# Barrier Wrap Technology: Enhancing Preservative Performance In Wood Utility Poles

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## Abstract

This paper reviews the tests performed to date on barrier wrap wood preservative systems, and discusses products now on the market and new, upcoming product offerings. Included in this review are the tests performed by the Building Research Establishment, Oregon State University, and Mississippi State University on barrier wrap systems. The ongoing tests have proven that the use of barrier wraps can significantly reduce the occurrence of decay and insect attack on treated and untreated wood structures when the ground contact portion of the wooden member is protected from soil contact by the barrier. The depletion of wood preservative in the ground line zone will also be addressed as part of the existing tests. Basidiomycota vector-function is suppressed by impermeable membrane barriers; preventing these decay fungi from efficiently translocating soil-source inorganic nutrients. Future research work is ongoing on these systems at outside universities and research centers worldwide and will be discussed briefly. The concept of using above ground retentions of wood preservatives for wooden members in ground contact if the member is properly protected with a barrier wrap will also be discussed. Recent adoptions by both the International Building Codes and the American Wood Protection Association (AWPA) are also discussed. Also discussed are the authors' personal findings on poles inspected in the field that have been protected by various barrier wrap systems, including those as simple as impervious paper and foamed-in-place systems now and formerly used in Texas, Hawaii and in Nebraska by the NPPD.

Keywords: Barrier Wraps, Service Life, Decay, Efficacy, Leaching, Depletion, Ground Contact

## Introduction

The concept of using a protective barrier to prevent attack on wood is not particularly new. In effect, many chemical preservative systems accomplish this by forming a barrier on the outer portions of the wood to prevent attack on the vulnerable inner portions of the wood. Similarly, millions of utility poles have had their service lives extended through the use of penetrating preservatives that are covered with a barrier wrap which holds the paste/gel preservative in-place while it migrates into the pole and also slows it rate of potential for leaching. Sometimes the two products are combined into a single "bandage" for simpler application.

Various physical barrier systems, typically plastic wraps, have been proposed for other uses through the years. Few of the wrap systems have achieved commercial success though for a variety of problems.

A recent development, several newer and more innovative Barrier Wrap systems, have proven to eliminate the problems of past systems through its combination of two essential attributes. First, the barrier system itself is a fairly thick, UV stabilized polyethylene with proven long term durability. Second, the plastic sheeting is adhered to the wooden substrate with either bitumen or other methods to "lock it in-place" and other systems, seem to form a tight, weather resistant system that affords long term protection to the wooden substrate.

Recent technical reports from well-respected and established wood preservation research organizations have demonstrated the performance of the barrier preservative systems. This report discusses and summarizes several of the research projects to date.

## Results and Discussion

### Fungus Cellar / Soil Bed Test at Oregon State University on Dipped and Undipped Treated Stakelets

In 1997, Oregon State University (OSU) researchers, T.C. Scheffer and J.J. Morrell, reported on a 2 year soil bed test where polyethylene boots were applied to both untreated and low retention treated stakes[1]. Ponderosa pine was chosen for the stakes since its sapwood has low decay resistance. Flat stakes were used and saw kerfs on the entire length of both flat faces were made on some stakes to simulate seasoning checks. These kerfs increased the severity of the test.

Half of the stakes in the test were fitted with a 2-mil polyethylene boot before insertion of the stakes into the test soil. The remaining stakes had no boot. In addition to the completely untreated stakes, stakes with low retentions of either a minimal-leaching ground contact preservative, copper naphthenate, or a boron containing above ground preservative, disodium octaborate tetrahydrate, were included.

The stakes were then inserted for 2 years in soil beds prepared from forest soil. This is the same methodology described in AWPA E14, Standard Method of Evaluating Wood Preservative in a Soil Bed. Water was periodically applied to the soil and "no attempt was made to keep water from entering the boots at the upper end." At the end of the 2 year exposure, the stakes were removed and weighed to determine any losses.

The boots effectively prevented any attack, even on the untreated stakes. The booted stakes whether they were kerfed or nonkerfed had losses ≤ 2% which the authors attributed to loss of extractives. The booted untreated stakes performed as well as the stakes with either of the preservative treatments.

