent preservative, the best legibility was found on the north sides of boxes representing 9 of 12 combinations of species and site, and on the south sides for boxes of the other 3 combinations. All stencils made with 4 of 12 combinations of marking material and undercoat-topcoat treatment were legible after 4 years of exposure on the north sides of the pretreated boxes of all species from all test sites. After the untreated southern yellow pine boxes had weathered 4 years, all stencils made with 8 of 12 combinations of marking material and undercoat-topcoat treatment were legible on the north side at all test sites and those made with 6 combinations were legible on the south side at all test sites.

Stencils were not sufficiently durable on the tops of either pretreated or untreated boxes to justify stenciling these surfaces of boxes that are to be exposed to the weather for more than 1 or 2 years.

Stencils survived best on untreated southern yellow pine except in Panama, where they were most legible on the pretreated pine.

Of the 4 marking materials, No. 3 was best on pretreated boxes, and No. 4 on untreated boxes. A topcoat was necessary for maximum durability of the stencils. The best single combination for stenciling on both pretreated and untreated boxes consisted of marking material 3 and topcoat material B.

Pretreating with material A preserved the legibility of the stencils on the southern yellow pine boxes in Panama but not at the other three test sites. Material A gives protection against stain and decay fungi needed at Panama.

The tightness of the bindings did not indicate a definite preference for either type.

Recommendations

The results of this study disclose that the following procedures will produce stencil markings having a reasonably good chance of remaining legible for 4 years of outdoor storage at all test sites investigated. Since no boxes were exposed in stacks, no results were obtained that apply directly to the durability of stencils on the concealed surfaces in a stack of boxes.

1. With one major exception, make the boxes of southern yellow pine. The exception being if boxes pretreated with material A are to be stored in a warm, dry climate, such as that at Yuma, Ariz., then red oak would be a better selection than southern yellow pine.

2. If individual boxes are to be widely spaced in storage, pretreat the boxes with material A only if it is likely that they may be stored in a warm wet climate similar to that at the Panama Canal Zone. If boxes are to be stored in stacks, pretreat all boxes for all storage sites with material A. The superficial pretreatment will probably be inadequate if the decay conditions are severe in the interior of the pile.

3. Stencil two opposite sides of the boxes and, if practical, position them in outdoor storage with the stencils facing north and south. The tops of boxes are not suitable for stencils if the boxes are to be stored for more than 1 or 2 years.

4. Use marking material 3 and topcoat material B for the stencils.

5. Whenever practical, store wood boxes in an area where the climate is similar to that in Ft. Churchill, Canada, or Madison, Wis., avoiding warm wet and warm dry areas.

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PRESERVATION OF THE EXTERIOR SURFACES OF WOODEN SHIPPING CONTAINERS TO RETAIN IDENTIFICATION SYMBOLS IN LONG-TERM OUTDOOR STORAGE

Final Report After 4 Years of Exposure

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PRESERVATION OF THE EXTERIOR SURFACES OF WOODEN SHIPPING CONTAINERS TO RETAIN IDENTIFICATION SYMBOLS IN LONG-TERM OUTDOOR STORAGE

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OBJECT

To obtain research information on the preservation of the exterior surfaces of wood shipping containers so that identification symbols can be retained in long-term outdoor storage.

INTRODUCTION

The available marking materials used for stenciling wood shipping containers have not proved durable in long-term outdoor storage. Because of the need by the military services for adequate marking of shipping containers in long-term outdoor storage, this investigation for Rock Island Arsenal Test Program TB4-006I (formerly TB5-1101F) was undertaken by the U. S. Forest Products Laboratory by authorization of the Office, Chief of Ordnance, to find or develop stencil systems, including protective treatments for the wood and stencil markings, that will provide increased legibility under long-term outdoor storage conditions.

On the basis of preliminary laboratory and short-term outdoor exposure tests, four marking materials and two undercoat and four topcoat treatments were selected for stenciling wood boxes for long-term outdoor storage at four test sites with different climatic conditions. The first progress report of the field tests describes in detail the preparation of the boxes and their installation at the test sites. The second, third, fourth, and fifth progress reports give the results of inspections made on boxes from each test site after 1, 2, 3, and 4 years of exposure. This final report summarizes the results obtained during the 4 years of exposure.

Test boxes were available for one more inspection, but the responsible personnel of Rock Island Arsenal decided to terminate this investigation with the inspection after 4 years of exposure. For this reason, and because the boxes contained dummy loads of no military value or significance, the remaining boxes were destroyed.

PROCEDURE

Preparation and Installation of Text Boxes

The detailed procedure of preparing and installing the wood boxes at the test sites is described in the first progress report.

Two hundred wood boxes,[1] Specification JAN-P-601A, style 4 (approximately 15 by 18 by 25 inches in size), as shown in figure 1 were constructed and exposed for this project. These boxes included 60 of red oak, 60 of Douglas-fir, and 80 of southern yellow pine. The Douglas-fir boxes differed from the box shown in figure 1 since they had tops of plywood that were marked to simulate four boards. The sides and top of each box were divided for stenciling into 40 test areas as shown in figure 2.

Four stencil marking materials were used with seven combinations of two undercoat treatments and four topcoat treatments. The two undercoat treatments were 1, pretreatment with material A, and 2, no pretreatment.

These marking materials and undercoat-topcoat treatments were coded for this work as:

Marking materials

The four marking materials are coded as 1, 2, 3, and 4. Marking materials 1 and 2 are black stencil inks, 3 is a red barn paint thinned with toluol to the consistency of a stain, and 4 is a black stencil paint of the water-emulsion type.

Undercoat-topcoat treatments

The code numbers and the materials used for the seven undercoat-topcoat treatments are given in the following tabulation:

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[1] These same boxes were also used for evaluation of three case liner materials under Rock Island Test Program TB4-006I (Formerly TB5-1101G), "Development of a Case Liner for Long-Term Outdoor Storage."

Figure 1. --Wood test box (JAN-P-106A, style 4) used in tests to evaluate the serviceability of stencil marking systems in long-term outdoor storage.

