CONDITION OF PRESERVATIVE TREATED FIELD BOXES AFTER 5 YEARS OF OUTDOOR EXPOSURE

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In Cooperation with the University of Wisconsin

CONDITION OF PRESERVATIVE TREATED FIELD BOXES

AFTER 5 YEARS OF OUTDOOR EXPOSURE

(Report on the Protection Provided by Certain Applications to Wooden Field Containers for Produce)

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Introduction

During the past decade, food growers, packers, and processors, have shown increased interest in the possibility of using preservative treatments for field containers and picking boxes. They realize, however, that additional research will be needed before preservative-treated boxes can be widely used as containers for foodstuffs.

Among the problems that need to be investigated are the effect of preservatives on the foodstuff, the cost of treatment per year of increased service life, and the effectiveness of the various preservative treatments.

To help supply some of this needed information, the U. S. Forest Products Laboratory, in cooperation with the National Wooden Box Association, began in 1949 an outdoor exposure test of 200 wooden boxes treated with various preservatives.

The test had three specific objectives: (1) to evaluate the effectiveness of various preservative treatments for wooden boxes under field conditions, (2) determine the value of water-repellent preservatives as agents for stabilizing the weight of containers, and (3) determine whether water-repellent treatment would reduce mechanical damage caused by repeated dimensional changes resulting from changes in moisture content.

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

This report presents the results of tests of the boxes after 5 years of exposure at Madison, Wisconsin.

Materials

The box shook, which was supplied by the National Wooden Box Association, was ponderosa pine. The boxes were assembled at the Forest Products Laboratory. The inside box dimensions were 20 by 14 by 7 inches, length, width, and depth, respectively. The boxes were assembled by hand, and sixpenny cement-coated box nails were used throughout. Each side was fastened to each end with 4 nails, the bottom was fastened to each end with 6 nails, and the top riser cleats were fastened to each end with 4 nails.

Most of the treating solutions were mixed at the Laboratory. The oil-soluble chemicals were dispersed in light volatile solvents, such as a commercially blended aromatic solvent, and coal-tar naphtha. Several preservatives were in water solutions. In one instance, the solution was ready for use as furnished by the supplier. In other instances, suppliers furnished the preservatives with information on their composition properties.

The different preservatives and treatments are listed in table 1.

Preparation and Test Method

To facilitate recording the data and also to provide a code system for the various preservatives, the boxes were divided into 21 consecutively numbered sets. Each set received a single treatment and consisted of 10 boxes, except set No. 21 which only had 7 boxes. Of the 21 sets, 15 were given a 1-minute dip in the preservative solution, 4 were left untreated to serve as controls, and 2 sets were treated by a standard pressure method. The boxes to be dipped were assembled before they were treated. The pressure treating was done on the shook. The treated shook were then kiln dried and assembled as described previously.

All of the treated boxes and two sets of untreated controls were placed empty on the test plot in the fall of 1949. As shown in figure 1, the boxes were stacked two high. The boxes in any one stack had received the same treatment. The ground was spaded and raked smooth before the boxes were placed. A brick was laid in the top box to keep the pair in place during storms. A method of restricted randomization was used for distributing the boxes on the test plot so that no repetition of set numbers occurred in any row or line. Late in the fall, after the start of cold weather, the boxes were inverted for the winter. In the spring, as soon as the ground could be worked, the area was raked and the boxes were returned to the original position. When the boxes were turned, care was taken to see that the same boxes were in contact with the ground.

From time to time during the summer months, the boxes were visually inspected for deterioration and physical damage. Also, representative boxes were weighed after rather extensive periods of dry weather and again shortly after rains.

One set of control boxes was placed in covered but unheated storage at the same time the others were put on the test plot. The fourth set of controls was subjected to diagonal compression tests at the time the boxes were placed in storage.

The boxes were removed from the test plot in November 1954, after 5 years of exposure. The exposure was terminated because the progress of decay was slow, and the pattern of effectiveness of the different treatments seemed to be established about as well as it could be from this test. At this time, all remaining boxes were subjected to a diagonal compression test. Furthermore, a visual examination was made of the nails used to fasten the sides and bottom to the ends.

The diagonal compression test was made in a universal testing machine. The box was placed on grooved loading blocks in such a way that the top riser cleat and the diagonally opposite bottom end joint were in compression. Figure 2 shows the machine setup and the location of the loading blocks. These blocks were purposely made short enough so that a minimum amount of support was offered to the joints and fastenings of the container. The machine was operated at 0.25 inch per minute, and an autograph recorder was used to record a load-deflection curve.

