Comments to DW ASAP by July 1st
C.S.
June 13,'83

TIMBER PRESERVATION CONSULTANCY REPORT (BOLIVIA)

By

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Submitted to:

The Director
Agriculture, Food and Nutrition Sciences Division
International Development Research Centre
Ottawa, Canada

May 1983

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INTRODUCTION

The author was retained as a consultant for a period of up to 15 days between April 18 and April 30, 1983, with the terms of reference:

a) to travel to La Paz and Santa Cruz, Bolovia, and Lima, Peru;*

b) to assist in the preparation of a project proposal in Timber Preservation (Bolivia) to be submitted to the Centre by the Bolivian Centro de Desarrollo Forestal;

c) to assess and advise the Centre on the capability of the national Bolivian staff, and the adequacy of laboratory installations and equipment to carry out the proposed project;

d) to assist the technical staff of the Centro de Desarrollo Forestal in preparing a detailed research plan to investigate methods of preserving locally available timber species for use by the local construction and mining industries, and other users;

e) to visit the Forestry Technology (Andean Pact) Phase II project* in Lima, Peru, to review the final research results which are closely related to the forest technology project in the Andean region; and,

f) to undertake such other assignments as are agreed upon between yourself and the Centre.

*Material supplied by F. J. Keenan, Morrison Hershfield, Ltd., negated the need for travel to Lima, Peru. However, travel to Tarija, Bolivia, was added to the itinerary (with the concurrence of IDRC representative Derek Webb).

During the consultancy the following offices or organizations were visited:

a) Centro de Desarrollo Forestal (CDF), La Paz

b) Programa Plantaciones Forestales, Santa Cruz

c) CDF Projecto PADT-REFORT, Santa Cruz

d) Facultad de Ciencias Agricoles, Universidad Gabriel René Moreno, Santa Cruz

e) Industria Madera "Guapay" and Compañia Industrial Maderera CIMAL. (Two large wood processing companies in Santa Cruz).

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f) PEÑA TIM, a "Koppers" wood treating plant using a water-soluble wood preservative - CCA.

g) Facultad de Agronomia y Forestal, Universidad Autonoma Juan Misael Saracho, Tarija.

So as to respond to the terms of the consultancy in an orderly fashion, this report will be divided into several parts as follows:

I. Background information, problem areas, research capability

II. Research program and assignments

III. Research procedures

IV. Equipment and training needs

V. Reference material

PART I.--BACKGROUND INFORMATION

I-1. La Paz

I met with Derek Webb, IDRC, in La Paz and we had some discussions on the kinds of information needed so that he together with CDF staff, could prepare an acceptable project proposal. Then for a very general review, I met with Jaime Cardozo (in charge of Planification) and Silverio Viscarra A. (in charge of Investigations and Extension). Viscarra was to join me in Santa Cruz and remain as my "counterpart" for the remainder of the Bolivian visit. During the stay in La Paz, Webb and Viscarra suggested that travel plans should be changed to include a visit to the forestry faculty of the University in Tarija and to determine the possibility of including this group in the wood preservation research program.

For purposes of protocol, a courtesy call was made to the offices of the National Director of CDF, Benigno Rodriguez G. and his assistant, Martin Gallardo. Viscarra and I reviewed the purpose of the visit and the interest of IDRC in supporting a meaningful research program related to wood preservation.

My first impressions of Cardozo and Viscarra were highly favorable in both areas of administration and technical competency. My good opinion of Viscarra did not diminish during our continued stay together.

Disconcerting though is the information that over the last ten years the Centro de Desarrollo Forestal has had twelve people filling the office of National Director. This high turnover in leadership must have its effects on program continuity. A similar problem occurs in their CDF PADT-REFORT laboratory in Santa Cruz as will be noted later.

I-2. Santa Cruz

I-2.1 Programa Plantaciones Forestales

This project is sponsored by the Camara Nacional Forestal (CNF) and is headquartered in Santa Cruz but has branches in all the major cities of Bolivia. The Camara is an association of private companies with an interest in forestry activities. For about two years they sponsored a journal, "Bolivia Forestal" that is no longer published.

The Programa Plantaciones Forestales is directed by Manuel Bass Werner and was started in 1975. The main thrust of the group is the establishment of extended areas of plantations near areas of consumption. Emphasis has been on the selection of various species of eucalypts, but also of interest are *Pinus patula*, *P. caribaea*, *P. radiata*, *Gmelina arborea*, *Swietenia macrophylla*, *Cedrela ordorata*, *Populus* spp. and others.

Now established in the Santa Cruz region are about 600 ha of mostly Eucalyptus grandis and E. citriodora. There is a 10-year plan to establish 4000 ha of eucalypts in this region. Other species of promise are: E. camaldulensis, E. tereticornis, E. saligna, E. robusta. At high elevations in the region of Cochabamba, species of interest are E. viminalis, E. globulus, E. maidenii, and E. camaldulensis. The oldest plantations are about eight years old and have diameters up to about 40 cm.

The eucalypts are a highly favored group for plantation culture in Bolivia as they are in Brazil, Ecuador, Colombia, and many other tropical and sub-tropical regions of the world.

High elevation plantations of mostly E. globulus have been established since about 1900 with most of the fellings used in the mines. About 300,000 supports per year are required and are supplied and put in use without preservative treatment. Mine timbers are generally 5 to 12 cm. in diameter and 2.5 to 5 m. in length. Service life of timbers are suggested to be ± three years. In our conversations Bass Werner suggested that there is a vested interest in this continuing supply of non-treated wood.

Bass Werner, as Director of the Programa Plantaciones Forestales, would like to see the main thrust of the IDRC sponsored program on wood preservation concentrate on the treatability of the eucalypts with a special effort to study cost of all operations: felling, transport, peeling, seasoning, preservative treatments, marketing.

He faults the Andean Pact research because not enough study was made on the economic factors related to the use of tropical hardwoods in construction.

Alberto Arce, formerly associated with the PADT-REFORT program is now associated with Bass Werner and is in charge of research. Thirty percent of his time can be assigned to the IDRC program. The resources of Programa Plantaciones Forestales and the Camara Nacional Forestal will also be available to the research program.

My visit with Bass Werner was at his office located on the grounds of the tree nurseries. It was the off season but nevertheless I get the impression of a well run organization that works. Bass Werner has a forestry degree and has been active in the forestry affairs of Bolivia and was a major contributor to "Bolivia Forestal" while it was in print. A most valuable person to have as a cooperator in the wood preservation research program even though he has no direct concern with utilization of native species.

I was informed that there is a pressure-vacuum plant in Cochabamba treating utility poles of E. globulus to a retention of 8-12 Kg/M^3 dry salt of chromated copper arsenate (CCA). Bass Werner suggested that some cost data might be obtained from this private company.

I-2.2 CDF Projecto PADT-REFORT

I was expecting to find Said Rabaj in charge but he has left the employ of CDF. Gregorio Cerrogrande is now in charge. Others on the staff are G. Figueroa, H. Cardozo, and J. Quinteros. Here as well, there has been a high turnover in leadership--six different project heads in six years!

There appears to be little change in the research facilities since my last visit in October-November 1977. A more than adequate woodworking facility is functional but little else.

A small pressure-vacuum treating plant is in disarray and is not in operation because of a missing mixing and storage tank. I suggested that four oil drums hooked in series could serve this purpose. It appears to be a gross waste of funds to purchase equipment if a group is poorly staffed or doesn't have the technical ability to improvise.

Of this group, Cerrogrande appears to be most capable but his research record over the four years he has been with PADT-REFORT has been minimal. He has produced a paper on physical properties (density and shrinkage) of four species from the La Chiquitania forest and two works on the macroscopic and microscopic identification of Bolivian woods. Both co-authored with José Ml. Goytia of the Spanish Technical Assistance Mission.

Instead of getting the equipment on hand in good working order (something wrong with the controls of the Hildebrand experimental dry kiln, Tinius-Olsen universal testing machine still in shipping crates, etc.), the staff appears to be waiting for a move to a new facility in the "Industrial Park." I visited the new laboratory site with Cerrogrande and was impressed with the five or so very large buildings on a hectare and more area. The buildings are over two stories high and consist of roofing only. In one building, equipment is partially in place for full scale testing of wall panels and columns. Provisions are being made for a pulp and paper facility, veneer and plywood, etc. Considering the poor financing of this group and their marginal competency, these plans are most pretentious. Cerrogrande suggests that they will be moving to the new site by the end of 1983. This does not appear to be likely. I can only suggest that what little funds and energy are now available could be better spent on the present location and on existing equipment.

PADT-REFORT can and should participate in the IDRC supported research program on wood preservation but I believe they are not capable of taking a leadership role. It appears that a joint effort of several groups will be necessary.

I-2.3 Universidad Gabriel Rene Moreno, Facultad de Ciencias Agricoles

On my last day in Santa Cruz, I discovered by accident that a well-trained and experienced wood technologist is on the faculty of the local university. My encounter with Federico Bascope V. expanded dramatically the possibilities and capabilities of a local research program. Bascope, some ten years ago, was also the National Director of CDF.

The facilities at the university are rather minimal for work in general wood technology but there is a well trained biologist who is competent in plant pathology. There are sufficient facilities for very small-scale laboratory wood durability assessment tests but would need additional equipment to handle a larger research program. Licenciada Norma Rodriguez is in charge of the Biology Laboratory and indicates an interest in conducting some aspects of the IDRC program.

Bascope informed me that there is a commercial treating plant, "PEÑA TIM" located in Santa Cruz at KM 10-1/2 Carr. Norte and we visited the facility together with Andres Remacha G. (de la Mision de Assistencia Tecnica Espanola). Remacha has been in the country about two years and has been offering training programs in wood drying and wood preservation. This is under the auspicies of the Camara Nacional Forestal. He has prepared two university level textbooks on drying and preservation. I attended his opening lecture on the wood drying course--some 60 students enrolled.

The preservation plant is a Kopper's design for use with CCA. Bascope has good relations with the owner who was out of town, and the plant could be available for the research program. It is strange that Bass Werner did not mention this nearby facility and mentioned only the plant at Cochabamba.

I-2.4 Guapay and CIMAL industries

During my stay in Santa Cruz, it was of interest to visit some wood industries to see the equipment and kinds of species being processed. These visits were made with Figueroa (PADT-REFORT).

The Guapay plant concentrates mostly on the production of mahogany (mara) lumber for export. This mill, as well as others in Santa Cruz, truck in logs or cants for distances of 300 km or more. They also produce sliced fancy veneer from mahogany and morado (Machaerium spp). CIMAL is a far larger plant that is only seven years old and processes some 15 species including general utility woods such as Ficus, Hura, and Podocarpus. Production is mostly in plywood, blockboard, flush doors, and fancy veneers. All equipment is from Germany and includes slicers and rotary peelers, veneer dryers, dry kilns, splicing machines, presses, etc, all well maintained and working. So after all, there is no shortage of technical skills in Santa Cruz or in Bolivia. ? see next para!

Visits to local industry suggests that wood is not used more on the local market because of a lack of information on wood properties or lack of technical skills in processing, but mostly because the local markets are not economically attractive.

Somewhat related to this was a visit with Viscarra to the Andean Pack "model" home in Santa Cruz. There were no signs identifying this house and its sponsor! Compared to conventional tile and brick homes in the area, the Andean Pact all-wood house with wood-cement exterior panels looked "cheap" but is not low cost.

As I may have suggested several years ago, perhaps the main thrust of the Andean Pact program should have been in studies to find ways to lower costs of lumber production and marketing problems rather than in engineering elegance.

/ I agree

I-3. Tarija

I-3.1 Universidad Juan M. Saracho Facultad de Agronomía y Forestal

The head of the forestry group is M. Lopez de la Vega with a profesional staff as follows:

M. Coro - Dendrology
D. Cruz Diaz - Wood Technology (in charge)
A. Cano C. - Wood Technology
C. Cossio N. - Silviculture
R. Aguilera F. - Photogrammetry
J. Moreno - Forestry
R. Justiano S. - Pathology

D. Cruz D. studied with D. Noack at the Hamburg Institute for about eight months and has a good technical background. Other members of the staff also appear competent and enthusiastic.

Equipment is available for evaluating physical and mechanical properties of wood (large Amsler with automatic stress-strain recording), microscope, drying ovens, drying chamber (without humidity control). Some distance off campus (5 minute drive) a new wood technology facility is under construction. In place is a high temperature boiler and a pressure-vacuum treating plant that is not quite completely assembled.

There is some interest in eucalypt culture here but the greatest concern is with the natural forests of the region. At a distance of about 100 km there are forests located in the Subtropical Moist Life Zone with about 40 species of interest and a Subtropical Dry Life Zone with about 15 species of interest. This latter forest type is being most actively exploited primarily for Quebracho colorado (Schinopsis spp). Most of the fellings are for export of railroad ties. Large quantities are also sawn into grape stakes for local vineyards. The demand for grapestakes is about 20,000 per year.

The local interest is in a research program to determine which of the species in both life zones could be offered as substitutes for Quebracho colorado with or without preservative treatments. Using species in the region, interests are also in developing the use of treated posts and poles, treated vineyard stakes, and treated construction lumber.

I-4. General Comments

As always, there is still the problem of deciding what kinds of technical information is lacking and if this lack is hindering the proper utilization of the forest resources.

As demonstrated by the CIMAL and Guapay operations, high-cost efficient processing plants can be established to produce a wide array of sophisticated wood products of high quality that meets world-market demands... all this without any benefit of PADT-REFORT research results.

Another concern is that already there exists a wood preservation plant in Cochabamba treating E. globulus and E. robusta poles for use in telephone and electric power lines. So why the research to demonstrate the feasibility of a product that is already commercially viable?

Some responses to this could be:

(a) Treatability of sapwood and heartwood of the many candidate species may vary significantly.

(b) Natural durability and resistance to termite attack of heartwood of plantation grown and forest-grown species may not be clearly defined.

(c) A 3-year supported program could be a good vehicle for enhancing the research capability of technical and professional staff at various institutions.

(d) The IDRC program could also be designed to encourage cooperation between organizations that are now hardly aware of each other's existence, e.g., government--universities--industry.

PART II. RESEARCH PROGRAM AND ASSIGNMENTS

The proposed research program can be divided in two geographic parts: 1) Santa Cruz; 2) Tarija.

II-1. Research Programs

II-1.1 Research Studies - Santa Cruz

(a) Study the treatability of heartwood and sapwood of selected plantation-grown eucalypts and selected forest-grown species.

(b) Evaluate the durability of heartwood (resistance to decay fungi attack) of species selected in (a) above.

(c) Evaluate the termite resistance of heartwood of species selected in (a) above.

(d) Determine the durability and termite resistance of sapwood treated to three levels of preservative salt retention. Two eucalypt species and two forest-grown species should be selected, representing specific gravity extremes.

(e) Determine felling, transportation, and material preparation costs to include peeling costs, preseasoning treatments to control stain and insect attack, and drying time.

(f) Establish demonstration test plots (graveyards) using pressure treated posts and heartwood stakes.

II-1.2 Research Assignments - Santa Cruz

The research program at Santa Cruz can be assigned as follows:

(a) CDF..Projecto PADT-REFORT (Cerrogrande) will be responsible for study No. II-1.1(a) and preparation of test material for study Nos. II-1.1(b), (c), and (d).

(b) Programa Plantaciones Forestal and Camara Nacional Forestal (Bass Werner and Arce) will be responsible for study Nos. II-1.1(e) and (f), and felling and transport of all materal required in study II-1.1(a), (b), (c), and (d).

(c) Universidad Gabriel René Moreno (Norma Rodriguez) will be responsible for study nos. II-1.1(b), (c) and (d). ✓

A considerable amount of coordination and cooperation between the various groups will be required to complete the research studies within the allocated three years and to observe the budgetary restraints. For these reasons, the appointment of Prof. F. Bascopé V. as the project coordinator and IDRC representative is strongly recommended. // adviser

II-2.1 Research Studies - Tarija

(a) Study the treatability of heartwood and sapwood of selected forest grown species harvested from the Subtropical Moist and Subtropical Dry Life Zones.

(b) Prepare durability assessment test material to be shipped to Univ. Gabriel René Moreno.

(c) Those species having a basic specific gravity over 0.60(?) and a large volume of treatable sapwood and/or a large volume of durable heartwood will be tested to determine mechanical properties relevant to use as railroad ties (substitutes for Quebracho colorado). ?

(d) Study termite resistance of heartwood of species slected in (a) above.

(e) Establish a serviceability post and stake test plot using species having durable heartwood screened in (b and d) above or treated material screened in (a) above.

II-2.2 Research Assignments - Tarija

(a) Universidad Autonoma Juan M. Saracho (Cruz and Cano) will be responsible for study Nos. II-2.1(a) to (e).

(b) Corp. Regional de Desarrollo de Tarija will assist in the collection of test material from the two forest types.

This program must be coordinated with the Santa Cruz research studies. It is suggested that Silverio Viscarra of CDF, La Paz, have this responsibility.

(See attached draft proposals for the Santa Cruz and Tarija studies prepared by S. Viscarra together with the Consultant. Appendix A)

PART III. RESEARCH PROCEDURES

III-1. Species Selection

III-1.1 Plantation-grown species (Eucalypts)

Low Elevation

E. grandis
E. camaldulensis
E. tereticornis
E. saligna
E. alba
E. robusta
E. citriodora
E. maculata

High Elevation

E. globulus
E. maidenii
E. viminalis

III-1.2 Forest-grown species

In this category forest inventory data should be used as a basis for selecting the most common species making up large volumes of the stocking. The candidate species should have wood properties that place them in a "utility" grouping that is not in demand for fine furniture, fancy veneers, or other special uses.

(a) Choré and Guarayos Forest Reserves (Santa Cruz)*

Ajo
Blanquillo
Colorado
Higueron
Mapajo
Ochoo
Amargo
Murure
Kagui
Tachore

*Above is a partial list of utility-grade species that are found in volumes over 1 M^3/Ha (see Viscarra draft proposal for additional inventory data). Ten eucalypt species and ten forest-grown species can be sampled.

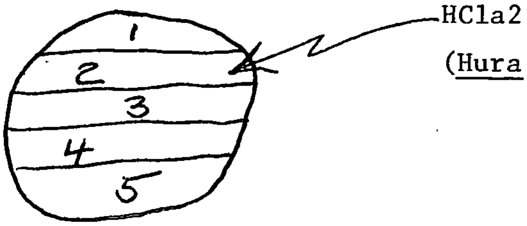
(b) Subtropical Moist and Subtropical Dry Forests (Tarija)

Forest survey data is available from the two Life Zones and using the same criteria as for the Santa Cruz Selection, ten candidate species will be chosen from Subtropical Moist and five from Subtropical Dry.

III-2. Harvest and Seasoning

(a) Appropriate Normas Técnicas (COPANT) for selection, collection, and conditioning of those species selected for determination of mechanical properties shall be followed. For this first screening, a sampling of five trees per species and four specimens per tree for testing in the green condition and four for testing in the dry condition for each strength property should be acceptable.

(b) For treatability, durability, and termite resistance tests, ten trees per species shall be sampled that are representative of site conditions. Bolts 2 m in length shall be selected from the base and upper bole (below the crown). Test bolts shall be debarked and sawn through and through to yield planks 3 cm thick. Each plank should be marked to indicate species, tree number, and location in the bole:



(*Hura crepitans*, tree # 1, bolt a, plank # 2)

Planks are to be stickered for air drying in an open shed.

(c) Parts of the bole not selected for tests in (b) can be debarked and otherwise prepared for seasoning studies, pretreatments to control stain and insect attack during seasoning, and for subsequent installation in graveyard demonstration plots and may consist of sapwood only (treated) or heartwood only (not treated). If more material is required for the Programa Plantaciones Forestal studies No. II-1.1(e) and (f), additional fellings of the test species shall be made.

**Note: All material prepared under (a), (b) and (c) above should be moved out of the plantations and forests as rapidly as possible, debarked, sawn, and given a dip treatment to control stain and insect attack during drying and storage.

The following chemicals and concentrations are suggested:

"A"	Permatox 10S*	40 pct. sodium pentaclorophenate 60 pct. borax
"B"	Ambrocide*	11 pct. lindane

Mix 10 kilograms of "A" and 7 liters of "B" in 400 liters of water.

*Available from Chapman Chemical Co., P.O. Box 9158, Memphis, TN 38109, USA.

III-3. Treatability Tests

The 3 cm thick planks prepared as indicated under (b) above shall be airdried for two months in an open shed and then slowly chamber or kiln dried to a uniform moisture content of 15 percent. Wafer assay tests to determine treatability shall be used (see refs. 6 and 7). Plugs shall be cut in locations along the plank that are free of checks, collapse or other defects. Eight plugs shall be cut from each tree: four plugs from bolt (a) and four plugs from bolt (b). From each bolt two plugs shall consist of sapwood and two plugs of outer heartwood. Plug diameter should be 2.54 cm (1 in.).

Wafers .64 cm (.25 in.) thick shall be prepared (see ref. 6,7) and one of each pair shall be edge painted with two coats of brushable epoxy or equivalent end-grain sealer. Results of treatability tests can be presented as shown in the attached table. Uncoated wafer retention will simulate retention of incised timbers or short members with large end-grain exposure. Coated wafers will reflect chemical retentions of long members where absorption is primarily through the side grain. (Plugs should be cut so that side grain of wafers are tangential faces and thus penetration is in the radial direction.)

Assuming a desired minimum retention of 150 Kg/M^3 of cresote or 7.5 Kg/M^3 of pentachlorophenol (5 pct. solution) or a minimum of 8 Kg/M^3 of CCA (using a .04 pct. solution) the following ratings for wafer absorption can be used:

	Oil Carrier Kg/M^3	Water Carrier Kg/M^3
Excessive absorption	>200	>400
Good absorption	150-200	200-400
Poor absorption	100-150	100-200
Very poor absorption	<100	<100

A ± 0.5 pct. solution of Safrinin O can be used as the water carrier, edge coated wafers could then be dried slightly after treatment and split along the grain into two 1/2-moons. Solution penetration across the grain, then, can be measured.

A total of 160 wafer tests per species will be required for the suggested sampling level.

DATA SHEET - TREATABILITY TESTS

		Sapwood					Heartwood				
Species code	Tree & Bolt No.	Air-dry[1] specific gravity	Oil Retention		Water Retention		Air-dry[1] specific gravity	Oil Retention		Water Retention	
			Coated Kg/M^3	Uncoated Kg/M^3	Coated Kg/M^3	Uncoated Kg/M^3		Coated Kg/M^3	Uncoated Kg/M^3	Coated Kg/M^3	Uncoated Kg/M^3
HC[2]	I a										
	I b										
	II a										
	II b										
	III a										
	III b										
	(etc.)										
Average a											
Average b											
Grand Average											

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[1] Based on weight and volume at 15 pct. moisture content.

[2] e.g., code for <u>Hura crepitans</u>.

III-4. Mechanical Properties

Selected species shall be sampled and tested in the green and dry (15 pct. moisture content) condition following appropriate COPANT standards (see ref. 8). The following properties may be of interest:

(a) Static bending...modulus of rupture, modulus of elasticity, work to maximum load

(b) Compression parallel to grain...maximum crushing strength

(c) Compression perpendicular to grain

(d) Shear parallel to grain

(e) Janka hardness

(f) Basic specific gravity

Species selected will be those growing in the Subtropical Moist and Subtropical Dry forests of the Tarija region that are found to have durable heartwood and/or treatable sapwood and otherwise good candidates as substitutes for Quebacho colorado railroad ties.

III-5. Heartwood Durability

Laboratory soilblock cultures following ASTM D 2017 (see ref. 2) shall be used to assess the natural durability of heartwood. Those species with a distinct heartwood making up a large volume of the bole shall be selected for this test from the Santa Cruz (plantation and forest-grown) region and the Tarija (forest-grown) region.

Ten trees per species shall be sampled with six soil blocks per tree cultured with each test fungus (at least two). About 3,000 soil-block tests are required.

The accelerated laboratory test is terminated when a 60 percent weight loss is obtained in nondurable wood reference blocks. Durability may be classified as follows:

Highly resistant	0-10 pct. weight loss
Resistant	11-24 pct. weight loss
Moderately resistant	25-44 pct. weight loss
Slightly or nonresistant	45 pct. or above weight loss

III-6. Decay Resistance of Treated Sapwood

Treated sapwood of two species of eucalypts and two species of forest grown trees shall be used in these assessments. The two species selected from each group should be representative of specific gravity extremes and should fall in the "Good Absorption" category as determined in the wafer treatability assay.

Suggested levels of treatment (obtained by varying treating solutions of CCA) may be 4, 8 and 12 Kg/M^3. Ten trees per species with six replications per test condition will require about 1,500 test blocks. Evaluations of resistance to decay fungi shall be conducted following ASTM D 1413 procedures (see ref. 1).

III-7. Termite Resistance

Species selected for heartwood durability assessments (paragraph III-5 and the four species selected for the determinations of decay resistance of treated sapwood (paragraph III-6) shall be used in the termite study.

Again, the sapwood will be treated to the same suggested three levels of CCA salt retention (III-6).

The technique developed by Howick and Creffield (see ref. 9) shall be used as a guide.

Test sites selected shall be adjacent to active subterranean termite colonies. Test specimens shall be inspected and rated after 6 months and 1 year of exposure. Rating system can be the same as that used in ASTM D 1758 (see ref. 3):

Numerical Rating	Description of Termite Attack
10	Sound, no attack
9	Trace of attack
7	Moderate attack
4	Heavy attack
0	Specimen destroyed

III-8. Field Tests--Stakes and Posts
(See refs. 3 and 4)

Based on test results obtained in III-3 through III-7 above, stake tests can be prepared from heartwood or treated sapwood (three levels of CCA and 8 Kg/M^3 of 5 pct. pentachlorophenol in heavy petroleum solvent) and installed in test plots to represent three climatic conditions (perhaps low elevation (Santa Cruz), intermediate elevation (Tarija) and high elevation (La Paz).

The stake tests may simulate sawn products (vineyard stakes, construction lumber, and railroad crossties).

Two-meter lengths of treated posts (three CCA retention levels) can also be installed at the same test sites noted above and can be of small top diameters (± 10 cm) to represent fencing and vineyard supports and large top diameters (± 20 cm) to represent utility poles.

The stake and post graveyard tests are supplementary to this study and cannot be completed within the three years allocated. Nevertheless, such long-term demonstration can be of considerable value for demonstration to potential users of treated wood products and should be included as an adjunct study to be carried out by the CDF or one of the cooperators.

U.S. Federal specifications are enclosed (see ref. 10) and can be used as a guide for determining desirable retention levels for various preservatives and products. It is suggested that for hardwoods under tropical exposure, the CCA retention should be increased by 25 percent. Cresote and penta retention may be followed as specified.

Also enclosed are the American Wood-Preservers' Association Standards P5-81 "Standards for Water-Borne Preservatives," (see ref. 5). It is my understanding that CCA wood treating salts supplied under the names Boliden K-33 or Wolman are both Type C with the following active ingredients:

Hexavalent chromium, as CrO_3	47.5 pct.
Copper, as CuO	18.5 pct.
Arsenic, as As_2O_5	34.0 pct.

Whatever CCA formula is used in this study, the exact composition must be made available from the supplier!

IV. EQUIPMENT NEEDS

A. Wafer Assay for Treatability

1. Plug or bung cutters - plug dia. 7/8" or 1"
   (McMaster-Carr Supply Co., P.O. Box 4355,
   Chicago, IL 60680, U.S.A.)

   Cat. No. 2806A21
   6 each at $21.00 — $126.00

2. Glass vacuum desiccator - 250 mm I.D.
   (Fisher Scientific, 711 Forbes Ave.,
   Pittsburgh, PA 15219 U.S.A.)

   Cat No. 08-631B
   2 each at $185.85 — $371.70

3. Dial and Vernier Caliper - 5 in., vernier 0.1 mm
   (McMaster-Carr Supply Co.)

   Cat. No. 8588A 12
   2 each at $28.19 $ 56.38

4. Aspirator
   (Fisher Scientific)

   Cat No. 09-956
   4 each at $15.15 $ 60.60

5. Vacuum Gauges - 0-30 in. (101 K Pa) Hg
   (Fisher Scientific)

   Cat No. 11-279A
   3 each at $31.00 $ 93.00

All other equipment needs available at the Santa Cruz and Tarija laboratories.

B. Specimen Preparation-Pretreatments

1. For stain and insect control during seasoning:

   Permatox 10-S 200 lbs. at $.67/lb. $134.00
   Ambrocide 10 gal. at $15.15/gal. $151.50

   (Chapman Chemical Co., P.O. Box 9158,
   Memphis, TN 38109 U.S.A.)

All other equipment needs available.

C. Soil Block Tests (See refs. 1 and 2)

Equipment should be of a size that can handle about 500 test block cultures per 16 week incubation periods. Requirements are:

1. Autoclave (Fisher 14-461-5 or equiv.) $278.95

2. 1000 French square bottles, 8 oz.
   (Fisher Scientific)

   Cat. No. 03-325DD
   84 at $96.50 per box $1,160.00

3. Incubation and Condition Room

   Will require purchase of suitable chamber or adapt a small room with humidity and temperature controls- (See ASTM D 1413 and D 2017) *

4. Laminar Flow Clean Bench (Fisher Scientific)

   Cat. No. 92-950 $1,155.00

*A suitable chamber may be made by installing temperature and humidity controls in a small room at a cost of less than $500 or the purchase of a chamber that may cost $10,000 and more.

V. TRAINING NEEDS

For setting up facilities for soilblock cultures and for a short training program, it is suggested that very early in the research program, Norma Rodriguez (Univ. G. R. Moreno, Santa Cruz) visit the Forest Products Laboratory, Madison, Wisconsin, to observe test procedures and to make arrangements for purchase of necessary equipment and supplies.

2 weeks

VI. REFERENCE ENCLOSURES (See Appendix B)

1. American Society for Testing Materials.
1976. Standard method of testing wood preservatives by laboratory soilblock cultures. ASTM D 1413. Philadelphia, PA.

2. _______.
1978. Standard method of accelerated laboratory test of natural decay resistance of woods. ASTM D 2017. Philadelphia, PA.

3. _______.
1980. Standard method of evaluating wood preservatives by field tests with stakes. ASTM D 1758. Philadelphia, PA.

4. _______.
1980. Standard method for field evaluation of wood preservatives in round post-size specimens. ASTM D 2278. Philadelphia, PA.

5. American Wood-Preservers' Association.
1981. Standards for water-borne preservatives. AWPA P5-81.

6. Chudnoff, M.
1970. Wafer assay for treatability of wood. For. Prod. J. 20(9): 103-107.

7. Chudnoff, M., and E. Goytia.
1971. Treatability of Puerto Rican woods. USDA Forest Serv. Inst. Trop. Forestry Res. Pap. ITF-11.

8. Comision Panamericana de Normas Tecnicas.
1972. COPANT R-461, 30: 1-006, R-464, R-466, R-463, R-465. Buenos Aires. (Not supplied, available from PADT-REFORT).

9. Howick, C. D., and J. W. Creffield.
1983. A rapid field bioassay technique with subterranean termites. IRG/WP/1188 Paper, 14th Meeting, Surfers Paradise, Australia. 9-13 May 1983.

10. U.S. Federal Specifications.
1968. Wood preservation: Treating practices TT-W-00571J (AGR-AFS). Fed. Spec. TT-W-571i.

APPENDIX A

VISCARRA PRELIMINARY PROPOSAL

PLANTEAMIENTO GENERAL PARA DESARROLLAR UN PROYECTO SOBRE PRESERVACION DE MADERAS EN BOLIVIA

El trabajo total está dividido en dos subproyectos:

SUBPROYECTO No. 1.- (SANTA CRUZ)

1. Título.- "Características de preservación y durabilidad natural de maderas nativas y de plantaciones procedentes del departamento de Santa Cruz".

2. Organismo contraparte.- Centro de Desarrollo Forestal

3. Organismos participantes.- Programa Plantaciones Forestales Cámara Nacional Forestal

4. Localización.- Santa Cruz de la Sierra

5. Objetivos.-

   5.1 Estudiar las características de durabilidad en condiciones naturales y de laboratorio de maderas prodedentes de plantaciones y del bosque natural de Santa +Cruz.

   5.2 Estudiar las características de preservación de las maderas procedentes de plantación y del bosque nativo de Santa Cruz.

   5.3 Aportar datos de rendimientos y costos en el tratamiento de impregnación.

   5.4 Capacitación de personal técnico nacional y divulgación de información referente a tratabilidad y durabilidad de muestras maderas.

6. Antecedentes.- El Programa Plantaciones Forestales ha venido desarrollando desde 1974 plantaciones de diferentes espécies en el departamento de Santa Cruz. Las espécies empleadas fueron mayormente exóticas de rápido crecimiento (eucaliptos).

   Actualmente las plantaciones están en etapa de raleo. Uno de los problemas que limitan la utilización de la madera producto de raleos es la es-

escasa durabilidad del material en algunas formas de uso como postes en contacto con el suelo.

El proyecto propuesto en este documento pretende determinar en una primera etapa, las características de durabilidad de la madera de plantación y estudiar la tratabilidad de esa madera con producto s químicos - tóxicos a insectos y hongos.

Luego, en una segunda fase se pretenden ampliar los estudios de durabilidad y tratabilidad, hacia las maderas nativas actualmente poco utilizadas y no explotadas.

7. Infraestructura disponible.-

Se cuenta con un laboratorio con varios equipos que pueden ser complementados en función al trabajo y a la metodología a desarrollar en el - presente proyecto.

8. Especies a estudiar y metodología general.-

8.1 Madera de Plantación (Espécies a estudiar en una primera etapa):

Eucalipto de zona baja (400 a 500 m.s.n.m.):

1 - Eucaliptus camaldulensis
2 - Eucaliptus tereticornis
3 - Eucaliptus grandis
4 - Eucaliptus saligna
5 - Eucaliptus alba
6 - Eucaliptus robusta
7 - Eucaliptus citriodora
8 - Eucaliptus maculata

Eucalipto de zona alta (900 a 1.200 m.s.n.m.):

1 - Eucaliptus globulus
2 - Eucaliptus maidenii
3 - Eucaliptus viminalis

8.2 Las espécies a estudiar en segunda etapa (maderas nativas) procedentes de las reservas forestales Choré y Guarayos) se seleccionaran - de la siguiente lista de volúmenes mayores a 0,5 m3/Ha.