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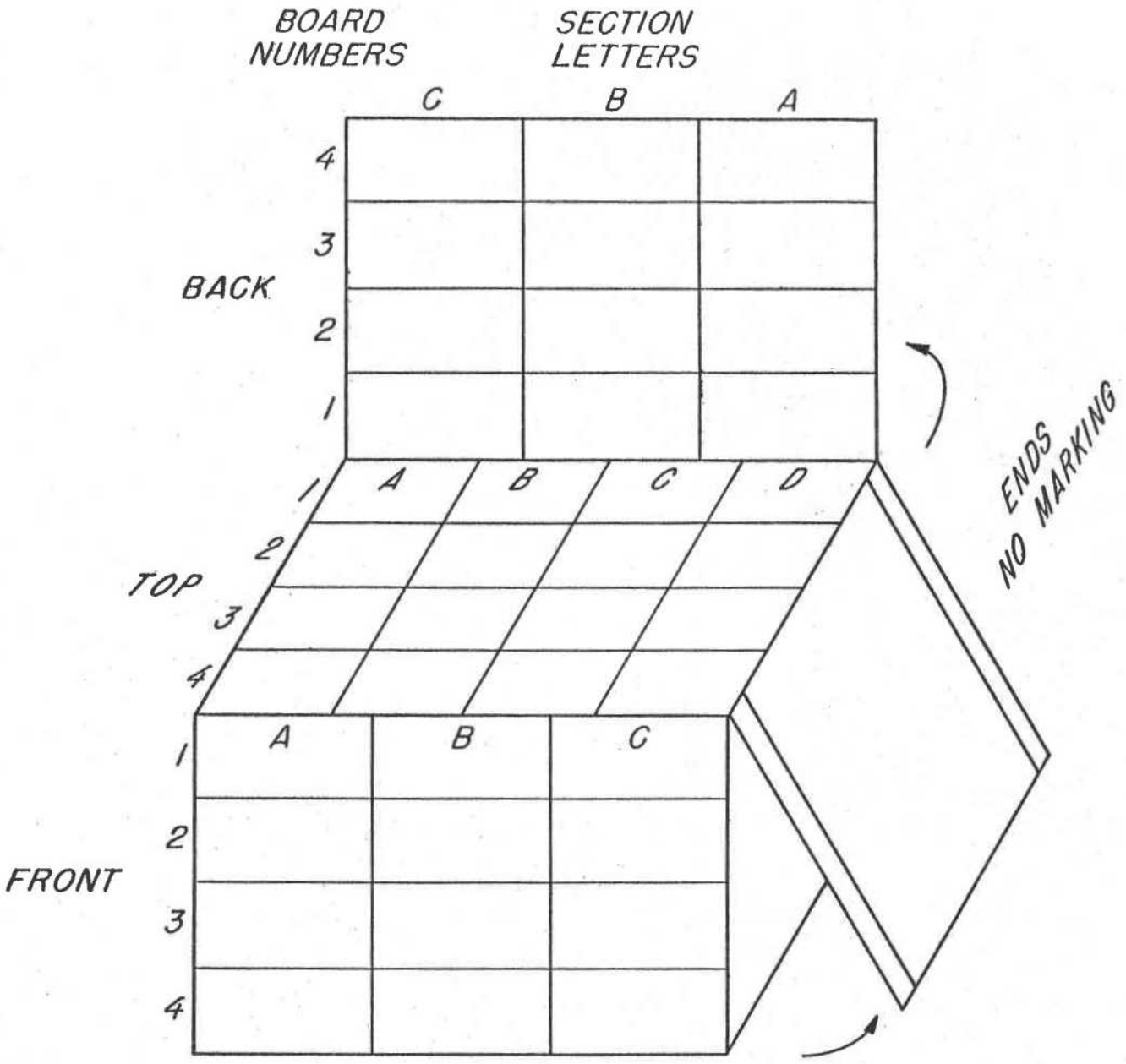

Figure 2. --Division of style 4 test box into boards and sections to obtain 40 areas for use in locating stencil systems.

Code No.	Pretreatment	Topcoat treatment
0	Material A	None
1	Do.	Material B
2	Do.	Material C
3	None	Material A
4	Do.	None
5	Do.	Material B
6	Do.	Material C

Material A is a water-repellent preservative and materials B and C are exterior varnishes.

In the figures and discussion of this report, combinations of marking materials and undercoat-topcoat treatments are designated by two code numbers. The first number always designates the marking material. For example, combination 1-0 designates marking material 1 with undercoat-topcoat treatment 0.

The marking materials and undercoat-topcoat treatments were randomly assigned to the test areas on the boxes. For boxes that received pretreatment with material A, the fronts, backs, and ends were immersed in the solution for 10 seconds. This method was also used for top boards that received this pretreatment. Plywood tops were pretreated by brushing material A on the assigned areas. The marking materials were applied by spraying through a stencil in a double-pass coat. Topcoat material A was applied by brushing, and topcoat materials B and C were applied by spraying in a heavy single-pass coat.

Steel bindings of two types were used on each box, 3/8- by 0.020-inch flat strap on one end and 16-gage round wire on the other end (Fig. 1).

Fifty boxes, 15 of each of the 3 pretreated species and 5 of southern yellow pine with no pretreatment, were exposed in outdoor storage at each test site in the order shown in figure 3. The boxes, with their backs facing north, were placed on creosote-treated 2- by 4-inch wood dunnage strips laid on the ground.

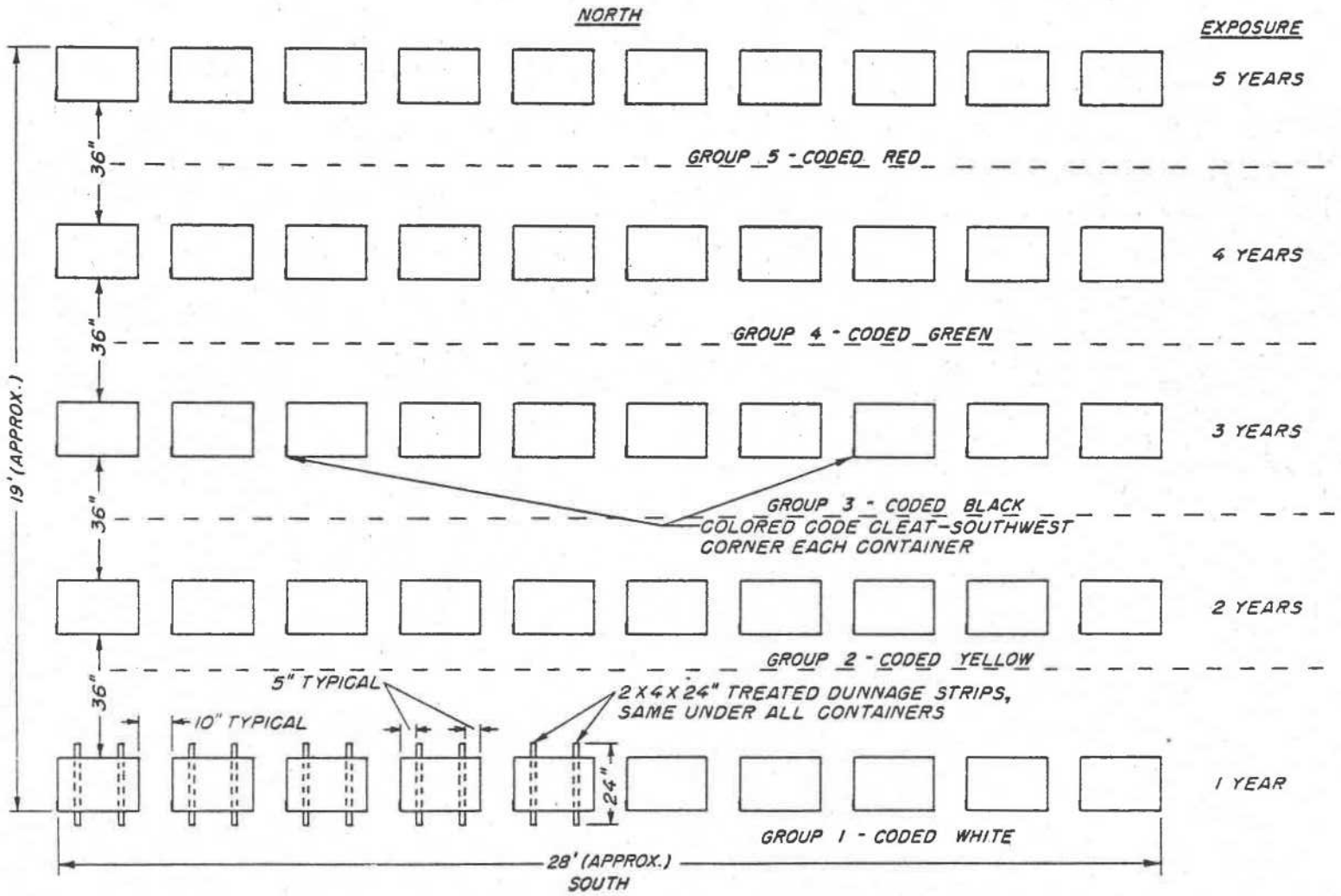

Figure 3.--Layout of nailed wood boxes in exterior exposure to evaluate marking systems. The backs of the boxes face north.

