Wood Preservation

Trends of today that will influence the industry tomorrow

By Alan F. Preston

No segment of the forest products industry provides such a positive vehicle for sustainable forestry as does the wood preservation industry. By extending the life of wood products far beyond that of the natural durability of the harvestable wood now available, the wood preservation industry acts as a major contributor to improving the environment, especially in regard to maintaining the nation's forests.

In spite of this positive contribution, the wood preservation segment of the forest products industry is coming under increasing scrutiny as a negative influence on the environment. Why is that? The simple answer lies in the word *chemicals*, and the fact that the use and application of chemicals inherently alters the wood and the environment in some manner. While there is little concern with the alteration of wood products with treatment chemicals, there is concern regarding the process of treating, the loss of chemicals in service, and perhaps of greatest importance, the ultimate disposal of the treated products at the end of their service life. In a broad sense, environmental concerns have long motivated change in the industry, for example, the replacement of mercury compounds many years ago. The profound changes in preservative chemistries now occurring in Europe and Japan can be viewed as the latest manifestations of environmentally motivated changes, and ones that will at some point impact the industry in this country.

Wood Preservation Industry in North America

The birth of modern wood preservation can be traced back to the pioneering work of John Bethell in the 1830s. He developed the pressure treating plant and process for the treatment of crossties with creosote. Since that time, in some respects little has changed, while in other respects, everything has changed.

Today, estimates of the size of the North American wood preservation industry vary from chromated copper arsenate (CCA) usage of around 70,000 tons of active oxide up to approximately 85,000 tons. Production of treated lumber is estimated to be 6 to 7 billion board feet (~15 million m^3).

The wood preservation business has changed from being primarily a producer of treated wood products for the utility industries (crossties, piles, and poles) to being predominantly a producer of treated lumber for use in building construction, manifesting itself most clearly in the use of treated wood for decks. Today, the volume of industrial products, such as ties and poles, produced is little different from 30 years ago when it dominated treated wood production; however, the "consumer" construction materials segment has grown during this period to around 70 percent of all treated wood products.

Figure 1 shows the exponential increase in CCA use in North America throughout the 1970s and 1980s, followed by a pattern of fairly constant production during the last decade.

In contrast to the growth seen with CCA during the past 30 years, the use of oilborne treatments has remained relatively constant during this period, a reflection of the slower growth in utility construction as compared with earlier in the 20th century. One trend that started with the oilborne preservative manufacturers and is now occurring to some extent with the waterborne preservative treaters, is the consolidation in the number of treating companies in the United States. This has been seen most markedly in West Coast oilborne markets where a number of old-line treating businesses or treating plants have closed down during the past 20 years, due to a combination of business and environmental factors. Waterborne preservative treaters are finding that the growth of large home improvement warehouse stores over the past decade has promoted a commodity attitude toward treated lumber products, and the just-in-time requirements of these stores favor treaters with multi-site operations capable of producing treated lumber products on demand.

In the quest for increased productivity in existing plants, the past few years have seen the installation of lumber-handling systems integrated into treatment facilities and designed to move lumber in and out of the treating plants as quickly and efficiently as possible (Fig. 2). Besides maximizing cylinder utilization, such systems allow for a highly efficient manpower usage. There are now plants operational in the eastern United States that have a daily lumber treatment capability of 1 million board feet when operating on a 24-hour basis. This trend toward consolidation of treatment capacity means that some treating companies are

