Wood Treating of Lumber Products- A Primer
or
Everything You Ever Wanted to Know About Wood Treating

by Jim Reinhardt, Elmer Botsai, William Dost and Lee Haskin

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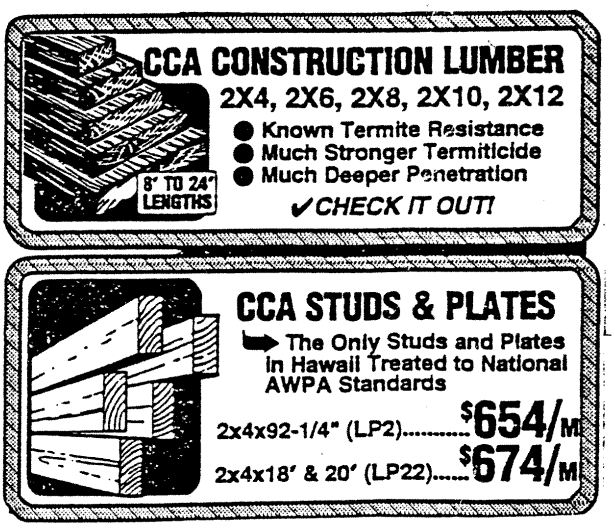
2007 Note: This article was written in 1995 and reflected the state of the art of wood treatment at the time. At the end of 2003, CCA treatment for wood was withdrawn from the residential market and limited to certain industrial and commercial applications. The effectiveness of borate treatment to protect construction lumber from damage by Formosan subterranean termites, unproven at that time, has since been well established.

With the recent media coverage of the hearings on Conrad Wood Preservative Company's request for an injunction to restrain the City and County of Honolulu from accepting Borate treated wood as meeting the building code requirements, it seems like a good idea to provide everyone with a background and the current "state of the art" of wood treating.

The Standards: The standards for treatment of wood have been formulated by the American Wood Preservers Association (AWPA), and are revised on more or less of a yearly basis. The current edition is 1995. The AWPA Standards are available from AWPA. PO Box 286, Woodstock, MD, 21163-0286, Tel: 410-465-3169 for $75. The standards most applicable to normal construction projects are: Standard C-2 for "Lumber, Timbers, Bridge Ties and Mine Ties- Preservative Treatment by Pressure Process". Within that standard, woods are listed by species and preservatives by type, with the required retention and penetration. Standard C-15 describes the treatment of "Wood for Commercial-Residential Construction" by preservative type, use (decking, sill plates, studs, etc.) and exposure (exposed-to-weather, above-ground-use, etc.). Other standards of interest are C-9 which describes the treatment of plywood; M-4 which contains a description of the requirements for treating cut ends and drilled holes, and C-1, which contains a precise formulation for the various approved preservatives.

requires lumber treated under the AWPA standards to be tested by an independent third party, to verify compliance with the standards. That function was previously performed by the American Wood Preservers **Bureau** (AWPB), which was a sister organization of AWPA for monitoring the compliance of treaters with the standards. Unfortunately, AWPB was disbanded at the end of 1992. Some, but not all of AWPB's roles have been taken on by the American Lumber Standards Committee (ALSC), an organization which monitors the grading of all softwood lumber in North America. The actual monitoring of lumber treatment is now done by independent testing laboratories. The M-2 standard requires that records be kept from each batch of treated lumber and if the samples from a batch fail to meet the standard, the entire batch must be retreated. This program is less rigorously enforced under ALSC than under AWPB, resulting in some decrease of quality control standards. Lumber treated in Hawaii is not currently inspected in accordance with AWPA M-2.



A portion of a lumber ad from the 21 Jan '96 Honolulu Advertiser. Note the reference to LP2 and LP22

AWPB LP-2/LP-22: The term "LP-2" refers to an AWPB specification for treatment of lumber in

above-ground-use; "LP-22" refers to the standards for treatment of lumber in ground-contact-use. Although AWPB no longer exists, those term are a convenient shorthand description for a complex set of requirements and are sometimes still used.