The test sites and dates when storage began are:

Ordnance Climatic Test Detachment, Fort Churchill, Manitoba, Canada (Sept. 22, 1954).
Ordnance Climatic Test Detachment, Yuma, Ariz. (Sept. 15, 1954).
Corozal General Depot, Panama Canal Zone (Oct. 15, 1954).
Test Site, Forest Products Laboratory, Madison, Wis. (Aug. 24, 1954).

Special site preparation in Canada included grading and filling with gravel. The soil of the sites in Arizona and Panama was treated with a 5 percent solution of DDT in No. 2 fuel oil. One pint per square foot was used in Arizona, and 1 quart per square foot was used in Panama. Photographs of the test sites appear in the first progress report on the field tests.

On or about January 10, 1958, one box at the Panama site was damaged in an apparent attempt to pilfer its contents. For this reason, the boxes were moved about 230 feet to a concrete base surrounded by a wire fence. The move was made between January 10 and February 17, 1958, during the fourth year of exposure. This new test site is shown in the fifth progress report on the field tests.

Climatic data were collected at or near each site during each year of exposure.

Inspection

Ten of the boxes, 3 of each of the 3 pretreated species and 1 of untreated southern yellow pine, were returned from each site for inspection after each year of outdoor exposure. All stencils were protected during shipment by sheets of hardboard banded over the surfaces or by wood shipping containers.

The stencils in each test area on each box were photographed and inspected for legibility. The legibility was rated as in the preliminary investigation. Ratings 1 and 2 are good to good minus; 3, 4, and 5 are fair plus to fair minus; 6, 7, and 8 are poor plus to poor minus; and 9 and 10 are bad plus to bad; all were rated according to the judgment of an experienced inspector. A rating of 5 or better was assigned only when all letters of a stencil were legible. A stencil with a legibility rating greater than 5 is not legible. Typical reference panels from the preliminary investigation are shown in figure 4.

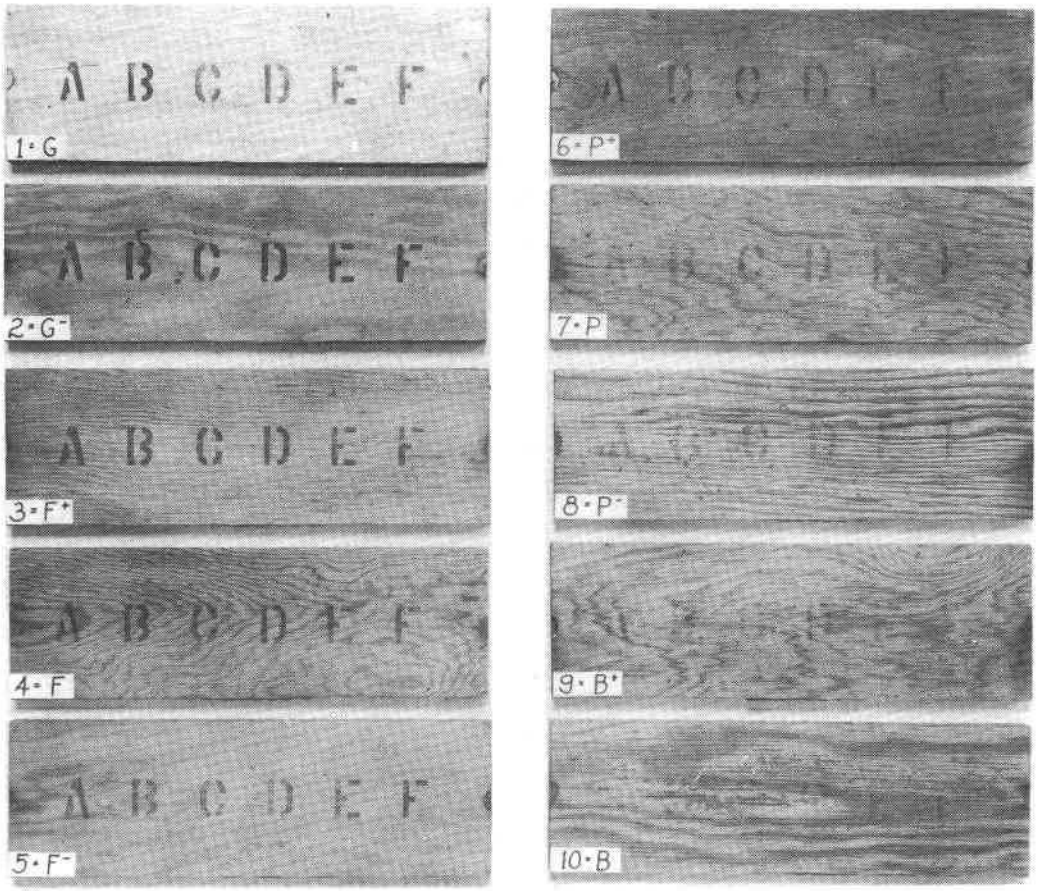

Figure 4. --Typical reference panels with ratings of legibility from 1 through 10, good through bad, for the stencil markings. A stencil with a legibility rating greater than 5 is not legible.

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In the inspections covered by the fourth and fifth progress reports, the steel bindings on all boxes were also inspected. They were pulled moderately hard by hand and rated from 1 to 10 for tightness. A tight binding was rated 1, a deflection of 1/2 inch was rated 4, a deflection of 1 inch was rated 7, and a broken binding was rated 10. Intermediate ratings were assigned according to the judgment of an experienced inspector.

RESULTS

Data on climate for the 4 years of exposure are given in figure 5.

The ratings of effectiveness for the stencils during the 4 years of exposure are given in figures 6 and 7. Ratings of effectiveness, computed from the ratings of legibility, are the percentage of the number of test areas that were rated from 1 to 5 for legibility (all markings legible).

In figure 6, the ratings for all combinations of marking materials and undercoat-topcoat treatments are averaged to show the effect of species, north (back) and south (front) exposure, pretreatment with material A, and test site. Figure 7 gives effectiveness ratings from the side or sides on which the stencils had the highest effectiveness for each combination of marking material and undercoat-topcoat treatment that were averaged for the three pretreated species and for all test sites except combinations 1-3, 2-3, 3-3, and 4-3. The excluded combinations appeared only on the tops of the boxes where the durability of the stencils was so poor that ratings from these surfaces were omitted to make the figures more compact.[2]

To aid in further evaluating the combinations of marking materials and undercoat-topcoat treatments that are rated 100 in effectiveness (all stencils legible) after 4 years of exposure in figure 7, ratings of legibility after the same period of exposure are given for them in figure 8.

The appearance of treated and untreated boxes of southern yellow pine after 4 years of weathering at the four test sites are illustrated in figures 9 and 10.[3]

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[2]Complete ratings for the stencils on all test surfaces of the boxes for each year of exposure can be found in previous progress reports.

[3]The appearance of boxes of each species after each year of exposure at the four test sites is shown in previous progress reports.

