FUTURE OF INDUSTRIAL WOOD PRESERVATION IN CANADA

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Summary

The production of industrial treated wood products in Canada is relatively steady at about 1 million cubic meters per year. With recent recommendations by PMRA for the continued registration of creosote, pentachlorophenol, ammoniacal copper zinc arsenate and chromated copper arsenate for these applications and with growing recognition of the full life cycle environmental benefits of wood products, the future of these products seems secure. However, there are several threats to the continued use of wood products treated with these preservatives and there are opportunities to further improve the environmental footprint of these products through increasing service life of the products; this can be achieved by improving industrial product specifications and quality control procedures and through improved in-service inspection and remediation programs. It may also be possible to introduce alternative chemical treatments with perceived lower health and environmental risks for these applications.

1. Current status of industrial treated wood products in Canada

Pressure treated wood remains the predominant material for many exterior exposed industrial products used in Canada. These include utility poles, railway track and switch ties, land and marine piling, bridge and other timbers, fence and guiderail posts, preserved wood foundations and industrial lumber products. While most of these products are available in different materials such as steel, aluminum, concrete, fiberglass and various polymers, treated wood products are still favoured because of their competitive cost and good performance.

It is estimated that approximately 1 million cubic meters (about 35 million cubic feet) of wood is treated annually in Canada for industrial purposes (Stephens et al. 1995) with little variation of this from year to year. In 1995, this wood had a value of about $340 million.

2. Benefits of treated wood for industrial products

Considering that there are many alternative materials and products for pressure treated industrial products (Figure 2), it raises the question of why treated wood products are still predominant in the market. For example, poles can be manufactured of concrete, steel, aluminum or fiberglass. Steel, concrete and even recycled plastic or rubber railway ties are available. Treated wood products have many recognized benefits, including good performance against biological organisms and weather and excellent environmental profile, easy to machine or fasten at the plant or in the field, high strength to weight ratio and competitive cost.

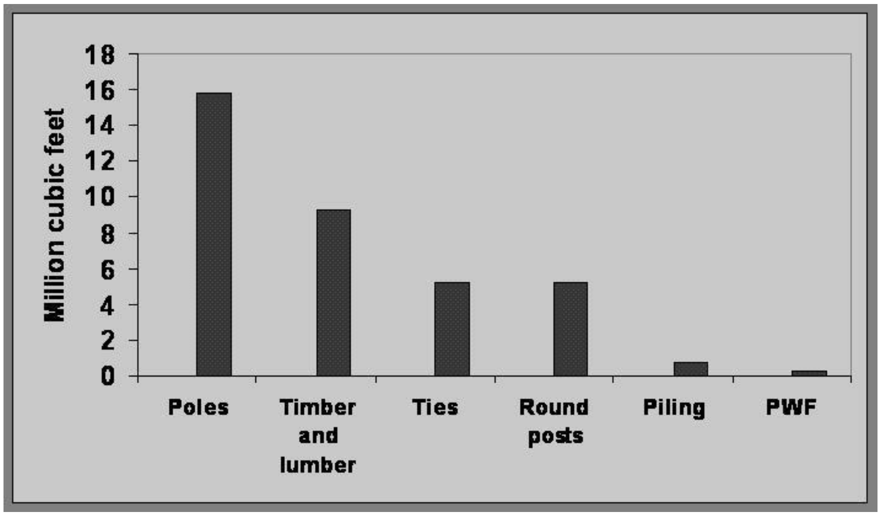


Figure 1: Production of industrial treated wood products in Canada (Stephens et al. 1995) Note: one cubic meter equals 35.3 cubic feet

Figure 2: Examples of alternative materials – steel poles and concrete ties

One of the main benefits of any wood product is its renewability and generally good environmental footprint. Most life cycle assessments comparing treated wood products with other materials confirm that energy consumption and release of green house gases and other emissions are lower in wood products than from competing materials (e.g. Figure 3, Erlandsson et al. 1992).