In comparison, the unbooted stakes showed evidence of attack in every group. Most of the stakes had weight losses of 10-40%. The best performing group in the unbooted series, the nonkerfed copper naphthenate group, had 3 of 10 stakes with an average weight loss of 30% while the remaining seven averaged 2%. This could have been due to a localized instance of copper tolerant fungi or uneven preservative distribution. Regardless, it shows the effectiveness of the barrier in that none of the booted stakes showed any attack.

The authors of the FPJ publication conclude that:

> "Booted stakes had little evidence of decay, whereas those without boots experience large weight loss and extreme shrinkage and deformation."

**Termite Tests at Mississippi State University**

In 2000, termite resistance tests were conducted at Mississippi State University (MSU) on barrier coated wood in comparison to non-coated wood[2]. The test was done according to AWPA Standard Method E-1, Standard Method for Laboratory Evaluation to Determine Resistance to Subterranean Termites. The barrier coating used in this test was supplied by the manufacturer of the Barrier Wrap system.

For the "no choice" portion of the test, common subterranean termites (*Reticulitermes spp.*) were presented with a test specimen that was either coated or uncoated. There was no other food source available in the test container and this is considered the more severe test for termite resistance.

The results of the no choice were very convincing. There was no attack on any of the coated wood and all of the termites had starved to death at the end of the

four week test. No detectable weight loss occurred for the coated samples in comparison to the 12-27% weight losses for the uncoated wood. There was heavy attack and only slight termite mortality at the test end for the uncoated controls. In this severe test, the barrier coating clearly showed its termite resistance capabilities.
For the "two-choice" part of this test, both uncoated and coated southern pine wafers are in the containers and the termites can choose a food source. Again, there was no attack on any of the coated wafers while the uncoated ones had mostly heavy attack with some moderate attack. This test shows that the barrier system is repellant to termites and they will seek another food source if one is available.

**Fungus Cellar / Soil Bed Test by British Research Establishment (BRE)**

In 1998, researchers at the British Research Establishment (BRE) reported the results of a soil bed test done on a barrier system[3]. The testing methodology was similar to that discussed above but it followed appropriate European standards.

An important point in this particular test series in that the stakes were only wrapped with the barrier and not completely booted. Thus there was the possibility of attack on the buried, but unprotected stake end. The wrapping was the two-part Barrier Wrap bitumen-polyethylene system and this test showed the importance of using a "boot" as opposed to a "wrap".

The stakes in this test were about 20 inches long and those that were wrapped had about 4 inches of exposed wood at each end of the stake with the center 12 inches being wrapped. The stakes were planted so that about 2 inches of the wrap was above the soil line and 10 inches was below along with the 4 inch unwrapped end. The samples are evaluated at 16, 32 and 48 weeks for attack and moisture content by cutting and evaluating 2-inch zones of each stake.

The results are again conclusive in that the portions of the stake protected by the barrier system had essentially no attack even though there was considerable attack on the unprotected ends of those stakes. Furthermore, the moisture contents of the below ground wrapped portions were below fiber saturation (<28%) while the exposed portion were 70-115%. Keeping wood dry is the first step in preventing its attack.

The unwrapped stakes were very wet with 95-170% moisture contents. The unwrapped stakes were also severely decayed at the end of the test with 40% weight loss in the ground line zone.

An important point is that there was an "interfacial zone" at the bottom edge of the wrap. Below that 2 inch zone, the unwrapped portion was wet and decayed and above that zone, the wrapped stake was dry and not decayed. In the interfacial zone, the attack and moisture contents were intermediate at 50%

moisture content and 5% weight loss at test end. This further demonstrates the efficacy of the wrap in that even if it is breached, the attack is prevented from extending any significant distance. To further elucidate the effect of “breaches” in the wrap, the BRE then conducted field stake tests where a saw cut was made in the plastic barrier wrap.

**Field Stake Test by British Research Establishment**

For this test[4], purposeful saw cuts were made in Barrier Wrap boots that otherwise encased the ends of the stakes. The cuts were halfway between the ground line and the end of the stake and were just through the plastic wrap. For comparison, stakes with undamaged boots and with a wrap as in the soil bed test were included. Naturally, untreated controls were included as well.