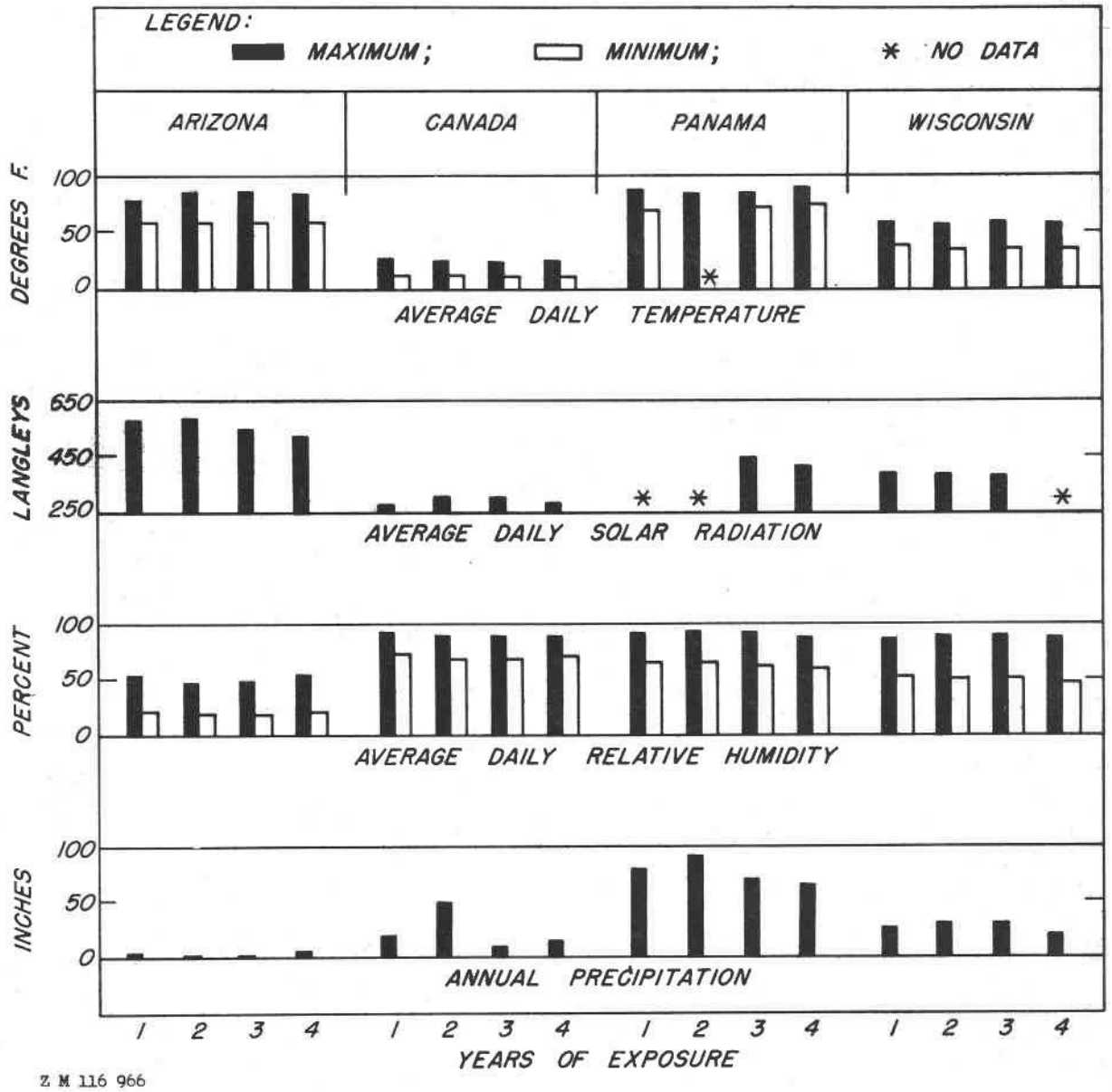


Figure 5. --Summary of weather data collected at or near the test sites during the 4 years of exposure of the test boxes.

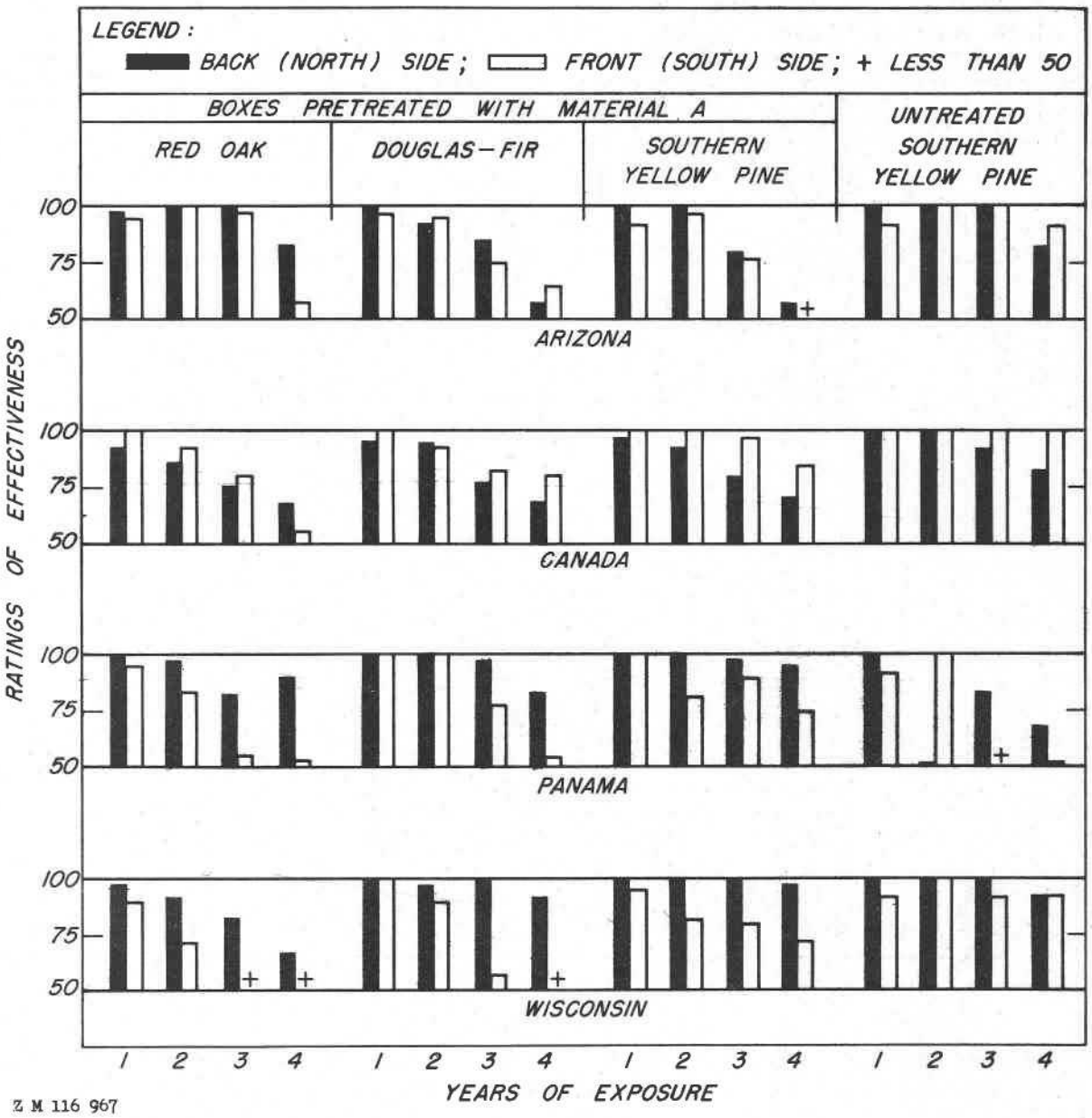


Figure 6. --Ratings of effectiveness (percentage of the number of test areas that were legible) for stencils by species, side of box, and site during 4 years of exposure. Each rating is for 36 areas on treated boxes or for 12 areas on untreated boxes. All materials and treatments are included in each rating.