Another positive benefit of use of treated wood for these long life products is the sequestration of carbon over a long time. Stephens et al. (1995) estimated that there was about 700 million cubic feet (20 million m^3) of industrial treated wood in service at any time (Figure 4). This translates to about 4 million tonnes of carbon stored for decades and continually replenished when wood products are replaced with wood.

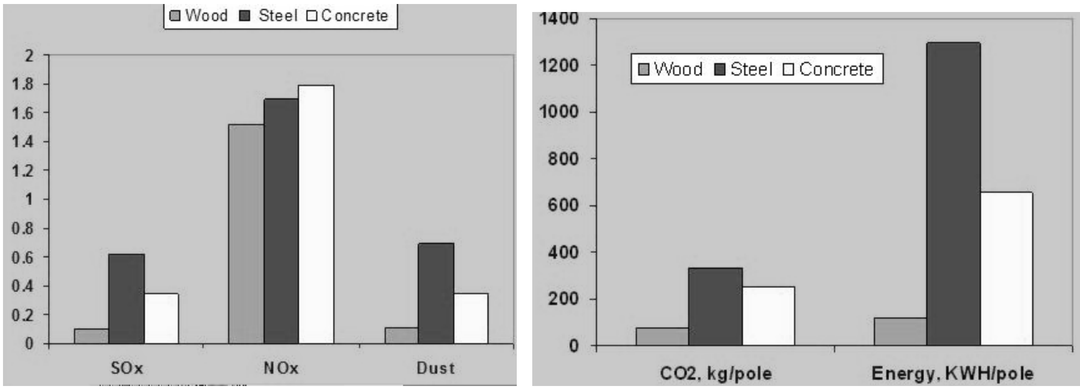
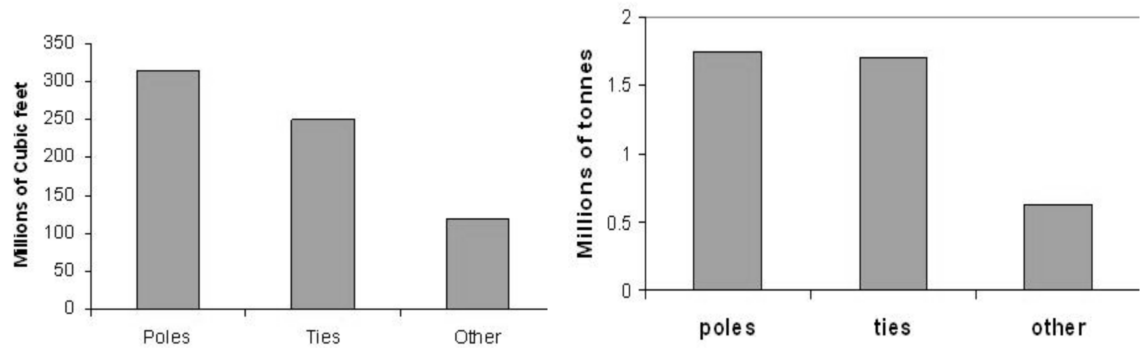


Figure 3: Life cycle emissions from poles of different materials (Erlandsson et al. 1992)



(a) (b)

Figure 4: (a) Estimated industrial wood in service in 2010 (Stephens et al. 1995); (b) estimated mass of carbon sequestered

3. Preservative treatments

3.1 *What preservatives are used?*

At this time, there are relatively few preservative options to treat these products. ***Creosote*** has been used to treat industrial products for more than a century. Over time, the number of products treated with creosote has declined due to substitution by other systems. However, it is still the preferred preservative for treatment of railway ties and marine piling and still used for some pole, land piling and bridge timber treatments. One of its main positive attributes is that when creosoted wood is removed from service it can be burnt as an energy source.