In the initial strength tests, some boxes were compressed from one side-end corner to the diagonally opposite side-end corner. The results of tests made this way were erratic and seemed to be influenced considerably by the condition of the glued edge joint in the bottom boards. Because of this uncontrolled variable, the rest of the boxes were tested with only the top riser cleat and the diagonally opposite bottom end joint in compression.

Results and Discussion

When the exposure was concluded, the boxes had a general weather-beaten appearance. Surface checks, some splits, cupping of the thinner boards, and nailpull were in evidence. It was extremely difficult to judge the degree or severity of these weathering defects, and no attempt was made to rank the boxes or treatments in this regard.

In considering the results of the test, it would be well to remember that the severity of the exposure probably was less than that imposed by service conditions. It is possible that accumulations of vegetable debris and frequent washings, for example, would promote faster decay than was encountered in the test. Furthermore, in actual service, picking boxes would be subjected to some degree of handling or mechanical damage.

Decay

During the last year of the exposure, the decay in the infected boxes increased much more than in any previous year. The wood was conspicuously softened in a large number of boxes, frequently to such an extent that the decayed portions could be readily pushed out of the boards. The variability of decay among replicate boxes was large. This variation, therefore, prohibited close comparison among the preservative treatments. Large variation in decay seems to be typical with surface-treated wood, as might be expected in view of factors other than the quality of the preservative that may have a prominent influence on the protection afforded. In this work, weather checks and insect scours (possibly by snails) on boards in contact with the ground contributed to the variation by rupturing the shallow zone of treated wood.

Average amounts of decay found in the various boxes after exposure periods of 3, 4, and 5 years are shown in table 1. Amounts for the lower boxes and upper boxes are given separately because of the different kind of infection hazard associated with each. The lower box of each pair was subjected to infection from the ground, whereas, the upper box necessarily became infected by airborne spores. Practically all the decay in both boxes occurred in the bottom boards. In the top box, moreover, it was limited largely to areas under the brick used to weight the box down. Although the boxes were inspected after only 2 years of exposure, there was not enough decay at the time to warrant reporting. Only the decay is considered because molding of the boxes was quite minor.

Based on the data given in table 1, the preservatives tested were grouped according to their order of effectiveness as follows:

Group A.--Less than 15 square inches of decayed wood on both upper and lower boxes after 5 years of exposure, which is indicative of relatively good decay control for boxes in both positions.

Treatment No. 17 -- ammoniacal copper arsenite, 0.27 pound per cubic foot by pressure.[2] (0 square inches).

Treatment No. 15 -- ammoniacal copper arsenite, 3.17 percent. (0 square inches).

Treatment No. 2 -- copper naphthenate, 1 percent copper. (7 square inches).

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[2]Unless otherwise indicated, all treatments were by 1-minute dip.

Treatment No. 16 -- nickel-arsenic-dichromate mixture, 0.21 pound per cubic foot by pressure. (12 square inches).

Group B.--More than 15 but less than 60 square inches of decayed wood on both boxes after 5 years of exposure. For the most part, Group B treatments were highly effective on upper boxes but only moderately effective on lower ones.

Treatment No. 4 -- copper 3-phenyl salicylate, 5 percent. (20 square inches).

Treatment No. 9 -- copper 8-quinolinolate, 0.1 percent and water repellent. (37 square inches).

Treatment No. 14 -- sodium pentachlorophenate, 2 percent and borax, 3 percent. (38 square inches).

Treatment No. 8 -- cocoamine salt of tetrachlorophenol, 0.94 percent, and water repellent. (39 square inches).

Treatment No. 6 -- rosin amine D-pentachlorophenate, 5 percent. (51 square inches).

Treatment No. 10 -- pentachlorophenol, 5 percent, and water repellent. (56 square inches).

Group C.--More than 60 but less than 100 square inches of decayed wood on both boxes after 5 years of exposure. For the most part, Group C were only moderately effective on both sets of boxes.

Treatment No. 12 -- orthophenyl-phenol, 5 percent, and water repellent. (68 square inches).

Treatment No. 1 -- pentachlorophenol, 5 percent, and ester gum. (90 square inches).

Treatment No. 11 -- water repellent alone, 15 percent. (98 square inches).

Group D.--More than 130 square inches of decayed wood on both boxes after 5 years of exposure. Group D treatments were relatively ineffective on lower boxes and only moderately effective on upper ones.