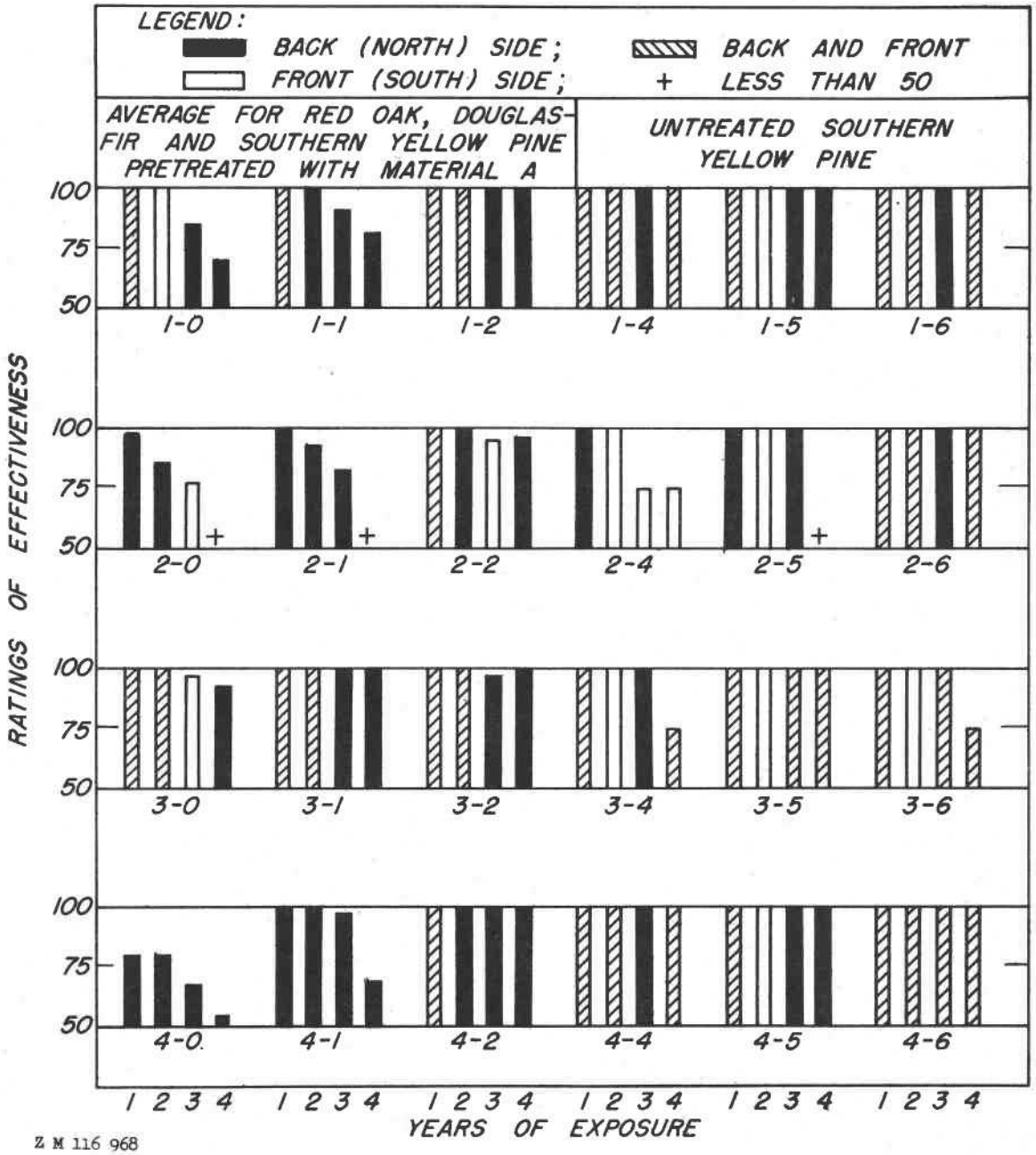


Figure 7. --Ratings of effectiveness (percentage of the number of test areas that were legible) during 4 years of exposure for the indicated combinations of marking material and undercoat-topcoat treatments, such as 1-0, where the marking material is designated by 1 and the undercoat-topcoat treatment by 0. Each rating applies to the best side of each group of boxes and is for 36 areas on 3 species of treated boxes from 4 test sites, or for 4 areas on untreated southern yellow pine boxes from 4 test sites.

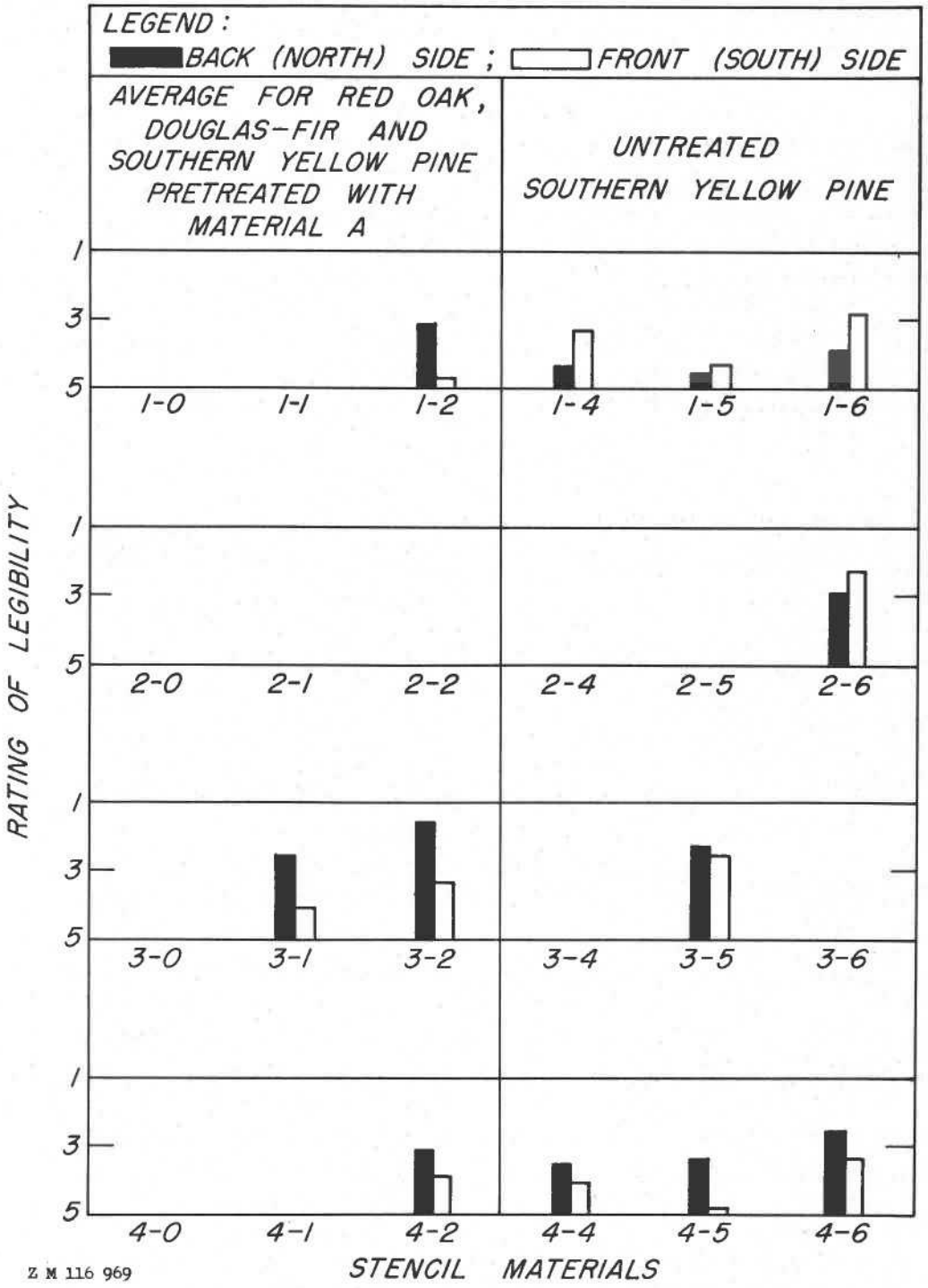
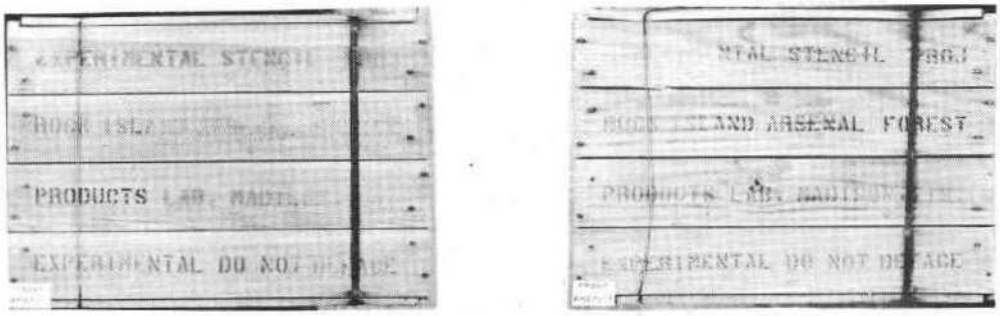
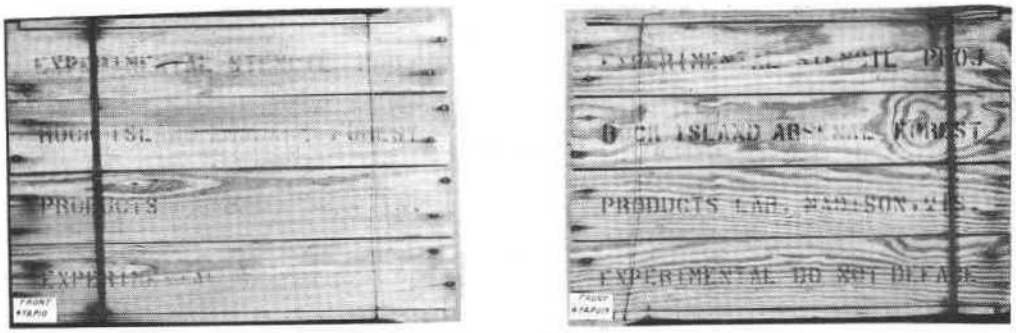