The European test protocol, EN252:1989, Field Test Method for Determining the Relative Effectiveness of a Wood Preservative in Ground Contact, was used. This test procedure is essentially the same as AWPA Standard Method E-7, Standard Method of Evaluating Wood Preservatives by Field Tests with Stakes. The only significant difference between the two procedures is that the rating scale for EN252 downgrades a stake more severely when the two scales are compared on the basis of loss of cross sectional area[5].

For this test, a series of low retention CCA stakes was also included. These stakes were dip treated for 3 minutes to an average 0.09 pcf which is about one-fourth of the normal ground contact level.

Per the test method, the stakes were evaluated by tapping them with a wooden mallet and then inspecting and rating those stakes that did not break upon impact. Obviously, only those portions not covered with the wrap or boot could be examined since the test is continuing.

After four years of exposure, all of the untreated control stakes are decayed as expected. The unwrapped CCA stakes are showing slight attack as are the untreated but wrapped stakes. The wrapped CCA stakes did not show any signs of attack.

All of the booted stakes including those with the purposeful saw cut are totally sound after four years of exposure. The test is continuing but, at this point, it appears that boots are effectively protecting untreated wood. This applies even to boots with significant breaches in the outer plastic barrier. This protection can be contributed to the secondary protective layer of bitumen.

**Soil Bed Post Test performed by Forintek**

Dr. Paul Morris managed a joint study between Forintek - Canada (Western Lab), PowerTech Labs, The BC Science Council, and BC Hydro. Both CCA-C treated and untreated Lodgepole pine posts were exposed for a period of eight years in a high decay exposure condition in a Soil Bed. Wrapping the ground contact portion of the posts with a bitumen – wax coated fabric wrap prior to exposing them to the conditions of the soil bed significantly reduced the amount of decay in the untreated posts and delayed the onset of decay in CCA treated posts.

After eight years exposure in this accelerated soil bed test, wrapped posts, treated to 4.0 kg/$M^3$ with CCA-C were performing as well as, or better than, unwrapped posts treated to 10 kg/$M^3$. The performance increase due to booting is 2.5 times on a retention basis.

For untreated posts, the average time to failure in the soil bed tests was 30 months for unwrapped material and 90 months for wrapped material, thus tripling the expected time for wood in a soil bed to reach a value of 7.0 (considered failure).

**Field Post Test by Forintek and BC Hydro**

In a second study, Paul Morris experimented with the use of barrier wraps, again in the form of a bitumen-wax impregnated fabric, at BC Hydro's Vancouver, BC test site over a nine year period by observing decay patterns and occurrence.

At the three-year inspection, treated and wrapped posts were rated at an average value of 8.8 compared to unwrapped CCA posts (pole stubs) rated at a value of 7.3. Time to reach failure (rating of 7.0) was 45 months for unwrapped material and 65 months for wrapped posts. In this study, no significant reduction in preservative was seen from either the wrapped or the unwrapped posts, which is attributed to the excellent fixative nature of CCA. (Other studies performed with mobile wood preservatives show significantly less migration from booted material [6-11].)

**Other Barrier Wrap Tests Conducted in Canada**

Barrier wraps were shown to provide valuable life extension to untreated Jack Pine posts In a extended multi-year study reported by Morris in his 1999 CWPA paper "Field Testing of Wood Preservatives in Canada IX: Performance of Posts and Lumber in Ground Contact". Morris reported that untreated Jack Pine, a non-durable softwood species, had a mean service life of 5.5 years in Canada from posts installed in 1938. Untreated Jack Pine posts installed with a simple polyethylene bag surrounding the ground contact portion of the posts had a mean service life of 7.4 years. Thus, the simple polyethylene bag roughly increased the expected service life by a factor +50% in Canada.

In the same study, but installed in 1967, untreated Jack Pine Posts surrounded by a <u>Polyurethane Foam</u>, when inspected in 1998, still had 5 of the original 17 posts still left in service and had a estimated Mean Service Life of >12.5 Years.