Hawaii LAS: Until recently, most lumber used in Hawaii was treated with CCA, under a special AWPB standard, the Hawaii-Use-Only (HUO) standard, sometimes referred to as the Hawaii Local Area Standard (HI-LAS), which allowed a lower level of treatment than that required by the LP-2/LP-22 standards. With the demise of the AWPB, the HUO standard also ceased to exist. Wood treated to the old HUO standard is still produced and is accepted by the building departments, however.

TERMS COMMONLY USED IN THE TREATING INDUSTRY:

Retention is the amount of preservative which remains in the treated wood. It is usually measured in pounds of preservative per cubic foot of wood (pcf) but is sometimes described with a percentage, comparing the weight of the preservative retained to the weight of wood (% wt/wt). Retention by pcf can best be determined by laboratory analysis; retention can also be approximated by measuring "solution uptake" or the amount of the preservative absorbed by the wood during the treatment process. Solution Uptake is most commonly used with the % wt/wt measurements.

Penetration is the depth that the preservative penetrates into the piece of wood, measured from the surface of the wood.

The **Assay Zone** is the selected depth in which the quantity of preservative is measured to calculate retention. For AWPA treatments, the standard depth is the outer 0.6" of the wood. For the AWPB Hawaii-Use-Only standard, the assay zone was defined as 0.2". The designation "0.25 pcf", when used in the context of AWPA treatments, means that 0.25 pounds of preservative was retained in each cubic foot of the outer 0.6" of the wood.

The **Formulation** of the treating solution is the recipe or precise mix of chemicals which make up the solution. For ACZA and CCA, this is an important analytical concern, but can be determined only by a skilled testing laboratory.

Incising is a process of making small slits in the surface of the wood, parallel to the grain, in order to obtain deeper penetration of the preservative. Standard incising produces slits 3/8" long, 7/8" apart, in rows spaced 3/8" apart, or about 2 slits per square inch. Micro-incising or double-density incising produces slits about 5/16" long, 1/2" apart, in rows spaced 3/16" apart, or about 6 slits per square inch, and are much less noticeable than the standard type. There is some discussion and controversy about possible reductions of strength as a result of incising.

Specifying or Ordering Treated Wood: While the AWPA standards describe preservative type, penetration, and retention for each wood species, a wide variety of treatments levels is available when purchasing lumber "on the market". For instance, the AWPA C-2 standard for ACZA, CCA and ACQ, for Douglas fir in above-ground-use requires a retention of 0.25 pcf and a penetration of 0.4" for lumber less than 5" thick. The HUO standard for the CCA, however, required a retention of the same 0.25 pcf but in an assay zone only 0.20" in depth. A relatively common level of wood treatment used for local projects is "CCA- 0.25 pcf or Refusal", which means that however much chemical the wood accepted during the time it was in the treating cylinder, that's how much you get. I recently saw lumber marked "CCA - 0.25 pcf" with no indication of penetration. Who knows how much chemical is in that. One Oregon treater markets Douglas fir treated to their own standard, which they call "PR-2", which is 0.40 pcf with an assay zone 0.2" in depth. It is critical that you identify the level of treatment you want and then be sure that your requirements are communicated to the supplier.

THE WOODS AND WOOD PRODUCTS

Heartwood vs Sapwood: As a tree ages, the older center portion of the tree trunk converts from sapwood to heartwood as it accumulates resins and other chemicals. The newer wood, the outer portions of the tree, or the "sapwood", have less of those chemicals. Because of the internal cellular structure and the increased accumulation of chemicals, the heartwood is very difficult to penetrate with wood treating chemicals. Penetration into the sapwood is much better. The heartwood, because of that build-up of chemicals, is inherently more decay and insect resistant than the sapwood for many wood species, particularly Douglas fir, but don't rely on that for the primary protection.

Douglas Fir: Most of the structural and framing lumber used in Hawaii is Douglas fir; most of it arrives in Hawaii in a "green" condition, ie. the moisture content (MC) above 19% and frequently above 28%. If the treatment is to be done to AWPA standards, Douglas fir must be dry at the time of treatment. Because Douglas fir has a high percentage of heartwood (70% to 80%) it is very difficult to treat. Even if the treater follows the prescribed procedures very carefully, treatment meeting the standards of AWPA C-2 for above-ground-use cannot be assured. Treatment meeting AWPA C-2 for ground-contact (the old LP-22) is nearly impossible to produce reliably.