Figure 8. --Ratings of legibility, on a scale of from 1 (good) to 10 (bad) after 4 years of exposure for the combinations of marking material and undercoat-topcoat treatment, such as 1-2, that had ratings of effectiveness of 100 (all markings legible) after 4 years of exposure, according to figure 7. Spaces are provided, but no ratings are given for the combinations that were not legible on all test areas.

Wisconsin



Arizona



Canada

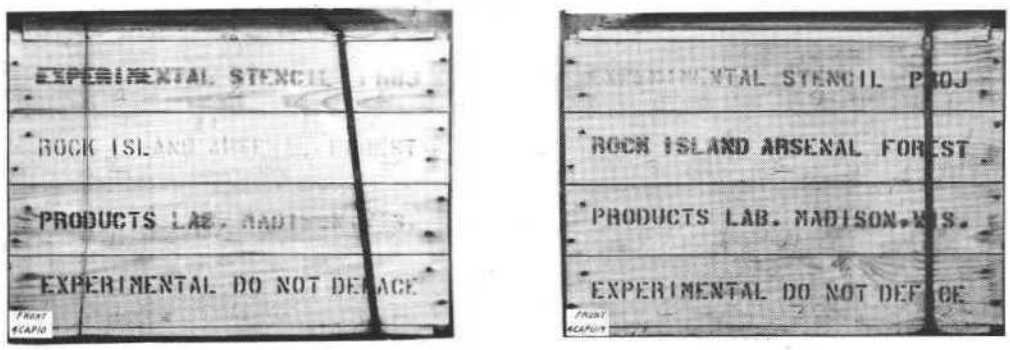


Figure 9. --Appearance of stencils on fronts (south sides) of boxes made of treated (left) and untreated (right) southern yellow pine after 4 years of outdoor exposure.

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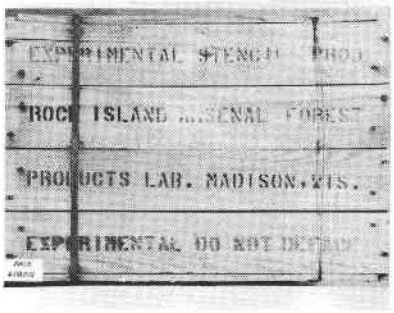
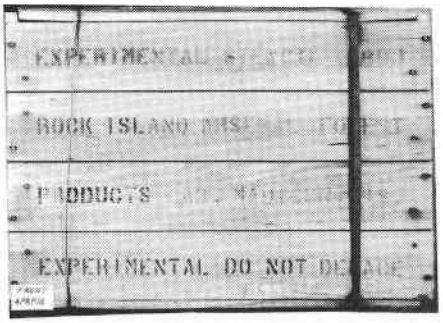
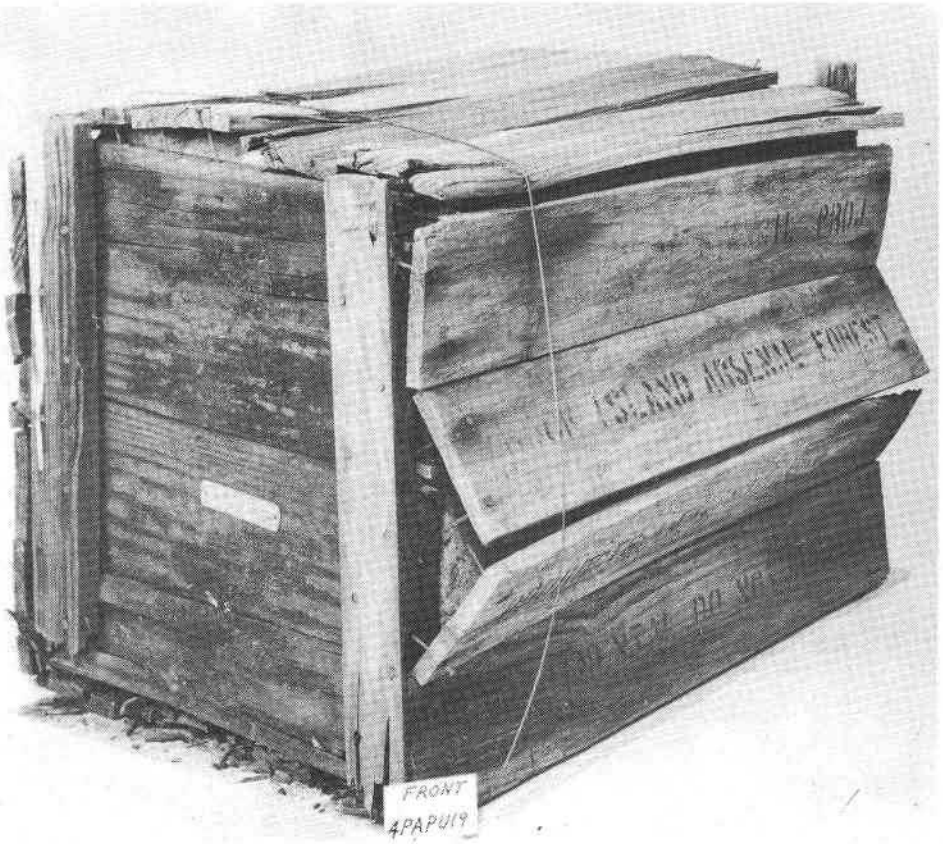


Back (North)



Front (South)

Pretreated with Material A



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Untreated

Figure 10. --Treated and untreated southern yellow pine boxes after 4 years of outdoor storage in Panama.

