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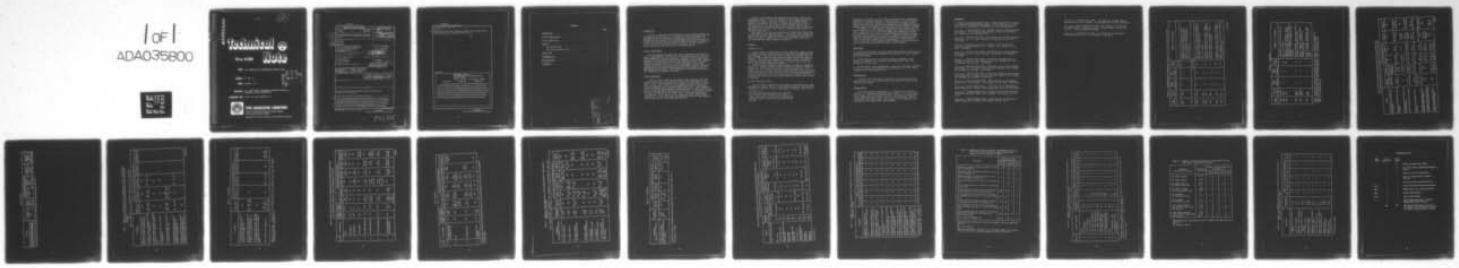

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The cooperative-treated piles at Coco Solo, Canal Zone, and the cooperative-, CEL-, and CEL/Industry-treated piles at Pearl Harbor were inspected by a diver in March and April 1976. After 13 years at Coco Solo, only the Douglas fir piles treated with ammoniacal copper arsenite followed by creosote (dual treatment) are performing satisfactorily. At Pearl Harbor, the remaining cooperative-treated piles are performing satisfactorily as are many CEL- and CEL/Industry-treated piles. These piles were

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impregnated with either creosote containing a toxic additive, a selected single treatment, a solution containing two toxic compounds, or a dual treatment.

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The cooperative-treated piles at Coco Solo, Canal Zone, and the cooperative-, CEL-, and CEL/Industry-treated piles at Pearl Harbor were inspected by a diver in March and April 1976. After 13 years at Coco Solo, only the Douglas fir piles treated with ammoniacal copper arsenite followed by creosote (dual treatment) are performing satisfactorily. At Pearl Harbor, the remaining cooperative-treated piles are performing satisfactorily as are many CEL- and CEL/Industry-treated piles. These piles were impregnated with either creosote containing a toxic additive, a selected single treatment, a solution containing two toxic compounds, or a dual treatment.

CONTENTS

INTRODUCTION

In order to determine the effectiveness of any proposed preservative treatment for wood piling, it is necessary to expose full-sized piles impregnated with that treatment in marine borer infested waters. To decrease the time required to obtain meaningful data without imposing any artificial conditions upon the evaluation method, exposures are carried out in tropical locations where marine borers and the rate of their attack are much greater than they are in temperate waters.

PILING INSTALLATIONS

The Civil Engineering Laboratory (CEL) is monitoring two installations of experimentally treated piles. One installation [1] at Coco Solo Annex, Rodman Naval Station, Canal Zone, consists of piles treated and supplied by the Cooperative Marine Piling Committee, an informal committee composed of representatives from the wood treating industry, the Forest Products Laboratory, and the W. F. Clapp Laboratories. The second installation [2-6] at Waipio Peninsula, Pearl Harbor, Hawaii, consists of Cooperative Marine Piling Committee piles plus four groups of CEL- and CEL/Industry-treated piles. The experimentally treated piles driven at both locations are summarized in Table 1.

PILING INSPECTIONS

From the initial inspection through the 1974 inspection, the piles exposed at both sites were inspected visually from the surface of the water [7-14]. One interruption in the exposure at Pearl Harbor occurred when, in August 1972, 120 of the experimental piles were accidentally pulled and brought ashore by Harbor Cleanup Unit HCU-1. Those removed were 42 of the Cooperative Marine Piling Committee piles and the CEL piles driven in 1963 and the 78 CEL piles driven in 1965. An inspection revealed that many of these piles were either lost or were broken and could not be identified. Thus, only 51 of the original 120 piles removed were redriven: four of the 1963 piles (two Cooperative Marine Piling Committee and two CEL), and 47 of the 1965 CEL piles [13].