Espécies	Reserva Guarayos M3/Ha.
1.- Ajo	5,26 •
2.- Bibosi	4,84
3.- Blanquillo	1,43 ⊙
4.- Cari cari	0,52 •
5.- Coco	0,71
6.- Colorado	1,19 ⊙
7.- Copaibo	1,80 •
8.- Coquino	1,80
9.- Cuqui	2,07 •
10.- Curupaú	1,91
11.- Gabetillo	0,81
12.- Guayabochi	10,56
13.- Higueron	2,38 •
14.- Jichituriqui	0,66
15.- Jorori	0,58
16.- Laguno	1,24
17.- Mapajo	5,35 •
18.- Mara	4,44
19.- Momoqui	1,93
20.- Ochoo	23,37 •
21.- Ojoso	0,93
22.- Pacay	1,57
23.- Paloto	1,09
24.- Pitón	0,51
25.- Piñon	0,65
26.- Sapito	1,32
27.- Sirari	0,61
28.- Sopaimori	0,65
29.- Sujo	052
30.- Tarara	0,72
31.- Toborochi	0,67
32.- Sujo	
33.- Turure	0,56
34.- Verdolago	3,04 ⊙
35.- Yesquero	0,98 ⊙
Sub Total	
Total bosque	93,91

Espécie	Reserva El Chore M3/Ha.
1.- Amargo ••	1,34 ⊙
2.- Bibosi	8,99
3.- Blanquillo •	1,16
4.- Cedrillo	0,92
5.- Coloradillo.	1,12
6.- Coquino	0,90
7.- Chocolatillo	1,16
8.- Gabetillo	1,27
9.- Guayabochi	1,07
10.- Kaqui	1,27 •
11.- Lecheso Leche leche	0,93
12.- Mapajo •	0,56
13.- Mara	1,14
14.- Mururé	4,13 ⊙
15.- Negrillo	1,30
16.- Ochoo •	26,79
17.- Ocorosillo	0,75
18.- Ojose	2,01 •
19.- Pacay	0,77
20.- Piraquina	0,68
21.- Picana	0,76
22.- Sirari	0,92
23.- Tachore	8,34 •
24.- Verdolago •	5,22
25.- Yesquero	0,62 ⊙
26.- Xipapote	6,05
Sub total	
Total bosque	87,38

p.br
.4 ochoo Treat a 3 levels of CCA
.6 Cuqui + evaluate soil block 000000000ooo000000000
• more, abundant species not for furniture or other special uses..

⊙ distict heartwood
test for soil block

8.3 Metodología General.-

En una primera fase se plantea el estudio de durabilidad y tratabilidad de madera procedente de plantación.

Este trabajo preliminar de once especies permitirá, (por tratarse de bosque implantado, cercano a la ciudad, de fácil acceso en la obtención de material de estudio) capacitarpersonal nacional y ganar experiencia que luego será aplicada en el estudio de las maderas nativas.

Para el estudio de durabilidad se instalaran cementerios de madera en diferentes regiones, donde el riesgo de ataque de hongos, termites y demás insectos sea elevado. Se considera también el estudio de la durabilidad por métodos de laboratorio (soil block según ASTM).

En el estudio de tratabilidad se aplicará el método de rebanadas o rodajas de madera impregnadas en desecador aplicando vacío y presión atmosférica. Estos ensayos se verificarán utilizando material a escala mayor (postes) impregnando en una planta de tratamiento por vacío-presión de la región.

10.-Requerimientos Básicos.-

10.1 Un vehículo tipo camioneta Toyota 4x4

10.2 Adiestramiento de dos técnicos de éste proyecto bajo un programa específico de trabajo a desarrollar en un laboratorio de Norte América (preferiblemente el FLP de Madison y la Universidad de Wisconsin). Al mismo tiempo que se desarrolla el programa de investigación, posiblemente se pueda asistir a los cursos sobre tecnología de la madera que organiza la Universidad de Wisconsin.

En lo posible, el adiestramiento bajo un programa de investigación comprenderá la realización de estudios en maderas bolivianas que no son posibles de realizar en Bolivia.

Se estima alrededor de un año para el adiestramiento del personal.

10.3 Adiestramiento de un técnico a nivel medio para que aprenda el manejo y mantenimiento de la planta de preservación del CDF. Sería conveniente que este entrenamiento se realice en el lugar de donde proviene la Planta (Cali- Colombia) o en un lugar de habla española. Tiempo de entrenamiento probable: tres meses.

10.4 Contratación de personal, consistente en:

- dos ingenieros Forestales por tres años, uno para trabajo de coordinación del proyecto en Santa Crus y otro para trabajo de campo.
- Un ayudante de investigación, tres años.
- Obreros.

10.5 Apoyo a personal nacional para evitar deserciones de investigadores por bajo sueldo. El apoyo debería consistir en pago de pasajes, viáticos y bonos de trabajo para crear las condiciones de estabilidad y continuidad de trabajo del personal del proyecto.

10.6 Bibliografía básica consistente en libros de texto, revistas, folletos y demás papers referentes a ciencia y tecnología de maderas.

10.7 Químicos de laboratorio: sales CCA, reactivos para ensayos de coloración del preservante en las muestras (penetración) resina epoxi para sellado de nuestras, pinturas, pintura-impermeabilizante, etc.

10.8 Accesorios para completar el equipo de laboratorio, consistente en Sacamuestras para incorporar al taladro, desecadores de vidrio con conexión en el tope para una manguera, vasos de precipitación, desímetros para control de preservante,

10. Forma de participación de las Instituciones en el programa (Subproyecto Nº 1):

9.1 CDF.- Aportará algunos técnicos, equipo de laboratorio (estufas, balanzas, etc), infraestructura (sus edificaciones del Padt Refort), personal de apoyo (chofer, secretaria).

9.2 - PPF.- El programa Plantaciones Forestales aportará con el material de ensayo procedente de Plantaciones, terreno para instalación de dos cementerios de madera recopilando información de costos (y algún personal de apoyo).

9.3 - CNF.- La cámara Nacional Forestal apoyará con el corte de árboles y preparación de muestras de ensayo y con el transporte del material.

9.4 - Universidad realizará los trabajos de biodeterioración de las muestras en condiciones de laboratorio.

SUBPROYECTO Nº 2.- (TARIJA............)

1. **Titutlo**.- Estudio de Preservación, Durabilidad, Propiedades Físicas y Mecánicas de Maderas ~~xxxxFactibilidad~~ del Departamento de Tarija

2. **Organismo Contraparte**.-

   Centro de Desarrollo Forestal

3. **Organismos Participantes**.-

   Universidad Juan Misael Saracho de Tarija

   Corporación Regional de Desarrollo de Tarija

4. **Localización**.-

   Tarija

5. **Objetivos**.-

   - Estudiar diferentes ~~especies~~ maderas nativas de dos zonas ecológicas del departamento de Tarija (bosque seco Subtropical y bosque húmedo subtropical), considerando su tratabilidad,
   - durabilidad, propiedades físicas y mecánicas.
   - Capacitación de personal técnico nacional en tecnología de maderas y divulgación de las características técnicas de las maderas de Tarija

6. Antecedentes.-

Hasta la fecha, no se realizó un estudio técnico en los bosques de Tarija tendiente al conocimiento de las características físicas, mecánicas, de tratabilidad y durabilidad.

Teniendo en cuenta que los bosques naturales del departamento tienen características diferentes de un lugar (Chaco) a otro (Tariquía) con especies de gran potencial para ingresar al marcado nacional maderero, si se conocen sus propiedades tecnológicas, el presente estudio pretende iniciar una investigación sistemática de las maderas del departamento de Tarija

7. Infraestructura disponible.-

7.1. Equipo.-

Se cuenta con una planta depreservación por vacío-presión una prensa universal de enayos AMSLER de 40 ton.
Estufas, balanzas, equipo de anatomía de maderas y ensayos físicos.

7.2. Personal.-

Dos ingenieros entrenados en técnología de maderas
Un dendrólogo con experiencia

8. Especies a estudiar y metodología general.-

8.1. Maderas de bosque seco subtropical:

(a preparar despues de revisión de inventarios forestales realizados en la región - se estudiarán unas 5 a 8 especies)

8.2. Maderas del bosque húmedo subtropical:

(se tomarán de acuerdo a los resultados del inventario por FAO en la zona sur-centro de Tarija) - posiblemente se estudien 12 a 15 especies)

8.3. Metodología General.-

En cuanto a tratabilidad y durabilidad, el trabajo será encarado demanera similar que paranel caso del Suproyecto 1 (Santa Cruz). La verificación de los resultados obtenidos en estudio de rodajas (wafers), se hará ensayando material de mayor tamaño.

En una primera fase (un año de duración) se pretende realizar los estudios de durabilidad y preservación, luego en una segunda fase (dos años deduración) se piensa considerar los ensayos físcos, y mecánicos de las maderas con mayor durabilidad natural.

Tiempo total del estudio en dos fases: tres años.

Los trabajos que no pudieran realizarse en Tarija (posiblemente pudrición demadera en condiciones delaboratorio), tienen pssibilidad de jecutarse en la Universidad de Santa Cruz.

9. Rquerimientos básicos.-

9.1 Accesorios para equipo de laboratorio

- Para presnsa AMSLER : accesorio para ensayo de cizalle según ASTM
  deflectómetros, y abrazaderas para ensayos de compresión paralela
- Para planta de impregnación: cañería de alta presión para la caldera y los tanques.
- Densímetros , accesorio para preparar las rodajas.

9.2. Camioneta

9.3. Un ingeniero en técnicas de preservación (coordinador del proyecto en Tarija)

- Adiestramiento de un técnico medio en manejo y mantenimiento de la planta de preservación dela Universidad. Tiempo estimado: tres meses en un laboratorio dehabla española.

9.4. Bilbiografía técnica, libros, folletos, revistas sobretecnología de maderas.

9.5. Algún material químico de laboratorio: sales, reactivos para coloración de las muestras, resinas epoxi,

9.6. Apoyo a personal nacional consistente en pasajes, viáticos y bonos de trabajo.

10. Forma de participación de las Instituciones.-

CDF: Proporcionando dos técnicos de apoyo, chofer, secretaria

Universidad: proporcionando equipo de laboratorio, infraestructara y personal técnico de experiencia.

Corporación de Desarrollo de Tarija: proporcionando el material de estudio, transporte de muestras a laboratorio

11. sugerencia para coordinador del proyecto en Tarija: S. Viscarra

APPENDIX B

REFERENCE PUBLICATIONS

Standard Method of Testing
WOOD PRESERVATIVES BY LABORATORY SOILBLOCK CULTURES[1]

This standard is issued under the fixed designation D 1413; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers determination of the minimum amount of preservative that is effective in preventing decay of selected species of wood by selected fungi under optimum laboratory conditions.

1.2 The requirements for preparation of the material for testing and the test procedure appear in the following order:

2. Applicable Documents

2.1 *ASTM Standards:*

D 841 Specification for Nitration Grade Toluene[2]

D 1193 Specification for Reagent Water[3]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[4]

2.2 *American Wood Preservatives Association:*

M-1-66 Method to Determine the Comparative Leachability of Wood Preservatives[5]

3. Summary of Method

3.1 Conditioned blocks of wood are impregnated with solutions of a preservative in water or suitable organic solvent to form one or more series of gradient retentions of the preservative in the blocks. After periods of conditioning or weathering, the impregnated blocks are exposed to one or more strains of wood-destroying fungi, one fungus for each test series. The minimum amount of preservative that protects the impregnated blocks against decay by a given test fungus is defined as the threshold retention for that organism. Failure to protect is evidenced by loss of wood from the treated wood blocks, as indicated by a loss in weight.

3.2 Provision must be made for coordinated preparation of the test cultures and for impregnation, conditioning, or weathering and conditioning, of the test blocks.

4. Apparatus

4.1 *Conditioning Room*, maintained at a selected temperature between 20 and 30°C

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[1] This method is under the jurisdiction of ASTM Committee D-7 on Wood and is the direct responsibility of Subcommittee D07.13 on Durability and Exposure.
Current edition approved April 30, 1976. Published June 1976. Originally published as D 1413 - 49. Last previous edition D 1413-61 (1970).

[2] *Annual Book of ASTM Standards*, Part 29.

[3] *Annual Book of ASTM Standards*, Parts 20, 21, 22, 29, 31, 37, and 40.

[4] *Annual Book of ASTM Standards*, Parts 13, 14, 15, 18, 26, 30, and 41.

[5] American Wood Preservatives Assn., 1625 Eye St., N.W. Washington, D.C. 20006

(68 and 86°F) and a selected relative humidity between 25 and 75 %. The selected temperature shall not vary more than ± 1°C (± 2°F) and the selected humidity not more than ± 2 %.[6]

4.2 *Incubation Room or Incubation Cabinet*, maintained at a selected temperature between 25 and 27°C (77 and 81°F) and a relative humidity between 65 and 75 %. The selected temperature shall not vary more than ± 1°C (± 2°F) and the selected humidity not more than ± 2 %.

4.3 *Drying Oven*—A suitable, vented oven, maintained at a temperature of 105 ± 2°C (220 ± 4°F).

4.4 *Steam Sterilizer*.

4.5 *Balances*, fast-acting types preferred, sensitive and accurate to 0.01 g.

4.6 *Vacuum Pump or Water Suction Pump*, capable of reducing pressure to 100 mm (3.94 in.) Hg, or less.

4.7 *Impregnation Apparatus*—A suitable desiccator or bell jar shielded to protect personnel in event of breakage, provided with suitable separatory funnel or auxiliary flask for holding the treating solution and vacuum gage or manometer (Fig. 1).

4.8 *Trays or Racks, or Pin Bars*—Trays or racks made from suitable screening to permit free air movement around each block during initial drying and for convenient handling of the test blocks. Pin bars facilitate handling (see 6.2).

4.9 *Weathering Apparatus:*

4.9.1 *Forced Draft Oven*.[7]

4.9.2 Apparatus designed for weathering salts-treated blocks is described in AWPA Method M-1-66.

4.10 *Culture Bottles*, cylindrical or square (Note 1), capacity nominal 225 or 450 cm³ (8 or 16 oz), fitted with screw caps without liners (Fig. 2).

NOTE 1—*Culture Bottles:*

(1) 225-cm³ (8-oz) French square, for use with one block only.

(2) 225-cm³ (8-oz) cylindrical, for use with one or two blocks.

(3) 450-cm³ (16-oz) cylindrical, for use with two blocks only.

4.11 *Soil Sieves*—U.S. No. 6 sieve in accordance with Specification E 11.

5. Reagents

5.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the Specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[8] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

5.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Type IV of Specification D 1193.

5.3 *Toluene*, conforming to Specification D 841.

6. Wood

6.1 *General Properties*—Pine sapwood, free of knots and visible concentration of resins, and showing no visible evidence of infection by mold, stain, or wood-destroying fungi, with 2¹/₂ to 4 rings/cm (6 to 10 rings/in.) should be used for standard comparative tests intended to show comparative wood preserving values of preservatives under test. If southern pine is used, it should be 40 to 50 % summerwood. Whenever practicable, selection of the wood for the test blocks should begin at the sawmill. Quartersawed boards are preferable. Newly cut boards, nominally (25 mm) (1 in.) thick, that are immediately kiln dried without antistain treatment provide chemical-free wood that has had minimum opportunity for fungus infection or deterioration before use in the soil-block culture test.

6.1.1 *Sapwood Identification*—When the boundary between heartwood and sapwood is difficult to recognize, use a color test[9] to distinguish between the two. Uneven absorptions may be caused by the presence of heartwood.

6.1.2 *Conditioning of Parent Boards*—

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[6] Scheffer, T. C., "Humidity Controls for Conditioning Rooms," Forest Products Laboratory Report No. 2048, U.S. Forest Service, 4 pp., 5 Figs., January 1956.

[7] Blue M Model OV 490 A

[8] "Reagent Chemicals, American Chemical Society Specifications," Am. Chemical Soc., Washington, D. C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N. Y., and the "United States Pharmacopeia."

[9] "Standard for Inspection of Treated Timber Products," AWPA Standard M2-73, Section 5.51.

Open-stack the boards in the conditioning room and permit them to come to equilibrium moisture content.

6.2 *Test Blocks* (Note 2), should be cubes milled as accurately as possible to 19 mm (0.75 in.). If desired (for example, for convenience in handling), blocks may be drilled through the center of a tangential face with a 3-mm drill (approximately 0.125 in. or a No. 30 drill). Pin bars may then be used for handling. The volume of the blocks without the hole should be 6.9 ± 0.2 cm^3, determined by caliper or by mercury displacement.

NOTE 2—Stored working stocks of test blocks and feeder strips in the conditioning room. It is desirable to weigh the blocks after they come to approximate equilibrium moisture content in storage or in the conditioning room, and to sort them into fairly narrow-range weight groups. Since the blocks are cut accurately to size this division into weight groups is, in effect, a segregation into density groups (see 10.4).

6.3 *Feeder Strips:*

6.3.1 *General Considerations*—One feeder strip is needed for each block in a culture bottle. If test blocks other than pine are used for special investigations, the sapwood selected for feeder strips should be capable of furnishing a satisfactory growth of the test fungus; for example, sweetgum sapwood often is used with hardwood test blocks and *Coriolus versicolor* (L.) Quél. = [*Polyporus versicolor* L. ex. Fr.] fungus.

6.3.2 *Size*—The feeder strips should be approximately 3 by 28 by 35 mm ($^1/_8$ by 1$^1/_8$ by 1$^5/_8$ in.) with the grain of the wood parallel to either of the long dimensions and with the edge grain exposed to the flat face, insofar as possible.

7. Test Fungi

7.1 *General Considerations*—Always include a tolerant fungus (see 7.2 and 7.3) in testing a preservative. Other economically important fungi may be used in addition to the tolerant fungus in special investigations, or in some cases substituted for it.

NOTE 3—The following numbers refer to standard strains of test fungi maintained in the American Type Culture Collection (ATCC), 12301 Parklawn Drive, Rockville, Md. 20852.

7.2 *Fungus Species for Softwood Sapwoods:*

7.2.1 *Lentinus lepideus* Fr. (Madison 534, ATCC No. 12653)—A fungus particularly tolerant to creosote or to mixtures containing creosotes.

7.2.2 *Gloeophyllum trabeum* (Pers. ex. Fr.) Murr. = [*Lenzites trabea* Pers. ex. Fr.] (Madison 617, ATCC No. 11539)—A fungus particularly tolerant to phenolic and arsenic compounds.

7.2.3 *Poria placenta* (Fr.) Cook = [*Poria monticolor* Murr.] (Madison 698, ATCC No. 11538)—A fungus particularly tolerant to copper and zinc compounds. Suggested for testing mercury compounds.

7.3 *Fungus Species for Hardwood Sapwoods:*

7.3.1 The three fungi listed in 7.2.

7.3.2 *Coriolus versicolor* (L.) Quél. = [*Polyporus versicolor* L. ex. Fr.] (Madison 697, ATCC No. 12679).

8. Culture Media

8.1 *Malt Agar Substrate*—For both stock test-tube and petri dish cultures of the test fungi use a nutrient medium consisting of about 2 weight % malt extract and 1.5 weight % agar. Sterilize the medium at 103 kPa (15 psi) for 20 min and allow to cool before inoculations.

8.2 *Soil Substrate*—Use a soil substrate with a water-holding capacity between 20 and 40 % (Note 4) and pH between 5.0 and 8.0. After breaking up all clumps, mix and screen the soil through the U.S. No. 6 sieve and store in large covered containers. The soil should not be so wet when it is sifted that the particles again stick together. Pass a sample of air-dry soil through a U.S. No. 6 sieve. Use this sieved soil to fill a small Buchner funnel approximately 50 mm in diameter and 25 mm in depth, and fitted with rapid-filtering paper, to somewhat more than capacity. Compact the soil by dropping the funnel three times through a height of 10 mm (0.4 in.) on a wooden tabletop. Level the soil surface by cutting off excess soil with a spatula at the top of the funnel without further compaction. Then place the filled funnel in a 400-cm^3 beaker and retain in an upright position by wedges at the sides of the funnel. Add water to the beaker to a depth slightly beyond the level of the filter paper. Allow the soil to wet by capillarity so as to reduce the danger of entrapping air within the column. When the upper soil surface shows signs of wetting, add more water until the water level approximates the upper surface of the funnel. Place a cover over the beaker, and allow the soil to soak for 12 h or overnight. Then place the funnel in a suction flask which is connected to a water aspirator or vacuum pump, and apply full suction for 15 min. During suctioning, cover the funnel with a moist cloth on which an inverted cup is placed to prevent evaporation of water from the exposed soil surface. After 15 min remove the funnel from the suction flask, scrape the soil into a weighed receptacle, and weigh to obtain the wet weight, W_1. Ovendry for 24 h at 105 ± 2°C (220 F ± 4°F) and reweigh soil, W_2. Determine soil moisture content (water-holding capacity) based on the ovendry weight of soil.

Water-holding capacity (WHC), %

$$= [(W_1 - W_2)/W_2] \times 100$$

Note 4—The water-holding capacity of a soil should be considered as that percentage of water, based on the ovendry weight of the soil, that is retained after subjecting the soil to the following procedure based on a method of Bouyoucos, G. J. A., "A Comparison Between the Suction Method and the Centrifuge Method of Determining the Moisture Equivalent of Soils." *Soils Science*, Vol 40, 1935, pp. 165–170.

8.2.1 *Preparation of Soil Culture Bottles*—The soil substrate, sifted and lightly compacted by tapping, should half-fill a culture bottle. This amount of soil, about 120 cm^3 for an 8-oz culture bottle, should weigh not less than 90 g when ovendried. The water in the completed soil culture bottle should be 130 % of the water-holding capacity of the soil. To determine the amount of additional water needed, weigh the volume of soil that will be used to half-fill a culture bottle, W_3. Dry this soil at 105 ± 2°C (220 ± 4°F) for 12 h and reweigh, W_4. Calculate the amount of water to be added to each culture bottle with that particular soil as follows:

Water required, g

$$= (\text{WHC} \times 0.013 \times W_4) + W_4 - W_3$$

8.2.2 Add the required amount of water to each culture bottle. Then add the corresponding volume of soil to each bottle. Level the soil surface and place directly on the soil one sapwood feeder strip for each test block to be used. Steam sterilize the prepared bottles, with caps loosened, at 103 kPa (15 psi) for 30 min. This sequence of steps generally leaves the inside surfaces of the culture bottles clean above the soil level and the water diffuses through the soil during sterilization without puddling. A funnel with a stem of large diameter that reaches nearly to the bottom of the culture bottles can be made and used to admit soil with minimum dust settlement on the glass.

9. Preparation of Test Cultures

9.1 After the sterilized soil culture bottles are thoroughly cooled, cut approximately 10-mm square fungus inoculum sections from a petri dish culture that is not more than 3 weeks (Note 5). Immediately place the square of inoculum in contact with an edge of the feeder strip on the soil. Close the culture bottles with lids released one-fourth turn from a tightened position, and incubate at the desired temperature for approximately 3 weeks or until the feeder strips are covered by mycelium. The culture bottles are now ready to receive the test blocks.

Note 5—When not in active use, store the test cultures in test tube agar slants in a refrigerator maintained between 2 and 5°C (35 and 40°F). When the slants are used to inoculate petri dishes, inoculate and incubate replacement slants until the surface of the slant is covered by mycelium prior to refrigeration. The test tube that works well is a 150 by 16 mm, equipped with a plastic screw cap. It is recommended that the liner in the cap be removed before using. Depending on the type of refrigerator used, check the agar slants every 1 to 2 months for loss of moisture. When the culture appears excessively dry, prepare new slants and inoculate (see 8.1). It is suggested that three test tube slants of each test fungus be maintained as outlined above.

10. Preparation and Impregnation of Test Blocks

10.1 *Initial Conditioning and Initial Weights*—Before impregnation, condition the test blocks by either of the following methods:

10.1.1 *Conditioning at Specified Temperature and Relative Humidity*—Mark each block (for example, with waterproof ink) and bring the test blocks to a constant moisture equilibrium in the conditioning room. Weigh the blocks to the nearest 0.01 g just before treatment. This weight (T_1) is referred to as the initial or untreated weight of the test block (Note 6). After weighing keep the test blocks in the conditioning room until they are to be impregnated with the preservative.

NOTE 6—Coding the different weights as T_1, T_2, etc., avoids confusion and simplifies recording data. The suggested system of T designations is as follows, record all weights in grams:

T_1 = initial weight of the conditioned or ovendried test block before impregnation,
T_2 = weight of the test block immediately after impregnation and wiping (equals T_1 plus grams of treating solution absorbed),
T_3 = weight of test block plus remaining preservative after conditioning and before exposure to the test fungus,
T_{3w} = weight of the test block plus remaining preservative after weathering or leaching and conditioning and before exposure to the test fungus,
T_m = weight of the test blocks immediately after removal from the test bottle and after adherent mycelium has been brushed off, and
T_4 = weight of the test block after test and after final conditioning.

10.1.2 *Ovendrying*—Dry the marked blocks in the drying oven (see 4.3) for 24 h. Remove the blocks to a desiccator and when cool weigh each block to the nearest 0.01 g. This weight is the initial or untreated weight of the block (T_1). Keep the ovendried blocks over phosphorus pentoxide in an appropriate desiccator until impregnated.

10.2 *Preparation of Treating Solutions of Preservatives Under Test*—Make up the treating solutions of the preservatives in appropriate gradient concentrations so as to leave in the blocks, after removal of the solvent, a range of retentions running from below to above the anticipated threshold. The lowest retention (exclusive of blocks treated with solvent only, see 10.6) shall be low enough to permit fungus attack and consequent decay and definite weight loss. When the preservative is soluble in water make the required concentrations with reagent water. Preservatives that are insoluble in water, such as creosote, creosote-coal tar solutions, and solutions of pentachlorophenol or copper naphthenate in an oil carrier, dilute with toluene. The dilutions are necessary to provide a uniform distribution of preservative at retentions low enough to permit fungus attack and to determine threshold values for the various test fungi employed. All preservatives should be in such a state of solution before use that the active ingredients will be well distributed throughout the treated wood. The number of concentrations to be made up for any given preservative depends on whether it is possible to anticipate a threshold and how close it is necessary to determine it. The preferred procedure is to run a preliminary test to locate an approximate threshold, and then to run a critical series of tests, narrowing the interval between concentrations around the level of the approximate threshold.

10.3 *Number of Blocks in a Treatment Group*—The number of blocks to be treated with a given concentration of preservative, for testing by a single fungus, may vary. Usually, it is desirable to treat the least number of blocks per concentration required to prepare no less than four test bottles. The smaller the interval between concentrations of treating solution, the smaller the number required. The primary concern should be to see that the number of blocks is sufficient to define clearly the relation between preservative retention and weight change in the blocks during test.

10.4 *Treatment Procedure*—It is desirable to choose blocks for treatment that have the narrowest practicable spread in density; for example, weight differences not exceeding 0.5 g among blocks in a given test are desirable and should be obtainable. Place the blocks to be treated with a given concentration of preservative in a suitable beaker and weight them down to prevent eventual floating on the treating solution. Place the beaker in the desiccator or bell-jar of the impregnation apparatus (Fig. 1) directly below the outlet from the separatory funnel or treating solution flask. Attach the apparatus to the vacuum or suction pump and reduce the pressure in the treating chamber to 100 mm (3.94 in.) Hg or less and hold this pressure for 20 to 30 min. Pour the prepared solution of the preservative into the separatory funnel or solution flask, using sufficient solution so that the blocks will remain covered after the treatment is completed. At the end of the holding period close the stopcock to the vacuum or suction pump and open the access to the separatory funnel or solution flask so that the treating solution flows into the beaker with the test blocks and covers them. Then the partial vacuum is broken. Remove the beaker from the treating chamber and cover with a watch glass or plastic film to minimize loss of treating solution by evaporation. Leave the blocks submerged in the treating solution for at least 30 min. A longer time is necessary for some treating solutions in order to obtain maximum and uniform absorptions in the blocks (Note 7). Remove the blocks from the solution individually, wipe lightly to remove surface preservative solution, and immediately weigh to the nearest 0.01 g (T_2). Record the gain in weight ($T_2 - T_1$) as the grams of treating solution absorbed (Note 6).

NOTE 7—Calculated retentions are based on equal distribution of the preservative in the wood. Such distribution is obtained only if the absorptions represent the total amount of liquid a block will hold. Most of the air has been evacuated from the wood before the preservative solution is introduced, leaving the cell cavities free to be filled with the solution. The amount of air space available to hold liquids has been determined for woods of different density and moisture content.[10] The approximate maximum absorption to be expected can therefore be computed from the percentage of air space and the specific gravity of the treating solution. The greater the volume of air space (the lower the density), the greater the absorption that should be obtained if all air cavities are filled. With water-soluble preservatives, absorptions are higher than for oil-type preservatives because water not only fills the air spaces, but is also absorbed in the cell walls.

10.5 *Calculation of Retentions*—Calculate the amount of preservative absorbed by the block, that is, the retention, as kilograms per cubic metre (kg/m³) of wood as follows:

$$\text{Retention, kg/m}^3 = (GC/V) \times 10$$

and as pounds of preservative per cubic foot (lb/ft³) of wood as follows:

$$\text{Retention, lb/ft}^3 = (GC(62.4)/100\ V)$$

where:

G = $(T_2 - T_1)$ = grams of treating solution absorbed by the block (initial weight of block before treatment subtracted from the initial weight plus the treating solution absorbed),

C = grams of preservative in 100 g of treating solution,

V = volume of block, cm³, and

62.4 = factor for converting grams per cubic centimetre to pounds per cubic foot.

To convert kg/m³ to lb/ft³, divide by 16.0.

10.6 *Control Blocks*—For each fungus used in a preservative test, condition and treat with solvent only at least five blocks taken from the density lot being used in that particular test. Put these control blocks through all steps of the decay test. The uniformity of weight loss caused in them by the test fungus serves as an indication of the normalcy of the individual tests and an indication of the stability of test conditions from one test to another. The control blocks also provide weight change data for use when it is desired to correct the weights of blocks for changes in moisture content in solvent retention. Similarly, untreated control blocks in the same density range should be put through all stages of the decay test when evaluating, for example, undiluted creosote or some chemical modification of wood.

11. Conditioning Treated Blocks

11.1 After the blocks have been impregnated and weighed to obtain absorption, space them on trays or racks and expose them under open laboratory room conditions for 48 to 72 h. Then place all such treated blocks, whether initially conditioned or ovendried, in the conditioning room and leave them there for 21 days, unless the blocks are to be weathered (see 12.1).

11.2 Weigh the individual blocks to the nearest 0.01 g (T_3) just before they are sterilized and subsequently placed in contact with the test fungus on the feeder strip (see Section 13). This weight (Note 5) will be used in determining the loss during the decay test (see Section 16).

12. Preservative Permanence

12.1 *Weathering Procedure for Oil-Type Preservatives*—Start the weathering procedure 3 days after treatment of the blocks. Expose the blocks first to a leaching test and then to a volatility test. The schedule for both totals is approximately 14 days.

12.1.1 *Leaching Test*—Space equally all blocks of a given retention group, but no more than eight per beaker, on hardware cloth supports in 600-cm³ beakers. Weight down the blocks in each beaker and add water to fill the beaker. Keep the water at room temperature for 2 hours. Then pour off the water, remove the weights and proceed with the volatility test.

12.1.2 *Volatility Test*—Prior to placing the beakers containing the blocks in the weathering apparatus (see 4.9.1), check to make sure that the blocks are still spaced equally on the

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[10] MacLean, J. D., "Effect of Moisture Changes on the Shrinkage, Swelling, Specific Gravity, Air or Void Space, Weight, and Similar Properties of Wood," Forest Products Laboratory Report No. 1448., U.S. Forest Service, 1958.

hardware cloth without touching the side of the beaker or one another. Weather the blocks for 334 h (13.9 days) at a suitable temperature to maintain the blocks at 48.9 ± 1.1°C (120 ± 2°F). Periodically, measure the temperature inside an untreated block by means of a thermocouple snugly or tightly fitted in a small hole drilled halfway through the block, to assure that the specified temperature is being maintained. Repeat for different beakers or trays to ensure uniform temperature throughout the oven.

12.2 *Leaching Procedure for Water-Borne Preservatives*—Expose the blocks to leaching by reagent water in a constant-temperature room maintained at 27 ± 1°C (80 ± 2°F). For each retention group, place four treated blocks in a 225-cm³ (8-oz), widemouth, screw-capped bottle and weight them down with inert material and cover the blocks with 50-cm³ of water for each block. Place the bottles containing the blocks covered with water in a vacuum desiccator and evacuate to a pressure of 100 mm (3.94 in.) Hg or less for ½ h or until air bubbles cease to escape from the submerged blocks. Then break the vacuum to allow the impregnation of blocks by the water, and remove the weights from the blocks. After 6, 24, and 48 h, and thereafter at every 24-h interval for a period of 2 weeks remove the leach water from the bottle, measure in a graduate and save for analysis if desired. Replace the amount of leach water removed by a fresh change of water.[5]

12.2.1 *Loss of Preservative*—Remove any film, especially in the case of copper bearing preservatives, adhering to the glass walls of the bottles with hydrochloric acid and add to the leach water for analysis. Check 10-cm³ aliquots of the 6-h leach water qualitatively for each of the components in the original salt formulation. When the presence of leached components has been established qualitatively, determine their amount by appropriate chemical analysis. Calculate the loss from the original retention, as determined by the weight increase of the blocks ($T_2 - T_1$).

12.3 *Weight After Weathering or Leaching*—At the end of the weathering or leaching procedure, place the blocks directly in the conditioning room. As soon as the blocks have reached a constant moisture equilibrium, weigh each block to the nearest 0.01 g (T_{3w}).

13. Sterilization of Treated Test Blocks and Placement in Culture Bottles

13.1 Before putting the test blocks in the culture bottles, place them by retention groups into closed containers and steam at 100 ± 2°C (212 ± 4°F) for 20 min. After cooling, aseptically place the test blocks, with a cross-section face centered in contact with the mycelium-covered feeder strip, in the previously prepared culture bottles (see 4.10 and 9.1).