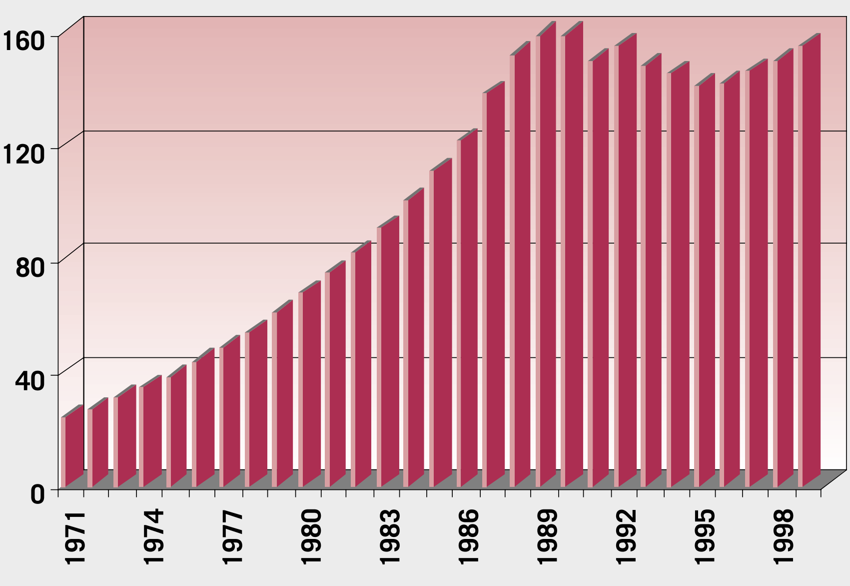

Figure 1. — Usage of CCA in North America, 1971 to 1999.

Figure 2. — High-capacity waterborne preservative southern yellow pine treatment plant with transfer deck. Plant capacity is up to 1 million board feet per day.

either ceasing operations or are being purchased and consolidated into multi-site operations.

Conversely, there is an increasing trend by the remaining independent treating companies to establish market, product, or alternative preservative niches that allow them to compete in areas where larger volume suppliers lack flexibility. One such opportunity is the marketing of treated wood products into international markets. While difficult to quantify, eastern U.S. treating companies are known to export to Europe, including Spain and the United Kingdom, as well as Saudi Arabia, Japan, other Asian countries, and of course Central American and Caribbean nations. The ready availability and treatability of the southern yellow pine resource, coupled with the efficiency of the U.S. treating industry, makes such exports viable, even when the U.S. dollar is strong. However, the move away from the traditional preservatives in a number of these offshore markets is a limiting factor for those treaters in the U.S. industry without the capabilities or desire to move to alternative treatment technologies.

There has been increasing media attention recently concerning the permanence of arsenic in treated lumber. While this attention was initiated in the alternative media, more recent stories have surfaced in mainstream broadcast and print journalism. The focus is often on the potential release of arsenic into the environment, either from material that is exposed to the environment prior to completion of the fixation process, or through the inevitable incremental losses that occur in service. The fixation issue is a difficult one to address in an era of commodity markets, just-in-time inventories, and very large treaters with multiple treatment sites. Several technology options exist for providing rapid CCA fixation, but all involve additional capital and operational costs that would be onerous to an industry surviving on commodity margins. The impact of this situation on the future of wood preservation in the United States is hard to predict. Unlike in Canada, where longer cycle times with difficult-to-treat species make the use of accelerated fixation processes more palatable, it seems unlikely that the southern yellow pine treaters in the United States will readily embrace fixation requirements and costs for CCA treatment. Furthermore, there is little evidence that the majority of U.S. treaters would react as the industry has in Japan, where similarly changing requirements led to a rapid, and essentially complete, switch to alternative wood preservatives that do not contain chromium or arsenic.

One area of wood preservation research and development that has seen significant and important strides over the last decade, both in terms of research and commercial usage, is the field of water-based emulsion water repellent technology. While the concept was originally investigated in the 1960s, it was some 20 years later that effective and easily used formulations were developed here in the United States. After a period of slow initial growth, these products are finally seeing substantial market acceptance in the eastern United States, and the long-term performance enhancements to be gained from this technology have recently been confirmed. Besides providing enhanced weathering appearance and similar attributes, water repellents can lower leaching and improve the performance of a range of wood-preservative components. Clearly, in a period of pressure to lower chemical loads in the environment, keeping wood dry, or at least drier, offers a significant step forward in reduc-