The other main preservatives are ***Pentachlorophenol in oil (PCP)*** was introduced as an alternative to creosote in the 1940's. It is used mainly for treatment of poles, timbers, guiderail posts and land piling. It can also be used for fuel in permitted cogeneration plants. There has been significant substitution of creosote and PCP treated products, such as utility poles, by CCA, over the past 10 years. Water-based ***Chromated copper arsenate (CCA)*** was developed in the 1930's. It was evaluated for poles in the late 1940's and became the primary preservative for residential products from the 1970's until December 2003, when it was withdrawn for these purposes. It is still an important industrial preservative for utility poles, land and marine piling, posts, timbers, industrial lumber and preserved wood foundations. Waterborne ***Ammoniacal copper zinc arsenate (ACZA)*** replaced ammoniacal copper arsenate as a preservative in the 1980's due to its lower arsenic leaching properties. ACZA is used primarily when a water based preservative with good penetrating performance is required e.g. for preserved wood foundations and for the treatment of Douglas-fir lumber, timbers, poles and piling, since this species does not accept CCA treatment well.


Creosote


Pentachlorophenol


Chromated copper arsenate


Ammoniacal copper zinc arsenate

Figure 5: Industrial wood preservatives used in Canada

3.2 *Future of current wood preservatives*

These preservative systems have been used for a long time and have been under considerable pressure throughout the world from environmental/health governmental and non-governmental groups. As a result, these preservatives are no longer in use in many countries. They have been under re-evaluation for industrial products through Health Canada's Pest Management Regulatory Agency for several years. A proposed Re-Evaluation Decision (RED) PRVD2010-03, Heavy Duty Wood Preservatives: Creosote, Pentachlorophenol, Chromated Copper Arsenate (CCA) and Ammoniacal Copper Zinc Arsenate (ACZA) was released on Aug. 20, 2010. It states the following:

- "Health Canada's Pest Management Regulatory Agency, under the authority of the *Pest Control Products Act*, is proposing continued registration for the sale and use of creosote, pentachlorophenol, chromated copper arsenate and ammoniacal copper zinc arsenate products in Canada.
- At this time, these products are critical to the wood preservation industry because there are considerable limitations with respect to registered alternatives."

There are several required industry changes accompanying this decision, but the PMRA requirements differ from those released almost concurrently by the US EPA due to the outcomes of the Canadian Strategic Options Process (SOP). Under the SOP for wood preservation, the Environment Canada *Recommendations for the Design and Operation of Wood Preservation Facilities – Technical Recommendations Documents (Environment Canada, 2004- TRDs)* were updated for all existing heavy-duty wood preservatives. A process was implemented in cooperation with Wood Preservation Canada by which all treating plants would conform to the recommendations in these documents and their conformance would be confirmed and certified through intensive plant audits.

In meeting the TRD requirements, most of the concerns of PMRA regarding the application of these preservatives were met.

Another outcome of the SOP process was the *Industrial Treated Wood Users Guidance Document* 2004, which provided guidelines for the storage, use and waste management of industrial wood products.

This re-registration incorporated a few preservative label amendments related to:

- Target retention rates
- Adequate stabilization and fixation of preservatives (BMPs and TRDs)
- Adherence to the most recent version of *Recommendations for the Design and Operations of Wood Preservation Facilities – Technical Recommendations Document*
- Updating the "environmental hazards" and "directions for use" sections of product labels to address potential contamination via runoff and improper disposal.

Thus, it appears that the continued used of these preservative systems for industrial products are assured for the foreseeable future. However, there are national and international factors that could have an impact on their future use:

UN Convention on Long-range Trans-boundary Air Pollution (LRTAP).

PCP and some of its breakdown products are still under consideration by LRTAP as Persistent Organic Pollutants (POP). If so designated, PCP could be subject to elimination of production and use by Parties to the Convention (including Canada).

Transportation of Hazardous Wastes (Canada)

There is some concern that treated wood shipped across provincial or international borders might be subject to hazardous waste testing, such as the Toxicity Characteristic Leaching Procedure (TCLP). This would add a high cost to the shipment of these materials and would disrupt attempts to manage waste treated wood through shipment to co-generation plants that are permitted to burn it as an energy source.