Hem-Fir: This is a mix of hemlock and firs other than Douglas fir. These wood species tend to have higher percentages of sapwood than Douglas fir and good penetration of the preservative is, therefore, easier to achieve. Hem-fir treated with CCA to the old HUO standard, is currently being stocked by Hardware Hawaii.

Pine: Most pine lumber, and southern pine in particular, has a high percentage of sapwood. Good penetration is, therefore, easier to achieve. "Thru" treatment can be expected. Obtaining pine lumber is, however, more difficult and requires special effort. Pine also has an increased vulnerability to warping and twisting, making it less popular in Hawaii.

Redwood: Contrary to the common myth, **redwood is not immune from termite infestation.** While old-growth all-heart redwood is more termite resistant than most other woods, that old growth material is very difficult to get and, given the voracity of Hawaii's termites, should not be relied on to provide protection. Use the standard preservative treatments.

Plywood: While most construction plywood is Douglas fir or a combination of Douglas fir and hemlock or larch, because of the thin laminations, lathe checks, and the alternating grain direction, thru treatment with CCA is readily achievable. For most uses, CCA is the treatment of choice for plywood. Excellent penetration and retention can also be obtained with Borate. For use with a light-colored semi-transparent stain on plywood siding, Tribucide or Clear-Bor would be appropriate. For use with a medium to dark stain, or a heavy body stain, CCA or Borate would be appropriate.

Glu-lam Lumber and Engineered Wood Products such as Oriented Strand Board and Particle Board: Most laminated and engineered wood products cannot be treated with water borne preservatives without invalidating the underlying product warranties. Oil-borne preservatives can be used but their effectiveness is not as good as the water-borne materials and the cost is significantly higher. Some investigation is on-going into the use of borate treated wood, with the treatment done prior to lamination or fabrication of the composite product.

THE CHEMICALS

ACZA, Ammoniacal Copper Zinc Arsenate, or "Chemonite" appears to the most effective of the available materials. ACZA has a very good "kill rate" and, because of the ammonia carrier, provides good penetration into Douglas fir. While classified as a "water-borne" treatment, the actual vehicle is ammonia, which provides better penetration into Douglas fir than most other preservatives. ACZA is permanent once it has been forced into the wood cells, making it appropriate for weather-exposed use. Wood must be dry, ie. less than 19% moisture content (MC) or heated according to very specific requirements before it is treated with ACZA; the treated wood is blackish/greenish, and is usually available only incised. It is approved under AWPA C-2, C-9 and C-15. The cost is about $125 per 1000 board feet (MBF). Wood treated with ACZA is currently

available only from mainland treating companies.

CCA, Chromated Copper Arsenate, "Wolman" or "Osmose" is an excellent preservative with a very good kill rate, but penetration into Douglas fir is limited (the AWPA required retention of 0.25 pcf with a 0.4" penetration is very difficult to achieve). CCA is water borne and chemically bonds to the wood cells, making it permanent and appropriate for weather-exposed use. Wood to be treated with CCA must be less than 26% MC; the treated wood is brownish green, although it is sometimes dyed brown. It is approved under AWPA C-2, C-9 and C-15, and available both incised and unincised, but the incised product provides much improved penetration and retention. The cost for wood treated to the HUO standard is about $60 to $65 per MBF. Incising will add another $15 per MBF. Hawaii Wood Preserving Co. (on Maui) and Hilo Coast Processing are currently treating wood with CCA in Hawaii.

ACQ, Ammoniacal Copper Quat, or "Preserve", is a new "environmentally friendly" preservative that appears to be about equal to CCA in effectiveness. It is water borne and chemically bonds to the wood cells, making it permanent and appropriate for weather-exposed use. Wood to be treated with ACQ must be "dry"; the treated wood is greenish-brown. The ACQ-B formulation is approved under AWPA C-2, C-9, and C-15, but it has not yet been approved by the City and County of Honolulu. The cost is about $185 per MBF for treatment to 0.25 pcf, and $225 per MBF for treatment to 0.4 pcf. ACQ treatment is currently available only from mainland treaters.