Ratings of tightness for the metal bindings after 3 and 4 years of weathering are provided in figure 11.

DISCUSSION OF RESULTS

It should be brought out in reviewing the data of this report that boxes of three species of wood were pretreated with material A and exposed in triplicate at each test site for each year of weathering. Only one species of wood and one box were exposed without pretreatment at each test site for each year of weathering.

Climate

Figure 5 shows that the four test sites represent a wide range in climatic conditions. An attempt to correlate each of the components of climate in figure 5 with the performance of stencils at the four test sites produced no reasonable correlation. This was not surprising, as previous studies have shown that the deterioration of finishes on wood when exposed to the weather is not controlled by a single component of climate.

Side, Species, Test Site, and Pretreatment

The ratings of effectiveness in figure 6 indicate that the performance of the stencils was affected by the direction in which they faced, species of wood, test site, and pretreatment of the box with material A.

On the pretreated boxes, all stencils were legible (effectiveness rating of 100) on the north sides for 3 of 12 combinations of species and site after 3 years of exposure. The three combinations were red oak boxes in Arizona and Douglas-fir and southern yellow pine boxes in Wisconsin. After 4 years of exposure, the highest rating of effectiveness for all stencils on any combination of side, species, and site was 97 for the north sides of the southern yellow pine boxes in Wisconsin. For the southern yellow pine boxes not pretreated, there were three sites (Panama excluded) at which all stencils were legible on at least one side of the box after 3 years, but after 4 years, all stencils were legible only on the south side of the box in Canada.

The relative performance of the stencils on the north and south sides of the boxes after 4 years of weathering was not consistent. For the boxes

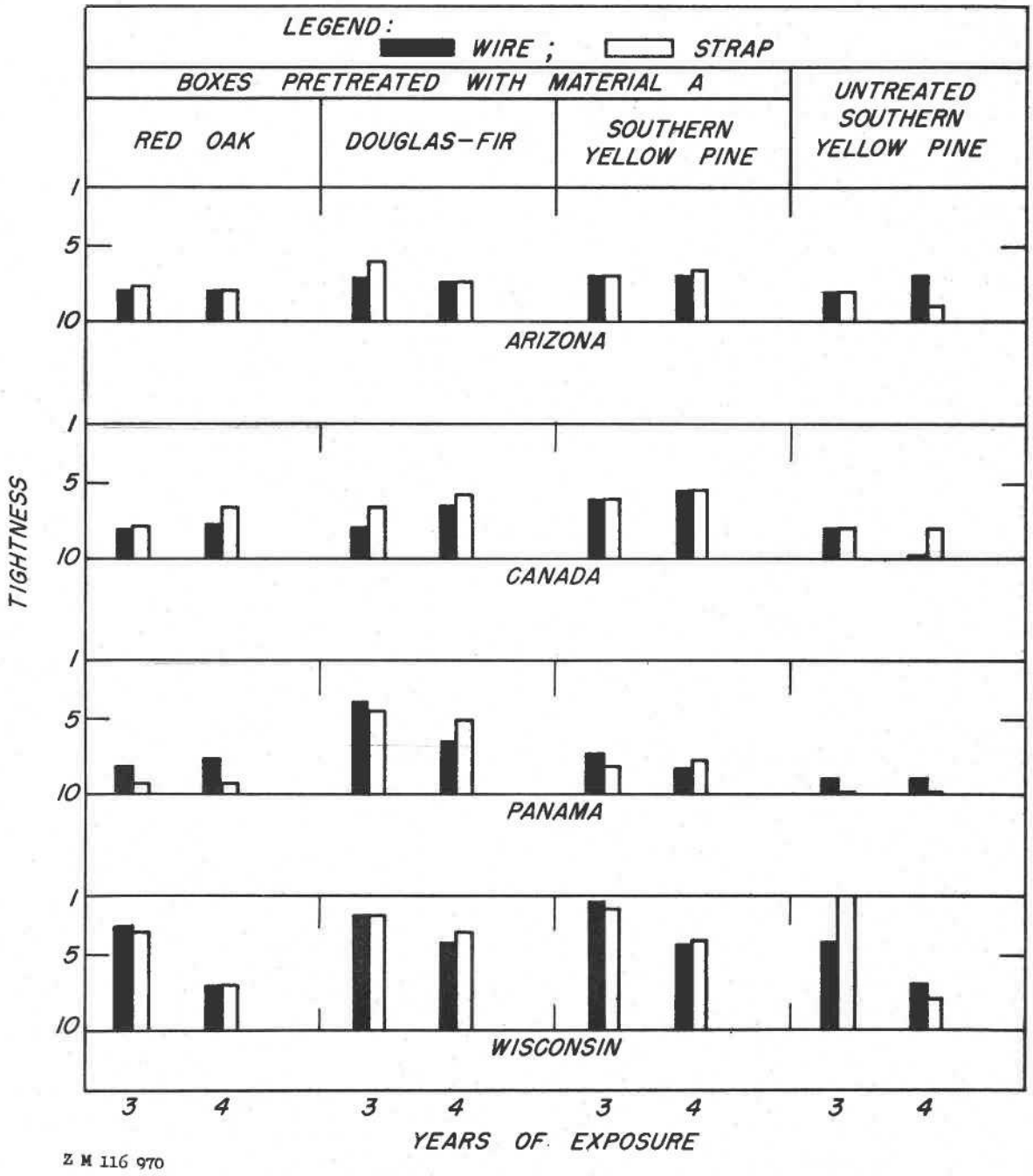

Figure 11.--Ratings of tightness on a scale of from 1 (tight) to 10 (broken), for steel bindings on wood boxes after 3 and 4 years of outdoor exposure. Each rating is for one binding on untreated boxes and for three bindings on pretreated boxes.

pretreated with material A, the highest stencil effectiveness was on the north sides for 9 of 12 combinations of species and site. The highest stencil effectiveness for the south sides of boxes was on the combinations of Douglas-fir in Arizona and Canada, and southern yellow pine in Canada. For the southern yellow pine boxes not pretreated, the stencil effectiveness was highest on the south sides of the boxes in Arizona and Canada, and on the north side of the box in Panama. It was equal on the north and south sides of the box in Wisconsin.

For the pretreated boxes, the decreasing order of stencil effectiveness by site, judged from the best side of the boxes after 4 years of weathering, was Wisconsin, Panama, Canada, and Arizona for stencils on Douglas-fir and southern yellow pine, but the order was Panama and Arizona, with Canada and Wisconsin equal, for stencils on red oak boxes. For the southern yellow pine boxes not pretreated, the decreasing order of stencil effectiveness by site, judged from the best side of the boxes after 4 years of weathering was Canada, Wisconsin, Arizona, and Panama.

On the same basis, the decreasing order of stencil effectiveness by species for pretreated boxes was southern yellow pine, Douglas-fir, and red oak in Canada and Wisconsin, but it was southern yellow pine, red oak, and Douglas-fir in Panama, and red oak, Douglas-fir, and southern yellow pine in Arizona.