14. Incubation and Duration of Test

14.1 Place screw cap snugly on each culture bottle, then loosen one-quarter turn (see Section 9). Place the culture bottles containing the test blocks in the incubation room and keep them there for 12 weeks.

15. Handling Test Blocks After Exposure to Test Fungi

15.1 At the end of the incubation period (see Section 14), remove the blocks from the culture bottles. Carefully brush off the mycelium. If data on moisture content in the blocks are desired, weigh the individual blocks to the nearest 0.01 g (T_m). Then place the blocks on trays or racks and first dry under relative humidity conditions at least 20 % below the relative humidity of the conditioning room, where the blocks will dry to a moisture content at least 2 % below the approximate average 12 % moisture they will reach in the conditioning room. Heat in excess of 32°C (90°F) should not be used. Then bring the blocks to moisture equilibrium in the conditioning room, after which weigh individually to the nearest 0.01 g (T_4).

16. Calculation of Weight Losses

16.1 Calculate the weight loss from the conditioned weights of the block immediately before and after testing, as follows (see Note 5):

$$\text{Weight loss, \%} = (100\ (T_3 - T_4)/T_3)$$

Use T_{3w} instead of T_3 in the case of weathered blocks.

17. Evaluation of Test Results

17.1 *Threshold Retention*—Determine the minimum amount of preservative that is effective in preventing significant decay, under the conditions of the test, by a particular fungus.

This amount of preservati
grams per cubic metre (kg
cubic foot (lb/ft³) of wood
"threshold retention." Th
mined by visual inspectio
the point at which weight
does not occur.

17.2 *Visual Evidence*
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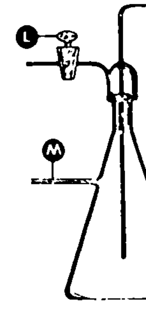
and weighed at the com
Distortion, shrinkage, ar
blocks should be conside
decay. The abnormaliti
nounced in the blocks wi
tions of preservative. bu
gressively less evident wi
until they are no longer
spection should not be rel
sometimes not readily s
the threshold retention l

17.3 *Use of Weight-Lo*
calculated weight-loss p
tion 16) may contain cert
plications. These may be
preservative during the t
of the blocks to come
moisture equilibrium as
riod. Such losses, which
may show a progressive



A – Vacuum
B – Plastic o
C – Test wo
D – Glass or
E – Treating
F – Polyethy
G – Three-w
H – Flask co
I – Glass jo
J – Glass jo
K – Flask fo
L – Stopcock
M – Line to s

This amount of preservative in terms of kilograms per cubic metre (kg/m^3) or pounds per cubic foot (lb/ft^3) of wood, is referred to as the "threshold retention." The threshold is determined by visual inspection and by estimating the point at which weight loss caused by decay does not occur.

17.2 *Visual Evidence of Decay*—Examine the blocks after they have been conditioned and weighed at the completion of the test. Distortion, shrinkage, and softening of the blocks should be considered as evidences of decay. The abnormalities are usually pronounced in the blocks with the lower retentions of preservative, but they become progressively less evident with higher retentions, until they are no longer apparent. Visual inspection should not be relied on since decay is sometimes not readily seen, especially near the threshold retention level.

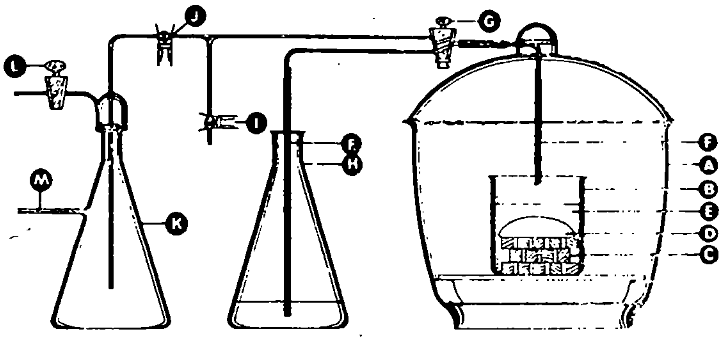
17.3 *Use of Weight-Loss Percentages*—The calculated weight-loss percentages (see Section 16) may contain certain operational complications. These may be the result of loss of preservative during the test period or failure of the blocks to come to exactly the same moisture equilibrium as before the test period. Such losses, which are not due to decay, may show a progressive increase from lower to higher retentions (Fig. 3), particularly in the case of a volatile preservative. When the weight losses in blocks show an increase, and the increase is progressive as the retention decreases, decay loss, in addition to any operational loss, is indicated. The threshold value is then considered to be the average retention at which this transition in weight loss is indicated. Slight surface decay that is not progressive may be shown by blocks having retentions that are somewhat above the threshold. In such instances, decay losses leading to determination of thresholds are not considered to occur until there is a definite increase in weight losses over and above those relatively low ones that result from surface decay.

18. Refining the Threshold

18.1 If the threshold is indeterminate because of wide intervals in the retention gradient chosen, or for any other reason, repeat the test using closer gradient intervals near the approximate threshold level, with a view to locating the threshold as accurately as possible.

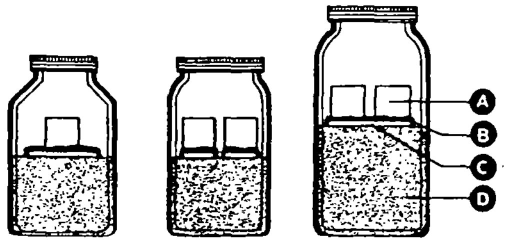
19. Report

19.1 Reports of test results should include concise information and data on all essential phases of the test.



A —Vacuum desiccator, internal diameter 250 mm.
B —Plastic or glass treatment beaker.
C —Test wood blocks.
D —Glass or other suitable weight.
E —Treating solution.
F —Polyethylene tubing.
G —Three-way stopcock with TFE-fluorocarbon plug.
H —Flask containing treating solution.
I —Glass joint with O-ring leading to either vacuum gage or mercury manometer.
J —Glass joint with O-ring.
K —Flask for vacuum trap.
L —Stopcock to atmosphere.
M —Line to source of vacuum.

FIG. 1 Apparatus for Vacuum Impregnation.



A – Wood cubes, 19-mm or 0.75-in.
B – Test fungus growing over feeder block.
C – Wood feeder block.
D – Soil.

FIG. 2 French Square and Cylindrical 225 cm³ (8 oz) and cylindrical 450-mm (16-oz) Culture Bottles with Metal Screw Lids.

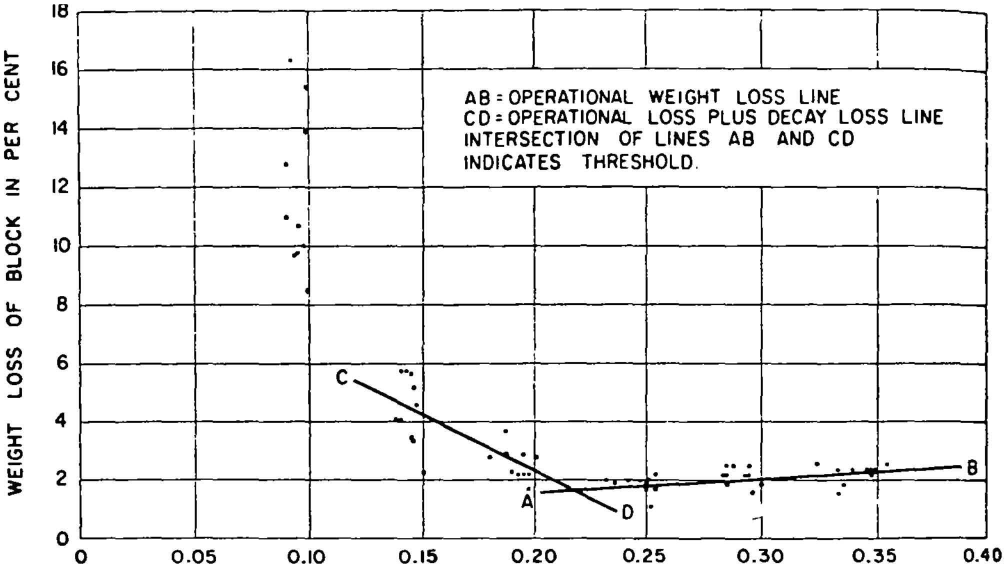


FIG. 3 Weight Loss for Pentachlorophenol Treated Blocks Put Through Soil-Block Test – Test Fungus Madison 617.

Designation: D

Standard Te
AMYLACE

This standard is issued under th
the year of original adoption or
year of last reapproval.

This method has been approved
No. 175a and for listing in the Do

1. Scope

1.1 This method cove
of the presence or abs
(starch-like material in
and melamine-resin glue

2. Reagents

2.1 *Iodine Test Solu*
dine and 5 g of potassiu
distilled water.

2.2 *Acetic Acid - Eth*
Add 20 parts of glacia
parts of 95 percent ethy
of distilled water by vol

3. Sampling

3.1 Except in special
ite of the sample of th
sible, from three or mo
chosen at random. Als
containers that appear
tive, and test such sam
a sample is taken, th
tainer should be thoro
a tendency for the
Place the samples in
containers and transpo
tory in these containe
reduce evaporation or

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AMERICAN NATIONAL STANDARD

ASTM D 2017 - 71 (Reapproved 1978)

Standard Method of
ACCELERATED LABORATORY TEST OF NATURAL DECAY RESISTANCE OF WOODS[1]

This standard is issued under the fixed designation D 2017; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the evaluation of the natural decay resistance of wood species. Adhering to the prescribed test conditions, the method may also be used to evaluate in the same terms the resistance of wood products or of other organic materials subject to decay by wood-destroying fungi such as those employed in the test.

2. Summary of Method

2.1 Wood samples are obtained that appropriately represent the timber species or product to be evaluated. The samples, prepared for testing as small blocks, are exposed to pure cultures of selected decay fungi growing in bottles on a substrate of soil topped by a feeder strip of decay-susceptible wood or filter paper. The test blocks are weighed before and after exposure, and the loss in weight is the measure of decay susceptibility or resistance of the wood. The test is terminated when a 60 percent weight loss is obtained in nondurable wood reference blocks.

3. Apparatus

3.1 *Conditioning Room* (or cabinets), with controlling instruments for maintaining temperature and relative humidity at convenient working levels, with tolerances, respectively, of ±1.1 C (2 F) and ±4 percent.[2] It may be advantageous to have the same temperature and relative humidity as specified for the incubation room (3.2).

3.2 *Incubation Room* (or cabinets), with temperature automatically maintained at 26.7 ± 1.1 C (80 ± 2 F) and relative humidity at 70 ± 4 percent.

3.3 *Balance*, direct-reading type preferred, sensitive to 0.01 g.

3.4 *Trays* made from suitable screening to permit free air movement around each block during initial drying and for convenient handling of the test blocks.

3.5 *Culture Bottles*, round or square, with a capacity of 225 cm^3 (8 oz), mouth diameter of at least 32 mm (1¼ in.), and fitted with screw caps (Fig. 1). The caps should be unlined in order to help ensure an adequate supply of air to the test fungus.

3.6 Conventional equipment and glassware for culturing and aseptic handling of fungi and test material, such as drying oven, autoclave, refrigerator, nutrient medium, transfer needles, forceps, Petri dishes, and test tubes.

4. Test Fungi

4.1 Test fungi shall consist of cultures of the following three wood-rotting fungi:[3]

4.1.1 *For Testing Softwoods: Lenzites trabea* Pers. ex Fr. (Madison 617), and *Poria monticola* Murr. (Madison 698).

4.1.2 *For Testing Hardwoods: P. monticola* Murr. (Madison 698), *L. trabea* Pers. ex. Fr. (Madison 617), and *Polyporus versicolor* L.

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[1] This method is under the jurisdiction of ASTM Committee D-7 on Wood.

Current edition effective July 10, 1971. Originally issued 1962. Replaces D 2017 - 63.

[2] For a simple apparatus for relative humidity control see Scheffer, T. C., "Humidity Controls for Conditioning Rooms," *Forest Products Laboratory Report No. 2048*, U.S. Forest Service, January 1956. Small centrifugally actuated mist dispensers used for humidification in homes have been found satisfactory for this purpose.

[3] These test fungi are available from the American Type Culture Collection, 12301 Parklawn Dr., Rockville, Md. 20852.

ex Fr. (Madison 697).

5. Culture Media

5.1 *Malt Agar Substrate*—The nutrient medium, which shall be used for the stock test-tube cultures and for Petri-dish cultures of the test fungi, shall be malt agar or some satisfactory equivalent. It shall be sterilized at 121 C (250 F) for 15 min.

5.2 *Soil Substrate*—A supply of loam soil to provide a substrate for the fungus (see 10.1).

6. Sampling

6.1 *Identification of Species* should be carefully determined by standard procedures.

6.2 *Samples from Trees*—In sampling a timber species for standard evaluation of decay resistance, only the heartwood shall be used. No sapwood is durable where conditions are favorable for decay. For general appraisal of a timber species, wood selected from trees should be taken, insofar as possible, from the outer third of the heartwood radius, on two (opposite) sides of the trunk, in the lowermost 4.5 m (15 ft) of the trunk (Note 1). The wood should be of representative quality for the species in such respect as freedom from defects, rate of growth, and density. Enough trees and areas should be represented to reveal any significant within-species variation in resistance. The more important the species and the wider its growing range, the greater the number of trees that usually will be needed to accomplish this; the minimum number for standard evaluation should in any case be 20. Where test results are derived through sampling of trees, the tree diameter (D.B.H.) should be reported. The age of the trees, if determinable, and the specific gravity of the wood should be included in the record.

NOTE 1—Decay resistance of heartwood in some species varies markedly according to position in the trunk. It is important, therefore, that the approximate position of sampling be uniform. The outer heartwood of the lower trunk represents, better than any other place that might be sampled, the bulk of the heartwood in a tree, and the wood there is typically the most decay resistant.

In some instances, particularly in tropical hardwoods, there may be no visible heartwood and sapwood zones. With such woods, the sampling should extend across the outer one third of the entire radius. The presence of any sapwood will then be apparent in the results, which can be grouped accordingly.

To compare the decay resistance of wood of different species by sampling trees for the purpose, the trees selected should be of at least comparable diameters and normal rates of growth.

6.3 *Samples from Lumber*—If the decay resistance of wood from trees of strictly saw-log size is of primary interest, a species may be evaluated on heartwood obtained from lumber. The board samples should be selected for normal quality and at random, but from sufficiently diverse places in a storage pile to make it probable that each board is from a different tree. Besides incorporating a quantity of trees, the sampling should be made to represent the principal areas on which the species is grown, for reasons given in 6.2. The total number of boards and sampling areas needed per species depends in this case also on the importance of the species and the expanse of the growing region. The minimum number of boards should be 20.

6.4 *Samples from Wood Products*—Occasionally it may be necessary to sample a wood product as a means of evaluating a species. If this is done, the objectives of sampling should be the same as noted in 6.3 for lumber. Depending on the representativeness of the lumber source of the product, product sampling may not accurately represent the wood species. In such a case, product sampling should be avoided unless the product itself is of chief interest.

7. Test Specimens

7.1 *Preparation of Specimens (Test Blocks)*—The samples shall be sawed into block specimens 2.5 by 2.5 by 0.9 cm (1 by 1 by ⅜ in.) in size, with the 0.9-cm (⅜-in.) dimension in the grain direction (see Fig. 1). The blocks shall be of normal growth rate and density, and free of knots and abnormal amounts of resin or gums and without visible evidence of fungus infection. The blocks shall be labeled as to source promptly after sawing; a waterproof ball point pen is very satisfactory for this.

7.2 *Number of Blocks*—The number of block replications per test condition (fungus and sample) shall be at least six.

8. Supplementary Blocks

8.1 *Reference Blocks*—If a softwood or softwood product is being tested, prepare 32 blocks (16 per fungus), having the dimensions of test blocks of pine (*Pinus* sp.) sapwood[4] or of some other coniferous wood of comparably low decay resistance (for example, either heartwood or sapwood of true fir (*Abies* sp.) or spruce (*Picea* sp.)). If a broadleaved species (hardwood) is being tested, prepare 48 sapwood blocks of sweetgum or of some other hardwood of comparably low decay resistance (for example, sapwood of beech (*Fagus*), birch (*Betula*), or maple (*Acer*)). Obtain the ovendry weights, R_1, of these blocks. The blocks will be subjected to decay in the manner and at the same time as the test blocks, and the progress of their decay will be used as a guide for terminating the incubation with the respective fungi (see 11.1.4). The terminal weight losses in these blocks also will serve as points of reference, establishing the fact that the test was of standard severity.

8.2 *Feeder Strips:*

8.2.1 *Wood Feeders*—Prepare a wood feeder strip for each culture bottle to be inoculated with *P. monticola* or *L. trabea*. These blocks shall be of sweetgum sapwood, or an alternative wood of low decay resistance such as prescribed in 8.1 for hardwood reference blocks, if the material being tested is a hardwood. If the test material is of softwood, the feeder strips may be either of a hardwood or a softwood species, such as noted in Paragraph 8.1. The blocks shall preferably be cut from quarter-sawed stock, to dimensions of 0.3 by 2.9 by 3.5 cm (1/8 by 1 1/8 by 1 3/8 in.) with the long axis in the grain direction.

8.2.2 *Filter Paper Feeders*—Prepare a filter paper feeder (rapid, qualitative type) with dimensions of 2.9 by 3.5 cm (1 1/8 by 1 3/8 in.) for culture bottles to be inoculated with *P. versicolor*.

9. Conditioning and Initial Weighing of Test Specimens

9.1 Place the labeled test blocks on screen-bottom trays and bring them to equilibrium weight in the conditioning room. Weigh them to the nearest 0.01 g. If the scale is outside the conditioning room, transfer the blocks to the scale in a closed container, so as to avoid weight changes due to differences in relative humidity between the conditioning and the scale room. This weight, W_1, will be the basis for determining the weight loss caused by decay during the test (Section 13).

10. Preparation of Test Bottles

10.1 Shortly before the decay phase of testing is to begin (see Appendix), put into the culture bottles the water, loam soil, and feeder in that order as described in 10.2 and 10.3 and as illustrated in Fig. 1. The soil (see 5.2) should have a water-holding capacity between 20 and 40 percent (Note 2) and pH between 5.0 and 8.0. A measured volume of 118 cm^3 (4 oz) of the sifted air-dry soil, lightly compacted by tapping, shall weigh not less than 90 g. The soil shall be mixed after breaking up all clumps and passed through a sieve having openings in the range 0.30 to 0.51 cm (0.12 to 0.20 in.). It should not be so wet when sifted that the particles stick together. Reserve soil should be stored in covered containers.

NOTE 2—The water-holding capacity of a soil shall be considered as that percentage of water, based on the ovendry weight of the soil, that is retained after subjecting the soil to the following procedure:

Fill a small Büchner funnel, approximately 5 cm in diameter and 2.5 cm in depth, and fitted with a qualitative filter paper, to somewhat more than capacity with air-dry soil previously passed through a 2-mm sieve. Compact the soil by dropping the funnel three times through a height of 1 cm on a wooden table top. Level the soil surface with a spatula. Then place the filled funnel in a 400-cm^3 beaker and retain in an upright position by wedges at the sides of the funnel. Add water to the beaker to a depth slightly above the level of the filter paper. Allow the soil to become wet by capillarity so as to reduce the danger of entrapping air within the column. When the upper soil surface shows signs of wetting, add more water until the water level approximates the top of the funnel. Place a cover over the beaker, and allow the soil to soak for 12 h or overnight. Then place the funnel in a suction flask, which is connected to a water aspirator or vacuum pump, and apply full suction for 15 min. During suctioning, cover the funnel with a moist cloth on which an inverted cup is placed. After 15 min remove the funnel from the suction flask, scrape the soil into a weighed receptacle, and determine its moisture content.

10.2 *Addition of Water*—The percentage of water in the bottled soil shall be 130 percent of the water-holding capacity of the soil. Measure the water into the bottles first. (The

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[4] For differentiating heartwood and sapwood see "Color Tests for Differentiating Heartwood and Sapwood of Certain Oaks, Pines, and Douglas Fir," *Forest Products Laboratory Technical Note 253*, U.S. Forest Service, revised June 1954.

sequence of first water and then the soil leaves clean glass surfaces above the soil level in the bottles. The water diffuses upward through the soil.) To determine the amount of water to add to a bottle, weigh the volume of air-dry soil that about half fills a bottle (118 cm^3 (4 oz)). Dry this soil at 105 C ± 2 C (220 F ± 4 F) for 12 h and calculate the percentage of water in the soil based on the ovendry weight of the soil. The amount of water to be added to a bottle will then be as follows:

$$\text{Water to add, g} = (1.30A - B)[D/(100 + B)]$$

where:

A = moisture-holding capacity, percent,
B = moisture content of air-dry soil, percent, and
D = g of air-dry soil to be used in culture bottle.

10.3 *Addition of Soil and Feeder*—Next add the soil. This is most conveniently done by volume measure, using a scoop of adjustable capacity and set to deliver just the needed weight of soil. Level the soil surface before it becomes wetted, by gently shaking the bottle, and place on it a feeder (see 8.2).

10.4 *Sterilization of Bottles*—Sterilize the prepared bottles, with caps loosened, at 121 C (250 F) for 30 min. Precautions should be taken during the cooling process to prevent contamination of the bottles from air-borne spores. When cool, the bottles at this point will be ready for inoculation.

11. Decay Procedures

11.1 Make provision for coordinated and timed preparation of the test cultures, conditioning of the test blocks, inoculation of the bottles, and subsequent procedures. Timing of a typical test is outlined in the Appendix.

11.1.1 *Inoculation of Bottles*—After the sterilized culture bottles are thoroughly cooled, cut the fungus inoculum, approximately 1 cm square, from a Petri-dish culture and place it on the soil next to the feeder strip. Incubate the inoculated bottles, with lids released by a slight turn from a tightened position, at 26.7 ± 1 C (80 ± 2 F) and 70 ± 4 percent relative humidity for approximately 3 weeks, or until the feeders are covered by mycelium. The bottles are then ready to receive the test blocks.

11.1.2 *Exposing of Test Blocks*—Put the conditioned and weighed test blocks into tightly closed containers and steam them at 100 C (212 F) for 20 min (Alternative sterilization methods may also be used in place of steam.) After cooling, place the blocks, one to a bottle, with cross section face down on the feeder strips in the prepared test bottles. This should be done aseptically, using sterilized forceps, to avoid mold contamination. Loosen the bottle caps by unscrewing them slightly. Then place the bottles in the incubation room. To avoid losing the identity of any blocks that may become severely decayed, it is desirable to label the bottles as well as the blocks.

11.1.3 *Exposing the Reference Blocks*—Expose the reference blocks (see 8.1) at the same time and in the same manner as the test blocks.

11.1.4 *Timing the Exposure Period*—At the end of 8 weeks' incubation, remove two reference blocks, carefully brush off the mycelium, ovendry, and weigh them promptly, and record the weight as R_2. Withdraw, dry, and weigh additional pairs of blocks at weekly intervals and terminate that portion of the test to which a particular group of twelve reference blocks pertains when a curve of the weight losses versus time reaches the 60 percent level (Note 3). Calculate the weight loss as follows:

$$\text{Weight loss, percent} = [(R_1 - R_2)/R_1] \times 100$$

NOTE 3—The sixteen replications of a given series of reference blocks will ordinarily permit weekly removals of block pairs after 8 through 15 weeks' exposure. If 60 percent weight loss does not appear attainable in 16 weeks, the severity of the test or the selection of reference wood must be considered inadequate, since the test fungi and prescribed procedure will ordinarily cause a 60 percent loss in a nondurable wood such as those listed in 8.1 within 12 weeks.

12. Handling Blocks After Exposure to Test Fungi

12.1 At the end of the exposure period (11.1.2 to 11.1.4), remove the test blocks and the adjustment blocks from the bottles, and carefully brush any surface fungus growth from the test blocks. If any block is so badly deteriorated that the label cannot be read, place it in the inverted lid of the culture bottle, and label the lid according to the identifications carried on the bottle. Then place the blocks on screen-bottom trays and again dry

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13. Calculation of Weight Losses

13.1 Calculate the percentage weight losses in the individual test blocks from the conditioned weights before and after exposure to the decay fungi as follows:

$$\text{Weight loss, percent} = [(W_1 - W_2)/W_1] \times 100$$

14. Evaluation of Results

14.1 The percentage weight losses in the test blocks provide a measure of the relative decay susceptibility or, inversely, of decay resistance of the sampled wood or material. With the incubation period prescribed, losses may range from 0 to about 70 percent. If a wood is highly decay resistant, slight gains in weight are often indicated, or there may be apparent slight losses without accompanying visible evidence of decay. Such results are a normal accompaniment of most tests and do not reflect any objectionable lack of precision in the procedure. The percentage of residual wood in the test blocks (100 − percentage loss) furnishes a measure of relative decay resistance. Since decay resistance is positively correlated with the percentage of residual wood, residual weight is sometimes preferable to weight loss for indexing decay resistance.

14.2 Decay resistance may also be described in more general terms that meet most practical needs. Based on the reputations for durability of a sizable variety of woods and on test data, the following relations have been developed and are suggested for general use in interpreting either weight losses or residual weights (Note 4):

Average Weight Loss, percent	Average Residual Weight, percent	Indicated Class of Resistance to a Specified Test Fungus
0 to 10	90 to 100	highly resistant
11 to 24	76 to 89	resistant
25 to 44	56 to 75	moderately resistant
45 or above	55 or less	slightly resistant or nonresistant

Examples of domestic heartwoods, indicated by both test and reputation to be prevalently in the foregoing classes of decay resistance when in ground contact (see 14.3), are as follows:

14.2.1 *Highly Resistant or Resistant*—Redwood, western red cedar, black locust, and white oak.

14.2.2 *Moderately Resistant*—Douglas fir, western larch.

14.2.3 *Slightly Resistant or Nonresistant*—Hemlocks, true firs, spruces, beech, and birches.

NOTE 4—The relations suggested were established and confirmed through tests of a number of woods. The considerable background of underlying data indicate that there is comparatively good agreement between weight losses in the test as described and service experience with the tested woods.

14.3 Woods do not necessarily occupy the same relative position in order of decay resistance when subjected to ground contact as when exposed above ground. Results obtained with the test fungi *Poria monticola* and *Polyporus versicolor* have indicated the class of decay resistance to be expected with ground contact. *Lenzites trabea*, although less able to attack resistant woods than the others, is believed to better index the class of resistance to be expected above ground.

15. Report

15.1 Reports of test results for a given wood or product shall contain concise information and data on essential features of the samples and testing including:

15.1.1 *For Tests of Woods:*

15.1.1.1 Species of wood and the test fungus.

15.1.1.2 Character of sample source (that is, trees, lumber, or product).

15.1.1.3 If tree sampling, tree diameters (D.B.H.: range and average). Also tree ages, if obtainable, and the average specific gravity of the sampled wood.

15.1.1.4 Geographical distribution of samples, and the number of trees or boards sampled in the respective localities.

15.1.2 *For Tests of Wood Products:*

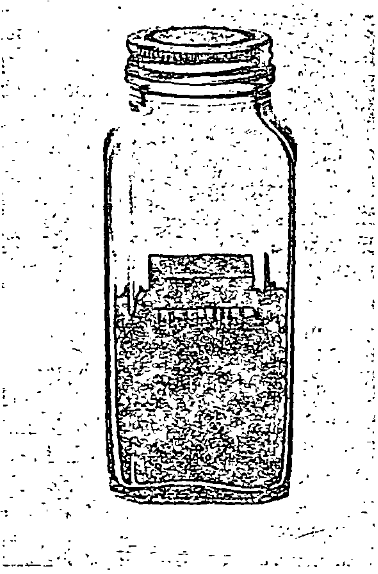
15.1.2.1 Essential composition of the product, and the test fungus.

15.1.3 *For Either Wood or Wood Product:*

15.1.3.1 Duration of exposure and the average weight loss in the reference blocks removed at the time the exposure was terminated. The average weight loss would be indicated by the curve value derived according to 11.1.4.

15.1.3.2 If there were any deviations from the standard procedure, they shall be fully described.

15.2 Results shall be reported in terms of the average percentage weight loss or percentage residual weight, or both, for each kind of wood or product, including a suitable statistical analysis to indicate the variability of the data. In the case of a wood species, report also the percentage of trees or boards that exhibited different levels of decay resistance, for example, as determined by the classification scheme shown in 14.2. In addition to an over-all summary of results for a particular wood or product, summarize the data relative to any specific sampling variables (for example, diameter class of sampled trees, or the sampling locality) with which the decay resistance shows a practically significant amount of correlation.



NOTE—In practice, the test block is not inserted until the bottle has been inoculated and the test fungus has covered the feeder strip (Section 11.1.1).

FIG. 1 Test Bottle Containing Soil, Feeder Strip, and Test Block.

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APPENDIX

A1. TIMING OF STEPS IN PREPARING TEST BOTTLES AND IN EXPOSING TEST SPECIMENS TO DECAY

A1.1 The following will serve as a guide to the sequence of steps and their timing in the decay phase of the testing. These steps normally will be briefly preceded by or initiated at about the same time as the conditioning and initial weighing of specimens (Section 9).

A1.1.1 *First Day*—Inoculate Petri dishes (or equivalent) with the test fungi, to provide inoculum for the test bottles (see 11.1.1). A 100-mm dish will supply inoculum for at least 50 bottles.

A1.1.2 *3rd to 10th Day*—Prepare test bottles (Section 10).

A1.1.3 *10th to 14th Day*—Inoculate test bottles (see 11.1.1).

A1.1.4 *35th Day*—Expose blocks (see 11.1.2 and 11.1.3).

A1.1.5 *83rd to 140th Day*—Make determinations of weight loss in the reference blocks (see 11.1.4) and stop the test when the prescribed 60 percent weight loss is indicated.

3

Designation: D 1758 - 74 (Reapproved 1980)

Standard Method of
EVALUATING WOOD PRESERVATIVES BY FIELD TESTS WITH STAKES[1]

This standard is issued under the fixed designation D 1758; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers accelerated procedures for determining the relative permanence and effectiveness of wood preservatives in stakes exposed in field plots.

1.2 The requirements for preparation of the material for testing and the test procedures appear in the following order:

2. Applicable Documents

2.1 *ASTM Standards:*

D 1413 Testing Wood Preservatives by Laboratory Soil-Block Cultures[2]

D 1625 Specification for Chromated Copper Arsenate[2]

3. Summary of Method

3.1 Wood stakes are impregnated with an appropriate series of retentions of a preservative, and then handled, prior to exposure in the field, according to specified procedures. The treated stakes are exposed in the ground to the action of wood-destroying fungi and termites in one or more selected field plots. An index of condition determined from grades assigned to the stakes for degree of decay and termite attack, in the course of periodic inspections, is used to express results periodically and at the termination of the test.

3.2 Two test procedures are outlined, employing two specimen types, ¾-in. stakes and nominal 2 by 4's, designated hereafter respectively as Method A and Method B. Method A, using smaller and more numerous specimens, is preferred for more rapid acceleration, and Method B for longer term tests of a quasi service nature.

4. Test Plot

4.1 *General Requirements*—A warm humid climate is preferred. Select a natural area of fertile, fallow, level land of uniform soil character that is moist but well drained and large enough to permit expansion and future stake installations. The presence of wood-destroying fungi and active subterranean termites shall be proved by observation or experience and checked by exposure of suitable small specimens of untreated wood. No natural or artificial fertilizer or other chemicals shall be applied to the plot during its use as a test ground. Protection against fire, predators and pilferage shall be provided as far as practicable.

4.2 *Control of Vegetation*—As a general rule vegetation shall be controlled manually or by suitable mechanical means only, with minimum soil disturbance. No chemicals that might influence the value of the tests shall be permit-

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[1] This method is under the jurisdiction of ASTM Committee D-7 on Wood and is the direct responsibility of Subcommittee D 07.13 on Durability and Exposure.

Current edition approved April 29, 1974. Published June 1974. Originally published as D 1758 - 62. Last previous edition D 1758 - 62 (1970).

[2] *Annual Book of ASTM Standards*, Part 22.

ted. Weeding and cleaning the plot shall be uniform over any given test area.

4.3 *Reuse of Ground*—Stakes placed in ground that has been used previously for test purposes shall not be set closer than 6 in. (150 mm) to any earlier stake location.

5. Test Specimens

5.1 *Selection of Wood*—Sapwood of southern pine, with 6 to 10 rings per inch, shall be the preferred wood for comparative tests. It shall be free of knots, excessive cross-grain and resins or other obvious defects, and it shall show no visible evidence of infection by mold, stain, or decayed fungi. Whenever practicable, select straight-grained wood for the test stakes at the sawmill. Acceptable freshly cut lumber shall be kiln-dried in order to avoid fungus infection before and during shipment. The wood shall not have been treated with chemicals to prevent sapstain. The dried lumber shall be stored flat in a dry room where it can reach an equilibrium moisture content (oven-dry basis) of 19 % or less. Sapwood or heartwood of any species may be used for special investigations. In such cases the test stakes shall be all sapwood or all heartwood in any given comparative series. Individual stakes containing both sapwood and heartwood shall not be used.

5.2 *Cutting Test Blanks*—Test blanks may be sawed from the dry lumber in any convenient lengths.

5.3.1 *Test Stake Dimensions*—For Method A the test blanks shall be surfaced four sides as accurately as practicable to 0.75 by 0.75 in. (19 by 19 mm), and cut to a length of 18 in. (457 mm). For Method B the test blanks shall be surfaced four sides as accurately as practicable to 1.5 by 3.5 in. (38 by 89 mm), and cut to a length of 18 in. (457 mm). The average volume of the A stake is 10.1 in.^{3} (165 cm^3) and of the B stake 94.5 in.^{3} (1546 cm^3). The ratios of surface area to volume in a 1.0 in. (25.4 mm) section of the stakes at the groundline are respectively 5.3 to 1.0 and 1.9 to 1.0.

5.4 *Storage of Test Blanks and Prepared Stakes*—Working stocks of test blanks or surfaced untreated stakes shall be stored flat under dry conditions.