Treatment No. 13 -- sodium orthophenylphenate, 5 percent. (131 square inches).

Treatment No. 5 -- orthophenylphenol, 5 percent. (133 square inches).

Treatment No. 18 -- salicylanilide, 0.5 percent. (136 square inches).

Treatment No. 3 -- zinc alkyl sulfate, 5 percent. (232 square inches).

On the basis of the results of this study, only the treatments in groups A and B would be deserving of consideration in further tests on field containers. It probably would be desirable, moreover, to bring to bear in any future testing some handling of produce in the boxes. One of the most striking of the present results was the high control of decay by ammoniacal copper arsenite applied by dipping. An obstacle to the use of this preservative by dipping, however, is a disagreeable liberation of ammonia from the dipping solution. Of the other waterborne preservatives, the mixture of sodium pentachlorophenate and borax appeared most promising. For box treatment, where the solvent must of necessity be a comparatively volatile oil, pentachlorophenol apparently needs supplementing by a water repellent. Orthophenylphenol also was made more effective by addition of a water repellent, but not sufficiently so to be promising for the protection of field boxes.

Effect of Water Repellents

A summary of the data on water-repellent treatments is given in table 2. Weights of boxes treated with proprietary water repellents are listed separately because their composition may differ materially from that of Forest Products Laboratory formulation No. 2. The average weight of boxes in dry weather was about 7.5 pounds.

In the first 2 years, the Forest Products Laboratory water-repellent formulation held the average water pickup to 0.3 and 0.9 pound (approximately 4 and 12 percent) in the upper and lower boxes, respectively. Corresponding pickups in boxes without water repellent were 1.2 (16 percent) and 1.9 pounds (25 percent). The weight stability imparted by the water repellent thus was rather substantial. But in the next 2 years the moisture gains were 1.7 and 2.3 pounds (22 and 31 percent) in the water-repellent treated boxes, and 3.3 and 2.9 pounds (44 and 39 percent) in the boxes without repellent. The weight stability of the water-repellent treated boxes had dropped considerably. In the fifth year, no evidence remained of a water-repellent effect on box weight. Increasing infection of the wood no doubt was responsible for some of the loss in effectiveness of the water repellents.

Condition of Nails

Since the evaluation of the condition of the nails was visual, it offered no units of comparison. Therefore, the condition of the nails can only be compared in a general way. Considering the condition of the nail shanks and the degree of deterioration, the treatments could be divided into four general groups as shown in table 3. Representative samples of nails from each set of boxes are shown in figure 3.

There did not appear to be a correlation between the condition of a nail shank and the effectiveness of a preservative treatment against decay.

Nevertheless, even though little or no decay was noted in the ends, the chemical treatments appeared to have some influence on the condition of the nails after 5 years. Preservatives incorporating a water repellent appeared to keep the nails in better condition than those that did not contain a water repellent. Moreover, the water-borne preservatives caused severe change in the condition of the nails. Deterioration of the nails, however, was not sufficient to noticeably affect box strength.

Untreated control boxes in covered storage showed considerably less change in nail condition than control boxes in outdoor exposure. Furthermore, untreated control boxes in outdoor storage had nails that showed more severe change in condition than many of the treated boxes.

Compression Strength

The average results of the diagonal compression test are given in table 4. The values for boxes on the ground and above ground are listed separately as well as combined in order to observe possible differential effects of the two exposure conditions.

Generally, the indicated relative order of strength in the two exposure groups was similar. But there were some notable exceptions, such as treatments Nos. 3, 5, 9, 15, and 18. However, because the discrepancies were not always in the same direction with respect to either ground or above ground exposure, it is believed that they resulted from some obscure factor or factors rather than from any variable relation between treatment and type of exposure. Therefore, there would seem to be no point in considering the results of ground exposure and above-ground exposure separately other than to note that, in general, the boxes on the ground withstood a higher average maximum load than the top boxes. Perhaps the top boxes were subjected to more extremes of wetting and drying and associated dimensional changes than were the ground boxes.

The last 2 columns of table 4 show that all treatments below No. 3 were associated with significantly greater (i.e. by 52 or more pounds) strength than the controls. Three observations would seem to be worthy of emphasis in this connection: (1) all but one of the 11 significantly stronger sets of boxes had been treated with either a waterborne preservative or with a preservative containing a water-repellent ingredient, (2) only 1 of the 6 other sets had received a water repellent, and none had been treated with a waterborne preservative, and (3) the greatest strength occurred in the pressure-treated boxes. The superior strength of the pressure-treated boxes presumably is attributable to a combination of the thoroughness of the application and the influence of the preservative.