Borate, Disodium Octaborate, (DOT), Inorganic Boron, SBX, "Tim-Bor" or "Hi-Bor", the focus of Honolulu's latest wood treating controversy, is an "environmentally friendly" preservative that is water-borne but does not chemically bond to the wood, making it inappropriate for weather-exposed use, unless the wood is protected. Exposure to weather during the construction period does not degrade the treatment below acceptable limits. The retention of Borate is typically described in % wt/wt terms. The currently established target levels are 1.43% wt/wt which is equivalent to about 0.4 pcf. In contrast to the other water-borne preservatives, wood to be treated with Borate should be green at the time of treatment, as the moisture within the wood allows the borate salts to continue to diffuse within the wood after treatment, eventually leading to distribution of the chemical throughout the wood. Because of that continuing diffusion, however, it is important that the retention in the outer fibers be adequate to produce an effective level after the diffusion. Borate is colorless in its natural form but Hi-Bor has a bluish dye added for identification. ClearBor is a colorless version which can be used where a colorless treatment is desired. Borate has no AWPA approval for Douglas fir lumber at this time, although it is included in AWPA C-31 for Southern Pine and Hem-fir. I understand that Borate at 0.42 pcf retention has been preliminarily approved by ICBO (the International Conference of Building Officials) as an acceptable treatment. The cost is about $75 to $80 per MBF. Honolulu Wood Treating and MIDPAC Lumber are treating wood with Hi-Bor.

The effectiveness of Borates against subterranean termites is the focus of the current controversy. Achieving an adequate level of retention seems to be the key. As with all preservatives used in Douglas fir, penetration is difficult and uneven. (See "Hilo Tests" below).

Tribucide is a locally formulated preservative made up of chlorpyrifos (Dursban) which is an insecticide and IPBC (polyphase) which is an fungicide in an oil carrier. The kill rate is not as good as for the water borne preservatives, but the treatment is clear, and can, therefore, be used on lumber which is to receive a semi-transparent stain, such as interior trim, cabinets and such. As an oil-borne material, it causes less grain raising and twisting/warping than water-borne materials. You may see reference to three formulations of Tribucide: Tribucide I, Tribucide II and Tribucide III. Tribucide I has not been produced since 1986, Tribucide III was never approved by the building department and has never been available. Tribucide II is the only one of the products which is currently available. Tribucide has no AWPA approvals. Cost is about $195 per MBF for dip treatment, which is appropriate for boards 1" thick and less; $300 to $335 per MBF for pressure treatment.

PermaClear 65 or PermaTrib, is a clear, oil borne insecticide/fungicide based on Zinc Naphthenate, which is used to treat trim and cabinetry. It's equal to Tribucide in both its uses and cost.

Penta, or Pentachlorophenol, is a translucent brown, oil borne preservative but its use has been severely restricted since 1988 as it is a suspected carcinogen. The old clear Penta is no longer available. You can still get brown penta treated lumber from mainland treaters, but it cannot be used in areas occupied by people, making Tribucide or PermaClear a better choice for most uses. Penta is mainly used for bridges, railroad trestles and such, and is approved under AWPA C-2, C-9 and C-15 (for some purposes). Cost is about $500 per MBF plus another $100 per MBF is the wood is not already kiln dried.

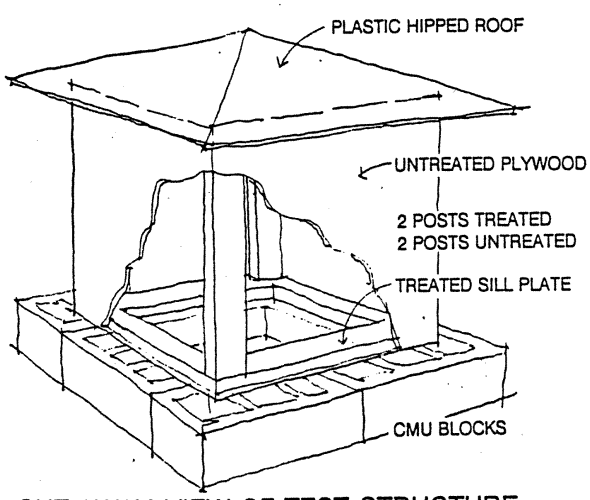
Creosote is a coal-tar derivative which has historically been used for treating telephone poles, railroad ties, and marine pilings. It's black and smelly and, while its uses are very limited, it does a very good job for those conditions for which it is appropriate. Like penta, it cannot be used in areas occupied by people. Creosote treated wood is most commonly available in two concentrations. The 12# version is used for non-water contact areas and costs about $300 per MBF. The 20# version is used in salt-water contact, such as marine piles, and cost is about $600 per MBF.