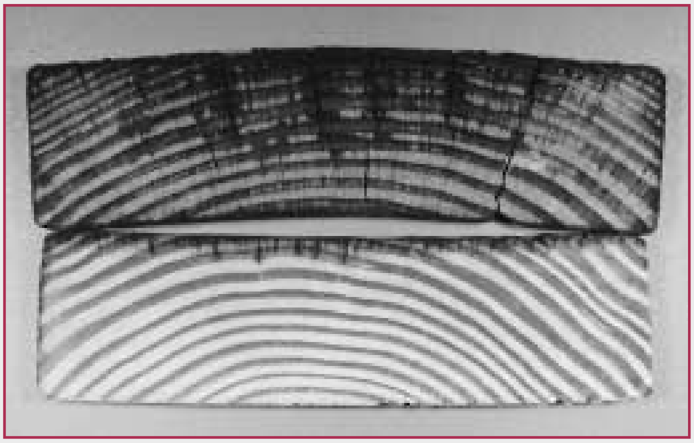

Figure 3. — Cross sections of end-matched 2-by-6 southern yellow pine deckboards after 9 years of exposure. Treatments are CCA without water repellents (top) and CCA with water repellents (bottom).

Preservative field termite test against Formosan termites, Hilo, Hawaii.

ing the demand for biocidal protection in service. These water repellents have been shown to provide long-term protection to wood in service. Figure 3 shows the dramatic differences in physical weathering performance (9-yr. field test) for cross sections cut from matched southern yellow pine boards treated with CCA, with and without water-repellent additives in the treating solution. The wider and appropriate use of this well-developed technology would clearly assist in protecting treated lumber and treated lumber markets from further encroachment by alternatives such as plastic lumber, which promote themselves as providing superior physical weathering compared to treated pine.

In the utility industry, oilborne preservative systems remain the preferred option for a significant majority of utilities. Pentachlorophenol remains the preferred preservative, although copper naphthenate has made inroads with a number of utilities. The concerns with copper naphthenate performance during the 1990s appear to have been alleviated following exhaustive research into instances of early failures that had occurred. Waterborne preservatives, primarily CCA, but to a limited degree ammoniacal copper zinc arsenate (ACZA), have been growing in market share, and the advent of preservative additives to improve the climbability in CCA-treated poles has assisted in this growth.

Treatments in the North American millwork industry are now almost entirely by short-duration dipping. Organic solvents remain the preferred preservative medium, although water-based formulations will clearly become dominant as solvent emission issues make continued use of organic solvents impractical. New options for millwork treatment are under development and some among these options will likely provide the enhanced performance that users of windows seek.

As the North American wood-preservation industry has matured, growth has increasingly become predicated on finding new markets that allow greater than GNP growth prospects for the industry. In the past, the industry has seen spurts of growth, for example, the use of preservatives in the crosstie industry, and the use of preservative-treated poles. During the past 30 years, we have seen the development of the treated lumber industry for outdoor applications such as decks and fences. Where do the future prospects lie? An area that has attracted attention is the need for treatment of the entire house frame system in regions where the Formosan termite is endemic. This type of treatment has been used in Hawaii for many years, as the ravages of the Formosan termite are all too apparent to homeowners in many parts of that island state. On the mainland, Formosan termites are slowly spreading through many regions of the southeast, but the largest, and oldest, concentration known is in and around New Orleans. In Louisiana, there are ongoing discussions on the necessity, desirability, and means of achieving effective treatments of lumber used in residential structures. Needless to say, the outcome of these discussions is being watched carefully as to the growth opportunities that may be pre-

Decay fruiting bodies growing from L-joint field test sample.

Composite L-joints showing swelling during field exposure test.

sented to the wood-treatment industry. It is this author's belief that the key to success for the wood-treating industry in this market application is development of effective, proven, and long-lasting treatments for spruce-pine-fir lumber, the preferred wood species for interior framing in the southern United States, as well as for southern pine lumber used in trusses and in other structural applications. Treatment options currently available for difficult-to-treat species such as spruce-pine-fir have known inadequate performance against Formosan termites; these treatments may seem to be a short-term answer but may be negative for the use of wood in the longer term. It is equally certain, however, that competitive industries and even factions within the wood industry itself are vying for slices of this potential opportunity. As with most decisions in our society, the consumers' best interests may likely fall victim to the competing pressures at work.