The foam has more than doubled the service life on untreated pine posts/pole stubs and both of these tests firmly address the valuable concept of barrier wraps extending the useful service life of untreated softwood species in Canada. These findings support the field observations by the authors' on foamed–in poles in service throughout the USA, esp. in Hawaii, Texas and in particular approximately 4,000 transmission poles at Nebraska Public Power District[12] (NPPD). The decay rate found in the pentachlorophenol pressure treated poles that were set in stabilized polyurethane foam foundations was .965%. The excavation of the foam during inspection and maintenance cycles is no longer mandated after observing 99% of these in-service transmission poles have no decay present.

**Testing in Costa Rica**

One of the authors of this paper performed testing of several barrier wrap and wrap emulating systems in Costa Rica in the late 70's and early 80's. Based on preliminary information provided by Bob Arsenault, wherein tests he prepared and set up for Bell Telephone Labs and Koppers, found that any barrier between soil and untreated wooden stakes/members significantly increased their service life in test plots in Bainbridge, GA and Orange Park, FL, similar testing was established in two test plots in Costa Rica. The test plots in Costa Rica, owned and operated by Jim Taylor of the REA, and managed by Warren Adams of Adams Engineering/Timber Products, were located in a very moist site near San Jose and a very arid, mountainous, but termite ridden site in Guanacoste. These sites were originally leased from the Costa Rican National Power Companies right-of-way groups in Costa Rica.

In these sites, very different findings occurred when testing barrier systems, with and without biocide pressure treated substrates. In the moist site, severe failures occurred when untreated SYP was placed in epoxy booted wraps, and inspection at 1 year and 18 months, resulted in site findings where " a mushy, mud-like" residue was found encased in a protective envelope of epoxy resin, when the stakes were dipped to mid-point and placed into test. But surprisingly, even with an inferior wood preservative like water-dispersible penta, pressure treated into the stakes, prior to epoxy coating, the stakes survived extended testing. Untreated and treated SYP stakes and post stubs, when wrapped or booted with a poly-plastic film, extended their useful service life to 3-5 times their unbooted lifespan, but boots were far superior to wrapping with poly-plastic sleeves, in which the entire ground contact section was not protected from soil contact. Base on this testing, and the inability of wood to effectively breath through thick film epoxy, the coating of wood members, with epoxy sealants is currently not recommended. The concept of protecting sub-standard retention wood (wood depleted to below threshold actives level) or wood treated with a questionable lifespan wood preservative system, is enforced by this testing in two Costa Rica test plots over 25 years ago.

## AWPA

The American Wood Protection Association has recently recognized the efficacy of the barrier wrap preservative systems in general and has recognized and now specified a new specific barrier (BP-1). A new preservative standard, AWPA Standard P-20, see below, outlines the general requirements for barrier systems while the specific barrier systems are listed in U1 Commodity Specification K. It should be noted that BP-1 is the Barrier Wrap system and the table below shows that lower retentions of preservatives in conjunction with BP-1 qualify for higher Use Category uses.

## The International Building Codes (ICC)

On March 1st, 2007, the ICC-ES (international Code Council Evaluation Services) issued an ESR (evaluation services report) entitled ESR-1834[14]. This report recognizes the use of a Barrier Wrap system, for use in wood members, where previously in the International Codes (IRC and IBC) only recognized wood treated to either AWPA Standards or recognized under a separate ICC-ES ESR, could be used in ground contact or at very high levels of wood preservation active ingredients (retention). This newly issued ESR now recognizes that wood, when properly wrapped with an approved barrier wrap system, properly evaluated by the ICC-ES and one that has an enforceable QC System, may be used in ground contact and ground proximity situations. Furthermore, the ESR recognizes that a significantly reduced retention of active ingredients in a properly barrier wrapped member, will perform as well as a properly pressure treated member c containing more active ingredients. Copies of this ESR are available and please contact the corresponding author should you desire to obtain a copy of this document.