Copper Naphthenate, or Wolman Treat 00, is an oil-borne preservative primarily used for treating "cut ends" and drilled holes during construction. It's bright green and has a strong odor which dissipates with time. It's good for field use. The 20% concentration is best. Wood pressure treated with Copper Naphthenate can be purchased on the mainland. Cost is about $360 per MBF.

Field Treatment: The cut ends of framing lumber and holes drilled thru studs and joists for plumbing and electrical lines must be treated to provide adequate protection and, in most cases, to qualify for the preservative warranty. Dip treating of cut ends will provide the most effective treatment; a heavy brush will also do a good job. Spraying cut ends and bored holes with a "Hudson Bay" type sprayer is accepted by most warranties. For bored holes, spraying is about the only realistic option. Dipping or spraying lumber for the basic treatment should only be done as a last resort; it is does not provide a level of treatment comparable to pressure treating. The CCA solution can be obtained from Osmose for field treatment of cut-ends. Copper Naphthenate is the next best material. Zinc Naphthenate is also available, as is a retail formulation of HI-BOR, which is a diluted version of the treating solution.

Handling of Treated Wood Products: A recent series of lawsuits in Hawaii was related to the procedures for handling Tribucide treated lumber. The same issues which arose in those cases should be of concern for the handling of treated wood products in general. **Treated wood products should be handled in strict accordance with the treater's instructions.** In your specifications, include instructions **requiring all workers to read and follow** the manufacturer's printed instructions for handling the particular products.

termite resistant wood products has not escaped the notice of industry; the development of new treating products is aggressively underway. Chemical Specialties, Inc. (CSI), one of the major manufacturers of wood treating chemicals, is proceeding with development of new insecticide-based products. As with the development of new medicines, one does not simply conjure-up a new product and rush it off to the market. Efficacy testing, analysis of worker and homeowner safety, EPA approvals, development of treating plant procedures and of quality control monitoring procedures must all be addressed. There are some very interesting new products "out there".



CUT-AWAY VIEW OF TEST STRUCTURE

The Hilo Tests on Borate: In March of 1994, Chemical Specialties Inc, a major producer of wood treating chemicals, initiated a year-long test to compare the efficacy of Borate with that of CCA and ACQ. 18 test structures were constructed, each 2'

square and 2' high, with a plastic hipped roof, with a 5½" eave overhang all around. The idea was to simulate little houses. Each foundation was made of six decorative concrete blocks, 4" x 8" x 16", with the wide (open) face in contact with the soil. An untreated wood stake was driven into the ground in the center of the space enclosed by the foundation, to encourage termite activity. A treated 2x4 sill plate was placed on the CMU, 2x4 posts placed at each corner, and 2x4 top plate run all around the top. The siding was untreated 3/8" Douglas fir plywood.
For each house, two posts at opposite corners were
left untreated; all other members were treated. For the members treated with CCA, retentions of 0.14 pcf and 0.27 pcf were used, unincised; for the ACQ, retentions were 0.10 pcf, 0.17 pcf and 0.35 pcf; for the Borate retentions were 0.48% wt/wt (±0.14 pcf), 0.92% wt/wt (±0.26 pcf) and 1.70% wt/wt (±0.48 pcf). Two untreated structures (for reference) and two structures fabricated with each chemical at each retention were tested. The structures were left in place in an orchard area in Hilo known to have a high level of termite activity, monitored at 3 month intervals, then disassembled and analyzed after 51 weeks.