6. Pretreatment Selection of Test Stakes

6.1 *Initial Weights*—Before impregnation the stakes shall be numbered and weighed to the nearest 1 g. Discard the upper and lower 2% of the stakes. Any deviation from this procedure, such as grouping on a weight or count basis, shall be reported in detail (12.1.10). The initial untreated weights shall be coded T_1.

6.2 *Coding the Weight*—The system of (tare) designations is as follows, with weights recorded in grams:

T_1 = initial weight of the test stake before impregnation; and

T_2 = weight of the test stake after impregnation and after wiping to remove superficial liquid (equals T_1 plus grams of treating solution absorbed).

NOTE 1—The T_2 weight does not apply in certain cases, as in treatments employing liquefied petroleum gas (see Section 7.7).

7. Treatment Procedure

7.1 *Preferred Treatment Method*—The preferred treatment method is a full-cell process simulating commercial practice as far as practicable with laboratory or pilot plant equipment. Use an initial vacuum, suitable temperature and an appropriate pressure period determined by trial lots, but omit the final vacuum. (See 7.6 for method of obtaining gradient retentions by toluene dilutions.)

7.2 *Standard Reference Preservative*—The standard reference preservative shall be a freshly made aqueous solution of chromated copper arsenate (CCA-Type C; Method D 1625; AWPA Standard P5). Periodically treat not less than 20 stakes with this preservative by a full-cell process to retentions of 0.20, 0.40 and 0.60 lb/ft^3 (3.2, 6.4 and 9.6 kg/m^3). Randomize the stakes over the plot area on the same basis as the treated test stakes. Record their condition at each inspection.

7.3 *Untreated Control Stakes*—Install not less than 20 untreated control stakes of each species of wood and of the same size used for preservative testing throughout the test area when the plot is first established and each time a new series of tests is installed. Installation shall be on the same random basis as the treated test stakes. Record the condition of the untreated control stakes at each inspection.

7.4 *Retention Populations*—The treatment retentions in any given group of treatments of a preservative shall represent as far as practicable a series running from low to high absorption in order to provide data on the effective protective retention level. The spread in the series shall be designed to straddle the expected or predetermined effective retention for outdoor stake tests. This retention may be based on experience, or on assumptions from the results of soil-block tests (Specification D 1413). The retention nearest the expected effective retention should be at or near the upper end of the series but lower than the highest retention selected. The lowest retention should be low enough to permit attack and provide proof of the presence of tolerant wood-destroying fungi, or termites, or both over the area of the test plot.

7.5 *Number of Stakes to Be Treated*—The number of stakes to be treated depends on available information and experience. In no case shall there be less than 10 stakes in a test. As a general policy, enough stakes should be treated to provide, within the graded retention population, extra stakes, or pilot stakes, that may be removed periodically in the early course of a test to determine the presence and progress of fungus or termite attack. Use such stakes where practicable to determine the identity of the attacking fungus and the depletion or change in character of the preservative tested. As examples, since the retentions in the stakes in a given charge will vary around the nominal retention for the charge, the above scheme may be accomplished by treating 20 stakes each in a series of nominal retention charges as follows:

Creosote: 6.0, 8.0, 10.0, 11.0, and 12.0 lb/ft^3 (96, 128, 160, 176, and 192 kg/m^3).

Pentachlorophenol: 0.10, 0.20, 0.30, 0.50, and 0.70 lb/ft^3 (1.6, 3.2, 4.8, 8.0, and 11.2 kg/m^3).

Chromated copper arsenate: 0.30, 0.40, 0.50, 0.60, and 0.70 lb/ft^3 (4.8, 6.4, 8.0, 9.6, and 11.2 kg/m^3).

7.6 *Preservative Analysis*—Analyze each preservative or preservative solution prior to treatment. If there is reason to believe that a change in composition occurs during treatment, analyze after each treatment, and avoid extended use of the same solution.

7.7 *Treatment Retentions*—Determine the amount of preservative absorbed by the individual test stakes as accurately as possible in terms of kg/m^3 as soon as they have cooled to approximate room temperature (*a*) by weighing them on suitable scales, or (*b*) by assay of representative stakes by a method appropriate for the preservative concerned.

7.7.1 Preservative retentions in stakes treated with preservatives in highly volatile solvent carriers cannot be calculated from before and after treatment weights since the solvent is removed during the processing. Retentions must therefore be determined by an analysis of treated stakes. This may be accomplished by one of two methods:

7.7.1.1 *Method 1*—Several extra stakes (not less than 10) the same size, species, and density range shall be included in each retention charge. Cross sections of these stakes taken at a point between 4 and 5 in. (100 and 125 mm) from one end shall be composited and analyzed. The resultant value shall be the retention for the entire charge.

7.7.1.2 *Method 2*—A sample shall be cut at a point between 4 and 5 in. (100 and 125 mm) from the tip end of each test stake representing half the cross section in ¾-in. (19 mm) stakes from a radial side as far as possible. Analyze each sample. The value determined shall be the retention for each stake. Coat surfaces exposed as a result of the sampling with a sealer such as a phenolic adhesive.

7.7.2 For the usual weight determination remove each stake individually from the treating chamber, wipe lightly to remove surface preservative or preservative solution, and weigh promptly to the nearest 1.0 g (Code T_2) (6.2).

7.8 *Calculation of Retentions*—Caclulate the retention of preservative or preservative solution as follows:

7.8.1 For undiluted preservatives such as creosote, or pentachlorophenol petroleum systems for example:

$$\text{Retention, kg/m}^3 = 1000\ G/V$$

7.8.2 For diluted preservatives such as toluene solutions of creosote, pentachlorophenol in petroleum carriers, or preservative salts in water solution:

$$\text{Retention, kg/m}^3 = 1000\ GC/V$$

where:

G = $(T_2 - T_1)$ = grams of preservative or preservative solution absorbed by the stake,

C = grams of preservative or preservative solution system in 100 g of treating solution, as a decimal fraction, and

V = volume of stake, cm^3:
0.000165 m^3 for Method A stakes, and

0.001546 m³ for Method B stakes.

To convert kg/m³ to lb/ft³ divide by 16.

7.8.1 *Test Stake Identification*—After calculation of treatment retentions identify each test stake adequately with a tag of weather-resistant metal or plastic.

7.9 *Alternative Treatment Methods*—If it is necessary or desirable to establish the plot potential, for creosoted stakes, for example, with respect to fungus or termite hazard, or both, by installing standard reference stakes treated with both undiluted creosote and with diluted creosote, an alternative treatment method applicable to creosote only may be used.

7.9.1 The creosote shall be a Standard AWPA P1 creosote with the following distillation pattern by the AWPA Standard flask method:

to 235°C 5 to 10 weight %
to 270°C 20 to 30 weight %
to 315°C 45 to 60 weight %
to 355°C 78 to 81 weight %

7.9.2 The creosote should be diluted with toluene to obtain approximate average charge retentions as follows:

	%	
	Creosote	Toluene
For 96 kg/m³ (6 lb/ft³)	20	80
For 128 kg/m³ (8 lb/ft³)	27	73
For 160 kg/m³ (10 lb/ft³)	33	67
For 192 kg/m³ (12 lb/ft³)	40	60

7.9.3 Treat the stakes by a full-cell process, and proceed as outlined under 7.1.

7.10 *Empty-Cell Treatments*—For comparative purposes empty-cell treatment processes may be used for creosote and for pentachlorophenol-petroleum solutions or for preservatives in volatile carriers, at the discretion of the operator.

8. After Treatment Handling of Test Stakes

8.1 *Stakes Treated with Water Solution*—Dry stakes treated with water-borne preservatives by air-seasoning, kiln-drying, or a combination of both. Stack the stakes so that air can circulate freely between them until their average moisture content is less than 30 %, oven-dry weight basis, or dry them in an oven or kiln at a temperature not to exceed 140°F until their average moisture content is less than 30 %. If other types of conditioning before installation are employed, report the method of after-treatment handling fully. In all cases the drying period shall be long enough, not less than 15 days, for the salt preservatives to dry thoroughly.

8.2 *Stakes Treated with Diluted Oil-Type Preservatives or with Preservatives Dissolved in Highly Volatile Solvents*—Cross-pile stakes treated with volatile solvent solutions, such as creosote in toluene, or pentachlorophenol in light petroleum solvents or in liquefied petroleum gas, horizontally over a flat base or other suitable support, or stack in a space rack frame, in such a manner as to permit free circulation to all faces of the stakes and to facilitate removal of individual stakes for periodic weighing. Continue the exposure until the average loss in weight is equivalent to at least 90 % but not more than 95 % of the amount of solvent or diluent is absorbed.

8.3 *Stakes Treated with Undiluted Preservatives*—Stack stakes treated with undiluted preservatives such as creosote or pentachlorophenol-petroleum solutions for drying as prescribed for air-seasoning under 8.1 for a period of not less than 15 days to permit drying of any superficial or bleeding liquid.

8.4 *Individual Stake Condition*—It is essential to maintain the integrity of the individual test specimens before installation as far as practicable. At the end of any drying or evaporation period, bundle or wrap only those stakes with treatment retentions within the limits of the coded retention cells together for storage. If there is any likelihood that oil-type preservatives may be transferred from one stake to another when bundled together wrap the test stakes individually in heavy aluminum foil.

8.5 *Storage of Treated Test Stakes*—Store the wrapped test stakes in a cool room until shipment for installation.

9. Installation of Stakes

9.1 *Time Lapse Between Treatment and Installation*—As a general rule the treated stakes should be installed in the test plot as soon as practicable after treatment (see 12.1.9).

9.2 *Spacing of Stakes in Test Plot*—For Method A, space the test stakes not less than 1 ft (300 mm) between specimens and not less than 2 ft (600 mm) between rows. For Method B space the test stakes not less than 2 ft (600 mm) between specimens and not less than 3 ft (900 mm) between rows.

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9.3 *Depth of Installation*—Install the stakes, with all tags oriented in the same direction in the row, at a depth of 9 to 10 in. (229 to 250 mm) to a legible groundline mark. Compact the soil around each stake at the appropriate groundline.

9.4 *Randomization*—Randomize the test stake, reference stake, and control stake settings in an appropriate manner within the selected test plot area.

9.5 *Mapping the Plot*—Map the plot and the position of each installed stake to facilitate inspection and records.

10. Inspection of Specimens

10.1 *Inspection General*—Whenever practicable inspect the test stakes, reference stakes, and control stakes in the fall after fungus activity slows down. The frequency of inspection depends on the indications of fungus or termite attack revealed by pilot stakes or selected stakes from the series of low to high retention specimens. In exploratory tests, make inspection annually. With preservatives of known effectiveness, present in sufficient concentrations, the first inspections as well as the intervals in subsequent inspections may be delayed at the discretion of the operator.

10.1.1 As a general principle leave test stakes in place at the original groundline setting as long as possible in order to avoid disturbing the soil-fungus-wood complex and acceleration of decay in any exposed area. Examine any stakes that have worked up out of the soil or that are no longer at the original depth of setting at any given inspection carefully for the amount of change at the groundline. If the amount of heaving is less than 0.25 in. (6.4 mm) reset the stakes as nearly as practicable to the original groundline mark. Use any convenient depth gage. If the heaving exceeds the above limit set the stakes as nearly as practicable to the current groundline. Raise depressed stakes to the original groundline. At each inspection compact the soil against the stake.

10.2 *Inspection Procedure*—Remove the stakes from the ground carefully by a straight upward pull, disturbing the soil as little as possible, using any appropriate leverage tool if the stakes are firmly fixed in the earth. Avoid rocking the stakes and enlargement of the stake holes as far as possible. Use a dull instrument, such as a putty knife or a dull knife blade, to scrape adhering soil from the wood surface. Avoid unnecessary probing, picking, and gouging of the wood. Test the soundness of the stake by use of the dull instrument. A light tap may be used with caution to test the groundline area for loss of impact strength. Some preservatives do not indicate loss in cross-section area or visible decay, but for all practical purposes preservative failure occurs if the strength of the wood is lost. Take special care in ratings made when the stakes are very wet, because softening due to high moisture content can be mistaken for decay.

10.3 *Grading Systems* (*for Below-Ground Condition*)—The grading system shall be as follows:

Decay Grades

Grade No.	Description of Condition
10	sound
9	trace of decay
7	moderate decay
4	heavy decay
0	failure due to decay

Termite Grades

Numerical Rating	Description of Condition
10	sound
9	trace of attack
7	moderate attack
4	heavy attack
0	failure by termite attack

A combined rating, for example, of a decay rating of 9 and a termite rating of 7 would be coded 9-7. In applying these ratings a sound stake shall be a stake in which the wood at the groundline or just below the groundline is firm and the corners still square. The general condition of a stake may appear suspicious, but minor softening in earlywood corners and abortive, shallow termite scoring shall be ignored. Apply Grade 9 to a test stake that shows slight but positive evidence of incipient decay or successful termite attack. A rating of 7 means that decay or termite attack has become firmly established, varying in degree over a fairly broad band, but revealing positive evidence that the preservative in test has lost its power to protect the outer wood fibers. At the lower end of the 7 rating band the deterioration approaches the 4 rating. If the stake can be broken easily by flexing or light tapping a preliminary 4 rating shall be reduced to a zero rating. The quality of the rating system is established by periodic comparison of the recorded ratings in subsequent inspections.

10.4 *Post Mortem*—Assay representative stakes for determination of the characteristics and amount of preservative residual. Select sound stakes and stakes just beginning to show evidence of incipient decay to determine the effective preservative residual that is presenting fungus attack at any given inspection time. Whenever practicable identify the principal fungi causing the decay.

11. Evaluation of Results

11.1 *Periodic Calculation of the Index of Condition*—Maintain a running record covering any given preservative population, identifying each test stake by number, grade, and date of inspection, preferably arranged in ascending order of retention or in a card record system that permits such an arrangement. Group the stakes with adjacent retentions in appropriate cells for creosote, for example. Calculate weighted averages for retention and grade within each cell. A sample calculation is shown in Table 1, where the weighted average retention for the 5.0 to 5.9 (80 to 94.4 kg/m^3) cell for low-residue creosoted stakes, 9 years in test, is shown as 5.3 lb/ft^3 (85 kg/m^3) and the average grade, or index of condition, is shown as 7.4.

11.1.1 *Alternative Methods for Summarizing the Periodic Inspection Data*—The results of the tests may be summarized in two ways, designated respectively "Depreciation Method" and "Dosage Response Method."

NOTE 1—The former is the traditional method yielding data for depreciation curves; the latter is a refinement in procedure designed not only to reveal automatically a best estimate of the effective preservative retention level under the conditions of the test, but also to provide data for drawing the traditional depreciation curves.

11.1.1.1 *Depreciation Method (Optional)*—Arrange the grading data in a format that will permit the selection of points for the drawing of depreciation curves, with a time scale in years as the abscissa and average rating as the ordinate. The method is illustrated in Table 2 and Fig. 1. The curves in Fig. 1 are drawn on a semilog scale to facilitate comparison with Fig. 2 and 3.

11.1.1.2 *Dosage-Response Method (Optional)*—Enter the pertinent data for each cell group in ascending order of retention in an appropriate table, to provide summary data on the relation of retention to grade rating for the whole preservative population at a given inspection period. An example of one format for such a table is shown in Table 3. The three right-hand columns in the table illustrate a process for smoothing the average retention and grade data by use of 3-point moving averages.

11.1.1.2.1 Using a retention scale on the abscissa and 3-point moving average grades on the ordinate, plot average rating against average retention, for example, such values as appear in the last two columns of Table 3. Draw best approximation curves through the plotted points. Examples of such curves for coal tar creosote, 7, 9 and 11 ½ years in test, are shown in Fig. 2. These curves reveal the approximate effective protection level of a retention, at any given inspection period, under the conditions of the test, for the ground-contact zone of the stakes.

11.1.1.3 *Depreciation Curves Derived from Dosage-Response Data*—Depreciation curves may be drawn by reading from a series of periodic dosage-response curves for comparison with traditional depreciation curve data from other stake tests. Illustrative data appear in Table 4, derived from Fig. 2. Examples of depreciation curves drawn from the data in Table 4 are shown in Fig. 3.

11.2 *Short-Cut Method*—In preliminary explorative or reconnaissance tests, or if the variation within a group retention cell can be considered insignificant, calculate the index of condition by the method illustrated in Table 5.

11.3 *Percent Index of Condition*—If the accuracy of results warrants it, the index of condition for any retention group may be expressed as percent index of condition by multiplying the calculated index of condition by 10.

11.4 *Termination of Test*—Since the index of condition of a given preservative population varies with the length of the exposure period, the test may be terminated at the discretion of the operator at whatever time observation, experience, or periodic dosage-response curves (see Fig. 2) indicate that the approximate protective retention level has been defined by the behavior of the treated stakes.

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12. Reports

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TABLE 1 Exam

lb/ft^3	kg/
5.1	8
5.2	8
5.5	8
5.8	9
5.9	9

TABLE 2 A

12. Reports

12.1 Reports of test results shall include as a minimum concise information on the following essential phases of the test:

12.1.1 Location of plot.

12.1.2 Weather data, including average rainfall and average temperature per month, average minimum and maximum temperature per month, and total annual rainfall.

12.1.3 Character of soil, including values for pH and moisture-holding capacity (see Method D 1413) of the upper 2 in. (51 mm).

12.1.4 Species of wood and size of test stakes; number of test stakes per group or charge.

12.1.5 *Preservatives*—Name and chemical description of both preservatives and preservative carriers, if any, sufficient to identify them fully.

12.1.6 Treating method, full cell, toluene dilutions, empty cell; average retention per group, lot or charge, including CCA controls, and range of retention or standard deviation. Information on method of determining retentions. If the preservative is in a solution of organic solvent remaining in the wood, show the retention of solvent and the concentration of preservative in the solution.

12.1.7 Average indexes of condition per charge or retention group of test stakes in periodic reports and at the time the test is terminated, with supporting tabular data and illustrative behavior curves. Comparative data on indexes of control CCA stakes and untreated stakes.

12.1.8 Time in test (11.5) (years to termination) for test stakes and treated reference stakes, if any.

12.1.9 Holding period between time of treatment and time of installation, details of after-treatment handling and storage conditions during interim.

12.1.10 Deviation, if any, from standard procedure.

TABLE 1 Example of Calculation of Index of Condition in a 5.0–5.9 lb/ft^3 (80 to 94.4 kg/m^3) Cell; Coal Tar Creosote, 9 Years in Test

		Grade and Number						Summation		
lb/ft^3	kg/m^3	10	9	7	4	0	*n*	lb/ft^3	kg/m^3	Grade
5.1	82	. . .	3	7	. . .	. . .	10	51.0	816	76
5.2	83	. . .	1	1	1	. . .	3	15.6	250	20
5.5	88	. . .	1	1	1	. . .	3	16.5	264	20
5.8	93	. . .	1	1	. . .	. . .	2	11.6	186	16
5.9	94	1	. . .	1	. . .	. . .	2	11.8	189	17
						Total	20	106.5	1704	149
						$\bar{x}$		5.3	8.5	7.4

TABLE 2 Average Ratings, Low Residue Coal Tar Creosote, ¾ In. Southern Pine Stakes, 1, 3, 5, 7, and 9 Years in Test; n = 40; 8 lb/ft^3 (128 kg/m^3) and 4 (64 lkg/m^3) Empty-Cell Groups

Years	Average Ratings	
	8 lb/ft^3 (128 kg/m^3)	4 lb/ft^3 (64 kg/m^3)
1	10.0	10.0
3	9.8	9.3
5	9.1	6.7
7	7.4	4.6
9	5.5	. . .

TABLE 3 Example of Summary and Analysis of Retention VS Grade Ratings; Low Residue Coal Tar Creosote, Empty-C Treatment, 11½ Years in Test

Cell Range kg/m³	Rating, Grade and Number								3-Point Moving Average		
	n	$\overline{X}$, kg/m³	10	9	7	4	0	X	n	$\overline{X}$, kg/m³	$\overline{X}$, Grade
51 to 62	17	59	. . .	. . .	5	2	10	2.5	(17)	(59)	(2.5)
66 to 78	18	72	. . .	1	10	4	3	5.3	51	72	5.0
82 to 94	16	85	. . .	2	14	. . .	. . .	7.2	46	85	6.4
101 to 110	12	106	. . .	3	8	. . .	1	6.9	40	101	7.4
117 to 125	12	118	3	2	7	. . .	. . .	8.1	36	118	8.1
130 to 136	12	131	7	3	2	. . .	. . .	9.2	28	128	9.1
146 to 149	4	147	2	2	. . .	. . .	. . .	9.5	24	147	9.3
168 to 173	8	171	5	2	1	. . .	. . .	9.4	18	171	9.6
184 to 189	6	186	6	. . .	. . .	. . .	. . .	10.0	22	183	9.7
192 to 200	8	192	6	2	. . .	. . .	. . .	9.8	20	200	9.9
222 to 224	6	223	6	. . .	. . .	. . .	. . .	10.0	(6)	(223)	(10.0)
Total	119		35	17	47	6	14				
Percent			29.4	14.3	39.5	5.0	11.8				

TABLE 4 Examples of Depreciation Curve Data Read From Dosage-Response Curves; Low Residue Coal Tar Creosote

Retention		Years in Test		
		7	9	11½
lb/ft³	kg/m³	Average Grade		
5.0	80	8.8	6.7	6.0
7.0	112	9.7	8.7	8.0
9.0	144	9.9	9.6	9.2
11.0	176	10.0	9.9	9.7
13.0	208	10.0	10.0	9.9

TABLE 5 Short-cut Calculation Index of Condition

Nominal Retention, lb/ft³	No. of Stakes in Group	Decay Grade, Y	No. of Stakes, f	Weighted Grades, fY
8	20	10	1	10
		9	2	18
		7	6	42
		4	8	32
		0	3	0
			20	102

$$I = \Sigma fY/\Sigma f = 102/20 = 5.1$$

where:

I = average index of condition for the group,
f = number of stakes in each grade, and
Y = decay grade.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa 19103, which will schedule a further hearing regarding your comments. Failing satisfaction there, you may appeal to the ASTM Board of Directors.

ue Coal Tar Creosote, Empty-Cell

	3-Point Moving Average		
	n	$\bar{X}$, kg/m³	$\bar{X}$, Grade
5	(17)	(59)	(2.5)
3	51	72	5.0
2	46	85	6.4
9	40	101	7.4
1	36	118	8.1
2	28	128	9.1
5	24	147	9.3
4	18	171	9.6
0	22	183	9.7
8	20	200	9.9
0	(6)	(223)	(10.0)

Low Residue Coal Tar Creosote

Weighted Grades, *fY*
10
18
42
32
0
102

and must be reviewed every five
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will receive careful consideration
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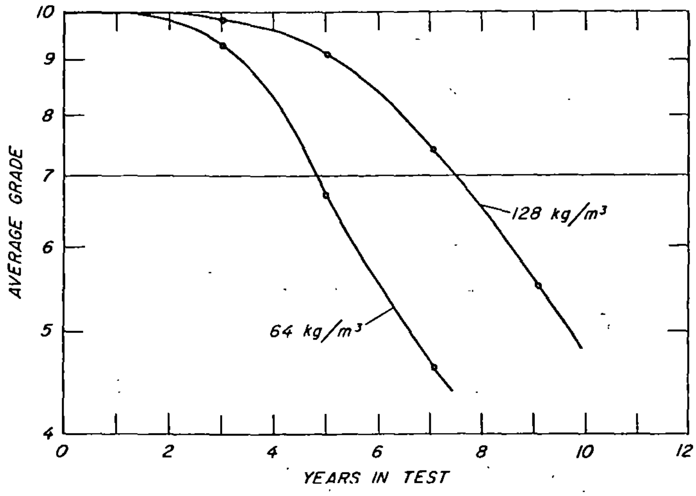

NOTE—In Figures 1, 2 & 3 convert the g/cm³ to kg/m³ by multiplying by 1000.

FIG. 1 Depreciation Curves; Low Residue Creosote; ¾-in Stakes 1, 3, 5, 7, and 9 Years in Test; Average Rating, 8 and 4 lb/ft³ Groups; *n* = 40

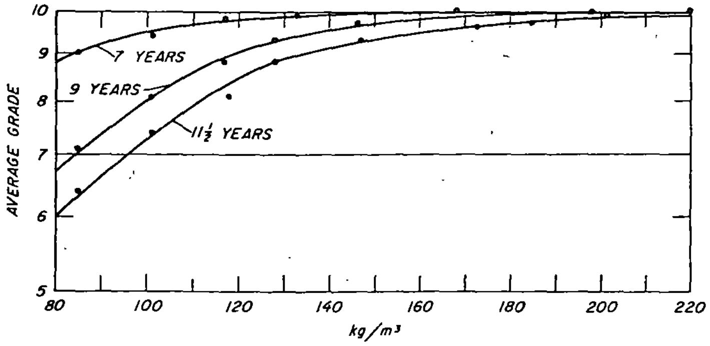

FIG. 2. Retention versus Grade; Dosage-Response Curves: Low Residue Coal Tar Creosote, Empty-Cell Treatment, 7, 9, and 11½ Years in Test

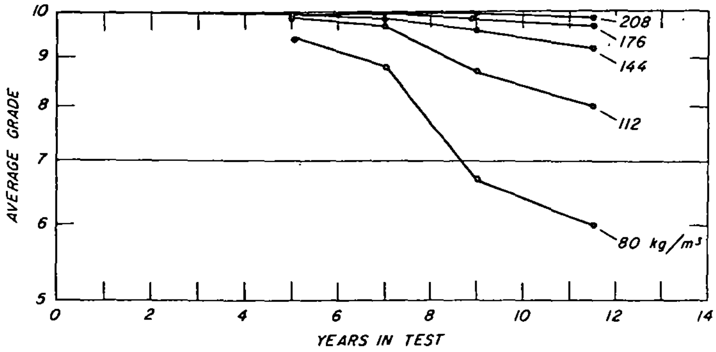

FIG. 3 Example of Depreciation Curves: Low-Residue Creosote 80, 112, 144, 176, and 208 kg/m³

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Designation: D 2278 – 66 (Reapproved 1980)

Standard Method for
FIELD EVALUATION OF WOOD PRESERVATIVES IN ROUND POST-SIZE SPECIMENS[1]

This standard is issued under the fixed designation D 2278; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the determination of the relative effectiveness of wood preservatives in round posts set in the ground in field plots. Two tests are described, one for small (3 to 5 in. (80 to 130 mm) in diameter) sapwood posts which is the preferred test if major interest lies in testing the preservative when fairly evenly distributed throughout the piece, and the second for large posts (7 to 10 in. (180 to 250 mm) in diameter) which is preferred when the preservative is tested under conditions of gradient retention and distribution normally encountered in commercial operations.

1.2 The requirements for preparation of the material for testing and the test procedures appear as follows:

	Section
Test Plot	3
Test Specimens	4
Treatment Procedure	5
After-Treatment Handling of Posts	6
Installation of Posts	7
Inspection of Specimens	8
Evaluation of Results	9
Reports	10

NOTE 1—The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units may be approximate.

2. Summary of Method

2.1 Commercial-size round wood posts are impregnated with an appropriate series of retentions of a preservative and are handled in accordance with specified procedures prior to exposure in the field. They are then exposed in the ground to the action of weather, wood-destroying fungi, and insects in one or more selected field plots. Periodic inspections are carried out on each post to determine immediate condition and end of service life. The computed average service life for each group is used to express results at termination of the test. The general pattern of preservative performance in posts may be indicated within 5 to 10 years; however, the test of a given retention group of any preservative is not terminated until at least 60 percent of the treated specimens have failed.

3. Test Plot

3.1 *Number and Climatic Location*—Decay test plots can be established over a wider climatic range than can subterranean termite test plots. When information on decay is of primary importance, a plot can be established in a temperate climate where termite attack is not serious. When termite as well as decay control is of interest, the plot shall be located in a relatively warm and moist area where subterranean termites are known to be a hazard. The choice of location is optional, but the investigator shall record which type of plot is involved. The location of test plots within a reasonable distance of a weather bureau station is encouraged.

3.2 *General Requirements*—The specific area selected for the plot shall be of essentially uniform soil character, level, moist but well drained land, remote from industrial contamination and large enough to accomodate all anticipated expansion for at least 25 years. It

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[1] This method is under the jurisdiction of ASTM Committee D-7 on Wood.

Current edition effective Sept. 20, 1966. Originally issued 1964. Replaces D 2278 – 64 T.

should be protected by fire lanes and should be fenced to prevent access of animals and discourage pilferage of posts. In a plot used essentially or exclusively for decay studies, a preliminary bioassay shall be made to prove that decay-producing organisms are present. If a background of data on the area exists or if wood debris in contact with the ground indicates suitable decay is present, further bioassay may be unnecessary. Otherwise a bioassay for decay can be made as follows: strips of $^1/_{20}$ to $^1/_{10}$-in. (1 to 3 mm) veneer of pine or gum sapwood can show rapidly whether fungi in the soil have sufficient decay-producing capacity. Strips of veneer should be buried horizontally approximately 3 in. (80 mm) deep at several places in the plot for at least 3 weeks during warm, moist weather; if the pieces show such evidence of decay as extreme brashness when broken in the hands, the plot is considered suitable. Where the test plot is to yield data on both decay and termites, the bioassay shall also include a test to determine whether or not termites are present. If the examination of wood debris on the ground, such as dead branches, wood chips, or other cellulosic materials, does not give sufficient evidence of good termite distribution, the contemplated test area can be "staked out" with untreated low-density sapwood stakes ($^3/_4$ by $^3/_4$ in. (19 by 19 mm) or other suitable sizes) and these stakes observed for termite activity. If the climate and rainfall are suitable for termite attack and a sufficient number of stakes have been attacked to show reasonable termite activity, the proposed test area will be deemed suitable.

3.3 *Soil and Vegetation*—The ground shall be in its native state or, if it has been used for agricultural purposes, it shall not have been tilled within 3 years of the date of establishment of the test plot. The area shall be capable of actively supporting vegetation, decay fungi, and, optionally, termites. A cover of organic matter or grass is desirable. A sandy loam or silt loam is the preferred soil. No artificial or natural fertilizers shall be applied to the plot during the test period. The following plot details shall be reported:

3.3.1 Vegetative cover,

3.3.2 Depth of the different soil horizons for a distance of 1 ft (300 mm or 0.3 m),

3.3.3 pH of soil samples (Note 1) taken from the first 6 in. (150 mm) of mineral soil directly below the organic matter,

3.3.4 Water-holding capacity of composite soil sample of the upper 6 in. (150 mm) as measured in accordance with ASTM Method D 1413, Testing Wood Preservatives by Laboratory Soil-Block Cultures,[2] and

3.3.5 General agricultural classification of soil type.

NOTE 2—Ten soil samples from various areas within the selected plot shall be taken and tested separately.

3.4 *Preparation of Plot*—The plot shall be selected so that a minimum of preparation of the plot is necessary (see 3.3).

3.5 *Control of Vegetation*—No chemicals shall be used to control the growth of vegetation either prior to or during the use of the test area. Woody vegetation or rank growths of weeds shall be mechanically removed only under the direct supervision of the persons making the studies. These recommendations are made to prevent damaging the posts and to prevent the use of chemicals that might unduly influence the value of the tests.

3.6 *Reuse of Ground*—Posts may be placed in ground that has been used previously for test purposes, but not sooner than 5 years after the last use. Old holes shall not be used for the placement of new posts.

4. Test Specimens

4.1 *Selection of Wood*—Round posts of pine species having 4 to 10 rings/in. (10 to 25 rings/cm) in the outside 1.5 in. (38 mm) and having not less than a 1.5-in. thickness of sapwood shall be used. Wood shall be free of large knots, excessive resin content, shakes, and other abnormalities and shall show no evidence of insect attack, decay, or heavy infection by mold or stain fungi. The same species of wood shall be used throughout any test designed to furnish data on relative fungicidal and insecticidal value of test preservatives. When the boundary between heartwood and sapwood is difficult to recognize, a color test[3]

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[2] *Annual Book of ASTM Standards*, Part 22.

[3] "Color Tests for Differentiating Heartwood and Sapwood, of Certain Oaks, Pines and Douglas Fir," Forest Products Laboratory Technical Note 253, U.S. Forest Service, revised June 1954.

shall be used to distin
4.2 *Size*—Either
be used for this sta
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4.2.2 *Size L*
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shall be used to distinguish between the two.

4.2 *Size*—Either of two sizes of posts may be used for this standard. They will be referred to hereinafter as Size S and Size L. The sizes given shall apply to seasoned materials.

4.2.1 *Size S* (*Small*)—Posts shall be 5 to 8 ft (1.5 to 2.5 m) in length. The diameter shall be 3 to 5 in. (80 to 130 mm) or the circumference shall be 9.4 to 15.7 in. (240 to 400 mm) respectively when measured 18 in. (460 mm) from the butt. It may be desirable to measure and segregate the posts into groups for treatment according to diameter dimensions, and later to distribute the size groups evenly between the test series. The average diameter within each series of posts shall be within the range from 4.0 to 4.6 in., (100 to 120 mm) measured 18 in. (460 mm) from the butt.

4.2.2 *Size L* (*Large*)—Posts preferred for this size are usually obtained by cutting a 30-ft (9.1 m) Class 6 or 7 pole into three 10-ft (3 m) sections having mid-point diameters of 7 to 10 in. (180 to 250 mm). An equal number of butt, center, and top cuts for each preservative are put in the ground at each test site.

4.3 *Preparation of Posts*—Whenever practical, selection of test posts shall begin in the woods. Posts shall be as free as possible of fungus infection (molds, sapstain, decay). Posts shall be smoothly hand or machine peeled to remove all cambium. Removal of sapwood shall be kept to a minimum.

4.3.1 Size S posts shall be air-seasoned or artificially dried to limit serious seasoning checks and to prevent fungus infection.

NOTE 3—To reduce fungus infection, it may be helpful to dip posts for not longer than 1 min in a 2.0 weight percent solution of sodium pentachlorophenate in water. If this precaution is used, it should be used on all posts within any comparative test, including untreated controls and note should be made in reporting. Removal of at least 1 in. (25 mm) of wood from each end of the posts to determine freedom from infection is recommended. Posts should be seasoned to a moisture content of 20 percent or less in the $\frac{1}{4}$ to $1\frac{1}{4}$-in. (6 to 32 mm) zone, and the moisture content recorded.