Related to the interest in treating entire house frames, another area of much apparent research activity is the use of borates in North American wood-preservation applications. Borates have been used commercially in wood preservation in Australasia for upwards of 50 years, for protecting wood products from Lytus beetles (Australia) and Anobiids (New Zealand). While the use of borates in New Zealand has declined sharply recently with that market moving toward the use of dry, untreated framing lumber, research and commercial application in the United States have grown. Applications now seeing market acceptance include framing and sill-plate lumber, and in some jurisdictions borates are considered to be suitable for protection from Formosan termites. Research is ongoing into the suitability of borate treatments for exterior applications, although there is not a lot of positive data available to support broad application in leaching environments. Research into novel organic boron complexes as wood preservatives continues, with a view to developing non-leachable complexes that may provide biocidal activity through the borate present in the complex. One intriguing opportunity with borate technology is the possibility of using vapor phase treatments. This involves the introduction of a weak organoborate complex into wood in the gaseous phase, with post-treatment hydrolysis inside the wood to boric acid as the active preservative. Challenges to commercialization include registration and volatile organic compound emission issues, but the unique potential of this technology for some applications is tantalizing.

The research into "copper" preservatives over the last couple of decades has seen the commercialization of a series of alkaline copper preservatives that are based on copper as the primary biocide solubilized as an aqueous amine or ammoniacal complex, in combination with cobiocides to provide protection against copper-tolerant fungi and against termites. These products are derived from ammoniacal copper arsenate (ACA), developed in the United States in the 1930s, and updated as ACZA in the early 1980s. Examples of these products are copper citrate, ACQ (alkaline copper quat), copper HDO (bis (N-

High-speed CCA treatment plant with accelerated fixation unit, northeastern United States.

Extensive use of treated wood in housing construction.

cyclohexyldiazeniumdioxy) copper), copper azole, and CDDC (copper dimethyldithiocarbamate). With the exception of CDDC, the products are similar in providing a one-step treatment of alkaline copper plus another soluble component to enhance the activity of the copper complex. Such non-arsenical copper-based products have found good growth markets in Europe and Japan, although to date only ACQ has been commercialized successfully in the United States, possibly because of the difficulty in marketing new preservatives. Considerable research continues with the copper-based preservatives. Extending their growth into the future will depend on enhancing copper fixation and complexation mechanisms. Recent research has shown that the addition of water-repellent additives to the treatment solutions can considerably enhance the weathering performance and other attributes of these products.

Regulatory pressures are increasingly driving parts of the European preservative industry toward the use of organic preservatives, especially in aboveground (UC3) applications such as decks, fences, and garden furniture. The use of organic solvent-based systems has a long history in Europe, and in millwork applications in the United States, but issues regarding emissions of the solvents used are mandating a future in waterborne emulsion systems. Undoubtedly, widespread developments in this area will be dependent on success in providing water repellent emulsion systems compatible with the organic preservatives, and in achieving penetration into species such as Ponderosa and Scots pine. A further consideration will be the cost/performance profile. The lowering of performance expectations already seen over the last decade in Europe with the widespread use of low retentions of copper-based preservatives may be expected to be taken a step further with the introduction of waterborne organic preservatives into the marketplace. This dubious downhill slide does not augur well for the long-term future of treated wood in Europe if durability performance drops below consumers' expectations. However, appropriate retentions of organic preservatives should provide adequate performance for wood used in aboveground applications in North America.

With the dominant U.S. markets being in outdoor wood applications such as decks and fences, perhaps the greater challenge from a North American perspective is the problem of wood surface degradation that occurs with non-metallic preservative treatments in the types of exposures encountered. Furthermore, little research has been carried out on failure mechanisms for organic preservatives, even in aboveground applica-

Field exposure tests of aboveground and ground-contact treatments for prevention of decay.

tions, while the practical use of such materials in ground contact, other than in oilborne carriers, remains a lofty goal.