Closer comparisons among the treatments are not warranted. There appears to have been little or no relation between the resistance to diagonal distortion and the amount of decay. This might have been predicted since visible decay did not occur in the nailed areas.

Also of interest is the fact that those boxes tested immediately after they were assembled had an average maximum compressive load of 296 pounds. The untreated control boxes in covered storage for 5 years exhibited a higher average test value of 358 pounds. These control boxes along with those subjected to the pressure treatment were the only sets to show somewhat more resistance to diagonal distortion after 5 years than the boxes that were tested immediately after they were assembled.

Summary

The results of a 5-year exposure test at Madison, Wis., of preservative-treated fruit and vegetable boxes permit placement of the tested preservatives into four decay-control groups.

The group that exhibited the best decay control consisted of the following preservatives: ammoniacal copper arsenite, 0.27 pound per cubic foot, applied by pressure; nickel-arsenic-dichromate mixture, 0.21 pound per cubic foot, applied by pressure; ammoniacal copper arsenite, 3.17 percent, applied by dipping; and copper naphthenate (1 percent copper) in light aromatic solvent, applied by dipping.

The following dip treatments were somewhat less effective but definitely promising: copper 3-phenyl salicylate, 5 percent, in coal tar naphtha; copper 8-quinolinolate, 0.1 percent, and water repellent in Stoddard solvent; sodium pentachlorophenate, 2 percent, and borax, 3 percent; cocoamine salt of tetrachlorophenol, 0.94 percent, and water repellent in mineral spirits; rosin amine D-pentachlorophenate, 5 percent, in light aromatic solvent; and pentachlorophenol, 5 percent, and water repellent in light aromatic solvent.

Effectiveness of the water repellents was judged by the box weights taken before and after periods of rainy weather. Regardless of the preservative, a rather high level of water repellency persisted for a period of 2 years, and a moderate level of repellency remained for an additional 2 years. During the fifth year, the effect of the water repellent on box weight was negligible.

Although the chemical treatments appeared to influence the condition of the nails after 5 years of outdoor exposure, there did not appear to be any correlation between the condition of the nail shank, the effectiveness of a chemical treatment against decay, or the average resistance of the boxes to diagonal distortion.

In the diagonal compression test, there were 11 sets of treated boxes with average strength values significantly greater than those of the untreated controls. Of these, 10 sets had been treated with either a waterborne preservative or with a preservative containing a water-repellent ingredient. Of those sets that were not significantly stronger than the controls, only one had a water repellent and none had been treated with a waterborne preservative.

Table 1.--Summary of treatments and preservatives used and of the average amounts of visibly decayed wood per box after 3 to 5 years of outdoor exposure

Treatment No.	Treatment[1]	Preservative	Average[2] retention	Decay in lower boxes[3]			Decay in upper boxes[3]			Sum of decay averages in the two sets of boxes
				3 years	4 years	5 years	3 years	4 years	5 years	5 years
			Lb. per cu. ft.	Sq. in.	Sq. in.	Sq. in.	Sq. in.	Sq. in.	Sq. in.	Sq. in.
1	Dip	Pentachlorophenol, 5 percent, and ester gum, 5 percent, in commercial aromatic solvent	2.4	8	13	89	1	0	1	90
2	Dip	Copper naphthenate, 1 percent metallic copper, in commercial aromatic solvent	1.9	1	1	6	1	0	1	7
3	Dip	Zinc alkyl sulfate, 5 percent (0.25 percent metallic zinc), in commercial aromatic solvent	2.0	11	30	217	13	14	15	232
4	Dip	Copper 3 -- phenyl salicylate, 5 percent, in coal-tar naphtha	1.5	12	2	20	0	0	0	20
5	Dip	Orthophenylphenol, 5 percent, in commercial aromatic solvent	1.7	68	56	115	17	6	18	133
6	Dip	Rosin amine D-pentachlorophenate, 5 percent, in commercial aromatic solvent	2.0	3	6	51	1	0	0	51
8	Dip	Cocoamine salt of tetrachlorophenol, 0.94 percent, and water repellent, 23 percent, in mineral spirits	1.8	1	6	9	11	16	30	39
9	Dip	Copper-8-quinolinolate, 0.1 percent, in Stoddard solvent and proprietary water repellent	1.7	6	8	28	0	1	9	37
[4]10	Dip	Pentachlorophenol, 5 percent, and water repellent, 15 percent, in commercial aromatic solvent	1.6	21	13	56	0	0	0	56
[4]11	Dip	Water repellent, 15 percent, in commercial aromatic solvent	1.5	26	27	50	36	28	48	98
[4]12	Dip	Orthophenylphenol, 5 percent, and water repellent, 15 percent, in commercial aromatic solvent	1.7	18	17	28	22	29	40	68
13	Dip	Sodium orthophenylphenate, 5 percent, in water	2.2	27	44	94	18	27	37	131
14	Dip	Sodium pentachlorophenate, 2 percent, and borax, 3 percent, in water	1.9	13	15	37	0	1	1	38
15	Dip	Ammoniacal copper arsenite,[5] 3.17 percent solution	2.3	0	0	0	0	0	0	0
16	Pressure	Nickel sulfate, 5.5 parts, sodium arsenate, 4.0 parts, arsenic acid, 1.5 parts, and sodium dichromate, 3.0 parts (by weight)	.21	1	12	12	1	0	0	12
17	Pressure	Ammoniacal copper arsenite[5]	.27	0	0	0	0	0	0	0
18	Dip	Salicylanilide, 0.5 percent in commercial aromatic solvent	1.8	9	12	102	11	0	34	136
7 and 20	None	Untreated controls	....	13	26	128	12	5	14	142