4.3.2 Size L posts should be conditioned in the usual manner for round timbers of the particular species employed in the tests, by air-seasoning, by artificial drying, by steaming, by heating in the preservative, or by a combination of these methods within the limits prescribed in 3.3 of ASTM Specification D 1760, Pressure Treatment of Timber Products.[2]

4.4 *Identification of Test Posts*—Identify each test post by burn-branding its code number and if applicable the approved identifying marks as listed in the "Brands Used on Forest Products" (*AWPA M6*)[4] or by attaching an aluminum, Monel, or other weather-resisting metal tag, or both. Identification should be placed at some uniform distance within 18 in. (460 mm) from the top.

5. Treatment Procedure

5.1 *Types of Test and Treatment Methods:*

5.1.1 *Type FC*—The *full-cell* treatment is employed to obtain gradient retentions of preservatives of the water-borne and oil and oil-borne types by varying the concentration of the preservative in the carrier.

5.1.2 *Type EC*—The *empty-cell* treatment is employed to obtain treatments similar to those used commercially. They are applied principally to oil type preservatives such as creosote and oil-borne preservatives such as pentachlorophenol in oil.

5.2 *Number of Posts to be Treated:*

5.2.1 *Size S Posts*—Treat enough posts to permit selection after treatment of at least 10 posts having preservative retentions closely approximating the required retention level for each of the planned graded retentions (see 5.5). The range of retentions in the selected posts shall not exceed the average by more than 10 percent for Type FC test posts nor 15 percent for Type EC test posts (Note 4). Treat all posts of one treatment group as one charge, or if the number of specimens is too large to be accommodated in the treating cylinder, prepare the charges so as to provide for equal distribution of the posts from each charge among the test plots.

NOTE 4—Posts with lower or higher retentions than the limits set for the chosen retention groups may be retained as pilot posts. Such posts installed in the plot or even used as fencing can be removed at any desired time to provide such useful data as early post condition, fungi causing initial or later attack, or both, as determined by culturing and by measuring preservative losses or changes as determined by chemical analyses of the posts. Making use of pilot posts, therefore, is strongly recommended.

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[4] "Brands Used on Forest Products," American Wood-Preservers' Association Manual of Recommended Practice M6, latest edition.

5.2.2 *Size L Posts*—Accept all posts treated as test specimens. However, each post shall be assayed at midpoint (5.10) so that its individual retention will be recorded. Size L posts may be treated either by themselves in an experimental or pilot cylinder or they may be treated in a commercial charge made up in its entirety of other round material of approximately the same cross-sectional dimensions, density, and moisture content.

5.3 *Preservative Analysis*—Analyze each preservative solution prior to treatment. If there is reason to believe that a change in composition occurs during treatment, analyze after each treatment and avoid extended use of the same solution. Store samples of original preservative solutions in suitable sealed containers for possible future reference.

5.4 *Untreated Control Posts*—In order to determine the average life of untreated posts in the test area, install a minimum of 10 untreated posts per 100 treated posts, distributing them in uniform manner over the test area. The untreated posts should be of the same size as the treated posts. When the untreated posts fail, record the causes of failure as well as the length of time that they remained under test. Remove the posts that fail from the test area.

5.5 *Graded Retentions of Preservatives*—In order to provide information as to the minimum effective retention of different preservatives, test each preservative in a geometric series (geometrical factor = 1.5) of two or three graded retentions (Note 5). The spread in the series shall be designed to straddle the expected or predetermined effective retention. This retention may be based on experience, or on assumptions from the results of soil-block tests (Method D 1413) and stake tests (ASTM Method D 1758, Evaluating Wood Preservatives by Field Tests with Stakes[2]). The retention nearest the expected effective retention should be at or near the middle of the series.

NOTE 5: *Examples*—The illustrations of the two and three-grade series are guides rather than mathematically precise retention requirements. The amount of preservative absorbed will vary inversely as the specific gravity of the test posts and some variation from the suggested retention levels is to be expected. *Two-grade retentions* (geometrical factor = 1.5): *Creosote or 5 percent pentachlorophenol-petroleum solution* 7.0 and 10.5 lb/ft.^{3} (112 and 168 kg/m^3) *pentachlorophenol* 0.35 and 0.53 lb/ft,^{3} (5.6 kg/m^3 and 8.5 kg/m^3) Fluor chrome arsenate phenol (FCAP) 0.35 and 0.53 lb/ft.^{3} (5.6 kg/m^3 and 8.5 kg/m^3) *Three-grade retentions* (geometrical factor = 1.5): *Creosote or 5 percent pentachlorophenol-petroleum solution* 6.0, 9.0 and 13.5 lb/ft,^{3} (96, 144 and 216 kg/m^3) *pentachlorophenol* 0.33, 0.50 and 0.75 lb/ft.^{3} (5.3, 8.0 and 12 kg/m^3) Fluor chrome arsenate phenol (FCAP) 0.33, 0.50 and 0.75 lb/ft.^{3} (5.3, 8.0 and 12 kg/m^3)

5.6 *Concentration of Treating Solutions for Type FC Tests*—Make up the treatment solutions for Type FC tests in appropriate gradient concentrations with a view to leaving in the posts at treatment a range of retentions running from below to above the anticipated minimum effective retention. All preservatives shall be in such a state of solution before use that the active ingredients will be uniformly distributed throughout the treated wood. The number of concentrations to be made up for any given preservative depends on whether it is possible to anticipate a protective retention and how close it is necessary to determine it.

NOTE 6—Adjust the concentrations of solid preservative chemicals or combinations of chemicals in oil or water vehicles so that the wood will absorb the required amount of the "dry" solid.

5.7 *Full-Cell Treatment*—For Type FC tests, which are designed as comparative tests of the relative order of effectiveness of preservatives (Note 7) impregnate the specimens by a full-cell process, using an initial vacuum, suitable temperature, and appropriate pressure period but omitting final vacuum. Promote the best possible distribution of the preservative in the wood (Note 8).

NOTE 7—The spread in retentions in the individual test posts has been shown by experience to be considerably wider in the case of empty-cell treatments than for full-cell treatments. The magnitude of the range in retention distribution shall be determined by trial. It is desirable to select the treated posts with a view to holding the range of retention as low as possible for each of the graded retentions chosen.

NOTE 8—Values in Type FC tests are based on approximately even distribution of the preservative in the wood. Evacuate the air from the wood as far as practicable before the pressure cycle is employed in order to leave the cell cavities free to be filled with the preservative solution. The amount of air spaces available to hold liquids has been determined for woods of different density and moisture content.[5] Therefore, the approximate maximum absorption to be expected can be computed from the percentage of air space in the wood and the specific gravity

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[5] MacLean, J. D. "Effects of Moisture Changes on the Shrinking, Swelling, Specific Gravity, Air or Void Space Weight and Similar Properties of Wood." Mimeographed report No. 1448, U.S. Department of Agriculture, 1958.

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5.8 *Empty-Cell Treatment*—For Type EC tests which are designed to compare the relative performance of wood treated by methods usually used commercially, impregnate the posts by an empty-cell process in imitation of the usual accepted commercial practice, adapted to the available treating equipment. Apply creosote or related material or oil-borne preservative solution undiluted. Adjust the treating process so as to leave in the wood suitable average amounts of preservative to conform to the plan for graded retentions prescribed in 5.5.

5.9 *Preservative Retention - Gain in Weight Basis*—For posts in which the preservative retention is measured by a gain in weight, measure and record the untreated weights immediately before treatment. To determine the amount of preservative absorbed, remove each post individually from the treating chamber, wipe lightly, if necessary, to remove excess surface preservative or preservative solution, and weigh promptly to the nearest 0.10 lb (45 g). Calculate the retention of preservative or preservative solution as follows:

$$\text{Retention, lb/ft}^3\ (\text{kg/m}^3) = A/B$$

where:

A = gain in weight, lb, (kg) and

B = volume, ft^3 (m^3).

5.10 *Preservative Retention - Assay of Treated Wood*—Retention based on gain in weight is considered accurate when posts are air-seasoned to 20 percent moisture or less. However, when green or partially seasoned posts are conditioned prior to treatment either by steam conditioning or boultonizing, gain in weight does not yield accurate over-all retention results due to the interchange of water between the timber under treatment and the treating solution. This occurs with both oil-type and water-type preservative solutions. In such cases, reliance should be placed on the assay of increment cores, but such retention figures are applicable only to the section or zone sampled. Assay data obtained from analyzing two or more zones are of value when preservative distribution is under study. This applies to air-seasoned posts also. The increment cores should be taken from the midpoint after the posts have cooled to ambient temperature. For Type L southern pine and ponderosa pine posts, utilize borings from 20 posts in a charge from the zone 0.5 to 2.0 in. (13 to 51 mm) when a single zone assay is being made. When individual posts are being assayed, use the composited zone samples from not less than four increment cores. Use ASTM methods for retention analyses. Otherwise, employ methods of the American Wood-Preservers' Association.

6. After-Treatment Handling of Posts

6.1 *Posts Treated with Water Solutions*—Dry posts treated with water-borne preservatives after treatment by air seasoning, kiln drying, or a combination of both (Note 9). Thus, upon final weighing after treatment, the posts may be stacked so that air can circulate freely between them until their moisture content is less than 30 percent. If stored outdoors, stacks shall be completely protected from the weather during drying. Alternatively, posts may be dried in an oven or kiln at a temperature not to exceed 140 F (60 C) until their moisture content is less than 30 percent, as evidenced by change in weight of the charge. Adequate air seasoning after treatment is necessary with many water-borne preservatives of the fixing type, to bring to completion certain chemical reactions.

NOTE 9—If a preservative requires special or other types of conditioning than that specified, report the method of after-treatment handling fully.

NOTE 10—It is believed that these reactions cannot take place well in the below ground area of a post, especially if the moisture content of the soil is high.

6.2 *Posts Treated with Undiluted Preservatives*—Posts treated with undiluted preservatives, for example creosote or pentachlorophenol-petroleum solution, should be close-piled immediately after treatment. The stacks shall be stored in a cool location and the posts shall be completely protected from the weather until they are sent to the test site for installation.

6.3 *Weighing Before Installation*—With the exception of posts treated with a water solution of preservative, weigh the posts to the nearest ounce or 0.10 lb (0.04 kg) within 24 h before they are shipped to the test plot for installation. If bleeding of preservative is indicated between the time of treatment and the time of installation, such posts must be reweighed or reassayed to correct for preservative losses.

7. Installation of Posts

7.1 *Time Lapse Between Treatment and Installation*—Install the posts in the test plot as soon as possible after treatment, consistent with the requirements outlined in Section 6. The lapse of time between treatment and installation shall not exceed 6 months.

7.2 *Spacing of Posts in Test Plot*—Space the posts not less than 2 ft (0.6 m) between specimens and not less than 3 ft (0.9 m) between rows.

7.3 *Depth of Installation*—Install the posts to a depth of 24 in. (0.6 m) for small posts and 36 in. (0.9 m) for large posts. Compact the soil against the posts.

7.4 *Location of Posts*—Randomize the posts in the test plot.

7.5 *Plot Map*—A plot map is essential to eliminate the danger of having unidentifiable posts.

8. Inspection of Specimens

8.1 *Frequency of Inspection*—One advantage of having untreated posts in the test plot is that guidance is obtained as to when the first inspection shall be made. The time between subsequent inspections will depend upon whether a new preservative is being tested or whether one is trying only to establish service limits.

8.2 *Inspection*—Fall is the preferable time of inspection. New posts should be installed at inspection time. Examinations shall be made without prior reference to records of previous years.

8.3 *Procedure*—Three alternative procedured may be used to inspect post specimens, but employ only one of these procedures throughout a test plot.

8.3.1 Posts can be withdrawn from the ground by jacks, etc.

8.3.2 The below-ground portion of the post can be exposed by removing the soil to the required depth. For both methods, use an instrument with a blunt point to determine the condition of the posts below the groundline. Excessive picking of the softer springwood in the specimens should be avoided. Special care should be taken in examinations when the posts are very wet, because softening due to high moisture content can be mistaken for decay. Also, the specimen can be damaged easily by indiscriminate probing when wet (Note 11), and

8.3.3 Posts can be left undisturbed below ground but be subjected to several firm and uniform alternate pushes from opposite directions. The push test is not enough if one wishes to get information on early decay or termite attack. In these cases, lifting is necessary.

NOTE 11—Prior experience in inspecting posts will assist correct diagnosis of post condition. To the extent possible, the same individual should carry out the periodic inspections.

In all three procedures, visually observe the upper portion of posts and note bleeding of the preservative and its extent. After any of the methods of examination or after resetting of the posts to their original depth, the soil shall be compacted against the posts.

8.4 *Grading Systems (for Below-Ground Condition)*—The grading system for reporting results shall be as listed in Tables 1 and 2. Two rating scales are shown for termite ratings. This is done to prevent confusion when recording data. When analysing the ratings, the numerical ones can be substituted. If desired, the numercial ratings may be used throughout.

8.5 *Index of Condition*—For comparison of the treatments either immediately or at the termination of the test, the index of condition as determined from the grades assigned to the posts shall be computed in terms of (*1*) decay grades only, (*2*) termite grades only, and (*3*) decay and termite grades combined, that is, the lowest grade from either cause. Compute the index of condition for each of the above categories by listing the grades and multiplying each grade by the number of individual posts in the retention group that received it as the lowest grade. The sum of the products, divided by the total number of posts rated in the retention group, gives the average index of condition of the retention group at the time that the ratings are made.

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8.6 *After-Test Analysis*—It is recommended that the above and below ground-line portions of the posts which are removed due to failure should be saved for use in identifying species of organism causing failure and determining quantity of preservative remaining.

9. Evaluation of Results

9.1 *Termination of Test*—The general pattern of preservative performance may be established within 5 to 10 years of post installation, but the test of a given preservative shall not be terminated until the average life has been attained and one should not try to estimate life expectancy until at least 10 percent but not less than two specimens of a retention group have failed from either decay or termite attack. Average life is usually attained when 60 percent of the specimens have failed.

9.2 *Lost Posts*—The number of posts lost or destroyed by other causes than decay or termite attack shall be deducted from the original number in their retention groups for any computations and such posts shall be adequately noted in the report.

9.3 *General Analysis*—The average life of different retention groups is used as an indication of the performance of a preservative in the posts in the test plot. If the range of retention (5.2 and Note 3) for a given nominal retention set of posts does not exceed 10 percent of the average retention in a full-cell treatment or 15 percent in an empty-cell treatment, the service life of individual posts in each set shall be averaged. When the range is greater than the above values, the service life shall be presented individually for each post in a set and arranged according to increasing retention. If the cause of failure due to decay or to termite attack can be determined separately for each post, or the percentage of failure due to each cause in a group of posts can be estimated, this information should be given. In the case of unusual results, particularly in failure of preservative due to decay, an isolation and identification of the causal fungus is desirable. In post tests, attention shall also be paid to chemical analyses during the lifetime of the posts. Posts can give information on the depletion of the preservative above ground, or at the ground line, at various times in their life. If the rate of depletion of preservative during the lifetime of the post is not required, then an analysis of the ground-line portion at the time of failure will supply information on the amount of preservative remaining in the region subject to attack. Appropriate assays can, therefore, be made to obtain this information. The average life and estimated standard deviation of retention shall be reported for each charge (nominal retention) of posts.

10. Report

10.1 A suggested test report is shown in Fig. 1. The report shall include concise information and data on the following essential phases of the test:

10.1.1 Location of plot,

10.1.2 Character of soil, including values for pH and moisture-holding capacity (See ASTM D 1413) of upper 6 in. (150 mm) of mineral soil (See 3.3),

10.1.3 Time in test (see 9.1) (years to termination) for test posts and treated reference posts,

10.1.4 Climatological data including (*a*) average rainfall and average temperature per month, (*b*) average minimum and maximum temperature per month, (*c*) number of days having more than 0.01 in. (0.25 mm) of rain, and (*d*) total annual rainfall,

10.1.5 Species of wood, dimensions of post, and average sapwood depth,

10.1.6 Preservative: name and chemical description of preservative and carrier sufficient to identify both fully,

10.1.7 Average retention per charge,

10.1.8 Average life and standard deviation per charge (retention group) of test posts at time test is terminated, and

10.1.9 Deviations, if any, from standard procedure.

TABLE 1 Decay Grades

Dscription of Condition	Grade No.
Sound	10
Trace of decay	9
Moderate decay	7
Heavy decay	4
Failure due to decay	0

TABLE 2 Termite Grades

Description of Condition	Numerical Rating	Recording Grade
Sound	10	A
Trace of attack	9	B
Moderate attack	7	C
Heavy attack	4	D
Failure by termite attack	0	E

Test Plot
Location ___
Soil type ___
Moisture-hol

Time of Test
From ___

Weather Data
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Average mor
Number of d
Average min
Average max
Total annual

Specimens
Species of w
Size of posts
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Numerical Rating	Recording Grade
10	A
9	B
7	C
4	D
0	E

l must be reviewed every five r revision of this standard or l receive careful consideration r comments have not received 6 Race St., Philadelphia, Pa. here, you may appeal to the

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Test Plot

Location ______________________________

Soil type ______________________________ pH __________

Moisture-holding capacity (top 6 in.) (ASTM D 1413) ______________________________

Time of Test

From__________to__________

Weather Data

Average monthly rainfall __________in.

Average monthly temperature __________F

Number of days per year having more than 0.01 in. of rain __________

Average minimum monthly temperature__________F

Average maximum monthly temperature __________F

Total annual rainfall __________in.

Specimens

Species of wood ______________________________

Size of posts: Length __________ ft, Average diameter__________in.

Thickness __________(in.) or percentage __________of Sapwood

Preservative

Name ______________________________

Chemical description of preservative and carrier ______________________________

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Results

The following tabular form may be used when the range of retentions permits averaging the test data for each charge of test posts; otherwise, results must be listed individually for each post.

Charge No.	Retention		Time in test, years	Life data for each retention group	
	Average lb/ft^3	Range		Average life	Percent failure

Remarks

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FIG. 1 Typical Report Form.

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AMERICAN WOOD-PRESERVERS' ASSOCIATION
STANDARD

P5–81

STANDARDS FOR WATER-BORNE PRESERVATIVES

Note: Standard P5–81 consists of three pages dated as follows: Pgs. 1–2, 1981; Pg. 3, 1977.

1. ACID COPPER CHROMATE (ACC)[a]

1.1 Acid copper chromate shall have the following composition:

Copper, as CuO	31.8%
Hexavalent chromium, as CrO_3	68.2%

subject to the following tolerances:

1.2 The analytical composition of the solid, paste, liquid concentrate or treating solution forms of the preservative may vary within the following limits:

	Min.[b]
Copper, as CuO	28.0%
Hexavalent chromium, as CrO_3	63.3%

1.3 The solid, paste, liquid concentrate or treating solution shall be made up of water soluble compounds selected from the following groups each in excess of 95 percent purity on an anhydrous basis:

Bivalent copper—e.g., copper sulfate
Hexavalent chromium—e.g., sodium or potassium dichromate, chromium trioxide

The commercial preservative shall be labeled as to its total content of active ingredients listed in the first paragraph.

1.4 Tests to establish conformity with the foregoing requirements shall be made in accordance with the standard methods of the American Wood-Preservers' Association.[c] (See Standard A2.)

2. AMMONIACAL COPPER ARSENATE (ACA)[a]

2.1 Ammoniacal copper arsenate shall have the following composition:

Copper, as CuO	49.8%
Arsenic, as As_2O_5	50.2%

subject to the tolerances listed in paragraph 2.2.

The above shall be dissolved in a solution of ammonia (NH_3) in water. The weight of ammonia contained in a treating solution shall be a minimum of 1.5 times the weight of copper expressed on the oxide basis. To aid in solution, not over 1.7 percent of glacial acetic acid may be added.

2.2 The analytical composition of the solid, paste, liquid concentrate or treating solution forms of the preservative may vary within the following limits:

	Min.[b]
Copper, as CuO	47.7%
Arsenic, as As_2O_5	47.6%

2.3 The treating solution shall contain bivalent copper and pentavalent arsenic derived from compounds in excess of 95 percent purity on an anhydrous basis.

The commercial preservative shall be labeled as to its total content of active ingredients listed in the first paragraph.

2.4 Tests to establish conformity with the foregoing requirements shall be made in accordance with the standard methods of the American Wood-Preservers' Association. (See Standard A2.)

2.5 The valency state of the arsenic component of ACA treating solutions shall be determined in accordance with Section 13 of AWPA Standard A2, to ensure that the arsenic is in the pentavalent form.

CHROMATED COPPER ARSENATE

3. TYPE A[a]

wolman

3.1 Chromated copper arsenate, Type A, shall have the following composition:

Hexavalent chromium, as CrO_3	65.5%
Copper, as CuO	18.1%
Arsenic, as As_2O_5	16.4%

subject to the following tolerances:

3.2 The analytical composition of the solid, paste, liquid concentrate or treating solution forms of the preservative may vary within the following limits:

	Min., %	Max., %[b]
Hexavalent chromium, as CrO_3	59.4	69.3
Copper, as CuO	16.0	20.9
Arsenic, as As_2O_5	14.7	19.7

3.3 The solid, paste, liquid concentrate or treating solution shall be made up of water soluble compounds selected from the following groups each in excess of 95 percent purity on an anhydrous basis:

Hexavalent chromium—e.g., potassium or sodium dichromate, chromium trioxide
Bivalent copper—e.g., copper sulfate, basic copper carbonate, cupric oxide or hydroxide
Pentavalent arsenic—e.g., arsenic pentoxide, arsenic acid. sodium arsenate or pyroarsenate

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[a] A list of trade names for water-borne preservatives is shown in Standard M9.

[b] The composition of treating solutions in use may deviate outside the limits specified in paragraphs 1.2, 2.2, 3.2, 4.2, 5.2, 6.2 and 7.2 provided: a. The preservative retention in treated material is determined by assay and the retention so determined conforms to the requirements specified in the Table of para. 3.1 in Standard C1. b. Immediate action is taken to adjust the composition of the treating solution.

[c] Acetic acid may be used if desired to adjust pH of treating solution to conform to paragraph 1.4.

The commercial preservative shall be labeled as to its total content of active ingredients listed in the first paragraph.

3.4 Tests to establish conformity with the foregoing requirements shall be made in accordance with the standard methods of the American Wood-Preservers' Association. (See Standard A2.)

4. TYPE B[a]

Boliden K-33

4.1 Chromated copper arsenate, Type B, shall have the following composition:

Hexavalent chromium, as CrO_3	35.3%
Copper, as CuO	19.6%
Arsenic, as As_2O_5	45.1%

subject to the following tolerances:

4.2 The analytical composition of the solid, paste, liquid concentrate or treating solution forms of the preservative may vary within the following limits:

	Min., %	Max., %[b]
Hexavalent chromium, as CrO_3	33.0	38.0
Copper, as CuO	18.0	22.0
Arsenic, as As_2O_5	42.0	48.0

4.3 The solid, paste, liquid concentrate or treating solution shall be made up of water soluble compounds selected from the following groups each in excess of 95 percent purity on an anhydrous basis:

Hexavalent chromium—e.g., potassium or sodium dichromate, chromium trioxide
Bivalent copper—e.g., copper sulfate, basic copper carbonate, cupric oxide or hydroxide
Pentavalent arsenic—e.g., arsenic pentoxide, arsenic acid, sodium arsenate or pyroarsenate

The commercial preservative shall be labeled as to its total content of active ingredients listed in the first paragraph.

4.4 Tests to establish conformity with the foregoing requirements shall be made in accordance with the standard methods of the American Wood-Preservers' Association. (See Standard A2.)

5. TYPE C[a]

Boliden & Wolman

5.1 The active ingredients in chromated copper arsenate shall have the following composition:

Hexavalent chromium, as CrO_3	47.5%
Copper, as CuO	18.5%
Arsenic, as As_2O_5	34.0%

5.2 The analytical composition of the solid, paste, liquid concentrate or treating solution forms of the preservative may vary within the following limits:

	Min., %	Max., %[b]
Hexavalent chromium, as CrO_3	44.5	50.5
Copper, as CuO	17.0	21.0
Arsenic, as As_2O_5	30.0	38.0

5.3 The solid, paste, liquid concentrate or treating solution shall be made up of water soluble compounds selected from the following groups each in excess of 95 percent purity on an anhydrous basis:

Hexavalent chromium—e.g., potassium or sodium dichromate, chromium trioxide
Bivalent copper—e.g., copper sulfate, basic copper carbonate, cupric oxide or hydroxide
Pentavalent arsenic—e.g., arsenic pentoxide, arsenic acid, sodium arsenate or pyroarsenate

The commercial preservative shall be labeled as to its total content of active ingredients listed in the first paragraph.

5.4 Tests to establish conformity with the foregoing requirements shall be made in accordance with the standard methods of the American Wood-Preservers' Association. (See Standard A2.)

6. CHROMATED ZINC CHLORIDE (CZC)[a]

6.1 Chromated zinc chloride shall have the following composition:

Hexavalent chromium, as CrO_3	20%
Zinc, as ZnO	80%

subject to the following tolerances:

6.2 The analytical composition of the solid, paste, liquid concentrate or treating solution forms of the preservative may vary within the following limits:

	Min., %[b]
Hexavalent chromium, as CrO_3	19
Zinc, as ZnO	76

6.3 Samples of chromated zinc chloride treating solution taken from a working tank or treating cylinder may show changes in composition as a result of treating operations. Such changes shall not serve to cause rejection of the preservative if they do not raise the ratio of zinc oxide to chromium trioxide to more than 7 to 1, and if it can be shown that the original fresh preservative was of the specified composition.

6.4 The solid, paste, liquid concentrate or treating solution shall be made up of water soluble compounds selected from the following groups each in excess of 95 percent purity on an anhydrous basis:

Hexavalent chromium—e.g., sodium dichromate, chromium trioxide
Zinc—e.g., zinc chloride

The commercial preservative shall be labeled as to its total content of active ingredients listed in the first paragraph.

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[a] A list of trade names for water-borne preservatives is shown in Standard M9.

[b] The composition of treating solutions in use may deviate outside the limits specified in paragraphs 1.2, 2.2, 3.2, 4.2, 5.2, 6.2 and 7.2 provided: a. The preservative retention in treated material is determined by assay and the retention so determined conforms to the requirements specified in the Table of para. 3.1 in Standard C1. b. Immediate action is taken to adjust the composition of the treating solution.

6.5 Tests to establish conformity with the foregoing requirements shall be made in accordance with the standard methods of the American Wood-Preservers' Association. (See Standard A2.)

7. FLUOR CHROME ARSENATE PHENOL (FCAP)[a]

7.1 The active ingredients in fluor chrome arsenate phenol preservative shall have the following composition:

Fluoride, as F	22%
Hexavalent chromium, as CrO$_3$	37%
Arsenic, as As$_2$O$_5$	25%
Dinitrophenol[b]	16%

7.2 The analytical composition of the active ingredients in the solid preservative or treating solution shall be between the following limits:

	Min., %	Max., %[c]
Fluoride, as F	20	24
Hexavalent chromium, as CrO$_3$	33	41
Arsenic, as As$_2$O$_5$	22	28
Dinitrophenol	14	18

7.3 The solid preservative or treating solution shall be made up of water soluble compounds selected from the following groups each in excess of 95 percent purity on an anhydrous basis:

Fluorides—e.g., sodium or potassium fluoride
Hexavalent chromium—e.g., sodium or potassium chromate or dichromate
Pentavalent arsenic—e.g., sodium arsenate
Dinitrophenol—dinitrophenol

Sodium or potassium hydroxide may be used to adjust the pH, and a solution of the preservative shall be essentially free of insoluble matter. The commercial preservative shall be labaled as to its total content of active ingredients listed in the first paragraph.

7.4 Tests to establish conformity with the foregoing requirements shall be made in accordance with the standard methods of the American Wood-Preservers' Association. (See Standard A2.)

8. pH OF TREATING SOLUTIONS

8.1 The pH of water-borne preservative solutions shall be within the following limits:

Preservative	*pH Limits*
ACA	Not applicable
ACC	2.0–3.9
CCA-Type A	1.6–3.2
CCA-Type B	1.6–3.0
CCA-Type C	1.6–3.0
CZC	2.8–4.0
FCAP	5.5–7.8

8.2 These pH values are preferably measured at an oxide concentration in the treating solution of 15–22 g./l. and at a temperature of 20–30°C. If a treating solution has a pH outside the stated limits, and it can be shown that it can be made conforming by adjustment of concentration to within the recommended limits, the solution shall be considered conforming to the standard.

Proceedings: 1942, 1943, 1944, 1949, 1950, 1951, 1952, 1953, 1954, 1955, 1956, 1957, 1958, 1960, 1964, 1965, 1966, 1967, 1969, 1971, 1972, 1974, 1975.

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[a] A list of trade names for water-borne preservatives is shown in Standard M9.

[b] An equal amount of sodium pentachlorophenate may be used in place of dinitrophenol provided the pH of the treating solution is in excess of 7.0.

[c] The composition of treating solutions in use may deviate outside the limits specified in paragraphs 1.2, 2.2, 3.2, 4.2, 5.2, 6.2 and 7.2 provided: a. The preservative retention in treated material is determined by assay and the retention so determined conforms to the requirements specified in the Table of para. 3.1 in Standard C1. b. Immediate action is taken to adjust the composition of the treating solution.

6

Wafer Assay For Treatability Of Wood

M. Chudnoff

Abstract

A wafer assay for treatability of wood is described. It is shown that oil absorptions obtained by a short vacuum-atmospheric pressure treatment of uncoated and edge-coated wafers can be related to the absorption of incised and unincised posts. Correlation coefficients are about 90 percent. Wafers could also be used to predict absorption of water-borne salts. It is suggested that heartwood material could be sampled as well for water assay, and absorptions could be related to commodities other than posts and to other treating methods.

IN THE FORESTS of Puerto Rico there are 30 or more tree species per acre. Elsewhere in the tropics the number may rise to 90. Several hundred are easily encountered over somewhat larger areas. This heterogeneity makes the assessment of species as to their individual wood characteristics very costly and it certainly confounds commercial development.

Wood products are vulnerable to insect and fungus attack, particularly in the humid tropics. For many applications, a preservative treatment would be of value. Yet there is no generally accepted laboratory standard for determining the treatability of wood, and no simple technique that could be used to rapidly screen hundreds of species available from a complex forest.

Based on observations of actual commercial treatments and results of pilot plant experiments, MacLean (6) classified the penetrability of American woods. Redding (8) used 2 by 2 by 43-3/16 inch (0.1 cu. ft.) heartwood and sapwood sticks to determine resistance to impregnation of some 200 species. Creosote was applied by a full-cell pressure process and by the open tank thermal method. A similar procedure was adapted by Bryce and Norcross (2) to assay 75 species of Tanganyika timbers. Commercial woods of Argentina, 5 by 5 by 10 cm. in size, were pressure treated by Tinto (11) in a creosote - gas oil mix and then classified as to treatability. Miller and Graham (7) used Douglas-fir test specimens, 1.5 by 1.5 by 6 inches along the grain, to determine absorptions of pentachlorophenol in an oil carrier applied by a pressure process. Broese van Groenou *et al.* (1) review penetrability testing and list some seven procedures developed in Germany. The brushing and trough immersion tests described have been standardized.

Longitudinal (9), transverse (10), and air flow both across and along the grain (3) have been used to determine permeability of hardwoods and softwoods. Flow rates have been correlated with retention of matched specimens pressure treated with creosote (10).

A sink-float test for Douglas-fir has been described by Graham (5). Plugs, cut to a diameter and length of 0.5 inch, are submerged in water or oil, held under a vacuum of 20 inches of mercury for 6 minutes, and then vented to atmospheric pressure. Plugs that sink are rated permeable. Remaining specimens are submerged under vacuum for an additional 20 minutes. Those plugs that continue to float after the second venting are rated refractory and those that sink are considered intermediate in treatability. Sink-float indications of treatability are commonly observed during boiling-in-water or vacuum conditioning of small wood blocks in preparation for microtome sectioning. This type of permeability test is effective for determining intra-species variability where there may be fairly small differences in specific gravity. It becomes awkward when evaluating woods that may vary in weight from less than 0.3 to over 1.0 g./cu. cm.

This report describes a wafer assay technique that has the simplicity of Graham's plug test and yet permits a rapid evaluation of a wide range of material. Treatability results are in terms of oil or water retentions in lb./cu. ft. that are directly related to those obtainable by a commercial preservative process.

Material Sampled

Data are available locally on the absorption of incised and unincised sapwood posts (4). Results are for a mix of tropical species treated with a 2 hr.-2 hr. hot-and-cold bath schedule using a 5 percent solution of pentachlorophenol dissolved in diesel oil. Posts had diameters that ranged from 2 to 4 inches and were 3 feet long. All sticks were end-coated with a resorcinol resin to limit preservative penetration to the side grain. Absorptions ranged with species from about 1 to 36 lb./cu. ft. (16 to 575 kg./cu. m.).

Some untreated trim pieces were still available from this early testing and were used to prepare disks or wafers. When submerged in oil and held under vacuum for short treating periods, wafers from the high absorbing woods had high retentions and those from the refractory species had very low retentions. Additional sapwood materials from other trees were collected

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The author is Principal Wood Scientist of the Institute of Tropical Forestry, USDA Forest Service, Rio Piedras, Puerto Rico. This paper was presented at Session 17 — Treatments and Coatings — of the 24th Annual Meeting of the Forest Products Research Society, July 1, 1970, in Miami Beach, Fla. It was received for publication in April 1970.