Because of the difficulties encountered in trying to observe submerged pile surfaces, it was decided that the 1975 inspections would be conducted by a diver. CEL let a contract to the Al Hanson Diving Service* to accomplish this work. A similar contract was let for the 1976 inspections. Mr. Hanson reports the percentage loss of cross-sectional area of each pile caused by borer attack as well as the extent and location of the attack [15]. Splits, checks and other defects or damage are also noted.

The piles at Coco Solo were inspected on 18 March 1976; the results of that inspection are shown in Table 2. The piles at Pearl Harbor were inspected on 20 April 1976; the results of that inspection are shown in Tables 3 through 6. Summaries of all of the inspections conducted at both locations are shown in Tables 7 through 11.

FINDINGS

Cooperative Piles

After 13 years of exposure at Coco Solo, ammoniacal copper arsenite followed by creosote (dual treatment) in Douglas fir is emerging as the best treatment. Only two of the six piles have been attacked, and the attack on one of these has been caused, at least in part, by a split in the pile. Chromated copper arsenate followed by creosote in southern yellow pine has sustained further attack in the past year so that now four of the six piles have been attacked.

At Pearl Harbor, ammoniacal copper arsenite followed by creosote in Douglas fir, chromated copper arsenate followed by creosote in southern yellow pine, 70-30 creosote-coal tar solution in Douglas fir, 70-30 creosote-coal tar solution containing 1% phenylmercuric oleate in southern yellow pine, 70-30 creosote-coal tar solution containing 5% phenylmercuric oleate in Douglas fir, and 70-30 creosote-coal tar solution followed by sheathing with cupro-nickel alloy have sustained no attack after 13 years of exposure.

CEL and CEL/Industry Piles

After 12 years of exposure at Pearl Harbor, piles treated with high retentions of creosote (28.6 pcf) containing 5% chlordane, and a moderate retention of creosote (17.4 pcf) containing 1% tributyltin oxide and 1%

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*Mr. Hanson has been the inspector of wood piles for the Port of Los Angeles for more than 25 years. Mrs. Hanson, who is both a licensed diver and diver tender, acts as his tender and records his data.

dieldrin are unattacked. After 11 years of exposure, the creosote-free treatments, 4% copper oxinate and 5% chlordane plus 1 or 2% tributyltin oxide, are in excellent condition. After 10 years of exposure, piles treated with basic zinc sulfate plus tributyltin oxide, ammoniacal copper arsenite plus 70-30 creosote-coal tar solution are in excellent condition.

In summary, 40 of the 69 (58%) CEL/Industry piles treated with creosote or solutions of toxic agents in creosote have been attacked after 12 years of exposure; 13 of the 35 (37%) single and combination creosote-free treated piles and 9 of the 12 (75%) creosote-plus-additive treated piles have been attacked after 11 years of exposure; 24 of the 48 (50%) single and combination (dual-treated) creosote-free treated piles and 1 of the 12 (8%) piles treated with a high retention of 70-30 creosote-coal tar solution or with ammoniacal copper arsenite plus 70-30 creosote-coal tar solution has been attacked after 10 years exposure.

CONCLUSIONS

1. At Coco Solo, Douglas fir piles treated with ammoniacal copper arsenite followed by creosote (dual treatment) are superior to all other treated piles exposed there.

2. At Pearl Harbor, piles treated with creosote containing a toxic additive or additives are, in general, performing better than those treated with creosote only.

3. At Pearl Harbor, piles impregnated (1) with selected single treatments, (2) with a solution containing two toxic compounds, or (3) with a dual treatment are performing equally well.

RECOMMENDATION

Because of the large number of piles that were initially attacked within the last year, at least one more diver inspection should be conducted at Pearl Harbor.

ACKNOWLEDGMENT

The author wishes to thank LCDR L. E. Vaughn, Fiscal and Supply Officer, U. S. Naval Station, Panama Canal, and Mr. G. F. Patton, Operations Foreman, Atlantic Terminal, for their assistance and cooperation in the inspections at Coco Solo; and Mr. D. Kim, Maintenance Control Department, Public Works Center, Pearl Harbor, for his assistance and cooperation in the inspections at Pearl Harbor.