[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 0.233 cubic foot.

[3] Each figure is the average decay area for 5 boxes except for the control boxes which are based on 10 boxes.

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

[5] Federal Specification TT-W-549a.

Table 2.--Weights, shortly after rainfall, of boxes with and without water-repellent treatment[1]

Water repellent and associated preservative	Month and year					
	5 1950	9 1950	9 1951	11 1952	9 1953	10 1954
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Upper Boxes						
FPL No. 2[2]						
and Pentachlorophenol	7.7	7.9	7.5	9.4	9.2	8.7
and Orthophenylphenol	7.8	7.8	8.0	9.1	8.8	8.6
No preservative	7.9	7.9	......	9.7	9.5	8.7
Average	7.8	7.9	7.7	9.4	9.1	8.7
Proprietary						
and Salt of tetrachlorophenol	......	8.1	8.7	10.6	10.3	8.7
and Copper 8-quinolinolate	7.8	8.0	7.8	8.4	8.1	8.6
No water repellent						
Pentachlorophenol	8.4	8.4	9.1	10.6	10.5	8.5
Orthophenylphenol	8.1	8.1	8.6	10.3	10.0	8.5
No preservative (controls)	8.7	8.7	10.0	12.2	11.5	8.9
Average	8.4	8.4	9.2	11.0	10.7	8.6
Lower Boxes						
FPL No. 2[2]						
and Pentachlorophenol	......	8.3	8.7	9.9	9.9	8.6
and Orthophenylphenol	......	8.4	8.8	9.6	9.1	8.4
No preservative	8.2	8.3	......	10.2	10.1	8.3
Average	8.2	8.3	8.8	9.9	9.7	8.4
Proprietary						
and Salt of tetrachlorophenol	......	8.5	9.3	9.4	9.1	8.3
and Copper 8-quinolinolate	8.2	8.3	8.5	9.0	9.0	8.9
No water repellent						
Pentachlorophenol	......	9.2	9.4	10.4	10.1	8.5
Orthophenylphenol	......	8.8	9.6	10.4	10.0	8.6
No preservative (controls)	9.4	9.4	10.0	11.1	10.3	8.4
Average	9.4	9.1	9.7	10.6	10.1	8.5

[1]Each value represents observations of 5 boxes, except for the control values, which represent 10 boxes. Preceding each weighing, the boxes had been essentially air dry for several days. The average weight of the boxes in dry weather was about 7.5 pounds.

[2]Comprised of the following ingredients and amounts, by weight, in the treating solution: 6.5 percent ester gum, 6.5 percent raw linseed oil, 2 percent paraffin wax.