In general, the termite activity was severe among most of the test structures. The two untreated structures were totally destroyed; very little remained at the end of the test period. Attack on the untreated members within the treated structures was generally severe; damage to the untreated plywood was variable but generally severe. Two of the structures, however, one treated with borate, one with ACQ, were completely undamaged, apparently due to the random chance that the termites just didn't hit them. In general, the termite attack tended to be more severe at the lower sill plate than at the top, probably due to proximity to the ground.

For the CCA treated members, no damage occurred to any portions of the sapwood (probably because of the high penetribility noted above). No more than "browsing" was noted on any of the CCA treated members. Damage to the CCA treated members was either non-existent or very light.

For the ACQ treated members, those treated to 0.10 pcf were very lightly damaged except for one member which was destroyed. Significant damage was observed in members treated to 0.15 pcf and 0.23 pcf. Members treated at 0.35 pcf were undamaged. As with the CCA, no damage occurred in any sapwood zones; the damage occurred where termites broke thru the thin zone of treatment in a heartwood area into the untreated interior zone.

For the Borate treated members, the termite damage occurred more frequently in the sapwood zones than in the heartwood. One of the structures treated to 0.14 pcf was severely damaged, the other was one of the totally undamaged structures. Damage to the structures treated to 0.26 pcf was variable. Severe damage was sustained by one member treated to 0.39 pcf and another treated to 0.71 pcf, but only browsing was typical at retentions above 0.39 pcf.

In general, the tests indicate that wood treated with CCA and ACQ suffered less damage than that treated with Borate. Wood treated to the common standards for CCA and ACQ of 0.25 pcf performed satisfactorily. Wood treated to the current Honolulu Building Code requirements of 1.4% wt/wt or 0.4 pcf, generally performed satisfactorily but did sustain some grazing.

It should be noted that the CSI test has been criticized by some termite and wood product scientists on the basis of detailed procedural and methodological reasons. One criticism has been that the standard used for evaluating the degree of damage to the wood was subjective, using a scale of 0 (no attack) to 4 (complete destruction) rather than what some consider to be a more precise measurement such as loss of weight or loss of measured strength. CSI notes that subjective ratings are common in such tests. A second criticism has been that the relative quantities of heartwood vs sapwood for each piece or each structure were not estimated prior to the test. CSI responds that the boards were end-matched and distributed throughout other structures for the test. Another concern was that the possible effects of moisture from the ground were not determined. CSI responds that the moisture content of the wood and of the blocks was measured. The most significant of the criticisms is that the remnants of the wood were accidentally discarded after analysis, but before being examined by other scientists.

Wood Treating- What I Would Use.
An Opinion Statement by Jim Reinhardt and Elmer Botsai

The following is the author's personal opinions in response to the frequently asked question, "What wood treatment should I use for my project?" The answer, of course, depends on the specifics of the project but some guidelines are useful.

Incising improves the penetration of the preservative. For concealed framing and even exposed lumber which can be "a little rough", incising will provide better treatment. It should be remembered, however, that incising **may reduce the structural capacity** so where the structural design margins are close, caution should be exercised.

Sapwood accepts treatment better than heartwood. Pine and Hem-fir have more sapwood than Douglas fir and will, therefore, accept treatment better. Once again, the structural capabilities of the specific wood species must be considered.

Wood Treatment is only as good as the depth of penetration into the wood and the quantity of chemical that remains. Require a laboratory assay **before the lumber is shipped**. Once the wood is on the jobsite, it's too late to correct a problem, if one exists. Defining the assay zone as 1/32" to 5/8" (the outer 1/32" is to be removed before the sample is taken) will avoid loading-up the outer surface of the wood, while getting nothing into the core.

Chemonite (ACZA) seems to provide the best protection for Douglas fir. This is probably because the ammonia carrier penetrates somewhat better than water and because ACZA is almost always incised. CCA provides excellent protection in plywood and in woods which are mostly sapwood, i.e. pine and Hem-fir. Where structural and appearance considerations allow it, require incising.

For most uses, Borate is quite acceptable **if it is treated to a minimum retention of 0.4 pcf.** Some grazing may occur on Borate treated wood, however.

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