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Table 1. Experimentally Treated Piles Driven at Coco Solo and Pearl Harbor

Year Driven	Source of Piles[a]	Number of Treatments	Piles Per Treatment	Total Piles	Summary of Treatments
Coco Solo					
1963	Coop	9	6	54	Inorganic salt followed by creosote (double treatment); 70-30 creosote-coal tar solution; phenylmercuric; oleate dissolved in 70-30 creosote-coal tar solution
Pearl Harbor					
1963	Coop	10	6	60	Same as Coco Solo plus: 70-30 creosote-coal tar solution followed by sheathing with 90:10 cupro-nickel alloy
1963	CEL	1	6	6	Type III creosote
1964	CEL	9	6	54	Creosote solutions of specific organic compounds and/or metal organic compounds
1964	OWPC	1 1 1	4 5 6	15	Creosote solutions of specific organic and metal organic compounds
1965	CEL	13	6	78	Solutions of specific organic and metal organic compounds in xylene or creosote
1966	CEL	2	6	12	Double treatment: Copper sulfate followed by tributyltin oxide

continued

Table 1. Continued

Year Driven	Source of Piles[a]	Number of Treatments	Piles Per Treatment	Total Piles	Summary of Treatments
1966	BCCWP	1	6	6	Chromated copper arsenate (Type B)
1966	AZLS	1	6	6	Basic zinc sulfate
1966	JHB	3	6	18	Ammoniacal copper arsenite; 70-30 creosote-coal tar solution; double treatment: ammoniacal copper arsenite followed by 70-30 creosote-coal tar solution
1966	AZLS/ CEL	1	6	6	Double treatment: basic zinc sulfate followed by tributyltin oxide
1966	BCCWP/ CEL	1	6	6	Double treatment: chromated copper arsenate (Type B) followed by tributyltin oxide
1966	JHB/ CEL	1	6	6	Double treatment: ammoniacal copper arsenite followed by tributyltin oxide

[a] Coop = Cooperative Marine Piling Committee; CEL = Civil Engineering Laboratory; OWPC = Osmose Wood Preserving Company of America; BCCWP = British Columbia Clean Wood Preservers, Ltd; AZLS = American Zinc, Lead, and Smelting Co.; JHB = J. H. Baxter and Co.

Table 2. Results of 1976 Inspection of Cooperative Piles at Coco Solo (installed in 1963)

(Lim = *Limnoria*; Mart = *Martesia*; Ter = *Teredo*; ML = Mud Line; TA = Tide Area; WL = Water Line)

Treatment	Percent Loss of Cross-Sectional Area for –					
	Piling No. 1	Piling No. 2	Piling No. 3	Piling No. 4	Piling No. 5	Piling No. 6
Ammoniacal copper arsenite followed by creosote in Douglas fir	3%: hole, Mart Some rot at top	70%: Hole in TA Pile hollowed out, caused by split	0%	0%	0%	0%
Chromated copper arsenate followed by creosote in Douglas fir	100%: TA 0%: –36" to ML	6%: TA (holes) 6" Mart 0%: ML	22%: TA, Lim 0%: –9" to ML	35%: TA 0%: –18" to ML	12%: TA, Mart, Lim 0%: –18" to ML	20%: TA (1 hole), Lim, Mart 0%: –12" to ML
Chromated copper arsenate followed by creosote in southern yellow pine	0%	3%: TA, Mart 0%: ML	3%: TA, Mart 0%: ML	2%: TA	4%: TA, Mart 0%: ML	0%
70-30 creosote-coal tar solution in Douglas fir	85%: TA 6%: ML, Lim, Mart	35%: TA, Lim, Mart, Ter 0%: –36" to ML	72%: TA 20%: ML, Lim	65%: TA, Lim, Mart 0%: –30" to ML	90%: TA 25%: ML, Lim, Mart, Ter	20%: TA, Lim, Mart 0%: –30" to ML
70-30 creosote-coal tar solution in southern yellow pine	85%: TA 20%: ML, Lim, Mart Some rot at top	35%: TA, Lim 0%: –18" to ML	60%: TA 40%: ML, Lim	85%: TA 22%: ML, Lim, Mart	96%: TA 70%: ML, Lim	85%: TA 40%: ML, Lim, Mart
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[a] in Douglas fir	35%: TA to –36" 5%: ML	55%: TA to –30" 8%: ML	30%: TA 8%: ML, Lim	70%: TA 0%: –27" to ML	22%: TA, Lim, Mart 0%: ML	24%: TA, Lim, Mart 0%: –30" to ML
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[a] in southern yellow pine	100%	100%	70%: TA 26%: ML, Lim	90%: TA 35%: ML, Lim	94%: TA 20%: ML, Lim, Mart, Ter	100%
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[a] in Douglas fir	100%	88%: TA 40%: ML, Lim, Mart, Ter	98%: TA 6%: +6" to +30" Lim, Mart	40%: TA, Mart, Lim, Ter 0%: –26" to ML	100%	100%: TA 25%: ML