Table 3.--Average condition of nails judged by visual appearance

Average condition of nails	Preservative	Water repellent	Method of application
		Percent	
Nails bright, little or no evidence of stain	None	None	(1)
Shanks generally bright with some stains or light corrosion. Condition of nail good	Copper-8-quinolinolate and water repellent	(2)	Dip
	Pentachlorophenol, 5 percent and water repellent	15	Do.
	Orthophenylphenol, 5 percent and water repellent	15	Do.
	Copper naphthenate	None	Do.
Definite evidence of stain and corrosion. Some pitting of shank surface, degree of deterioration medium	Cocoamine salt of tetrachlorophenol, 0.94 percent, and water repellent	23	Do.
	Sodium pentachlorophenol, 2 percent, and borax, 3 percent	None	Do.
	Orthophenylphenol, 5 percent	None	Do.
	Rosin amine D-pentachlorophenate, 5 percent	None	Do.
	Pentachlorophenol, 5 percent, and ester gum, 5 percent	None	Do.
	Copper-3-phenylsalicylate, 5 percent	None	Do.
	None	15	Do.
Heavy corrosion, shank of nail pitted, roughened and deteriorated often to the extent of reducing nail shank diameter	None	None	(3)
	Sodium orthophenylphenate, 5 percent	None	Dip
	Ammoniacal copper arsenite, 3.17 percent	None	Do.
	Salicylanilide, 0.5 percent	None	Do.
	Zinc alkyl sulfate, 5 percent	None	Do.
	Ammoniacal copper arsenite	None	Pressure
	Nickel sulfate, 5.5 parts, sodium arsenate, 5.0 parts, arsenic acid, 1.5 parts, and sodium dichromate, 3.0 parts	None	Pressure

[1]Untreated controls in covered storage.

[2]Proprietary water repellent, percentage unknown.

[3]Untreated controls on exposure site.

Table 4.--Average results[1] of diagonal compression test of field boxes after 5 years of outdoor exposure

Boxes on ground		Boxes on top		Boxes on ground and top considered together	
Treatment No.	Average[2] maximum load	Treatment No.	Average[2] maximum load	Treatment No.	Average[3] maximum load
	Pounds		Pounds		Pounds
4	241	Controls	162	Controls	202
2	242	18	190	1	227
Controls	242	1	192	2	228
9	247	3	197	4	239
1	262	5	214	18	244
15	268	2	215	9	248
6	283	4	237	3	249
8	288	6	241	15	258
14	295	8	241	6	262
18	298	11	243	8	265
11	301	14	245	5	269
3	302	13	247	14	270
10	305	10	247	11	272
12	313	9	248	10	276
5	325	12	248	12	281
13	334	15	249	13	291
17	361	16	277	16	321
16	366	17	383	17	372

[1]The least significant difference at the 5-percent level for comparing two treatments each averaged over both locations = 61, for comparing a treatment to the controls, each averaged over both locations = 52.

[2]Values are averages for 5 tests, except the control values, which are averages of 10 tests.

[3]Values are averages for 10 tests, except control values which are averages of 20 tests.