The results for the southern yellow pine boxes show that pretreatment with material A preserved the legibility of the stencils in Panama, but not of those at the other three test sites. Material A, a water-repellent preservative, gives protection against stain and decay fungi that is needed at Panama, but not at the other three test sites (see figs. 9 and 10). Other factors, however, should be considered. The test boxes in this study were not stacked but were spaced several feet apart, simulating conditions of weathering and decay on one or more surfaces of boxes at the top or sides of a pile of boxes. The test exposure did not simulate conditions around other boxes in a pile where, under certain conditions, the occurrence of stain and decay fungi may more than offset the advantage gained by shading. Therefore, unless previous experience indicates that decay and stain are not likely to occur, it is advisable to treat all wood boxes with a water-repellent preservative if they are to be stacked in outside storage.

Marking Materials and Undercoat-Topcoat Treatments

In figure 7, the stencils are rated for each combination of marking material and undercoat-topcoat treatment by side of box, with all species and sites included in each rating. After 4 years of weathering of the pretreated boxes, stencils made of 4 (1-2, 3-1, 3-2, 4-2) of 12 combinations of marking material and undercoat-topcoat treatment were legible on all north areas, but none was legible on all south areas to which they were applied. After 4 years of weathering of the southern yellow pine boxes not pretreated, stencils made of 8 of the 12 combinations of marking material and undercoat-topcoat treatment were legible on all north areas and those made of 6 combinations were legible on all south areas.

The combinations of marking material and undercoat-topcoat treatment that have a rating in figure 7 of 100 in effectiveness after 4 years of weathering are rated in figure 8 for legibility on a scale of from 1 (good) to 10 (bad) after the same period of weathering. To have a rating of 100 in effectiveness, the stencils in all test areas for which the rating applies must each have a legibility rating no worse than 5. The ratings of legibility in figure 8 measure how much better the average legibility is than the minimum requirement.

According to figure 8, the marking material that performed best on the pretreated boxes was marking material 3. On the untreated southern yellow pine boxes, the best performance was given by marking material 4, which was only slightly superior to marking material 1. A topcoat treatment was necessary for maximum durability of the stencils. Topcoat material C was most helpful on both treated and untreated boxes. If, however, one combination of marking and topcoat materials is to be used on both pretreated and untreated boxes, the data indicate that marking material 3 with topcoat material B is the combination to apply.

Metal Bindings

Ratings of tightness for the metal bindings after 3 and 4 years of weathering are given in figure 11. After 4 years of weathering, the decreasing order of tightness by species was Douglas-fir, southern yellow pine, and red oak in Wisconsin and Panama, but southern yellow pine, Douglas-fir, and red oak in Arizona and Canada. For all species, the tightest bindings were on the boxes exposed in Wisconsin. These boxes received less handling and were moved much shorter distances than the boxes from the other sites, which may account for the relative

tightness of their bindings. Pretreating the southern yellow pine boxes with material A generally improved the tightness of the bindings at all sites.

The bindings that rated 10 for tightness broke during weathering, probably by rusting. After 4 years of weathering, four wires were broken, two in Canada and two in Panama, and four straps were broken, one in Canada and three in Panama. The number of broken bindings and the tightness of the bindings do not indicate a definite preference for either type.

Report by V. P. MINIUTTI

E. A. MRAZ

Supervised by V. P. MINIUTTI

Approved by DON BROUSE

LIST OF PRIOR REPORTS

1. Forest Products Laboratory. Preservation of the Exterior Surfaces of Wooden Shipping Containers to Retain Identification Symbols in Long-Term Outdoor Storage -- First Preliminary Evaluation Tests. Part I. Report No. 55-1. 1955.

2. Forest Products Laboratory. Preservation of the Exterior Surfaces of Wooden Shipping Containers to Retain Identification Symbols in Long-Term Outdoor Storage -- First Progress Report on Field Tests. Part 2. Report No. 55-1. 1955.

3. Forest Products Laboratory. Preservation of the Exterior Surfaces of Wooden Shipping Containers to Retain Identification Symbols in Long-Term Outdoor Storage -- Second Progres Report on Field Tests. Report No. 56-1. 1956.

4. Forest Products Laboratory. Preservation of the Exterior Surfaces Of Wooden Shipping Containers to Retain Identification Symbols in Long-Term Outdoor Storage -- Third Progress Report on Field Tests. Report No. 57-1. 1957.

5. Forest Products Laboratory. Preservation of the Exterior Surfaces of Wooden Shipping Containers to Retain Identification Symbols in Long-Term Outdoor Storage -- Fourth Progress Report on Field Tests. Report No. 58-1. 1958.

6. Forest Products Laboratory. Preservation of the Exterior Surfaces of Wooden Shipping Containers to Retain Identification Symbols in Long-Term Outdoor Storage -- Fifth Progress Report on Field Tests. Report No. 59-1. 1959.

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Diamond Ordnance Fuze Laboratories
Connecticut Avenue & Van Ness Street, N.W.
Washington 25, D. C.
Attn: Technical Reference Section ORDTL 06.33

1 - Director
Aeronautical Materials Laboratory
Naval Air Material Center
Philadelphia 12, Pa.

10 - Commander
Armed Services Technical Information Agency
Arlington Hall Station
Arlington 12, Va.
Attn: TIPDR

1 - Prevention of Deterioration Center
National Academy of Science
National Research Council
2101 Constitution Avenue
Washington 25, D. C.

1 - Ministry of Supply Statt
British Joint Service Mission
1800 K Street, N. W.
Washington, D. C.

1 - Canadian Army Staff
2450 Massachusetts Avenue, N. W.
Washington 8, D. C.
Attn: GSO-1, A&R Section

1 - Commanding Officer
Detroit Arsenal
Center Liner, Mich.
Attn: ORDMX-B

2 - Commanding General
Frankford Arsenal
Philadelphia 37, Pa.
Attn: ORDBA-1300

1 - Commanding Officer
Picatinny Arsenal
Dover, N. J.
Attn: Technical Information Section

1 - Attn: Plastics & Packaging Laboratory

1 - Commanding Officer
Raritan Arsenal
Metuchen, N. J.
Attn: National Maintenance Point Point, ORDJR-OML

1 - Commanding Officer
Raritan Arsenal
Metuchen, N. J.
Attn: H&K Lab. Division ORDJR-E

1 - Commanding Officer
Springfield Armory
Springfield, Mass.
Attn: ORDBD-TX

1 - Commanding Officer
Watervliet Arsenal
Watervliet, N. Y.
Attn: ORDBF-RR

1 - Mr. Melvin E. Ault
Ordnance Member
Army Packaging Board
Ordnance Packaging Office
Rossford Ordnance Depot
Toledo 1, Ohio

2 - Commanding Officer
Rossford Ordnance Depot
Toledo 1, Ohio
Attn: Ordnance Packaging Office

1 - Commanding General
Wright Air Development Center
Wright-Patterson Air Force Base
Dayton, Ohio
Attn: WCRTG

1 - Dept. of the Navy
Bureau of Ordnance
Code Maf-1-g
Washington 25, D. C.

1 - U.S. Naval Supply, Res. & Dev. Facility
Library
Naval Supply Point
Bayonne, N. J.

1 - Commanding Officer
Watertown Arsenal
Watertown 72, Mass.
Attn: Technical Information Section, ORDBE-LX

1 - Commanding Officer
U.S. Naval Air Station
Overhaul & Repair Dept.
San Diego, Calif.

1 - Chief
Bureau of Supplies & Accounts
Dept. of the Navy
Code S-82, Room 2435
Arlington Annex
Washington 25, D. C.