continued

Table 2. Continued

Treatment	Percent Loss of Cross-Sectional Area for –					
	Piling No. 1	Piling No. 2	Piling No. 3	Piling No. 4	Piling No. 5	Piling No. 6
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[a] in southern yellow pine	100%	85%: TA 5%: ML, Lim	99%	86%: TA 94%: ML, Lim, Mart	94%: TA 90%: ML, Lim	98%: TA 50%: ML, Lim, Mart

[a]Nominal percentages. Analyses of core borings showed that considerably less than the nominal percentage got into the wood [11].

Table 3. Results of 1976 Inspection of Cooperative Piles at Pearl Harbor, Plus One Set of Piles Treated With Creosote by CEL (installed in 1963)

(Mart = *Martesia*; Lim = *Limnoria*; ML = Mud Line; TA = Tide Area)

Treatment	Percent Loss of Cross-Sectional Area for -				
	Piling No. 1	Piling No. 2	Piling No. 3	Piling No. 4	Piling No. 5
Ammoniacal copper arsenite followed by creosote in Douglas fir	0%	0%	0%		
Chromated copper arsenate followed by creosote in Douglas fir	4%: TA, Mart, Lim	7%: TA, Mart, Lim	2%: ML, Lim		
Chromated copper arsenite followed by creosote in southern yellow pine	0%	0%	0%		
70-30 creosote-coal tar solution in Douglas fir	0%	0%	0%		
70-30 creosote-coal tar solution in southern yellow pine	6%: TA, Lim, Mart	TA, incipient Lim 2%: ML, Lim			
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[a] in Douglas fir	5%: TA, Lim	0%	1%: TA, Lim		
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[a] in southern yellow pine	0%				

continued

Table 3. Continued

Treatment	Percent Loss of Cross-Sectional Area for -				
	Piling No. 1	Piling No. 2	Piling No. 3	Piling No. 4	Piling No. 5
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[a] in Douglas fir	0%				
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[a] in southern yellow pine	6%: TA, Lim 7%: ML, Lim	0%			
70-30 creosote-coal tar solution in southern yellow pine followed by sheathing with cupro-nickel alloy	0%				
CEL creosote in Douglas fir	2%: TA, Lim, Mart 3%: ML, Lim	0%	3%: TA, Lim	0%	3%: TA, Lim, Mart

[a]Nominal percentages. Analyses of core borings showed that considerably less than the nominal percentage got into the wood [11].

Table 4. Results of 1976 Inspection of CEL- and Industry-Treated Piles at Pearl Harbor (installed in 1964)

(Lim = *Limnoria*; Mart = *Martesia*; Ter = *Teredo*; TA = Tide Area; ML = Mud Line)

Group[a]	Creosote Additive	Creosote Retention (lb/ft^3)	Additive Retention (lb/ft^3)	Percent Loss of Cross-Sectional Area for –					
				Piling No. 1	Piling No. 2	Piling No. 3	Piling No. 4	Piling No. 5	Piling No. 6
1	None	32.9	0.00	2%: TA, Lim	2%: TA, Lim	0%	3%: TA, Lim	3%: TA, Lim	3%: TA, Lim
2	5% chlordane	28.6	1.4	0%	0%	0%	0%	0%	0%
3	2.5% chlordane	28.5	0.7	0%	0%	1-2%: TA, Lim	3%: TA, Lim	0%	0%
4	1.25% chlordane	26.3	0.3	0%	0%	0%	1%	0%	3%: TA, Lim, split
5	30% copper naphthenate	8.3	0.27[b]	3-4%: TA, Lim	0%	1%: TA, Lim	2%: TA, Lim	2%: TA, Lim, Mart	0%
6	15% copper naphthenate	9.4	0.15[b]	2%: TA, Lim, Mart	0%	32%: TA, Lim 5%: ML	0%	45%: TA, Lim	18%: TA, Mart, Lim, Ter
7	7.5% copper naphthenate	10.9	0.09[b]	65%: TA, Lim	0%	35%: TA, Lim 0%: –12" to ML	2%: TA, Lim	3%: TA, Lim	2%: TA, Lim
8	14% copper naphthenate 1% tributyltin oxide	14.8	0.23[b] 0.15	0.5%: TA, Mart 7-8%: split, Lim	3%: TA, Mart	0%	7%: TA, Lim, Mart, Ter	45-48%: TA, Lim, Mart	8%: TA, Lim, Mart