Aside from the high-profile opportunity under development in regard to the protection of lumber from Formosan termite attack, perhaps the area of wood protection that has seen the greatest change in attitude towards protection issues is the area of wood-based composites. Researchers have worked in this area for many years in spite of tepid interest, at best, from the wood composite manufacturers. The recent sea change of heart in this area appears to be driven by several convergences. These include the drive to develop higher margin products that are distinct from commodity panel markets; the spate of highly publicized lawsuits during the past decade from decay of certain untreated composite siding products; the Formosan termite situation and its potential impact on wood-based composite panel products used in that region; the desire to develop further markets for composite products used in situations where decay, termite attack, weathering, and dimensional change may occur; and finally, by a desire not to be left behind by their competitors (the me-too syndrome). Treated composite products are now on the market and it is clear from the current rush of development activity that further products and processes will be commercialized over the coming years. Unfortunately for traditional wood treaters, because composites swell dramatically during treatment with water-based preservatives, it is unlikely that significant post-composite manufacturing treatment will be carried out, except in instances where solvent or vapor-phase treatments are practical and competitive. Most preservatives will be incorporated into the product during the manufacturing process.

Innovative Approaches

Beyond the use of biocides to protect wood and wood-based composites, modification of the wood substrate remains an academic research favorite in the United States, Europe, and Japan. It is an alluring concept, but one where for some technologies cost effectiveness remains dubious. Undoubtedly, the greatest potential for chemical modification systems is in the protection of higher-value wood composites, but even here further development is needed. The recent moves toward the application of heat treatment concepts in Europe appear promising for lumber, although challenges remain in regard to protection from insect attack, potential of fungal degradation by tolerant organisms, and the effects of moisture ingress even if the wood structure is stable. In all such systems, innovative approaches to quality control of the treated wood product will be needed for quality assurance.

As mentioned earlier, considerable progress has been made in the area of water-based emulsion water repellent technology and it is obvious that appropriate utilization of such technologies can provide a significant step toward the goal of protecting wood products in service in an era of demand for lowered levels of biocide use. Clearly, keeping wood dry, or at least considerably drier, offers a significant step forward in reducing the need for biocidal protection in service. It is apparent that with the likelihood of increasing reliance on organic biocides in the years to come, emulsion preservatives and wood stabilizers will become the norm in our industry in the foreseeable future. The evolving knowledge in this area will provide the foundation for this technology.

Some of the most fundamental research in the area of wood treatments is focused on super-critical fluid treatments. Several groups are known to be working with these treatments. While supercritical fluids such as carbon dioxide offer greater versatility of biocide choice than is the case with vapor boron treatments, serious questions remain concerning the practicality and cost of commercial-scale operations, performance in service, and the inability of super-critical fluid treatments, at least at this time, to protect wood products from water ingress in service.

In summary, the wood-protection industry is at an exciting juncture. The clamor for using less wood from the forest implies the need to more efficiently use and maintain that which is available, and hence a greater use of protection technology. An ever-increasing proportion of the available wood supply is from plantation softwoods with little natural durability; therefore, preservatives are necessary. Strategies for protection technologies must in the future incorporate considerations of ultimate disposal of the treated product, as well as providing the consumer with products that most appropriately fit the purpose for which they are designed.

The unintentional spread of wood-destroying organisms such as the Formosan termite presents both opportunities and challenges for the wood products industry. Solutions must incorporate the needs of consumers, contractors, financial backers, and the wood products industry in its various guises.

Finally, the wood-protection industry must continue to seek solutions and opportunities that allow wood protection to be viewed as an overwhelmingly positive environmental force in human endeavor and in the utilization of precious forest resources. At the same time, we must understand that some perceptions in regard to the chemicals we use are real and not just emotional responses to old phobias. While the industry has an excellent record in most aspects relating to environmental concerns, further effort and continuing development and change can enhance the value of the wood-protection industry as a means of dramatically slowing forest harvest rates and ensuring the retention of native forests in perpetuity.

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