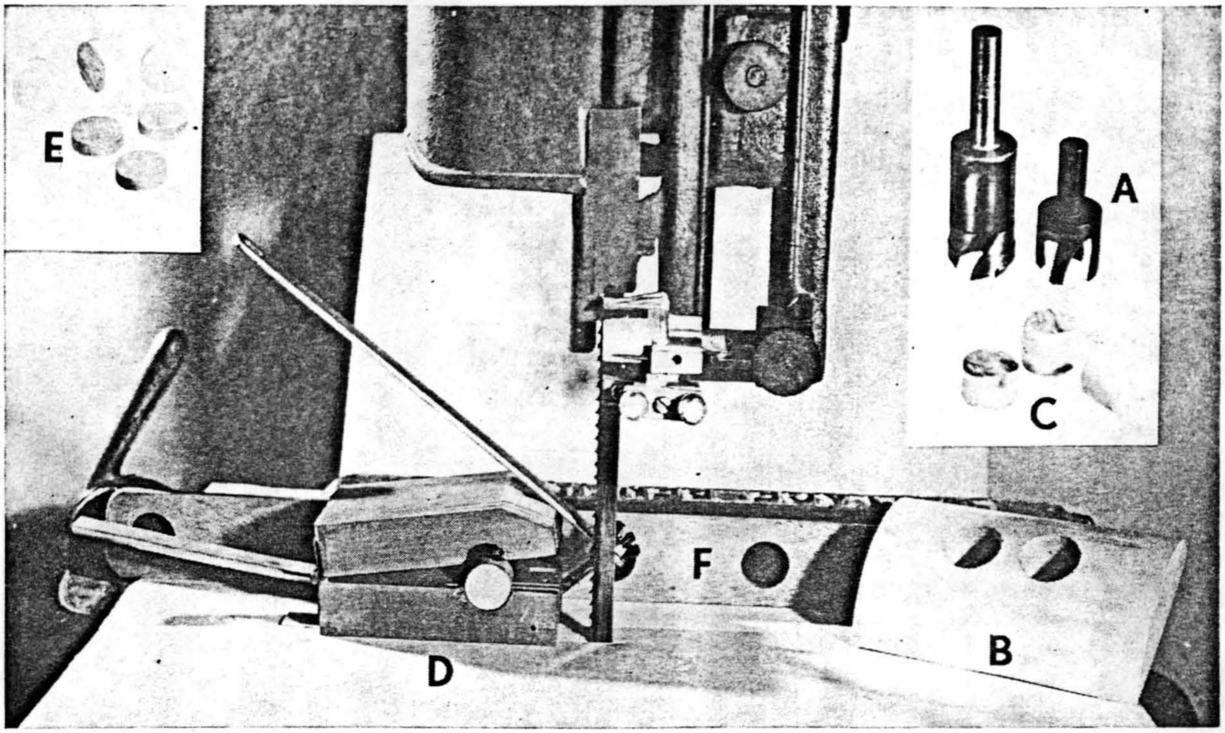

Figure 1. — Steps in the preparation of wafers from test billets. The plug cutter (A) was mounted in a drill press and fed into the air-dried billet (B) in a radial direction towards the pith. The plugs (C) were 7/8 inch in diameter and about 1 inch in length. The plugs were held in the squeeze clamp (D) and cut into wafers (E) using a four tooth-to-the-inch band saw. Sapwood wafers only were used in this study and were removed from the second 0.25-inch zone beneath the cambium. To accurately obtain this thickness, a removable fence (F) was inserted against the fixed fence.

for testing to substantiate these first wafer absorption-post absorption relationships. The species assayed are listed in Table 2 in order of increasing specific gravity (weight and volume at 12 percent moisture content). From 2 to 5 trees per species were sampled. To accelerate drying prior to wafer preparation, short bolts were debarked and sawn lengthwise to yield 3 billets. The center section was about 1 inch thick.

Wafer Assay

Preparation of Wafers

The steps followed in preparing wafers are illustrated in Figure 1. Several tools were used for cutting plugs. Hole saws were unsatisfactory due to the fuzzy grain generated in low density woods. Bung cutters gave good results, the prong type shown in Figure 1 being particularly effective with dense species. Two wafers were prepared for each of the trees sampled. One was edge-coated with 2 coats of brushable epoxy paste and the other was left uncoated. The side to end grain ratio of the wafers is approximately 2 to 1.

Wafer Treatments

Wafer diameters and thicknesses were measured with a vernier caliper to 0.1 mm. and volumes calculated. Weights to the nearest 0.01 g. were determined before and after edge coating. Wafers were submerged in a water or diesel oil bath (70°F.) in a vacuum desiccator and held under a vacuum of about 30 inches of mercury for 10 minutes. The desiccator was then vented to atmospheric pressure, and the wafers were kept submerged for an additional 10 minutes. The treating solution was then drained off, the wafers blotted to remove surface liquid, and the specimens reweighed. Oil or water retention in g./ cu. cm. or lb./cu. ft. was then calculated.

The effect of treating time on wafer absorption is shown in Table 1. From a 3 minute vacuum - 3 minute atmospheric pressure schedule to a 60 minute vacuum - 60 minute atmospheric pressure schedule there were small differences in absorption of edge-coated or uncoated wafers of yagrumo macho (*Didymopanax morototoni* (Aubl.) Decne and Planch). The absorptions of uncoated cadam (*Anthocephalus cadamba Miq.*) were

Table 1. — EFFECT OF VACUUM - ATMOSPHERIC PRESSURE TREATING TIMES ON OIL ABSORPTION.

	Treating Times (min. of vacuum - min. of atmospheric pressure)			
Species	3-3	10-10	30-30	60-60
	— — — Absorption (lb./cu. ft.) — — —			
Yagrumo macho				
Edge-coated	2.1[1]	2.5	2.5	2.3
Uncoated	8.9	9.1	9.4	9.8
Cadam				
Edge-coated	8.1	11.1	21.2	27.4
Uncoated	25.0	25.0	26.9	26.8

[1] Each value is the mean of 3 wafers.

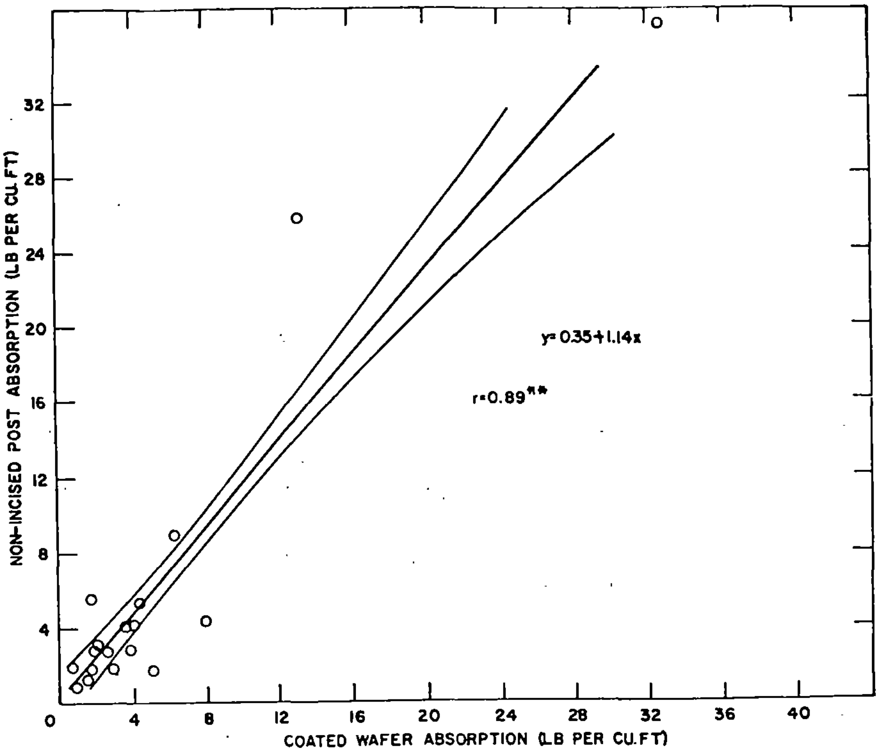

Figure 3. — Relationship between edge-coated wafer absorption and unincised post absorption; 95 percent confidence limits are shown.

18.9 lb./cu. ft., a threefold increase over the edge-coated wafers. Table 2, therefore, shows retentions of an oil or water carrier for either side grain penetration only (edge-coated wafers) or both side and end grain penetration (uncoated wafers).

A comparison was made between the data on oil absorption of incised and unincised posts (4) and the oil absorptions of uncoated and edge-coated wafers. An incised post presents a surface that is receptive to both side-and end-grain penetration of the preserving fluid, a condition simulated by the uncoated wafer. The edge-coated wafer permits penetration only through the side grain as is mainly so for unincised posts. Except by species, the wafer material was not matched with the posts. Regressions are based on random pairing of replicates, but only species means are plotted in Figures 2 and 3. Figure 2 is a simple regression relating uncoated wafer absorptions with those of incised posts. Confidence limits at the 95 percent level are shown. The correlation coefficient is quite high at 0.88. It should be noted that the ends of the posts were sealed against end-grain penetration and that the posts were not selected or sorted as to presence or frequency of knots. Thus, these wafer assays are for run-of-the-mill sticks of sufficient length where absorption through the end grain is inconsequential.

Figure 3 shows the relationship between oil absorption of edge-coated wafers and unincised posts. Again the correlation coefficient is high (0.89). In both Figures 2 and 3, at a wafer absorption of 6 lb./cu. ft., the 95 percent confidence limit is about 1 lb. The regressions are significant at the 0.01 level and as the correlation coefficients are approaching 1, we can, with confidence, use wafer assays to predict treatability.

Table 3. — CLASSIFICATION OF TREATABILITY IN OIL OF INCISED POSTS PREDICTED BY UNCOATED WAFER ASSAYS.[1]

Inadequate Absorption (less than 6 lb./cu. ft.)		
mangle blanco	moca (5.7)	uvilla
Acceptable Absorption (6 to 12 lb./cu. ft.)		
caimitillo	hoja menuda	pomarrosa
casuarina	mangle prieto	rabo raton
eucalipto	maria	roble blanco
guaba	motilla	
guama	pendula	
Excessive Absorption (over 12 lb./cu. ft.)		
cadam	pino	

[1] Posts were treated with a 2 hr. - 2 hr. hot-and-cold bath schedule using pentachlorophenol in an oil carrier. Where there is disagreement with the wafer prediction, actual post retention is shown in parenthesis.

Table 4. — CLASSIFICATION OF TREATABILITY IN OIL OF UNINCISED POSTS PREDICTED BY EDGE-COATED WAFER ASSAYS.[1]

Inadequate Absorption (less than 6 lb./cu. ft.)		
casuarina	mangle prieto	pomarrosa
guaba	maria	rabo raton (5.6)
guama	moca	roble blanco
hoja menuda	motillo	uvilla
mangle blanco	pendula	
Acceptable Absorption (6 to 12 lb./cu. ft.)		
caimitillo	eucalipto	
Excessive Absorption (over 12 lb./cu. ft.)		
cadam	pino	

[1] Posts were treated with a 2 hr. - 2 hr. hot-and-cold bath schedule using pentachlorophenol in an oil carrier. Where there is disagreement with the wafer prediction, actual post retention is shown in parenthesis.

Table 3 presents a classification of treatability in oil of incised posts given a 2 hr. - 2 hr. hot-and-cold bath and is based on the 10 minute vacuum - 10 minute atmospheric pressure uncoated wafer test. We have assumed an oil absorption of less than 6 lb./cu. ft. as inadequate, a range of 6 to 12 lb./cu. ft. as acceptable, and absorptions over 12 lb./cu. ft. as excessive. Of the 18 species listed in Table 3, 13 have acceptable absorptions, 3 are predicted to undertreat, and 2 to overtreat. Moca, by wafer assay, is predicted to have an average absorption less than 6 lb./cu. ft.; but posts of this species actually had an absorption of 5.7 lb./cu. ft. which, if rounded off, would place it in the acceptable group.

Predictions of treatability in oil of unincised posts based on the edge-coated wafers are given in Table 4. Of the 18 species listed, 14 will have inadequate absorption, 2 acceptable, and 2 excessive. The advantage of incising for mixed lots of tropical woods is obvious. Again there is some error. Rabo raton has an absorption only slightly less than 6 lb./cu. ft. which could place it in the acceptable 6-12 lb./cu. ft. group.

The water retentions of the edge-coated and noncoated wafers given in Table 2 are more awkward to interpret in terms of acceptable or non-acceptable absorptions of water-borne preserving salts. Generally, preservative salts are applied by a full-cell process using concentrations of 2-3 percent. If we presume a boiling-in-water thermal process where the salt solution is held in the cold tank only (many salt combinations will precipitate if heated) and if we assume a minimum dry salt retention of 0.75 lb./cu. ft. to be obtained with a stronger 5 percent solution, then we may suggest a classification of treatability based on wafer assays in water. For unincised posts (edge-coated wafers) all of the species listed in Table 2, except pino, would have inadequate solution absorptions. The very high water retention of pino suggests a treating solution concentration halved to the regular 2-3 percent. If the salt concentration can be doubled to 10 percent, only cadam would have an acceptable absorption.

A classification of treatability of incised posts (uncoated wafer assays in water), based on the 5 percent concentration and a minimum dry salt retention of 0.75 lb./cu. ft., may also be made. About 7 of the 18 species listed in Table 2 would have inadequate absorption, *i. e.*, less than 15 lb./cu. ft. solution retention. Cadam and pino would have retentions over 1.5 lb./cu. ft. of dry salt. If we could prepare a 7 percent treating solution and hold out these two high absorbing plantation species for special handling, then all of the species, by incising, could be acceptable for treatment. Dry salt retentions would average about 1 lb./cu. ft., ranging from 0.7 to 1.6 lb./cu. ft.

Summary

A simple but highly sensitive wafer assay for treatability of wood has been developed. Preliminary screening of the many species available in tropical forests, as well as plantation-grown woods, can be made with little effort. Our testing has been limited to sapwood material and wafer absorptions have been correlated only with those of incised and unincised posts. Though application of the technique has been restricted, it has been demonstrated that a small wafer only 2.5 cc. in volume reflects liquid flow paths and absorptions obtained by material several thousandfold larger in size. Other observations may be listed:

1) Plugs can be extracted easily from small crooked stems, and wafers can be cut from any narrow zone between pith and bark.

2) A 10 minute vacuum-10 minute atmospheric pressure treatment of wafers requires no special apparatus (a water operated aspirator could be used in place of a vacuum pump.)

3) The 7/8 inch diameter and 1/4 inch thickness gives a side grain to end grain ratio of 2 to 1 and results in wafers that reflect a wide range of treatability; absorptions of less than 1 to about 40 lb./cu. ft.

4) The relation of wafer and post absorptions results in correlation coefficients of almost 90 percent, with regressions significant at 0.01 level.

5) Edge-coated (side grain penetration) and uncoated (side plus end grain penetration) wafer absorptions demonstrate that most tropical hardwoods require incising to obtain an acceptable preservative treatment.

6) Wafers could be used to sample heartwood as well as sapwood zones and absorptions may be related to commodities other than posts and to treating processes other than the hot-and-cold bath method used in this study. Wafer assays could be used, as well, to study the influence of solvents, drying rates, temperature, growth rate, and other factors that may affect treatability of wood.

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FOREST SERVICE RESEARCH PAPER ITF-11

SEPTEMBER 1971

TREATABILITY OF PUERTO RICAN WOODS

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FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

RESUMEN

Un ensayo de discos, sencillo pero altamente sensitivo, fue usado para clasificar los tratamientos de preservación de las maderas más comunes de Puerto Rico y las Islas Vírgenes. La albura se evaluó solamente para reflejar el gran número de árboles de diámetro pequeño disponibles para espeques y postes pequeños.

La absorción de los discos fluctuó entre menos de una y cerca de 40 libras por pie cúbico. La absorción de aceite en los discos recubiertos y los no recubiertos puede relacionarse con la absorción de los postes con y sin incisiones que han sido tratados en un sistema de baño caliente y frío. Se pronosticó que de las 53 especies de postes sin incisiones evaluadas, solamente seis obtendrían un tratamiento adecuado (6-12 libras por pie cúbico). De tener incisiones los postes, 32 especies tendrían una retención aceptable. Se pueden anticipar resultados similares para las sales preservativas solubles en agua. La información obtenida de algunas especies indicaba que la absorción de discos no recubiertos podría ser usada también para predecir la retención de los postes tratados en un proceso de alta presión en célula vacía.

ABSTRACT

A simple but highly sensitive wafer assay was used to classify the treatability of the more common woods of Puerto Rico and the Virgin Islands. Sapwood only was tested to reflect the large number of small diameter trees available for posts and short poles.

Wafer absorptions ranged from less than 1 to about 40 lb./cu. ft. Oil absorption of coated and uncoated wafers can be related to the absorption of non-incised and incised posts treated in a hot-and-cold bath system. For non-incised posts, only 6 out of the 53 species evaluated were predicted to obtain an adequate treatment (6-12 lb./cu. ft.). If incised, 32 species would have an acceptable retention. Similar results may be anticipated for water-borne preserving salts. Data from a few species indicated that absorption of uncoated wafers could also be used to predict retention of posts treated by a high pressure empty-cell process.

O.D.C. 812.2

TREATABILITY OF PUERTO RICAN WOODS

by

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INTRODUCTION

Wood products are vulnerable to insect and fungus attack, particularly in the humid tropics. For many uses, impregnation with preservatives would be of value. Unfortunately, not all. timbers are equally receptive to such treatments. Species treatability may be detected by laboratory permeability studies (6), in pilot plant experiments (1,3,5), or in actual commercial operations (4). Such classifications of treatability are helpful not only in the application of preservatives, but also in the application of fire retardants, anti-shrink chemicals, water repellents, and other modifying agents.

A wafer assay technique for determining treatability of wood has been described (2). Reliable species differentation is possible without expensive pressure-vacuum systems or elaborate laboratory liquid-gas flow instrumentation.

Based on this wafer assay method, the treatability of some 50 native and exotic woods common to Puerto Rico and the nearby Virgin Islands is reported here. Values are in terms of oil or water retentions in lb./cu. ft., and reflect either side grain penetration only (edge-coated) or a combined end and side grain flow (uncoated).

WAFER ASSAY METHOD

Material

Species assayed are listed in Table 1 in alphabetical order. With a few exceptions, five trees per species were sampled. Present major use potential is for posts and small poles, so only sapwood of small-diameter trees (3-5 in. dbh) was tested. To accelerate drying prior to wafer preparation, short bolts were debarked and sawn lengthwise to yield three billets.

Preparation of wafers

The steps followed in preparation of test wafers are as previously described (2) and are illustrated in Figure 1. Several tools were tried for cutting the plugs. The prong type is particularly effective with high density species. Four wafers were prepared for each of the trees sampled. Two were edge-coated with two coats of brushable epoxy paste to seal end grain and the other two were not coated. The side to end grain ratio of the wafers is approximately 2 to 1.

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[1] In cooperation with the University of Puerto Rico

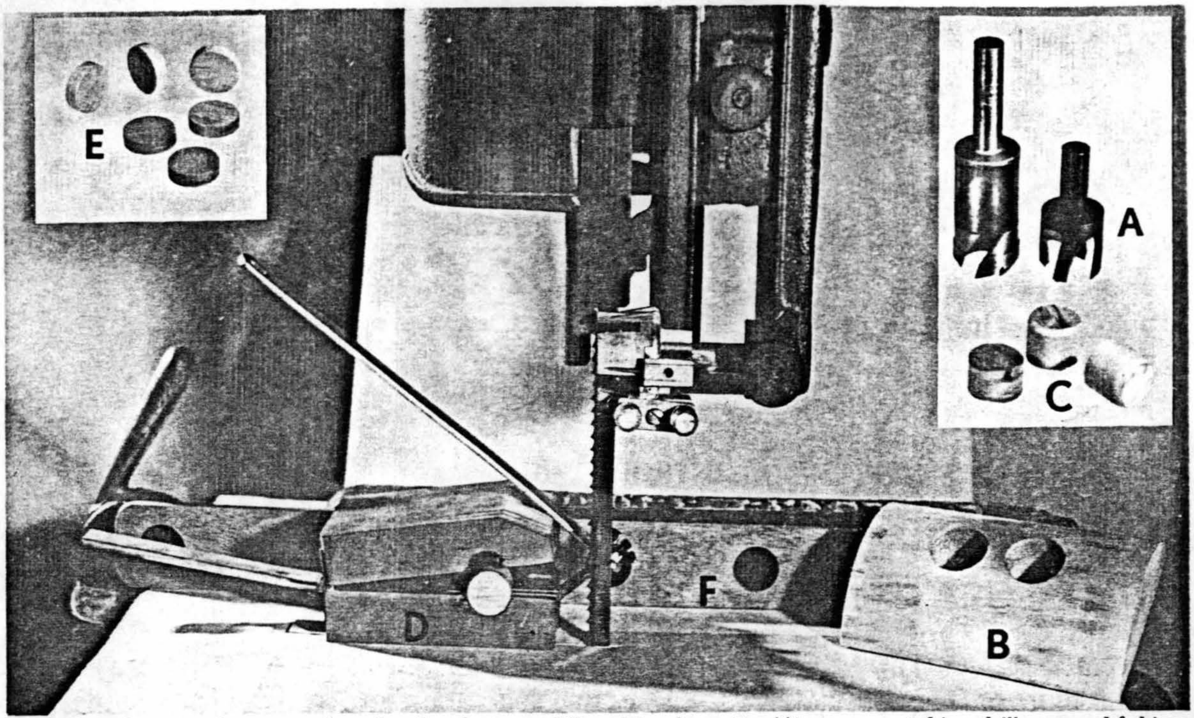

Figure 1. – Steps in the preparation of wafers from test billets. The plug cutter (A) was mounted in a drill press and fed into the air-dried billet (B) in a radial direction towards the pith. The plugs (C) were 7/8 inch in diameter and about 1 inch in length. The plugs were held in the squeeze clamp (D) and cut into wafers (E) using a four tooth-to-the-inch band saw. Sapwood wafers only were used in this study and were removed from the second 0.25-inch zone beneath the cambium. To accurately obtain this thickness, a removable fence (F) was inserted against the fixed fence.

Wafer treatments

Wafer diameters and thicknesses were measured with a vernier caliper to 0.1 mm and volumes calculated. Weights to the nearest 0.01 g were determined before and after edge coating. Wafers were submerged in water or diesel oil bath (70°F) in a vacuum desiccator and held under a vacuum of about 30 in. of mercury for 10 minutes. The desiccator was then vented to atmospheric pressure. Wafers were kept submerged for an additional 10 minutes. The treating solution was then drained off, the wafers blotted to remove surface liquid, and reweighed. Oil or water retention in lb./cu. ft. was then calculated. Also calculated were the air-dry specific gravities based on weight and volume at the test moisture content of 12 percent.

RESULTS

Table 1 lists the oil and water absorptions for edge-coated and uncoated wafers. The air-dry specific gravities are also given. Liquid retentions range from less than 1 lb. to about 40 lb./cu. ft. For almost all species, the uncoated wafers (combined end and side grain penetration) have retentions substantially higher than that for the edge-coated material (side penetration only). Differences are slight only in the highly permeable species; i.e., kadam, pino, achiotillo, manzanillo, corcho. Within species, variability in wafer absorption is least for the uncoated specimens. The coefficient of variation averages about 15 percent as compared to 30 percent for edge-coated wafers. All of the high absorption species have an air-dry (12 percent moisture content) specific gravity of 0.65 or less. However, within this density group there is an equal number of species with very low absorptions. With only a few exceptions, water absorptions are much higher than oil absorptions. This may be accounted for by differences in viscosity and the availability of interfibril spaces to water movement.

Details of a field technique designed to achieve this are summarised below.

- Site selection: Specimens may be installed around an active termite mound colony (Figure 1) or in an area shown by pre-baiting to be actively foraged by termites of the required species.

- Site preparation: A narrow trench 225 mm deep is dug either encircling the mound or in a line for each row of specimens (Figure 2). Where specimens are to be installed in a grid pattern, trenches must also be dug to connect each end of the rows.

- Specimens: Specimens to be assessed are machined to 35 x 35 x 250 mm.

- Bait specimens: Bait specimens of the same size are prepared from a timber species previously shown to be highly susceptible to the termites against which the assessment is to be conducted.

- Feeder strip: Lengths of 2 mm veneer, 100 mm wide, also of a highly susceptible species are used to link all specimens together.

- Installation: Each specimen is installed vertically, sandwiched between two bait specimens and in direct contact with them (Figure 3). Each group of three (bait, specimen, bait) is then connected by feeder strip which is installed touching one face of the specimen. Four veneer thicknesses are used and the strips are located in the region 25-125 mm below ground level (Figure 3).

- Watering: As trenches are filled in, specimens and strips are liberally 'watered-in' thus providing consolidation and an attractively moist environment for termites to explore.

- Exposure above ground: Only 25 mm of each specimen remains above the ground line after trenches have been filled in (Figures 1 & 4). Experience has shown that the portion above ground is rarely consumed and excessive amounts left protruding are thus considered to be of little value. However, in areas where grass or bush fires are prevalent it is preferable for the specimens to be installed below ground-line.

- Inspection procedures: At each inspection (preferably no more frequently than once every six months), assemblies are completely dismantled and the specimens with their baits, are set aside for assessment (Figures 5 & 6).

- Visual rating of specimens: Test specimens and bait specimens are assessed and rated according to the severity of termite damage. The rating system used by the authors is that described by Beesley (3).

- Reinstallation: After assessment, the trench is cleared of any remaining feeder strip and the test is then completely reinstalled as described above.

9

THE INTERNATIONAL RESEARCH GROUP ON WOOD PRESERVATION

WORKING GROUP I
Sub-group 4

BIOLOGICAL PROBLEMS
Termite problems related to structures and products

A rapid field bioassay technique with subterranean termites

by

C.D. Howick and J.W. Creffield

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Paper prepared for the 14th Meeting in Surfers Paradise, Australia
9-13 May 1983

IRG SECRETARIAT
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SWEDEN

2 March 1983

CONCLUSIONS

A simple but highly sensitive wafer assay is used to classify the treatability of the more common woods of Puerto Rico and the Virgin Islands. Conclusions are as follows:

1. For the 53 species tested, sapwood wafer absorptions ranged from less than 1 to about 40 lb./cu. ft.

2. Within species, variability in absorption is least for non-coated wafers (combined end and side grain penetration). The coefficient of variation averages about 15 percent as compared to an average of 30 percent for edge-coated wafers (side grain penetration only).

3. Generally, water absorptions are much higher than oil absorptions.

4. Oil absorptions of coated and uncoated wafers can be related to the absorption of non-incised and incised posts treated by a thermal process.

5. Without incising, only 6 of the 53 species can be treated adequately using oil in a hot-and-cold bath system. If incised, 32 species will have an acceptable absorption; i.e., 6-12 lb./cu. ft. Somewhat similar results may be anticipated if treatments are with water-borne salts.

6. A few preliminary tests indicate that absorptions of uncoated wafers can also be used to predict retentions of posts treated by a high pressure empty-cell process.

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Table 4. -- CLASSIFICATION OF TREATABILITY IN WATER OF INCISED POSTS PREDICTED BY UNCOATED WAFER ASSAYS

Inadequate Absorption - less than 15 lb. per cu. ft.[1]

- algarrobo
- ausubo
- camasey
- caoba dominicana
- capá blanco
- casia de Siam
- granadillo
- guaba
- guamá
- guara
- guaraguao
- jaguey blanco
- mangle blanco
- mangle colorado
- moca
- motillo
- péndula
- quenepa
- San José
- teca
- ucar
- uvilla
- verdiseco
- yagrumo hembra
- zarcilla

Acceptable Absorption - 15 to 30 lb. per cu. ft.

- almacigo
- almendra
- caimitillo
- caimitillo verde
- casuarina
- espino rubial
- eucalipto
- hoja menuda
- laurel avispillo
- mangle prieto
- monteguero
- manzanillo
- maría
- maricao
- moral
- palo blanco
- palo de cucubano
- palo de matos
- pomarroso
- rabo ratón
- roble blanco
- tabonuco
- tulipán africano
- yagrumo macho

Excessive Absorption - over 30 lb. per cu. ft.

- achiotillo
- corcho
- kadam
- pino

---

[1] Based on a treating solution salt concentration of 3.0 percent and a minimum dry salt retention of 0.45 lb. per cu. ft.

Table 2. -- CLASSIFICATION OF TREATABILITY[1] IN OIL OF NON-INCISED POSTS PREDICTED BY EDGE-COATED WAFER ASSAYS.

Inadequate Absorption - less than 6 lb. per. cu. ft.

- almendra
- ausubo
- camasey
- caoba dominicana
- capá blanco
- casia de Siam
- casuarina
- espino rubial
- granadillo
- guaba
- guamá
- guara
- guaraguao
- hoja menuda
- jaguey blanco
- laurel avispillo
- mangle blanco
- mangle colorado
- mangle prieto
- monteguero
- maría
- maricao
- moca
- moral
- motillo
- palo blanco
- palo de cucubano
- palo de matos
- péndula
- pomarrosa
- quenepa
- rabo ratón
- roble blanco
- San José
- tabonuco
- teca
- ucar
- uvilla
- verdiseco
- yagrumo macho
- zarcilla

Acceptable Absorption - 6 to 12 lb. per cu. ft.

- algarrobo
- almácigo
- caimitillo
- caimitillo verde
- eucalipto
- yagrumo hembra

Excessive Absorption - over 12 lb. per cu. ft.

- achiotillo
- corcho
- kadam
- manzanillo
- pino
- tulipán africano

---

[1] Assuming a 2 hr. - 2 hr. hot-and-cold bath schedule.

Table 3. -- CLASSIFICATION OF TREATABILITY[1] IN OIL OF INCISED POSTS PREDICTED BY UNCOATED WAFER ASSAYS

Inadequate Absorption - less than 6 lb. per cu. ft.

- ausubo
- caoba dominicana
- casia de Siam
- jaguey blanco
- mangle blanco
- mangle colorado
- moca
- quenepa
- San José
- teca
- uvilla
- zarcilla

Acceptable Absorption - 6 to 12 lb. per cu. ft.

- algarrobo
- almendra
- caimitillo
- caimitillo verde
- camasey
- capá blanco
- casuarina
- espino rubial
- eucalipto
- granadillo
- guaba
- guamá
- guara
- guaraguao
- hoja menuda
- laurel avispillo
- mangle prieto
- monteguera
- maría
- maricao
- moral
- motillo
- palo blanco
- palo de cucubano
- péndula
- pomarrosa
- rabo ratón
- roble blanco
- tabonuco
- ucar
- verdiseco
- yagrumo macho

Excessive Absorption - over 12 lb. per cu. ft.

- achiotillo
- almácigo
- corcho
- kadam
- manzanillo
- palo de matos
- pino
- tulipán africano
- yagrumo hembra

---

[1] Assuming a 2 hr. - 2 hr. hot-and-cold bath schedule.

Table 1.--WAFERS ASSAYS OF TREATABILITY IN OIL AND WATER OF COMMON WOODS OF PUERTO RICO
BASED ON A 10 MINUTE VACUUM--10 MINUTE ATMOSPHERIC PRESSURE SCHEDULE. (Continued)

Common Name [1]	Scientific Name	Air-dry[2] Specific Gravity	Oil Retention		Water Retention	
			Edge-Coated (lb./cu. ft.)	Uncoated (lb./cu. ft.)	Edge-Coated (lb./cu. ft.)	Uncoated (lb./cu. ft.)
Mangle colorado	*Rhizophora mangle* L.	1.01	0.9	4.8	2.8	13.1
Mangle prieto	*Avicennia nitida* Jacq.	.90	2.4	6.8	4.3	20.3
Mantequero	*Rapanea ferruginea* (Ruiz & Pav.) Mez.	.75	1.0	8.6	4.9	19.6
Manzanillo	*Sapium laurocerasus* Desf.	.58	19.6	19.7	26.2	28.5
María	*Calophyllum brasiliense* Camb.	.70	4.0	12.5	3.1	18.1
Maricao	*Byrsonima coriacea* (Sw.) DC.	.79	2.5	11.0	3.5	19.2
Moca	*Andira inermis* (W. Wright) H.B.K.	.87	1.9	5.4	3.4	11.0
Moral	*Cordia sulcata* DC.	.57	4.8	11.0	5.1	19.4
Motillo 4/	*Sloanea berteriana* Choisy	.97	4.3	7.4	2.1	11.5
Palo blanco	*Casearia guianensis* (Aubl.) Urban	.72	3.4	11.6	4.1	21.0
Palo de cucubano	*Guettarda scabra* (L.) Vent.	.78	1.6	7.7	2.0	14.8
Palo de matos 4/	*Ormosia krugii* Urban	.58	2.1	12.7	9.1	21.3
Péndula	*Citharexylum fruticosum* L.	.81	0.9	7.4	2.2	14.4
Pino *	*Pinus caribaea* Morelet	.47	31.9	32.8	42.2	43.0
Pomarrosa *	*Eugenia jambos* L.	.87	1.7	6.3	3.2	17.3
Quenepa *	*Melicoccus bijugatus* Jacq.	.78	1.3	3.5	5.3	13.7
Rabo ratón	*Casearia arborea* (L.C. Rich.) Urban	.76	1.7	9.0	3.6	21.2
Roble blanco	*Tabebuia heterophylla* (DC.) Britton	.69	2.9	8.2	5.0	17.8
San José	*Sabinea florida* (Vahl.) DC.	.89	1.3	5.0	1.9	9.9
Tabonuco	*Dacryodes excelsa* Vahl.	.62	2.3	6.9	4.3	15.9
Teca *	*Tectona grandis* L. f.	.70	1.2	5.1	2.5	12.7
Tulipán africano *	*Spathodea campanulata* Beauv.	.43	11.4	23.6	9.5	22.0
Ucar	*Bucida buceras* L.	1.08	1.1	5.9	2.2	9.9
Uvilla	*Coccoloba diversifolia* Jacq.	.90	1.5	5.3	3.1	11.4
Verdiseco	*Tetrazygia elaeagnoides* (Sw.) DC.	.84	1.3	6.6	3.1	14.4
Yagrumo hembra	*Cecropia peltata* L.	.32	5.5	17.0	3.2	13.3
Yagrumo macho	*Didymopanax morototoni* (Aubl.) Dec. & Planch.	.42	4.8	9.8	6.9	23.2
Zarcilla	*Leucaena glauca* (L.) Benth.	.93	0.5	2.1	2.0	4.2

1/ Species are listed in alphabetical order.

2/ Based on weight and volume at 12 percent moisture content.

3/ Exotics are marked with an asterisk.

4/ Less than five trees sampled.

Table 1.--WAFER ASSAYS OF TREATABILITY IN OIL AND WATER OF COMMON WOODS OF PUERTO RICO BASED ON A 10 MINUTE VACUUM--10 MINUTE ATMOSPHERIC PRESSURE SCHEDULE.