continued

Table 4. Continued

Group[a]	Creosote Additive	Creosote Retention (lb/ft^3)	Additive Retention (lb/ft^3)	Percent Loss of Cross-Sectional Area for –					
				Piling No. 1	Piling No. 2	Piling No. 3	Piling No. 4	Piling No. 5	Piling No. 6
9	7% copper naphthenate 0.5% tributyltin oxide	8.6	0.07[b] 0.08	0%	3-4%: TA, Lim	0%	2%: TA, Lim	30%: TA, Lim	7%: TA, Lim, some Mart
10	None	18.6	0.00	26%: TA, Mart, Lim 9-10%: ML, Lim	17%: TA, Lim, Mart	30%: TA, Lim 26%: ML, Lim	16%: TA, Lim, Mart holes 6%: ML, Lim		
11	1% tributyltin oxide	13.9	0.14	4%: TA, Lim	40%: TA, Lim 3%: ML, Lim	13%: TA, Lim 4%: ML, Lim	30%: TA, Lim 4%: ML, Lim	29%: TA, Lim	
12	1% tributyltin oxide 1% dieldrin	17.4	0.18 0.18	0%	0%	0%	0%	0%	0%

[a]Treatment groups 1 through 9 had six Douglas fir piles each; there were four pine piles in group 10, five in group 11, and six in group 12.

[b]As metallic copper.

Table 5. Results of 1976 Inspection of CEL-Treated Piles at Pearl Harbor (installed in 1965)[a]

(Lim = *Limnoria*; Mart = *Martesia*; Ter = *Teredo*; TA = Tide Area; ML = Mud Line)

Treatment (Solutions in Xylene)	Retention (lb/ft^3)	Percent Loss of Cross-Sectional Area for -					
		Piling No. 1	Piling No. 2	Piling No. 3	Piling No. 4	Piling No. 5	Piling No. 6
4% copper oxinate	0.87[b]	0%	0%	1%: TA	1%: TA, Mart, Lim	1%: TA, Mart	0%
2% copper oxinate	0.49[b]	0%	2%: TA, Lim	10%: TA, Lim, Ter	0%	3%: TA, Lim	0%
2% copper oxinate 2% tributyltin oxide	0.25[b] 0.25	3%: TA, Lim	4%: TA, Lim 3%: ML, Lim	2%: TA, Lim	0%	0%	3%: TA, Mart, Lim
3% copper oxinate 1% Victoria green base	0.69[b] 0.26	0%	2%: TA, Lim	-	0%	0%	3%: TA, Lim, Mart
5% chlordane 1% tributyltin oxide	1.3 0.27	0%	0%	0%	0%	0%	0%
5% chlordane 2% tributyltin oxide	1.5 0.62	0%	1%: TA, Mart	0%	0%	0%	0%
1.5% copper oxinate 0.5% Victoria green base 50% creosote	0.27[b] 0.09 9.2	4%: ML, Lim	7%: TA through ML, Lim, Mart, Ter	5%: TA, Lim	3%: TA, Mart, Lim 3%: ML, Lim, Mart	3%: ML, Lim	5%: TA, Lim, Mart 5%: ML, Lim

continued

Table 5. Continued

Treatment (Solutions in Xylene)	Retention (lb/ft^3)	Percent Loss of Cross-Sectional Area for -					
		Piling No. 1	Piling No. 2	Piling No. 3	Piling No. 4	Piling No. 5	Piling No. 6
0.75% copper oxinate 0.25% Victoria green base 75% creosote	0.25[b] 0.08 24.7	0%	TA, split 2%: ML, Lim	0%	0%	3%: ML, Lim	7%: TA, Lim 2%: ML, Lim

[a]These piles were accidentally pulled in August 1972 and redriven in May 1973.