## Hurdle Theory

Hurdle theory has been discussed by many authors in the past. Albin Beacker described his first 'hurdle theory" for the use of barrier wraps in 1988 in a paper presented to the SAWPA (South African Wood Preservers' Assoc.) Beacker described his thoughts on this subject as the use of a barrier to prevent soil contact with a wooden member would significantly reduce the amount of microbial population which would have access to the woody substrate and by reducing the microbial (fungal) population in the pole, especially at or near ground contact, the decay fungi would never obtain a population of significant and aggressive enough size and density to sufficiently damage a wooden pole. Work by these authors and others[13] have shown that although this hypothesis to "hurdle theory" doers make sense, two secondarily considered, but of primary importance also occur. These are that, (1) in addition to lowering the fungal population in a wooden member protected from soil contact having a significantly reduced fungal population, that also, (2) in a properly protected wooden member surrounded by a barrier wrap, the moisture content in the section below grade, protected by a barrier wrap,, has a significantly lowered moisture content, sometimes so low it cannot support microbial growth, and (3) that the wood toxic components, either from the leaching of the toxic actives from the previously applied biocide, or the leachable constituents from the woods inherent heartwood zone, is greatly reduced, thereby keeping the barrier wrapped wooden member, now not ' in soil or soil-borne water" contact at a threshold which cannot be readily attacked by biologically available organisms. Unpublished work at both OSU (Oregon State University) and MSU (Mississippi State University) have to date, proven that the ingress of liquid water to a wooden pole stub and also moisture vapor going into a properly barrier wrap pole stub is drastically reduced or slowed.

# P20-07 AMERICAN WOOD-PRESERVERS' ASSOCIATION **STANDARD**



## *ALL BARRIER PROTECTION SYSTEMS*

Jurisdiction: AWPA Subcommittees P-3 and P-4

This Standard was adopted in 2007.



**1. Scope**

1.1 This Standard covers barrier protection systems used to augment preservative treated wood and wood based components for ground contact uses, such as posts, poles, piling and the like. The barrier system protects the decay and termite susceptible portions of the underlying wood member. Barrier protection systems are made of impermeable, weather resistant materials and are permanently affixed to the wood.

**2. General Requirements**

2.1 Barrier systems are impermeable, weather resistant boots or sleeves with the properties and performance specified in this section.

2.2 Boots or sleeves shall have a weather seal at the top and be adhered or otherwise permanently affixed to the wooden members or other means shall be used to prevent slippage of the post from the barrier system.

2.3 Polyethylene geomembranes used for boots and sleeves shall have a minimum thickness of 0.012 in. (0.30 mm) and meet the specifications of ASTM D4801 for weather resistance. Other materials used for boots and sleeves shall demonstrate equivalent weather resistant performance and form a barrier between the treated wood and the surrounding soil.

2.4 Dynamic impact testing done by Section 4.2 shall show no punctures through the barrier.

2.5 Barrier preservative systems shall have performance equivalent to or better than a 7 rating (i.e. decay or termite attack of 10-30% of cross section) in field stake tests conducted using AWPA E7 methodology. Acceptable alternate test methodologies are ASTM D1758 and EN252.

*NOTE 1: For wood preservatives and other systems rated by field stake tests, it is generally accepted that ratings of less than 7 denote the end of service life for wooden products installed in ground.*

2.6 The barrier system shall be designated by the time period rounded to the closest whole year that wood treated to the above ground retention appropriate to the specie and preservative and that has the barrier system gives equal performance to wood treated to in-ground contact retention levels that does not have the barrier system using test methodology specified in 2.5. A minimum of three years exposure data is necessary.

*NOTE 2: For example, a barrier system with 64 months of satisfactory test documentation would be denoted as a "Five Year Barrier System".*

2.7 Termite resistance shall be documented for all barrier systems using D3345, AWPA E1 or equivalent test methodology. The tests shall be judged acceptable if untreated southern pine controls have >20% weight loss and the wood with barriers has <2%. In addition, there can be no holes penetrating the barrier.

**3. Treatment**

3.1 Barrier systems may be used with wood members treated with appropriate preservatives and processes detailed in AWPA standards. Acceptable preservative systems are listed in Section 6.

3.2 Boots or sleeves shall be preformed and applied to the wood so that the wood is solidly encased. The manufacturing process shall be done under controlled conditions to ensure proper performance of the barrier system.