Common Name 1/	Scientific Name	Air-dry 2/ Specific Gravity	Oil Retention Edge-Coated (lb./cu. ft.)	Oil Retention Uncoated (lb./cu. ft.)	Water Retention Edge-Coated (lb./cu. ft.)	Water Retention Uncoated (lb./cu. ft.)
Achiotillo	*Alchornea latifolia* Sw.	.47	20.8	21.0	30.2	34.4
Algarrobo	*Hymenaea courbaril* L.	.92	5.8	8.9	4.0	14.2
Almácigo	*Bursera simaruba* (L.) Sarg.	.35	9.5	12.8	22.7	28.8
Almendra * 3/	*Terminalia catappa* L.	.53	3.2	6.2	4.1	14.6
Ausubo	*Manilkara bidentata* (A.DC.) Chev.	.96	1.1	5.1	2.7	11.6
Caimitillo 4/	*Micropholis chrysophylloides* Pierre	.87	8.0	12.1	-	18.7
Caimitillo verde 4/	*Micropholis garciniaefolia* Pierre	.93	5.8	10.8	5.2	16.2
Camasey 4/	*Miconia laevigata* (L.) DC.	.71	1.2	6.3	2.3	13.7
Caoba dominicana *	*Swietenia mahagoni* Jacq.	.76	1.6	5.2	4.9	13.6
Capá blanco	*Petitia domingensis* Jacq.	.81	0.9	6.0	2.0	10.4
Casia de Siam *	*Cassia siamea* Lam.	.85	1.6	5.2	2.6	10.6
Casuarina * 4/	*Casuarina equisetifolia* L.	.95	3.8	10.3	3.9	17.7
Corcho	*Torrubia fragrans* (Dum.-Cours.) Standley	.65	16.8	19.6	24.4	33.2
Espino rubial	*Zanthoxylum martinicense* (Lam.) DC.	.74	1.4	7.1	5.7	18.8
Eucalipto *	*Eucalyptus robusta* J.E. Smith	.57	6.2	9.7	4.5	23.4
Granadillo	*Buchenavia capitata* (Vahl.) Eichl.	.75	3.2	9.6	3.9	11.8
Guaba	*Inga vera* Willd.	.66	3.5	7.6	4.1	10.1
Guamá	*Inga laurina* (Sw.) Willd.	.79	2.0	6.7	4.9	12.3
Guara	*Cupania americana* L.	.81	1.6	7.1	2.3	14.0
Guaraguao	*Guarea trichilioides* L.	.63	1.9	6.6	2.6	13.7
Hoja menuda	*Myrcia splendens* (Sw.) DC.	.79	5.1	10.7	4.7	15.4
Jaguey blanco	*Ficus laevigata* Vahl.	.55	2.4	5.1	5.6	12.3
Kadam *	*Anthocephalus cadamba* (Roxb.) Miq.	.37	27.4	28.7	34.7	40.7
Laurel avispillo	*Nectandra coriacea* (Sw.) Griseb.	.90	1.8	7.0	2.6	15.5
Mangle blanco	*Laguncularia racemosa* (L.) Gaertn. f.	.74	1.1	4.7	2.6	11.6

1/ Species are listed in alphabetical order.

2/ Based on weight and volume at 12 percent moisture content.

3/ Exotics are marked with an asterisk.

4/ Less than five trees sampled.

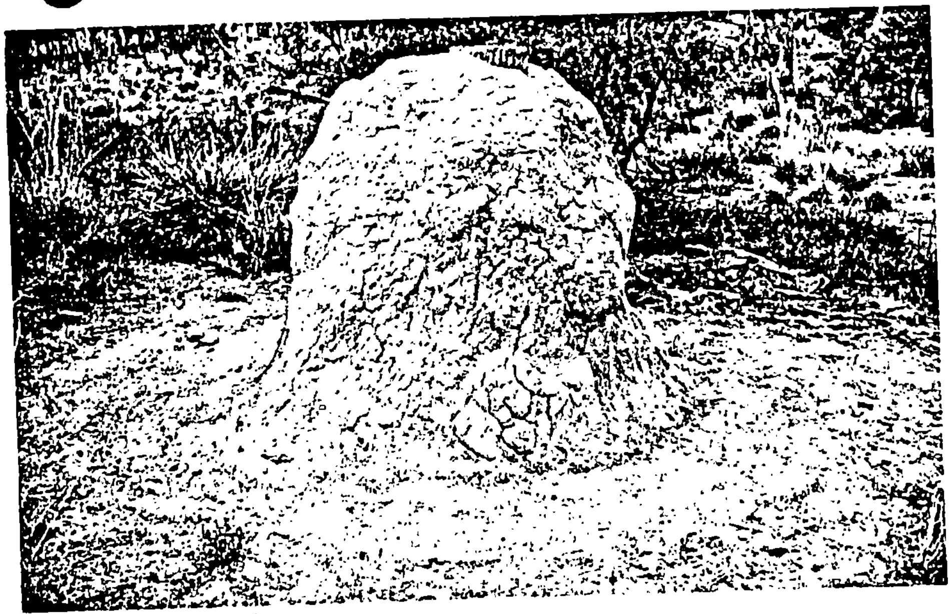

Figure 1

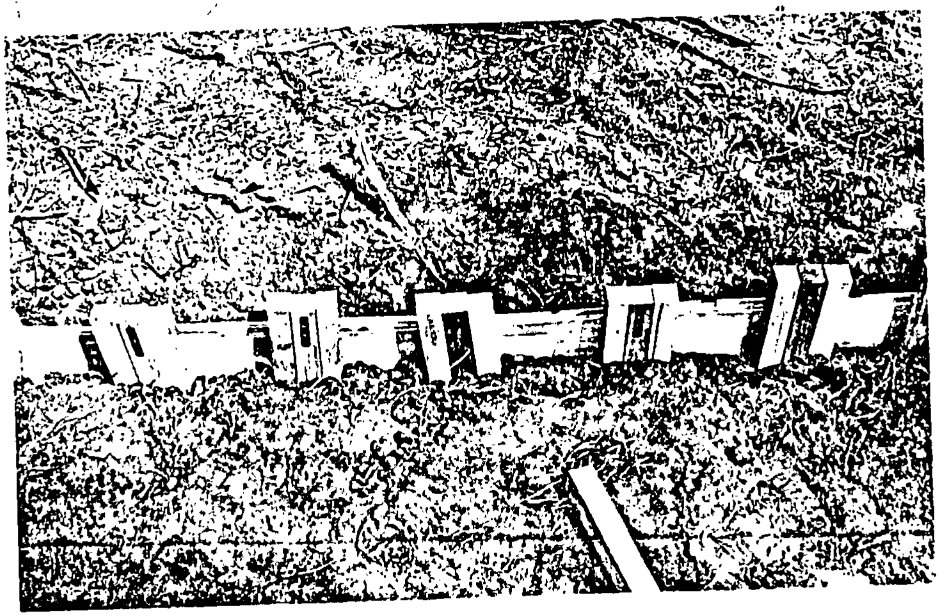

Figure 3

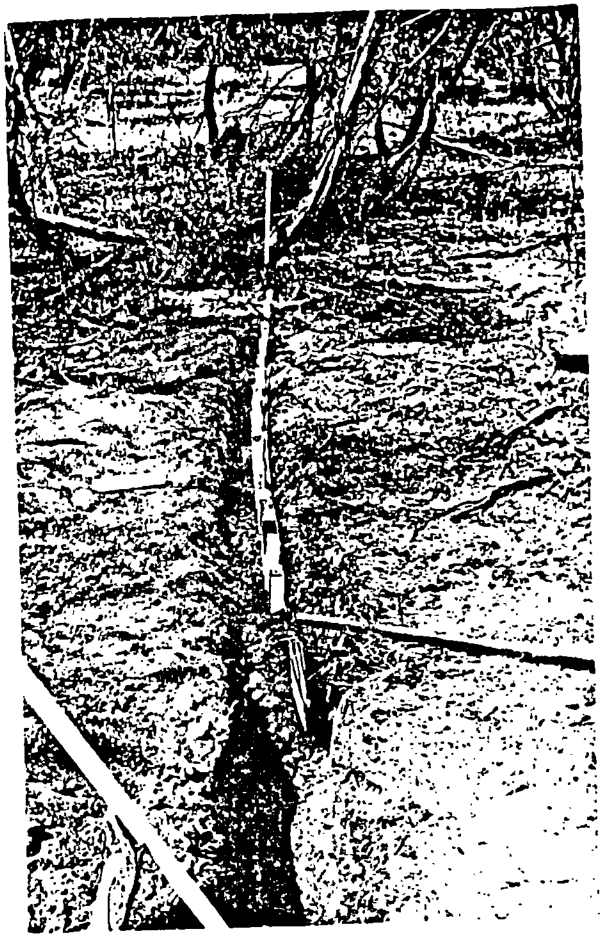

Figure 2

In the earlier study (2), a comparison was made between oil absorption of incised and non-incised posts and the oil absorption of uncoated and edge-coated wafers. Posts were treated by a 2 hour - 2 hour hot-and-cold bath schedule and wafers were treated as described above. Eighteen species were matched. It was determined that uncoated wafer absorptions simulate that of the incised posts ($Y = 1.21 + 0.89X$) and absorptions of coated wafers simulate those of non-incised posts ($Y = 0.35 + 1.14X$). In both regressions, correlation coefficients (r) were about 0.9.

The oil retentions, then, of the species listed in Table 1, not only indicate relative permeability or treatability but, also, levels of absorption likely to be obtained in a hot-and-cold bath preservation system. Table 2 presents a classification of treatability in oil of non-incised posts given a 2 hour - 2 hour thermal bath and is based on the edge-coated wafer assay. We have assumed an oil absorption of less than 6 lb./cu. ft. as inadequate, a range of 6 to 12 lb./cu. ft. as acceptable, and absorption over 12 lb./cu. ft. as excessive. Of the 53 species tested, 41 are predicted to have inadequate absorptions, 6 to have acceptable absorptions, and 6 to have an excessive uptake.

Predictions of treatability in oil of incised posts, based on the non-coated wafer assay, are given in Table 3. For the same 53 species, 32 have acceptable absorptions, 12 undertreat, and 9 overtreat. Of the 12 poor absorbers, only quenepa and zarcilla have retentions less than 5 lb./cu. ft. The advantage of incising for treating mixed lots of tropical woods is evident.

Water retentions given in Table 1 are somewhat difficult to interpret in terms of absorption of preserving salts. Generally, these water-borne chemicals are applied by a full-cell process using concentrations of 2-3 percent. If we assume a boiling-in-water thermal process where the salt solution is held in the cold tank only, and if we specify a minimum dry salt retention of 0.45 lb./cu. ft., then we could predict treatability as shown in Table 4. Less than one-half of the 53 species would have acceptable absorptions if incised posts were to be treated with a 3.0 percent preservative salt concentration. This would mean a solution retention of 15 to 30 lb./cu. ft. or 0.45 to 0.90 lb./cu. ft. dry salt residual. If posts were not incised only four species would be receptive to this thermal treatment and they are achiotillo, almácigo, corcho, and manzanillo. Kadam and pino absorptions would be excessive; i.e., over 30 lb./cu. ft. solution retention. Treatment levels of these two plantation species can be reduced by lowering the bath concentration to 2.0 percent.

There is very limited data on the response of these woods to a pressure-vacuum preservative treatment. Twelve of the species listed in Table 1 have been treated with a petroleum oil carrier using 2 hours of pressure at 150 psi followed by a one-half-hour vacuum at 27 in. of mercury. Non-incised all-sapwood posts were used. There is also some retention data for 5 additional species treated for 3 hours at 125 psi followed by a 1 hour vacuum period. In both cases preservative temperature was ambient.

A simple regression based on the absorption of the pressure-treated posts and non-coated wafer assays of the same species is significant at the 0.01 level. The correlation coefficient is about 0.91. Post absorptions are predicted by: $Y = 0.99 + 0.88X$. Thus, not only are the relative order of treatablility of posts and wafers about the same, but absorptions pound for pound are also of about the same magnitude. These tests indicate that longitudinal penetration from the ends of non-incised posts is a significant preservative flow path when treating under high pressure.

Figure 4

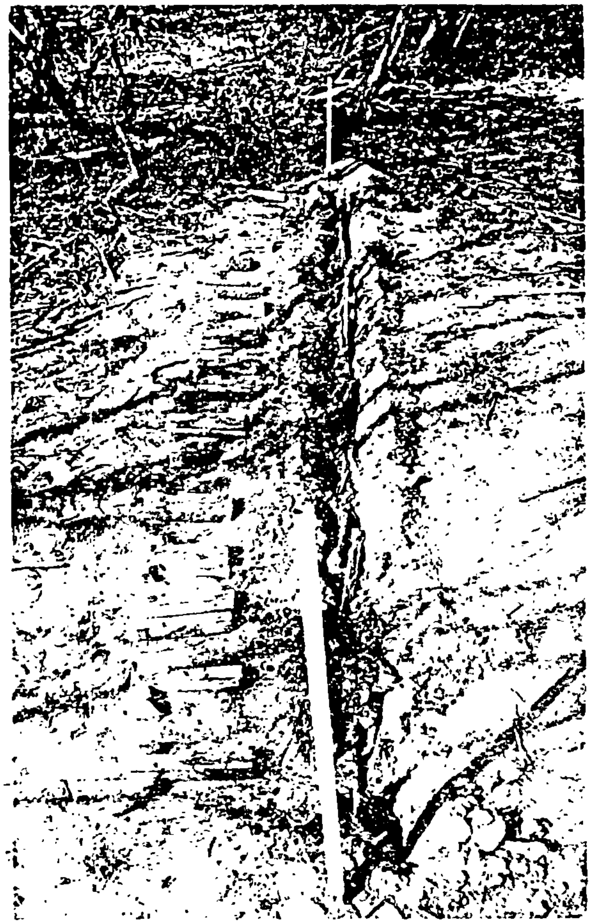

Figure 5

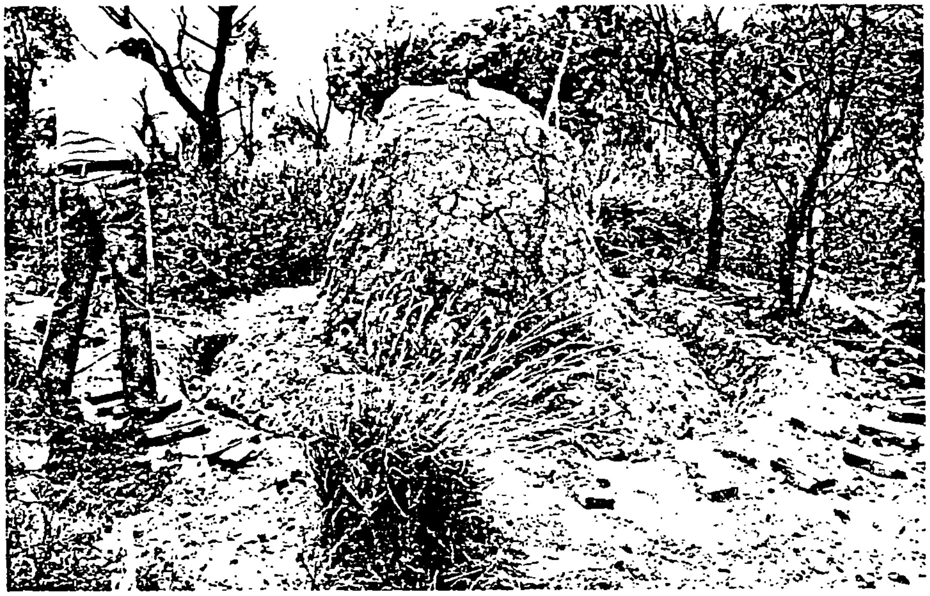

Figure 6

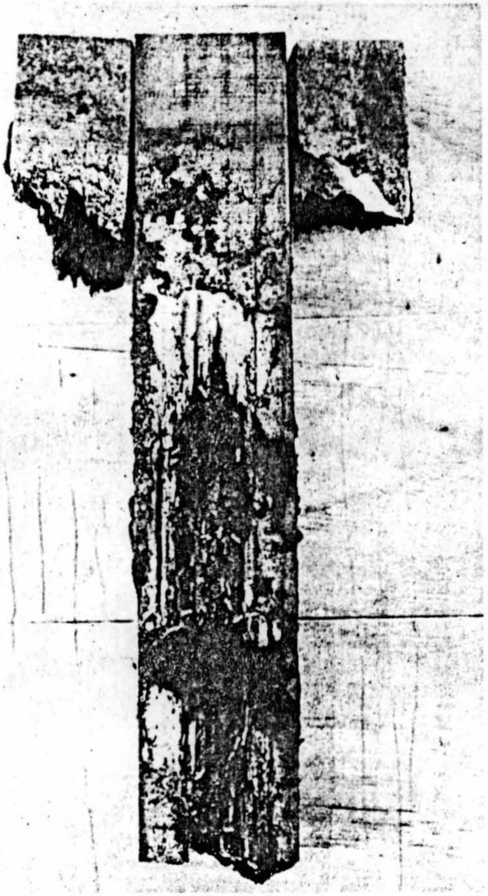

Figure 7

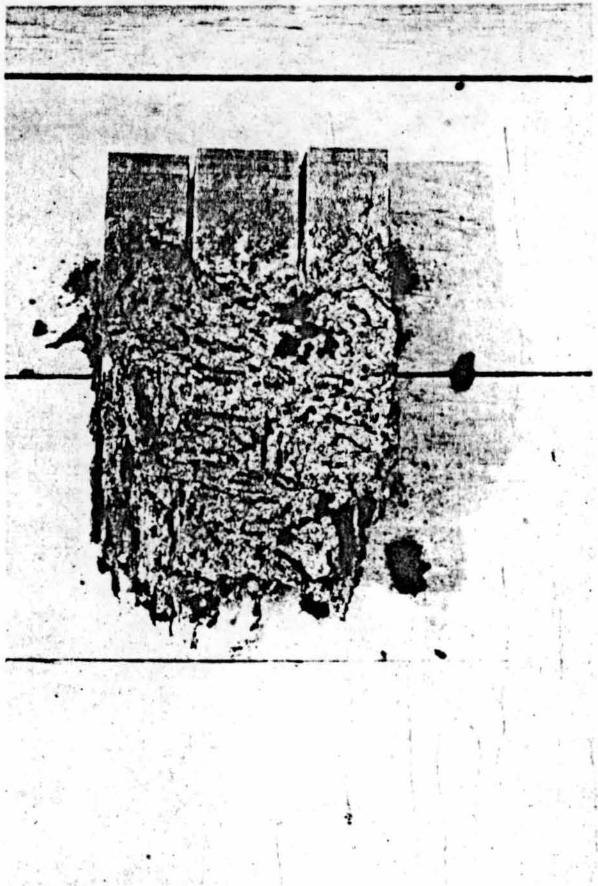

Figure 8

Figure 9

TT-W-00571J (AGR-AFS)
October 31, 1974
INTERIM REVISION OF
Fed. Spec. TT-W-571i
October 28, 1968

INTERIM FEDERAL SPECIFICATION

WOOD PRESERVATION: TREATING PRACTICES

This Interim Federal Specification was developed by the U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, P. O. Box 5130, Madison, Wisconsin 53705, based upon currently available technical information. It is recommended that Federal agencies use it in procurement and forward recommendations for changes to the preparing activity at the address shown above.

The United States Department of Agriculture has authorized the use of this Interim Federal Specification as a valid exception to Federal Specification TT-W-571i.

1. SCOPE

1.1 Scope. This specification covers the treatment of different forms and species of wood with various preservatives. It covers treatments of wood items that will be exposed to either moderate or severe hazard of attack by wood-destroying organisms so that an appreciable retention of preservative as well as significant penetration into wood is necessary. Such results are attainable by pressure processes which are acceptable for all products listed in tables I, II, and III. Certain other processes are acceptable for some items provided that they yield the retention and penetration requirements specified herein. These processes include thermal treatments of some species of poles, and double-diffusion treatments of posts, poles, and lumber. Reference is made to TT-W-572, Wood Preservative, Water Repellent, for the treatment of items such as window sash that are used under mild exposure conditions whereby adequate protection is afforded by short-dip treatments.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issues in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

Federal Specifications:

TT-C-645 - Creosote, Coal Tar, Technical.
TT-C-650 - Creosote-Coal Tar Solution.
TT-C-655 - Creosote, Technical, Wood Preservative, (For) Brush Spray or Open-Tank Treatment.
TT-W-535 - Wood Preservative; Fluoride-Chromate Arsenate-Phenol Mixture.
TT-W-546 - Wood Preservative; Acid Copper Chromate Mixture.
TT-W-549 - Wood Preservative; Ammoniacal Copper Arsenite Mixture.
TT-W-550 - Wood Preservative; Chromated Copper Arsenate Mixture.
TT-W-551 - Wood Preservative; Chromated Zinc Chloride Mixture.
TT-W-568 - Wood Preservative; Creosote-Petroleum Solution.
TT-W-570 - Wood Preservative; Pentachlorophenol, Solid.
TT-W-572 - Wood Preservative; Water Repellent.
TT-W-1894- Wood Preservative; Tributyltin oxide.

(Activities outside the Federal Government may obtain copies of Federal Specifications, Standards, and Handbooks as outlined under General Information in the Index of Federal Specifications and Standards at the prices indicated in the Index. The Index, which includes cumulative monthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

(Single copies of this specification and other Federal Specifications required by activities outside the Federal Government for bidding purposes are available without charge from Business Service Centers at the General Services Administration Regional Offices in Boston, New York, Washington, DC, Atlanta, Chicago, Kansas City, MO, Fort Worth, Denver, San Francisco, Los Angeles, and Seattle, WA.

(Federal Government activities may obtain copies of Federal Specifications, Standards, and Handbooks and the Index of Federal Specifications and Standards from established distribution points in their agencies.)

FSC 5510

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless a specific issue is identified, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Wood-Preservers' Association (AWPA) Standards:

A1--Standard Methods for Analysis of Creosote and Oil-Type Preservatives.
A2--Standard Methods for Analysis of Waterborne Preservatives and Fire-Retardant Formulations.
A3--Standard Methods for Determining Penetration of Preservatives and Fire Retardants.
A4--Standard Methods for Sampling Wood Preservatives.
A5--Standard Methods for Analysis of Oil-Borne Preservatives.
A6--Method for the Determination of Oil-Type Preservatives and Water in Wood.
A7--Standard Wet Ashing Procedure for Preparing Wood for Chemical Analysis.
A8--Qualitative Recovery of Creosote or Creosote-Coal Tar Solution from Freshly Treated Piles, Poles, or **Timber** (Squeeze Method).
A9--Standard Method for Analysis of Treated Wood and Treating Solutions by X-ray Emission Spectroscopy.
A10--Standard Methods of Analysis of CCA Treating Solutions and CCA Treated Wood by Colorimetry.
C1--All Timber Products--Preservative Treatment by Pressure Processes.
C2--Lumber, Timbers, Bridge Ties, and Mine Ties--Preservative Treatment by Pressure Processes.
C3--Piles--Preservative Treatment by Pressure Processes.
C4--Poles--Preservative Treatment by Pressure Processes.
C5--Fenceposts--Preservative Treatment by Pressure Processes.
C6--Crossties and Switch Ties--Preservative Treatment by Pressure Processes.
C8--Western Redcedar and Alaska Yellow-Cedar Poles--Preservative Treatment by the Full-Length Thermal Process.
C9--Plywood--Preservative Treatment by Pressure Processes.
C10--Lodgepole Pine Poles--Preservative Treatment by the Full-Length Thermal Process.
C14--Wood for Highway Construction--Preservative Treatment by Pressure Processes.
C16--Wood Used on Farms--Preservative Treatment by Pressure Processes.
C18--Standard for Pressure--Treated Piles and Timbers in Marine Construction.
C23--Round Poles and Posts Used in Building Construction--Preservative Treatment by Pressure Processes.
C28--Standard for Preservative Treatment of Structural Glued Laminated Members and Laminations Before Gluing of Southern Pine, Pacific Coast Douglas-fir, and Western Hemlock by Pressure Processes.
M2--Standard for Inspection of Treated Timber Products.
M3--Standard Quality Control Procedures for Wood Preserving Plants.
M4--Standard for the Care of Pressure-Treated Wood Products.
M5--Glossary of Terms Used in Wood Preservation.
M6--Brands Used on Forest Products.
P4--Standard for Petroleum Oil for Blending with Creosote.
P8--Standards for Oil-Borne Preservatives.
P9--Standards for Solvents for Oil-Borne Preservatives.

(Copies of the Standards and Instructions of the American Wood-Preservers' Association may be obtained from its Secretary-Treasurer, 1625 Eye Street, N.W., Washington, DC 20006. Prices may be obtained from the Secretary-Treasurer.)

Technical society and technical association specification standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

3. REQUIREMENTS

3.1 General requirements. Since difficulty may be encountered in obtaining the specified retention and penetration, it is the responsibility of the supplier to select piles, poles, and posts for treatment that have sufficient sapwood thickness to permit obtaining the retention and penetration specified. Suitable conditioning and, for some species, incising prior to treatment and the use of treating conditions which do not damage the wood according to AWPA standards C1 and M3, are further responsibilities of the supplier (see 3.4 and 3.5). Unless otherwise specified in the contract or purchase order (see 6.2), the treatment of various products and species shall be in accordance with tables I, II, and III and footnotes thereto. Inspection of treated products shall be made in accordance with paragraphs 4.2 to 4.2.7 inclusive. Whenever differences exist between this specification and corresponding industry specifications, the requirements of this specification shall prevail.

3.2 Segregation of material for treatment. The material shall be separated or spaced so as to insure contact of treating medium with all surfaces. Whenever the quantity of material ordered is sufficient, items of different species, size, conditioning, and retention requirements shall be treated in separate charges.

3.3 Empty-and full-cell processes. Empty-cell treatment shall be used with preservative oils and oil-borne preservatives except when the retention specified is greater than can be obtained by an empty-cell process. Water-borne preservatives shall be injected by the full-cell process whenever the product is to be used in coastal waters or in foundations. A modified full-cell process, as described in AWPA Standard C1,may be used for plywood and sawn material less than 5 inches in thickness and not intended for use in marine exposure or foundations. Control over wood temperature is essential in treating wood with waterborne preservatives containing chromates which are unstable in contact with wood at high temperatures.

3.4 Seasoning. Green material shall be adequately seasoned or conditioned before impregnation with preservative. This practice applies particularly to sawn material that is difficult to penetrate and to round material of thin sapwood species. All sawn material that is to be treated with an oil-type preservative and used in buildings or other places where high moisture content or shrinkage after installation would be objectionable shall be dried before treatment. When sawn material is treated with a permanent-type, chromium-containing preservative, such as chromated copper arsenate, the moisture content prior to treatment as determined by resistance-type moisture meter, shall not be more than 25 percent. The moisture content shall be measured at a depth equivalent to the required penetration up to a maximum of 1.5 inches. When treated with other waterborne preservatives, sawn material shall be suitably seasoned or conditioned prior to treatment. Unless otherwise specified (see 6.2), lumber 2 inches (nominal) or less in thickness and plywood that is treated with a waterborne preservative shall be dried after treatment to a moisture content of not more than 19 percent.

3.5 Incising. All lumber and timbers of species that are difficult to penetrate, such as Douglas-fir, western larch, western hemlock, redwood, and pines that are predominantly heartwood, shall be incised prior to treatment, provided the incisions will not make the material unfit for the use intended.

3.6 Marking. Unless otherwise specified (see 6.2), treated material shall be either hammer or heat branded, dye stamped, or metal tagged in accordance with AWPA Standards M1 and M6. Information shall be included for specific commodities, as given in the following:

3.6.1 Poles 50 feet or less in length shall be branded or tagged 10 feet from the butt. Poles 55 feet or more in length shall be branded or tagged 14 feet from the butt. All poles shall have the required branding or tagging included on the butt face. The brand shall identify species, class and length, preservative, retention, supplier, and year of treatment.

3.6.2 Piles shall be branded or tagged in two places approximately 5 and 10 feet from the butt. The brand shall identify species,class and length, preservative, retention, supplier, and year of treatment.

3.6.3 Posts shall be branded or tagged at or within 12 inches of the top. The brand shall identify preservative, supplier, and year of treatment.

3.6.4 Crossties shall be branded at least on one end. The brand shall identify preservative, supplier, and year of treatment.

3.6.5 Crossarms shall be branded on one face. The brand shall identify preservative, supplier, and year of treatment.

3.6.6 Sawn material more than 2 inches (nominal) in thickness and treated with an oil-type preservative shall be individually branded or tagged on one end to identify species, preservative, retention, supplier, and year of treatment: When treated with a waterborne preservative, it may be dye stamped on the surface.

3.6.7 Sawn material less than 2 inches in thickness or plywood when treated with an oil-type preservative may be bundled with tags being attached to the bundles to identifysspecies, preservative, retention, supplier, and year of treatment. In lieu of tags attached to bundles, when such material is treated with a waterborne preservative, the required information may be dye stamped on the outer pieces of a bundle.

4. QUALITY ASSURANCE PROVISIONS

4.1 The Government reserves the right to perform and/or retain services for any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements. Tests to verify the accuracy of inspection reports furnished by the supplier shall be made either by employees of the purchaser or by commercial inspection companies retained by the purchaser. The purchaser may elect to employ the services and accept the stamp or brand of an independent quality control agency. When treated wood, as specified by a Government agency, is procured by a contractor for the construction of a building or other facility for that agency, the contractor shall submit to that agency an inspection report from an independent commercial inspection company acceptable to the purchaser. An omission of this inspection report is permissible if the treated wood bears the brand or stamp of an independent quality control agency acceptable to the purchaser. In the invitation for bids, the purchaser will designate the general procedure to be used in confirming the quality of the product.

4.1.1 Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein, and complete inspection records shall be furnished either to the purchaser's office or otherwise stipulated in the order or contract.

4.1.2 Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government (see 4.1).

4.1.3 Inspection of the untreated stock shall be made in a period within 10 days of treatment.

4.1.4 The Government reserves the right to conduct or retain services for inspections at destination. When the results obtained at destination disagree with those obtained at origin, the results of the destination inspection shall be binding.

4.1.5 When inspection is made at destination, it will be made within 30 days of delivery. AWPA methods of assay will be used and an assay retention of 90 percent of the stipulated assay retention will be accepted as conforming. (See footnote 10, table II).

4.2 Instructions. Unless otherwise specified, AWPA Standard M2 (with certain exceptions as given below) shall be followed in the inspection of all treated wood purchased by the Government.

4.2.1 Penetration. In the inspection of piles, building poles, building posts, or Group B utility poles (37.5 in. or more in circumference 6 ft from the butt), each piece shall be bored at the approximate midpoint for the determination of penetration. Any piece that does not show the specified penetration shall be rejected. If 15 percent or more of the pieces in any charge or lot of piles, building poles, Group B utility poles, or building posts fail to meet penetration requirements, the entire charge or lot shall be rejected.

In determining the penetration in Group A utility poles (less than 37.5 in. in circumference 6 ft from the butt), 20 representative poles in a charge shall be bored at the approximate midpoint. If 18 of the borings meet penetration requirements, the Group A poles in the charge as a whole shall be accepted, but the nonconforming poles shall be rejected. If 16 or 17 of the borings meet penetration requirements, each Group A pole in the charge shall be bored and only those meeting penetration requirements shall be accepted. If less than 16 of the borings meet penetration requirements, the charge shall be rejected.

4.2.2 Retention. For the assay of a charge of poles, a single boring shall be taken from each of 20 randomly selected poles. For the assay of piles, the number of borings from any charge shall be according to the following schedule:

Number of piles in charge	Number of borings
20 or more	20 from 20 randomly selected piles
15 to 19	One from each pile
Less than 15	At least 20, with an equal number from each pile

The borings shall be cut to the proper length for the species as shown in tables II and III.

4.2.3 In the inspection of treated round fence posts, 30 representative posts of a lot shall be bored from measurement of penetration. If less than 80 percent of the borings show the specified penetration, the entire charge shall be rejected. If 80 percent or more of the borings meet the penetration requirement, a composite sample of one boring from each of 30 posts shall be taken for assay. The borings for assay shall be cut to the proper length for the species as shown in table II. The inspection of sawn posts shall be conducted according to the procedure outlined in 4.2.4 for the inspection of treated timbers.

4.2.4 In the inspection of treated lumber or solid timbers, 20 representative pieces of a lot shall be bored for measurement of penetration. Southern and ponderosa pine shall be bored from sapwood faces only. Douglas-fir, western hemlock, western larch, redwood, and other species of pine shall be bored from heartwood faces only. If 80 percent or more of the borings meet the penetration requirements, the lot is considered to meet penetration requirements. For laminated timbers, see footnote 7. For the assay of treated southern andpponderosa pine lumber of timber, a composite sample of the outer 0.60 inch of borings shall be taken from sapwood. For the assay of Douglas-fir, western hemlock, western larch, redwood, and other species of pine lumber of timber, a composite sample of the outer 0.60 inch of borings shall be taken from heartwood. Single borings shall be taken from 48 representative pieces treated with creosote or creosote-containing solutions, and from 20 representative pieces treated with pentachlorophenol orwaterborne preservatives. Retentions in lumber or timbers of species not mentioned above shall be determined by gage readings.

4.2.5 In the inspection of treated plywood, penetration shall be determined by taking borings 12 inches from any edge into one face of each of not less than five panels in any lot. Borings shall be tested for penetration by the appropriate procedure described in AWPA Standard A3. Penetration in plywood shall be considered adequate if each veneer is penetrated. For the assay of treated plywood, samples shall be taken from not less than five panels in each lot. These samples shall be taken at a point 12 inches from any edge. Plywood 5/8 inch or less in thickness shall be sampled through the full thickness. Plywood more than 5/8 inch in thickness shall be sampled from the lower grade face to a depth of 5/8 inch.

4.2.6 The determination of the amount of creosote or creosote-containing solutions in a sample of borings shall be made according to AWPA Standard A6. The determination of the amount of pentachlorophenol in a sample of borings shall be made according to AWPA Standard A5. The determiantion of the amounts of waterborne preservatives in a sample of borings shall be made according to AWPA Standard A2.