[b]As metallic copper.

Table 6. Results of 1976 Inspection of CEL- and Industry-Treated Piles at Pearl Harbor (installed in 1966)

(Lim = *Limnoria*; Mart = *Martesia*; Ter = *Teredo*; TA = Tide Area; ML = Mud Line)

Treatment	Retention (lb/ft^3)	Percent Loss of Cross-Sectional Area for –					
		Piling No. 1	Piling No. 2	Piling No. 3	Piling No. 4	Piling No. 5	Piling No. 6
Chromated copper arsenate, Type B	0.50	89%: TA, Lim, Mart; tapers to 28% ML, Lim	82%: TA, Lim, Mart, Ter 35%: ML, Lim	2%: TA, Mart	100%	38%: TA, Mart, Ter, Lim 7%: ML	2%: TA, Mart
Basic zinc sulfate	2.77	0%: Few Mart holes	0%	2%: TA, Mart	0%	1%: TA, Mart	0%
Ammoniacal copper arsenite	0.51	0%	2%: TA, Lim, Mart	0%	1%: TA, Mart	1%: TA, Mart holes	1%: TA, Mart, Lim
Chromated copper arsenate, Type B Tributyltin oxide	0.50 0.13	0%	0%	3%: TA	0%	0%	1%: TA
Basic zinc sulfate Tributyltin oxide	2.66 0.09	0%	0%	0%	0%	0%	0%
Ammoniacal copper arsenite Tributyltin oxide	0.51 0.11	0%	0%	0%	0%	0%	0%
70-30 creosote-coal tar	31.7	0%	7%: TA, Lim, Mart	0%	0%	0%	0%
Ammoniacal copper arsenite 70-30 creosote-coal tar	0.51 19.6	0%	0%	0%	0%	0%	0%
Copper sulfate Tributyltin oxide	0.06[a] 0.19	6%: TA, Mart, Lim	4%: TA, Lim	3%: TA, Lim	3%: TA, Lim	0%	2-3%: TA, Lim
Copper sulfate Tributyltin oxide	0.03[a] 0.20	3%: TA, Lim	2%: TA, Lim	0%	88%: TA, Lim, 9" hole	1%: TA, Lim	16%: TA, Lim, 6"-long hole

[a] *As metallic copper.*

Table 7. Summary of Inspection Results on Cooperative Piles at Coco Solo (installed in 1963)

Treatment	Number of Piles Reported Attacked in -									
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Ammoniacal copper arsenite followed by creosote in Douglas fir	0	1	0	1	2	2	3	1	2	2
Chromated copper arsenate followed by creosote in Douglas fir	0	2	3	1	3	3	5	5	6	6
Chromated copper arsenate followed by creosote in southern yellow pine	0	2	1	0	3	2	2	1	2	4
70-30 creosote-coal tar solution in Douglas fir	0	2	3	5	6	6	6	6	6	6
70-30 creosote-coal tar solution in southern yellow pine	1	1	3	4	5	5	6	6	6	6
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[a] in Douglas fir	1	1	2	5	6	6	6	6	6	6
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[a] in southern yellow pine	3	3	3	6	6	6	6	6	6	6
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[a] in Douglas fir	2	3	5	5	6	6	6	6	6	6
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[a] in southern yellow pine	1	3	5	5	6	6	6	6	6	6

[a]Nominal percentages. Analyses of core borings showed that considerably less than the nominal percentage got into the wood [11].

Table 8. Summary of Inspection Results on Cooperative Piles at Pearl Harbor, Plus One Set of Piles Treated With Creosote by CEL (installed in 1963)[a]

Treatment	Number of Piles Reported Attacked in -			
	1973	1974	1975	1976
Ammoniacal copper arsenite followed by creosote in Douglas fir	0	0	0	0
Chromated copper arsenate followed by creosote in Douglas fir	2	0	1	3
Chromated copper arsenate followed by creosote in southern yellow pine	0	0	0	0
70-30 Creosote-coal tar solution in Douglas fir	1	0	0	0
70-30 creosote-coal tar solution in southern yellow pine	2	0	0	2
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[c] in Douglas fir	NR[b]	NR	0	2
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[c] in southern yellow pine	NR	NR	0	0
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[c] in Douglas fir	NR	NR	0	0
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[c] in southern yellow pine	NR	NR	1	1
70-30 creosote-coal tar solution in southern yellow pine followed by sheathing with cupro-nickel alloy	NR	NR	0	0
CEL creosote in Douglas fir	NR	3	1	3

[a] These piles were accidentally pulled in August 1972 and redriven in May 1973.