**4. Results of Treatment**

4.1 Performance – Specify the barrier system boot or sleeve by designation of its years of performance per Section 2.7.

4.2 Dynamic Impact Performance – Three specimens of nominal wood 4 by 4 inch (100 by 100 mm) booted material shall be conditioned for four hours or more at room temperature. The specimens shall be tested with a Gardner Impact Tester or equivalent using a 2.2 pound (1 kg) impact load and an impactor with a flat impact end with cross-sectional areas of 0.15 square inch (100mm$^2$). The impactor shall be released from a height of 4.9 inches (125 mm). The test shall be repeated five times on each specimen for a total of 15 impacts. The specimens shall then be visually examined for punctures.

4.3 If testing specified in Section 2.5 is done with retentions less than that designated for UC4A and performance of the material with the barrier system is satisfactory per Sections 2.5 and 2.7, then retentions designated for UC3B may be used with the barrier system.

**5. Quality Assurance of Treatment**

5.1 Boots or sleeves shall be inspected by an independent third party inspection agency to ensure consistent product quality.

**6. Preservatives**

6.1 The preservatives used shall be listed in AWPA Standard P1/P13, P5 or P8.

**U1 COMODITY SPECIFICATION K, TABLE 1**

| Barrier Protection System | Preservative System (s) | Parent Commodity Specification(s) | Use Category | |
|---|---|---|---|---|
| | | | Without BP System | With BP System |
| BP-1 | CCA-C, ACQ-B, ACQ-C, ACQ-D, CBA-A, CA-B | A Table 3.0 | UC4A | UC3B |
| | | | UC4B | UC3B |
| | | | UC4C | UC3B |
| | CCA-C, ACQ-B, ACQ-C, ACQ-D, CBA-A, CA-B | B Table 3.1.1 | UC4A | UC3B |
| | | | UC4B | UC3B |

The BP-1 (Barrier Wrap) system was the first system to be standardized by the AWPA but it is just one of many that could come forth. It is hoped that the proponents and manufacturers' of other barrier wrap systems will choose to embrace product standardization and come forth in future years with their own supporting data packages and seek AWPA Standardization. Ideally, many new products will be available to both the contractor and to the consumer for protection of wood (poles, posts and lumber) in ground / soil contact. The potential for protection and extension of wooden crossarms with Barrier Wraps is further supported and this concept will be discussed in future papers and work by these authors'. Work is also currently underway by several parties, including these authors'. To add ACC to the AWPA Standards and to perform adhesion testing on PCP (pentachlorophenol) and Creosote thermally treated and pressure treated wood poles, to add them to this AWPA Specification in the near future.

**New Product Offerings and System Under Development**

Recently new and existing products which have track proven or laboratory proved efficacy towards extending wood preservative service life in wood poles have been offered to the market. These include the Poly/Aluminum Laminate Field Liners offered by Copper Care Wood Preservatives, Inc. and also by Osmose Utility Services, Inc. Other systems, such as the PostSaver system have been used for many years around the world for protection of smaller wooden members in ground contact, and will soon have product offerings to suit larger wooden members, such as distribution and transmission poles.

Several system have been launched or are now being evaluated which also, in addition to containing a weather resistant impervious barrier, also contain a biocide, which may in effect produce a bio-active fungistatic layer between to the wood and the soil. Some products in the past have offered an 8 micron Aluminum foil laminated between heavy-duty poly film as a vapor barrier within the barrier wrap, but new offerings now being evaluated by these authors and others, show a significant improvement in this technology, when the Aluminum film is replaced with a metal Copper laminate to enhance durability of the metal laminate when embedded in soil.

## Summary and Conclusions

Barrier wraps can be used to successfully lower the moisture content of wooden members near the ground line and slow decay and insect attack. All the studies published to date on certain barrier wrap systems show it to be superior to many other wrap systems since it actually contains dual protection:  the bitumen inner layer protects wood in contact with this “tar-like” substance, or a closely adhered film, and the outermost polyethylene film layer further hinders attack and prevents water absorption (which may or may not contain a fungistatic component as well).

Further investigation into barrier wrap systems by Baecker and others has shown that a wooden member that has been protected by a barrier wrap can use a much lower retention of active ingredient in the preservative system leaching is significantly reduced, and is discussed in detail in his “ hurdle theory” paper.

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