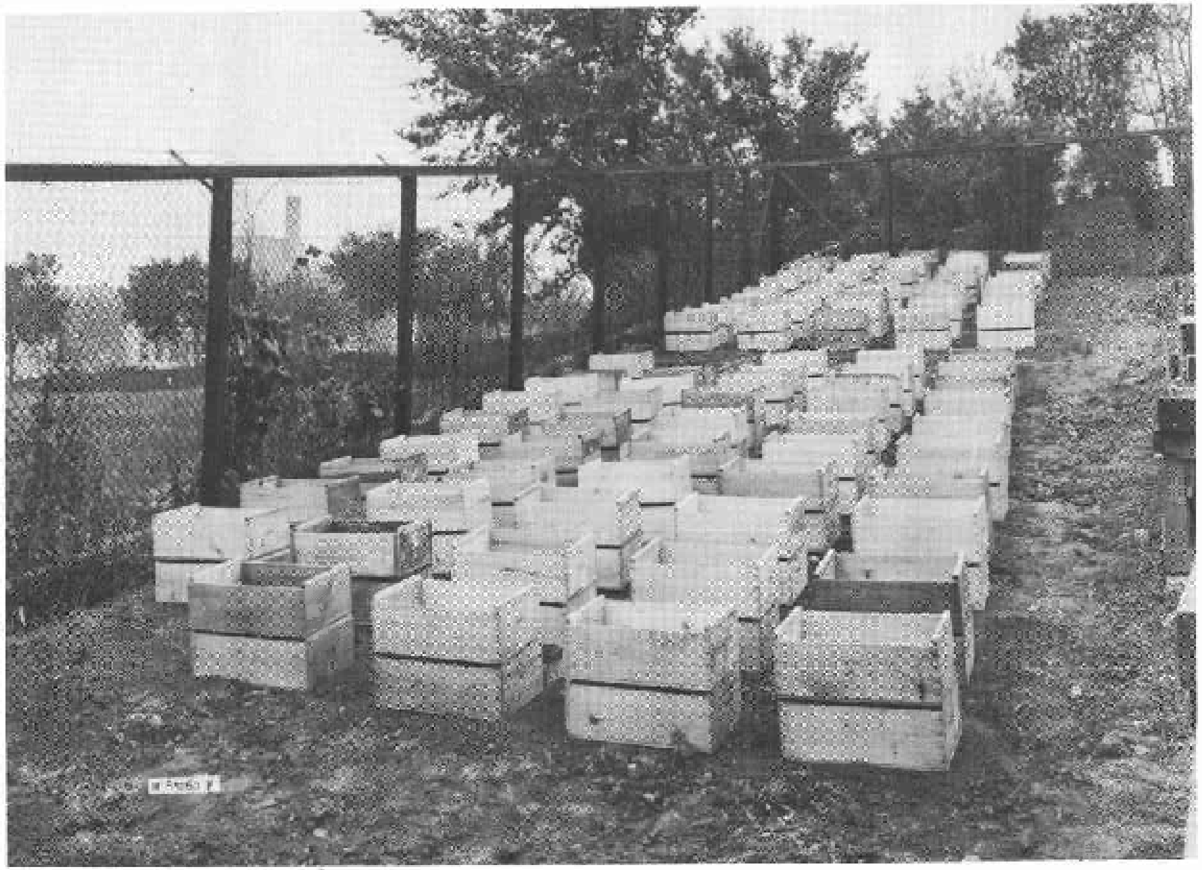

Figure 1. --Test plot with treated picking boxes stacked two high and positioned for the exposure period.