[b] NR = not reported.

[c] Nominal percentages. Analyses of core borings showed that considerably less than the nominal percentage got into the wood [11].

Table 9. Summary of Inspection Results on CEL- and Industry-Treated Piles at Pearl Harbor (installed in 1964)

Group[a]	Creosote Additive	Creosote Retention (lb/ft^3)	Additive Retention (lb/ft^3)	Number of Piles Reported Attacked in -					
				1971	1972	1973	1974	1975	1976
1	None	32.9	0	1	1	1	0	4	5
2	5% chlordane	28.6	1.4	0	2	1	0	1	0
3	2.5% chlordane	28.5	0.7	0	1	2	0	2	2
4	1.25% chlordane	26.3	0.3	0	2	0	0	3	2
5	30% copper naphthenate	8.3	0.27[b]	0	2	1	0	2	4
6	15% copper naphthenate	9.4	0.15[b]	2	3	3	0	4	4
7	7.5% copper naphthenate	10.9	0.09[b]	1	2	2	1	3	5
8	14% copper naphthenate 1% tributyltin oxide	14.8	0.23[b] 0.15	1	2	5	0	5	5
9	7% copper naphthenate 0.5% tributyltin oxide	8.6	0.07[b] 0.08	0	2	2	0	4	4
10	None	18.6	0	0	1	4	3	4	4
11	1% tributyltin oxide	13.9	0.14	0	1	4	2	5	5
12	1% tributyltin oxide 1% dieldrin	17.4	0.18 0.18	0	0	0	0	0	0

[a] Treatment groups 1 through 9 had six Douglas fir piles each; there were four pine piles in group 10, five in group 11 and six in group 12.

[b] As metallic copper.

Table 10. Summary of Inspection Results on CEL-Treated Piles at Pearl Harbor (installed in 1965)[a]

Treatment (Solutions in Xylene)	Retention (lb/ft^3)	Number of Piles Reported Attacked in -			
		1973	1974	1975	1976
4% copper oxinate	0.87[b]	0	2	1	3
2% copper oxinate	0.49[b]	4	2	2	3
2% copper oxinate 2% tributyltin oxide	0.25[b] 0.25	4	0	0	4
3% copper oxinate 1% Victoria green base	0.69[b] 0.26	3	2	1	2
5% chlordane 1% tributyltin oxide	1.3 0.27	0	2	0	0
5% chlordane 2% tributyltin oxide	1.5 0.62	0	2	1	1
1.5% copper oxinate 0.5% Victoria green base 50% creosote	0.27[b] 0.09 9.2	6	4	4	6
0.75% copper oxinate 0.25% Victoria green base 75% creosote	0.25[b] 0.08 24.7	4	4	1	3

[a] These piles were accidentally pulled in August 1972 and redriven in May 1973.

[b] As metallic copper.

Table 11. Summary of Inspection Results on CEL- and Industry-Treated Piles at Pearl Harbor (installed in 1966)

Treatment	Retention (lb/ft^3)	Number of Piles Reported Attacked in -					
		1971	1972	1973	1974	1975	1976
Chromated copper arsenate, Type B	0.50	3	3	3	5	4	6
Basic zinc sulfate	2.77	0	0	3	2	0	2
Ammoniacal copper arsenite	0.51	0	0	3	2	1	4
Chromated copper arsenate, Type B Tributyltin oxide	0.50 0.13	0	0	0	2	1	2
Basic zinc sulfate Tributyltin oxide	2.66 0.09	0	0	0	1	0	0
Ammoniacal copper arsenite Tributyltin oxide	0.51 0.11	0	0	0	0	0	0
70-30 creosote-coal tar	31.7	0	0	0	1	1	1
Ammoniacal copper arsenite 70-30 creosote-coal tar	0.51 19.6	1	0	1	0	0	0
Copper sulfate Tributyltin oxide	0.06[a] 0.19	2	4	3	1	2	5
Copper sulfate Tributyltin oxide	0.03[a] 0.20	0	1	0	2	3	5

[a] As metallic copper.

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