4.2.7 To obtain and test a sample of oil from a marine piling for compliance with quality requirements, AWPA Standards A8 and A1 shall be used.

5. PREPARATION FOR DELIVERY

5.1 This section is not applicable to this specification.

6. NOTES

6.1 Recommended practices in the procurement and use of treated wood.

6.1.1 Tables I, II, and III are schedules of approved practices for the preservative treatment of wood in various forms with creosote and creosote-containing solutions, pentachlorophenol, and waterborne preservatives which are intended for Government use. The net retentions in the tables are minima. Higher net retentions may be needed for severe use conditions and should be specified; they should also be specified for moderate use conditions whenever a product is of critical structural importance or whenever it is used in a situation where replacement would be very costly. It is recommended that observations of penetration be made on a number of pieces selected at random from each shipment received at destination. The presence or absence of the mark of a quality control agency or independent inspection agency acceptable to the purchaser should also be noted. When the wood contains such a mark and the penetration observed conforms to the specification, the shipment may be accepted. When the penetration observed casts doubt on the quality of the treatment, a thorough inspection by either the Government, a quality control agency, or an independent inspection agency should be made and any nonconforming shipment or lot should be rejected.

6.1.2 Coal-tar creosote, creosote-coal tar solution, creosote-petroleum solution, pentachlorophenol, and the four waterborne preservatives ACA, CCA Type I, CCA Type II, and CCA Type III (tables I, II, and III) are ordinarily to be used for wood exposed to severe exposure conditions, such as contact with soil or water and for important above-ground structures exposed to the weather. Since oil-type preservatives, in addition to affording protection against decay, also retard weathering and checking, they are generally preferable to waterborne preservatives for the treatment of sawn wood that has no exacting requirements on cleanliness or odor and is to be used in contact with the ground. If cleanliness, freedom from odor, or paintability are desirable, either of the four waterborne preservatives mentioned above will give good protection to sawn wood in ground contact provided that the wood is selected for its receptiveness to treatment and treated to meet the minimum penetration and retention requirements listed herein.

6.1.3 Painting of treated wood involves special considerations. Wood treated with creosote, solutions containing creosote, and pentachlorophenol in heavy petroleum solvent, cannot ordinarily be painted satisfactorily. When requested, it can be conditioned by the producer to improve its cleanliness. Difficulties may be encountered in painting wood treated with pentachlorophenol in a light petroleum solvent. When purchasing wood treated with such solutions, the supplier should be required to designate a type or brand of paint that will give satisfactory results on wood so treated. Wood treated with waterborne preservatives should be properly seasoned after treatment (see 3.4) and may require 1 ght brushing or sanding in order to provide a paintable product. Since "cleanliness" is a relative term, it is recommended that the purchaser make known his specific requirements and the end use of the material, and that the supplier be required to furnish evidence that the material be suitable for that use. In the absence of widely used methods for determining cleanliness, paintability,and water repellency of pentachlorophenol-treated wood, the purchaser may elect to use arbitrary test methods or those described in Federal Specification TT-W-572.

6.1.4 The serviceability of treated wood is impaired through cutting or damage to the treated surface. Whenever it is possible, machining, cutting, trimming, etc., should be done prior to treatment. When cutting or damage to the surfase of treated wood cannot be avoided, the instructions given in AWPA Standard M4 should generally be followed. Cut surfaces of wood treated with oil-borne preservatives should be given at least two brush applications of either creosote or a solution of at least 5 percent pentachlorophenol in a suitable solvent, or one heavy application of a grease or suitably bodied preservative composition containing at least 10 percent pentachlorophenol. Cut surfaces of wood treated with a waterborne preservative should be given one application of a concentrated solution of the preservative used in the treatment. (See AWPA Standard M4.) The choice should be based upon cleanliness requirements.

6.2 Ordering data. Purchasers should select the preferred options permitted herein, and include the following information in procurement documents:

(a) Title, number, and date of this specification.
(b) Moisture content required at acceptance (see 3.4).
(c) Minimum information required in the branding or marking (see 3.6).
(d) Treatment other than normally required (see 3.1).
(e) Condition of surface following treatment (see 6.1.2 and 6.1.3).

6.3 Invitation for bids. Invitations for bids should state the quantity, form, species, grade, the fabrication of the wood, the preservatives and retentions required, the corresponding treatment specifications to be complied with, and also any special requirements, such as cleanliness, paintability, water repellency, and drying of timbers after treatment with waterborne preservatives.

Table I.--Treatment of sawn wood products

Form of product and service conditions	Penetration	Assay zone	Minimum net retention of active preservative[1]												Treating specifications[2] (AWPA C1 and others listed below)
			Coal-tar creosote (Fed. Spec. TT-C-645)	Creosote-coal tar solution (Fed. Spec. TT-C-650)	Creosote-petroleum solution (Fed. Spec. TT-W-568)	Pentachlorophenol (Fed. Spec. TT-W-570)			Acid copper chromate (Fed. Spec. TT-W-546)	Ammoniacal copper arsenite (Fed. Spec. TT-W-549)	Chromated copper arsenate type I, type II, or type III (Fed. Spec. TT-W-550)	Chromated zinc chloride (Fed. Spec. TT-W-551)	Fluor chrome-arsenate-phenol mixture (Fed. Spec. TT-W-535) type I or type II	Tributyl-tin oxide (Fed. Spec. TT-W-18%)	
						In 5.0 to 7.5 percent solution with heavy petroleum solvent (AWPA P9 type A)	In solution with light petroleum solvent (AWPA P9 type C)	In solution with volatile solvent (AWPA P9 type B)							
	In. and/or pct of sapwood	In.	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	
Ties															C2 and C6
Crossties, switch ties, and bridge ties															
Beech, birch, and maple	85	Gage only	7.0	7.0	7.0	0.35	--	--	--	--	--	--	--	--	
Red oak	65 pct of rings	....do....	Refusal	Refusal	Refusal	Refusal	--	--	--	--	--	--	--	--	
Black and red gum	1.5 or 75	....do....	10.0	10.0	10.0	.5	--	--	--	--	--	--	--	--	
Ash, black and honey locust, hickory, black walnut, white oak, and interior Douglas-fir	90	....do....	Refusal	Refusal	Refusal	Refusal									
Coastal Douglas-fir, western hemlock, and western larch	0.5 and 90	....do....	8.0	8.0	8.0	.4	--	--	--	--	--	--	--	--	
Southern and ponderosa pines	2.5 or 85	....do....	8.0	8.0	8.0	.4	--	--	--	--	--	--	--	--	
Jack, lodgepole, and red pines	.5 or 90	....do....	7.0	7.0	7.0	.35	--	--	--	--	--	--	--	--	
Timbers[2]:															C2, C14, C16, and C18
Solid															
For use in coastal waters															
In areas where *Limnoria tripunctata* and pholads are known to be active, or in southern areas for which information on the borer hazard is lacking the dual treatment shall be used (see table III)															
In areas where moderate to heavy limnoria attack is expected but pholads are absent															
Coastal Douglas-fir	0.75 and 90	0 -0.60	--	--	--	--	--	--	--	2.50	2.50	--	--	--	
Western hemlock	.75 and 90	0 - .60	--	--	--	--	--	--	--	2.50	2.50	--	--	--	
Southern pine	2.5 or 85	0 - .60	--	--	--	--	--	--	--	2.50	2.50	--	--	--	
In areas where teredo are present with light limnoria activity															
Coastal Douglas-fir	.75 and 90	0 - .60	[3]25.0	--	--	--	--	--	--	2.50	2.50	--	--	--	
Western hemlock	.75 and 90	0 - .60	[3]25.0	--	--	--	--	--	--	2.50	2.50	--	--	--	
Southern pine	2.5 or 85	0 - .60	[3]25.0	--	--	--	--	--	--	2.50	2.50	--	--	--	
In areas where teredo are present with no limnoria activity															
Coastal Douglas-fir and western hemlock	.75 and 90	0 - .60	[5]20.0	--	--	--	--	--	--	--	--	--	--	--	
Southern pine	2.5 or 85	0 - .60	[5]20.0	--	--	--	--	--	--	--	--	--	--	--	
For important structural members used in fresh water or in ground contact															
Coastal Douglas-fir and western larch	.75 and 90	0 - .60	12.0	12.0	12.0	.60	--	--	--	.60	.60	--	--	--	
Western hemlock	.75 and 90	0 - .60	12.0	12.0	12.0	.60	--	--	--	.60	.60	--	--	--	
Southern pine	2.5 or 85	0 - .60	12.0	12.0	12.0	.60	--	--	--	.60	.60	--	--	--	

Table I.--Treatment of sawn wood products--continued

Form of product and service conditions	Penetration	Assay zone	Minimum net retention of active preservative[1]												Treating specifications[2] (AWPA C1 and others listed below)
			Coal-tar creosote (Fed. Spec. TT-C-645)	Creosote-coal tar solution (Fed. Spec. TT-C-650)	Creosote-petroleum solution (Fed. Spec. TT-W-568)	Pentachlorophenol (Fed. Spec. TT-W-570)			Acid copper chromate (Fed. Spec. TT-W-546)	Ammoniacal copper arsenite (Fed. Spec. TT-W-549)	Chromated copper arsenate type I, type II, or type III (Fed. Spec. TT-W-550)	Chromated zinc chloride (Fed. Spec. TT-W-551)	Fluor chrome-arsenate-phenol mixture (Fed. Spec. TT-W-535) type I or type II	Tributyltin oxide (Fed. Spec. TT-W-1894)	
						In 5.0 to 7.5 percent solution with heavy petroleum solvent (AWPA P9 type A)	In solution with light petroleum solvent (AWPA P9 type C)	In solution with volatile solvent (AWPA P9 type B)							
	In. and/or pct of sapwood	In.	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	
Timbers--cont.															
Solid--cont.															
For other timbers used in fresh water or in ground contact															
Coastal Douglas-fir, western larch, and redwood	0.75 and 90	0 -0.60	10.0	10.0	10.0	0.50	0.62	0.62	0.50	0.40	0.40	--	--	--	
Western hemlock, jack, lodgepole, sugar, red, northern white, and western white pines	.75 and 90	0 - .60	10.0	10.0	10.0	.50	.62	.62	.50	.40	.40	--	--	--	
Southern and ponderosa pines	2.5 or 85	0 - .60	10.0	10.0	10.0	.50	.62	.62	.50	.40	.40	--	--	--	
For use above ground	(8)														
Coastal Douglas-fir; western hemlock; western larch; redwood; jack, lodgepole, red, northern white, and sugar pines	.5 and 90	0 - .60	8.0	8.0	8.0	.40	.40	.40	.25	.25	.25	0.45	0.25	--	
Southern and ponderosa pines	2.5 or 85	0 - .60	8.0	8.0	8.0	.40	.40	.40	.25	.25	.25	.45	.25	--	
Glued-laminated	(7)	(9)													C28
For use in coastal waters															
In areas where *Limnoria tripunctata* and pholads are known to be active, or in southern areas for which information on the borer hazard is lacking the dual treatment shall be used (see Table III)															
In areas where moderate to heavy limnoria attack is expected but pholads are absent															
Coastal Douglas-fir	.75 and 90	0 - .60	--	--	--	--	--	--	--	2.50	2.50	--	--	--	
Western hemlock	.75 and 90	0 - .60	--	--	--	--	--	--	--	2.50	2.50	--	--	--	
Southern, ponderosa, and red pines	2.5 or 85	0 -3.00	--	--	--	--	--	--	--	2.50	2.50	--	--	--	
In areas where teredo are present with light limnoria activity															
Coastal Douglas-fir	.75 and 90	0 - .60	[3]25.0	--	--	--	--	--	--	2.50	2.50	--	--	--	
Western hemlock	.75 and 90	0 - .60	[3]25.0	--	--	--	--	--	--	2.50	2.50	--	--	--	
Southern, ponderosa, and red pines	2.5 or 85	0 -3.00	[3]25.0	[4]25.0	--	--	--	--	--	2.50	2.50	--	--	--	
In areas where teredo are present with no limnoria activity															
Coastal Douglas-fir and western hemlock	.75 and 90	0 - .60	[5]20.0	--	--	--	--	---	--	--	--	--	--	--	
Southern, ponderosa, and red pines	2.5 or 85	0 -3.00	[5]20.0	[6]20.0	--	--	--	--	--	--	--	--	--	--	

Table I.--Treatment of sawn wood products--continued

Form of product and service conditions	Penetration	Assay zone	Minimum net retention of active preservative[1]												Treating specifications[2] (AWPA C1 and others listed below)
			Coal-tar creosote (Fed. Spec. TT-C-645)	Creosote-coal tar solution (Fed. Spec. TT-C-650)	Creosote-petroleum solution (Fed. Spec. TT-W-568)	Pentachlorophenol (Fed. Spec. TT-W-570)			Acid copper chromate (Fed. Spec. TT-W-546)	Ammoniacal copper arsenite (Fed. Spec. TT-W-549)	Chromated copper arsenate type I, type II, or type III (Fed. Spec. TT-W-550)	Chromated zinc chloride (Fed. Spec. TT-W-551)	Fluor-chrome-arsenate-phenol mixture (Fed. Spec. TT-W-535) type I or type II	Tributyl-tin oxide (Fed. Spec. TT-W-1894)	
						In 5.0 to 7.5 percent solution with heavy petroleum solvent (AWPA P9 type A)	In solution with light petroleum solvent (AWPA P9 type C)	In solution with volatile solvent (AWPA P9 type B)							
	In. and/or pct of sapwood	In.	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	
Timbers--cont.															
Glued-laminated--cont.															
For use in fresh water, in ground contact, or for important structural members not in contact with ground or water															
Southern pine, coastal Douglas-fir, and western hemlock	(7)	(9)	12.0	12.0	12.0	0.60	0.75	0.75	--	--	--	--	--	--	
For use above ground															
Southern pine, coastal Douglas-fir, and western hemlock	(8)	(9)	6.0	6.0	6.0	.30	.30	.30	--	--	--	--	--	--	
Laminates prior to gluing															C28
For use in ground contact															
Coastal Douglas-fir	1.25	0.5-1.00	12.0	--	--	.60	.75	.75	0.50	0.40	0.40	--	--	--	
Western hemlock	1.25	.5-1.00	12.0	--	--	.60	.75	.75	.50	.40	.40	--	--	--	
Southern pine	3 or 90	.5-1.00	12.0	--	--	.60	.75	.75	.50	.40	.40	--	--	--	
For use above ground															
Coastal Douglas-fir and western hemlock	1.0	.5-1.00	6.0	--	--	.30	.30	.30	.25	.25	.25	--	--	--	
Southern pine	3 or 90	.5-1.00	6.0	--	--	.30	.30	.30	.25	.25	.25	--	--	--	
Lumber:															C2, C14, C16, and C18
For use in coastal waters															
In areas where *Limnoria tripunctata* and pholads are known to be active, or in southern areas for which information on the borer hazard is lacking the dual treatment shall be used (see table III)															
In areas where moderate to heavy limnoria attack is expected but pholads are absent															
Coastal Douglas-fir	0.5 and 90	0 -0.60	--	--	--	--	--	--	--	2.50	2.50	--	--	--	
Western hemlock	.5 and 90	0 - .60	--	--	--	--	--	--	--	2.50	2.50	--	--	--	
Southern, ponderosa, and red pines	.75 or 85	0 - .60	--	--	--	--	--	--	--	2.50	2.50	--	--	--	
In areas where teredo are present with: light limnoria activity															
Coastal Douglas-fir	.5 and 90	0 - .60	[3]25.0	--	--	--	--	--	--	2.50	2.50	--	--	--	
Western hemlock	.5 and 90	0 - .60	[3]25.0	--	--	--	--	--	--	2.50	2.50	--	--	--	
Southern, ponderosa, and red pines	.75 or 85	0 - .60	[3]25.0	[4]25.0	--	--	--	--	--	2.50	2.50	--	--	--	
In areas where teredo are present with: no limnoria activity															
Coastal Douglas-fir and western hemlock	.5 and 90	0 - .60	[5]20.0	--	--	--	--	--	--	--	--	--	--	--	
Southern, ponderosa, and red pines	.75 or 85	0 - .60	[5]20.0	[6]20.0	--	--	--	--	--	--	--	--	--	--	

Table I.--Treatment of sawn wood products--continued

Form of product and service conditions	Penetration	Assay zone	Minimum net retention of active preservative[1]												Treating specifications[2] (AWPA C1 and others listed below)
			Coal-tar creosote (Fed. Spec. TT-C-645)	Creosote-coal tar solution (Fed. Spec. TT-C-650)	Creosote-petroleum solution (Fed. Spec. TT-W-568)	Pentachlorophenol (Fed. Spec. TT-W-570)			Acid copper chromate (Fed. Spec. TT-W-546)	Ammoniacal copper arsenite (Fed. Spec. TT-W-549)	Chromated copper arsenate type I, type II, or type III (Fed. Spec. TT-W-550)	Chromated zinc chloride (Fed. Spec. TT-W-551)	Fluor-chrome-arsenate-phenol mixture (Fed. Spec. TT-W-535) type I or type II	Tributyl-tin oxide (Fed. Spec. TT-W-1894)	
						In 5.0 to 7.5 percent solution with heavy petroleum solvent (AWPA P9 type A)	In solution with light petroleum solvent (AWPA P9 type C)	In solution with volatile solvent (AWPA P9 type B)							
	In. and/or pct of sapwood	In.	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	
Lumber--cont.															
For use in fresh water in ground contact or for important structural members not in contact with ground or water															
Coastal Douglas-fir, western hemlock, western larch, and redwood	0.4 and 90	0 -0.60	10.0	--	10.0	0.50	0.62	0.62	0.50	0.40	0.40	--	--	--	
Southern and ponderosa pines	2.5 or 85	0 - .60	10.0	10.0	10.0	.50	.62	.62	.50	.40	.40	--	--	--	
Jack, lodgepole, red, northern white, western white, and sugar pines	.4 and 90	0 - .60	10.0	10.0	10.0	.50	.62	.62	.50	.40	.40	--	--	--	
Interior Douglas-fir	90	0 - .60	10.0	--	10.0	.50	.62	.62	.50	.40	.40	--	--	--	
Black or red gum	1.5 or 75	0 - .60	8.0	--	8.0	.40	.50	.50	.50	.40	.40	--	--	--	
Red oak	65 pct of annual rings	0 - .60	7.0	7.0	7.0	.35	.44	.44	.50	.40	.40	--	--	--	
White oak	95 pct of sapwood	--	Refusal	Refusal	Refusal	Refusal	Refusal	--	--	--	--	--	--	--	
For use above ground															
Coastal Douglas-fir, western hemlock, western larch, and redwood	0.4 and 90	0 - .60	8.0	8.0	8.0	.40	.40	.40	.25	.25	.25	0.45	0.25	0.06	
Southern and ponderosa pines	2.5 or 85	0 - .60	8.0	8.0	8.0	.40	.40	.40	.25	.25	.25	.45	.25	.06	
Jack, lodgepole, red, northern white, western white, and sugar pines	.4 and 90	0 - .60	8.0	8.0	8.0	.40	.40	.40	.25	.25	.25	.45	.25	.06	
Interior Douglas-fir	90	0 - .60	8.0	8.0	8.0	.40	.40	.40	.25	.25	.25	.45	.25	.06	
Black or red gum	1.5 or 75	0 - .60	6.0	6.0	6.0	.30	.30	.30	.25	.25	.25	.45	.25	.06	
Red oak	65 pct of annual rings	0 - .60	6.0	6.0	6.0	.30	.30	.30	.25	.25	.25	.45	.25	.06	
White oak	95 pct of sapwood	--	Refusal	Refusal	Refusal	Refusal	Refusal	--	--	--	--	--	--	--	
Posts (sawn)			See requirements on timbers for use in ground contact												C2, C14, C16

Table II.--Treatment of round wood products

Form of product and service conditions	Penetration	Assay zone	Minimum net retention of active preservative[1]									Treating specifications[2] (AWPA C1 and others listed below)
			Coal-tar creosote (Fed. Spec. TT-C-645)	Creosote-coal-tar solution (Fed. Spec. TT-C-650)	Creosote-petroleum solution (Fed. Spec. TT-W-568)	Pentachlorophenol (Fed. Spec. TT-W-570)			Acid copper chromate (Fed. Spec. TT-W-546)	Ammoniacal copper arsenite (Fed. Spec. TT-W-549)	Chromated copper arsenate type I, type II, or type III, (Fed. Spec. TT-W-550)	
						In 5.0 to 7.5 percent solution in heavy petroleum solvent (AWPA P9 type A)	In solution with light petroleum solvent (AWPA P9 type C)	In solution with volatile solvent (AWPA P9 type B)				
	In. and/or pct of sapwood	In.	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	
Piles:												C3
For use in coastal waters												
In areas where *Limnoria tripunctata* and pholads are known to be active or in southern areas for which information on the borer hazard is lacking the dual treatment shall be used (see table III)	--	--	--	--	--	--	--	--	--	--	--	
In areas where moderate to heavy limnoria attack is expected but pholads are absent												
Coastal Douglas-fir	1.0 and 85	0 -1.0	--	--	--	--	--	--	--	2.50	2.50	
Southern pine	4.0 or	0 - .5	--	--	--	--	--	--	--	2.50	2.50	
	90	.5 -2.0	--	--	--	--	--	--	--	1.50	1.50	
In areas where teredo are present with light limnoria activity												
Coastal Douglas-fir	1.0 and 85	0 -2.0	[3,10]22.0	--	--	--	--	--	--	--	--	
Southern pine	4.0 or 90	0 -3.0	[3,10]25.0	[4,10]25.0	--	--	--	--	--	--	--	
In areas where teredo are present with no limnoria activity												
Coastal Douglas-fir	1.0 and 85	0 -2.0	[5]20.0	--	--	--	--	--	--	--	--	
Southern pine	4.0 or 90	0 -3.0	[5]20.0	[6]20.0	--	--	--	--	--	--	--	
For land or fresh-water use												
Coastal Douglas-fir, western hemlock, lodgepole pine	0.75 and 85	0 -1.0	17.0	17.0	17.0	0.85	--	--	--	1.00	1.00	
Southern and ponderosa pines	3.5 or 90	0 -3.0	12.0	12.0	12.0	.60	--	--	--	.80	.80	
Jack pine	1.5 or 85	0 -2.0	12.0	12.0	12.0	.60	--	--	--	.80	.80	
Red pine	2.5 or 85	0 -2.0	12.0	12.0	12.0	.60	--	--	--	.80	.80	

Table II.--Treatment of round wood products--continued

Form of product and service conditions	Penetration	Assay zone	Minimum net retention of active preservative[1]									Treating specifications[2] (AWPA C1 and others listed below)
			Coal-tar creosote (Fed. Spec. TT-C-645)	Creosote-coal-tar solution (Fed. Spec. TT-C-650)	Creosote-petroleum solution (Fed. Spec. TT-W-568)	Pentachlorophenol (Fed. Spec. TT-W-570)			Acid copper chromate (Fed. Spec. TT-W-546)	Ammoniacal copper arsenite (Fed. Spec. TT-W-549)	Chromated copper arsenate type I, type II, or type III, (Fed. Spec. TT-W-550)	
						In 5.0 to 7.5 percent solution in heavy petroleum solvent (AWPA P9 type A)	In solution with light petroleum solvent (AWPA P9 type C)	In solution with volatile solvent (AWPA P9 type B)				
	In. and/or pct of sapwood	In.	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	Pcf	
Poles (round):												
Building[11]												C4
Coastal Douglas-fir	2.5 or half of radius and 90	0.25-1.0	12.0	--	--	0.60	--	--	--	0.60	0.60	C23
Southern and ponderosa pines	...do....	.5 -2.0	12.0	--	--	.60	--	--	--	.60	.60	
Red pine	...do....	.1 -1.6	13.5	--	--	.68	--	--	--	.60	.60	
Utility												
Coastal Douglas-fir	0.75 and 85	.25-1.0	[12]9.0, 12.0	--	--	[12].45, 0.60	0.75	0.75	--	.60	.60	C4
Southern and ponderosa pines	3.0 or 90	.5 -2.0	[12]7.5, 9.0	--	--	[12].38, .45	.56	.56	--	.60	.60	
Red pine	2.5 or 85	.1 -1.6	[12]10.5, 13.5	--	--	[12].53, .68	.85	.85	--	.60	.60	
Jack pine	1.5 or 85	.1- .75	[12]12.0, 16.0	--	--	[12].60, .80	1.0	1.0	--	.60	.60	
Lodgepole pine	0.75 and 85	.1- .75	[12]12.0, 16.0	--	--	[12].60, .80	1.0	1.0	--	.60	.60	
Interior Douglas-fir, western larch	0.5 and 100	.1- .6	16.0	--	--	.80	1.0	1.0	--	.60	.60	
Western redcedar	0.5 or 100	.1- .6	16.0	--	--	.80	1.0	1.0	--	.60	.60	
Western redcedar, Alaska yellow and northern white cedars	0.5 or 100	0 - .5	20.0	--	--	1.0	--	--	--	--	--	C7, C8
Posts (round):												
Building[11]												
Coastal Douglas-fir	2.5 or half of radius and 90	.25-1.0	12.0	--	--	.60	--	--	--	.60	.60	C23
Southern and ponderosa pines	...do....	.5 -2.0	12.0	--	--	.60	--	--	--	.60	.60	
Red pine	...do....	.1 -1.6	12.0	--	--	.60	--	--	--	.60	.60	
Fence												
Douglas-fir, western hemlock, and western larch	0.4 and 100 up to 1.0	0 -1.0	6.0	6.0	7.0	.30	.38	.38	0.50	.40	.40	C5
Southern, ponderosa, and red pines	2.0 or 85	0 -1.0	6.0	6.0	7.0	.30	.38	.38	.50	.40	.40	
Jack pine	1.5 or 85	0 -1.0	6.0	6.0	7.0	.30	.38	.38	.50	.40	.40	
Lodgepole pine	1.25 or 85	0 -1.0	6.0	6.0	7.0	.30	.38	.38	.50	.40	.40	

Table III.--Treatment of special wood products

Product and use conditions	Requirements on treatment				Other requirements
	Preservative	Retention[1]	Assay zone	Penetration	
		Pcf	In.	In. and/or pct of sapwood	
Dual-treated marine piles	--	--	--	--	Kiln drying after first treatment not permitted.
Coastal Douglas-fir					
First treatment	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	1.00	0-1.00	1.0	Do.
Second treatment	Creosote[5]	20.0	0-1.00	(13)	Do.
Southern pine					
First treatment	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	1.00	0-1.00	1.0	Do.
Second treatment	Creosote[5]	20.0	0-1.00	4.0 or 90	Do.
Dual-treated lumber and timbers for marine use	--	--	--	--	Do.
Coastal Douglas-fir					
First treatment	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	1.50	0-0.60	0.5 and 90	Do.
Second treatment	Creosote[5]	20.0	0-0.60	0.5 and 90	Do.
Western hemlock					
First treatment	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	1.50	0-0.60	0.5 and 90	Do.
Second treatment	Creosote[5]	20.0	0-0.60	0.5 and 90	Do.
Southern pine					
First treatment	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	1.50	0-0.60	1.0	Do.
Second treatment	Creosote[5]	20.0	0-0.60	2.5 or 85	Do.
Mine timbers	--	--	--	--	Mixed hardwood species commercially available are acceptable.
For structures classified as permanent	See table I, timbers in ground contact	--	--	--	Do.
For other structures	5 pct solution of either acid copper chromate, or fluor-chrome-arsenate-phenol mixture or 8 pct solution of chromated zinc chloride	Refusal	--	--	Do.
Lumber for use in contact with, or in close proximity to, foodstuffs	2.5 to 5.0 pct solubilized copper-8-quinolinolate (AWPA P8) dissolved in volatile solvent (AWPA P9)	0.25 by gage	--	--	Prior to treatment, lumber shall be milled to correct width and thickness, and, if practical, cut to correct length. Surface of treated wood shall be clean and free of residual solvent.

Table III.--Treatment of special wood products--continued

Product and use conditions	Requirements on treatment				Other requirements
	Preservative	Retention[1]	Assay zone	Penetration	
		Pcf	In.	In. and/or pct of sapwood	
Lumber for building foundations	--	--	--	--	Only seasoned lumber 2 in. or less in thickness. Each charge shall be assayed.
Douglas-fir, western larch	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	0.60	0-0.60	0.5 and 90	Lumber shall be incised prior to treatment.
Western hemlock	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	0.60	0-0.60	0.5 and 90	Do.
Southern and ponderosa pines	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	0.60	0-0.60	0.7 or 90	Lumber shall contain not more than 20 pct heartwood and no boxed heart.
Plywood					
For use in coastal waters	Creosote[3]	25.0	See 4.2.5	Each veneer penetrated	Exterior grade plywood shall be used.
	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	2.50	See 4.2.5	.....do......	Do.
For use in building foundations					
Douglas-fir	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	0.60	See 4.2.5	.....do......	Do.
Southern pine		0.60	See 4.2.5	.....do......	Plywood shall contain no heartwood faces.
For use in fresh waters or in ground contact	Creosote[3]	10.0	See 4.2.5	.....do......	Exterior grade plywood shall be used.
	Pentachlorophenol in heavy solvent (AWPA P9 type A)	0.50	See 4.2.5	.....do......	Do.
	Pentachlorophenol in light or volatile solvent (AWPA P9 types C or B)	0.62	See 4.2.5	.....do......	Do.
	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III)	0.40	See 4.2.5	.....do......	Do.
For use above ground	Creosote[3]	8.0	See 4.2.5	.....do......	Do.
	Pentachlorophenol in heavy, light, or volatile solvent (AWPA P9 types A, C, or B)	0.40	See 4.2.5	.....do......	Do.
	Ammoniacal copper arsenite or chromated copper arsenate (types I, II, or III), acid copper chromate or fluor-chrome-arsenate-phenol mixture	0.25	See 4.2.5	.....do......	Do.
	Chromated zinc chloride	0.45	See 4.2.5	.....do......	Do.
	Tributyltin oxide	0.06	See 4.2.5	.....do......	Do.

Footnotes for Tables I, II, and III

[1] Whenever a method for the determination of retention in a treated product by the assay of a sample is described in an AWPA specification, purchase shall be made on that basis and a retention by gage shall not be accepted in competitive bids.

[2] These standards cover treatment of species most commonly treated. For species offered and not covered by existing standards, the supplier shall furnish evidence of satisfactory experience. Penetration requirements for most generally available products are covered in AWPA specifications and footnotes below. When penetration is not otherwise specified herein or in AWPA specifications, the penetration in the sapwood shall be not less than 2.5 inches unless 85 percent of the sapwood depth is penetrated (see footnote 11). For wood species not included herein or in AWPA specifications, the penetration of heartwood faces shall be not less than 0.4 inch in lumber (i.e., sawn material less than 5 in. in thickness) and not less than 0.5 inch in timbers (i.e., sawn material 5 in. or more in thickness). Retention shall be consistent with end use of the product.

[3] Conforming to class 3 of TT-C-645.

[4] Conforming to class 5 of TT-C-650.

[5] Conforming to either class 1, 2, or 3 of TT-C-645.

[6] Conforming to either class 1, 2, 3, 4, or 5 of TT-C-650.

[7] For ground contact use: For members more than 75 square inches in cross section at the groundline, every member shall be bored for penetration. For members 75 square inches or less in cross section at the groundline, 20 members per charge shall be bored for penetration. Should the charge contain less than 20 members, each member shall be bored. When inspecting southern yellow pine laminated timbers for penetration, borings shall be taken from two different laminations from each member. When boring coastal Douglas-fir or western hemlock laminated timbers for penetration, one boring shall be taken from the edge of each of the two face laminations and one boring from each of two different interior laminations in each member.

If any boring taken from any member fails to meet the penetration requirement, that member shall be rejected. If 90 percent or more of the members bored meet the specified requirements for either size category, the charge shall be considered to meet penetration requirements. If less than 90 percent of the members bored meet the specified requirements for either size category, the charge shall be rejected.

[8] For above-ground use. One boring shall be taken from each of 20 members in a charge. If 80 percent or more of the borings show a penetration of 2.5 inches or 85 percent of the sapwood in southern and ponderosa pine or 0.50 inch in the heartwood of coastal Douglas-fir or western hemlock, the charge shall be considered to meet penetration requirements. Should a charge contain less than 20 members, each member shall be bored and any member shall be rejected if it fails to meet the penetration described in the foregoing.

[9] For the assay of glued-laminated timbers, 20 borings shall be taken from the 0- to 3.0-inch zone in southern pine and 0 to 0.60 inch in coastal Douglas-fir or western hemlock.

[10] When reserve treated stock is assayed or when inspection is made at destination, a sample of the preservative shall be obtained from a randomly selected piling by the procedure given in AWPA Standard A8. The properties of the recovered oil shall meet the following requirements when tested by AWPA Standard A1:

	Creosote		Creosote-tar solution	
	Classes 1 and 2	Class 3	Classes 1, 2, 3, 4	Class 5
Percent distilling to:				
270°C minimum	15	15	15	15
355°C maximum	75	70	65	65
Specific gravity of fraction at 38°C/15.5°C:				
235° to 315°C minimum	1.025	1.030	1.025	1.030
315° to 355°C minimum	1.095	1.105	1.095	1.105
Residue above 355°C.	-----	1.160	-----	1.160

[11] In round building poles or in round posts used in post-and-beam types of foundations, penetration in each piece 10 inches or less in diameter shall be at least one-half of the radius. In each piece more than 10 inches in diameter, penetration shall be at least 2.5 inches. In all cases, 90 percent of the sapwood shall be penetrated. Mechanical means to obtain the required penetration, such as incising or boring, are permitted. Borings to determine penetration shall be taken from the incised area. Borings for assay shall be taken from the approximate midpoint, but not from the incised area.

[12] The higher retention is required for large poles (Group B, 37.5 in. and over in circumference), for all poles used under severe service conditions and for all poles having a high replacement cost.

[13] 1.0 inch and 85 percent if sapwood is 2.0 inches or less; 1.75 inches if sapwood is more than 2 inches.

MILITARY INTERESTS:

Custodians:

Army - ME
Navy - SH
Air Force - 84

User activity:

Army - AT

Review Activities:

Preparing activity:

AGR - AFS

GPA DC 75-4314