Z M 83260 F

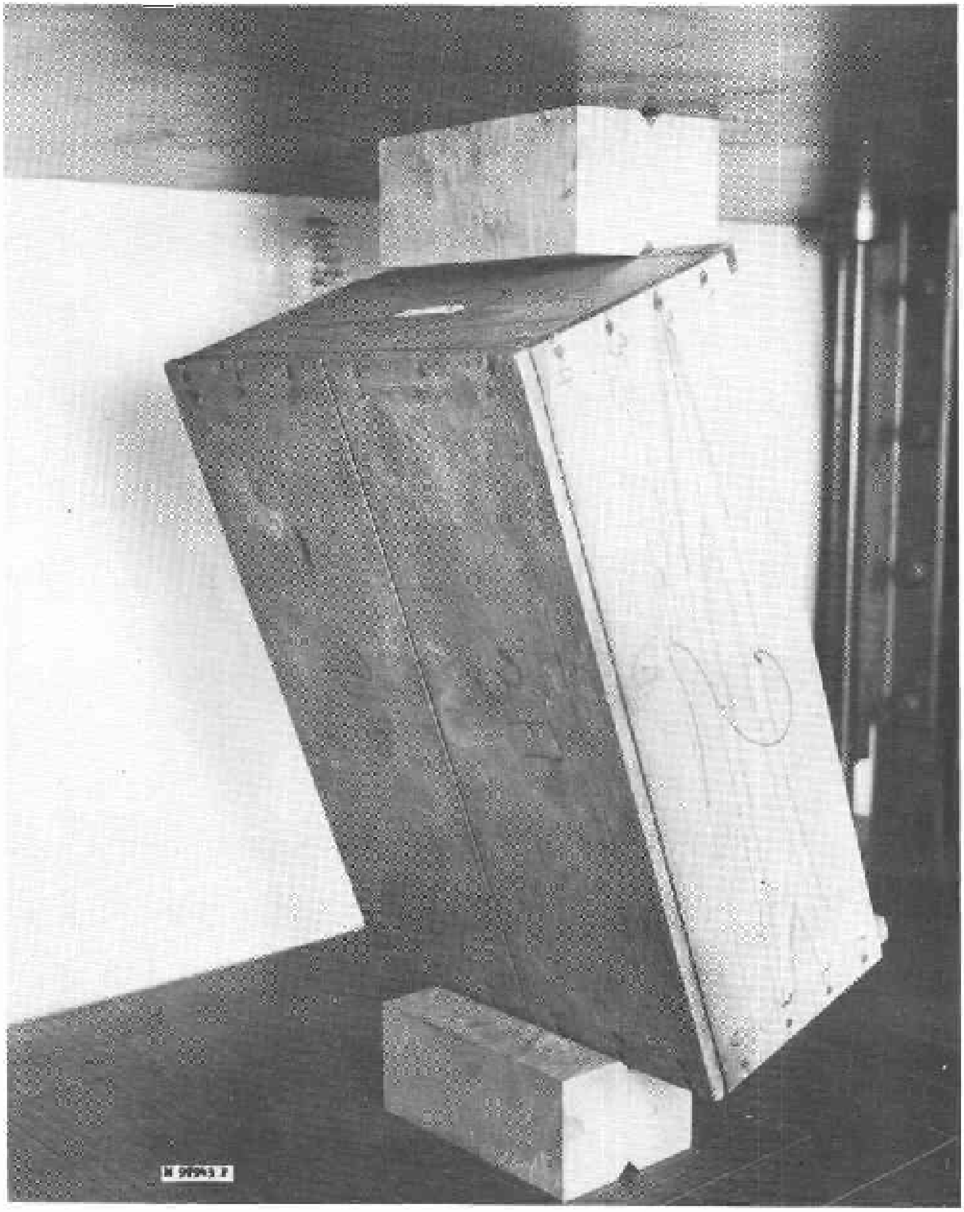

Figure 2. --Treated picking box positioned for the diagonal compression test after 5 years of exposure.

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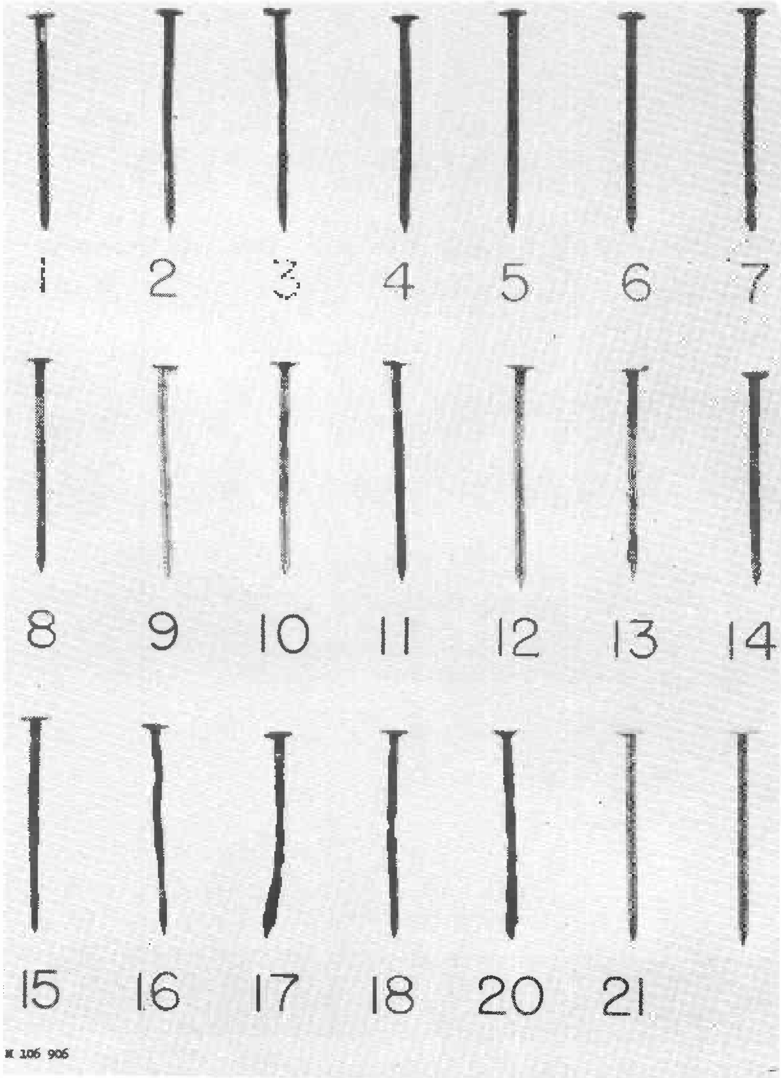

Figure 3. --Representative condition of sample of nails from each set of treated boxes subjected to 5 years of exposure. The unnumbered nail in the lower right hand corner is a sixpenny, cement-coated, box nail as taken from the keg. The dark color of this nail is caused by the cement coating.

Z M 106 906