Ministère du Développement Durable de l'Environnement et des Parcs (MDDEP) 2009 *Lignes directrices relatives à la gestion du bois traité*

This recent MMMEP publication expresses concerns about the use of pressure treated wood based on TCLP tests on wood poles and prohibits its use for the following applications:

- *Sensitive places (aquatic environments, quays, playing fields, culverts);*
- Creosote or PCP treated wood for retaining earthwork and walls in the urban environment
- Construction of composters;
- Agricultural applications where wood can be in contact with animals, their food, or food products.

Ongoing issues with management of waste treated wood - especially the waterborne treatments

These and similar concerns mean that there will continue to be pressure on the use of these preservatives for these applications

3.3 *Potential for alternative wood preservatives for industrial products*

Prior to 2004, most residential treated wood products were treated with CCA; however at this time, a label change was made to restrict this treatment to industrial/commercial products (including preserved wood foundations). Alternative preservatives alkaline copper quat (ACQ) and copper azole (CA) were approved for treatment of residential products, but were restricted by their PMRA labels from use for the treatment of the industrial products described in this paper. These and other treatments should be evaluated for their suitability for industrial products, especially if restrictions are placed on the current treatments. This is discussed by Cliff Baker in his paper in these proceedings.

3.3.1 Alkaline copper quat (ACQ) and copper azole (CA)

While these have been confirmed as effective wood preservatives in both above ground and ground contact applications, products treated to high retentions with these copper amine based preservatives have relatively high copper leaching characteristics (Figure 6) and greater fastener corrosion properties compared to CCA.

It appears to be possible to mitigate the copper leaching characteristics through moderate temperature stabilization of the wood after treatment. This effect is shown in Figure 7; low solution strengths or retentions in wood result in fast stabilization to a high degree, while high retentions require longer and do not reach the same level of stabilization. However, at higher temperature, more rapid and more complete copper stabilization occurs.

Furthermore, copper leaching from these systems can be reduced over the long term, by temporarily protecting the treatment with a water repellent or other finish to allow stabilization reactions to reach a higher degree of completion (Nejad and Cooper 2010). An example of the effectiveness of various semi-transparent deck finishes to reduce leaching of copper form CCA treated decking samples over three years of natural weathering exposure is shown in Figure 8. Thus, the concerns about high copper leaching from high retention treatments can be relieved by incorporating post treatment conditions and in-service maintenance into the application of these treatments for higher retention industrial products.

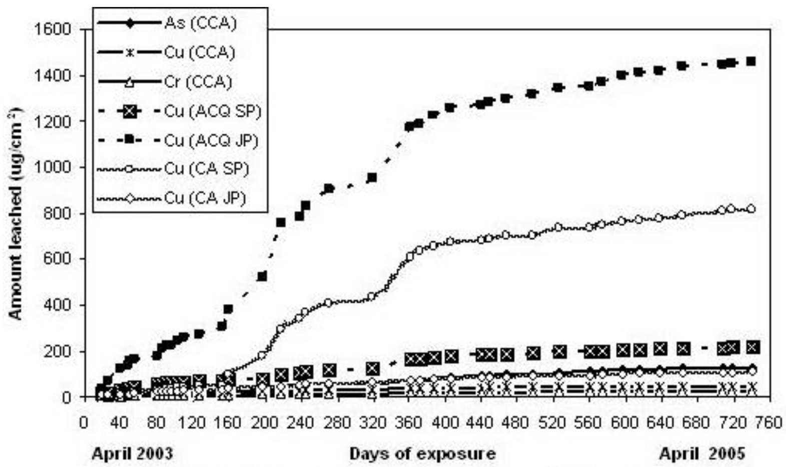


Figure 6: Comparison of leaching of preservative components from horizontally oriented wood exposed to natural weathering for 2 years (Stefanovic and Cooper 2006). **Note: retentions for ACQ - jack pine, 11.9 kg/m^3; southern pine 3.8 kg/m^3. Retentions for CA – jack pine 3.8 kg/m^3; southern pine 1.8 kg/m^3, CCA 9.8 1.8 kg/m^3.**

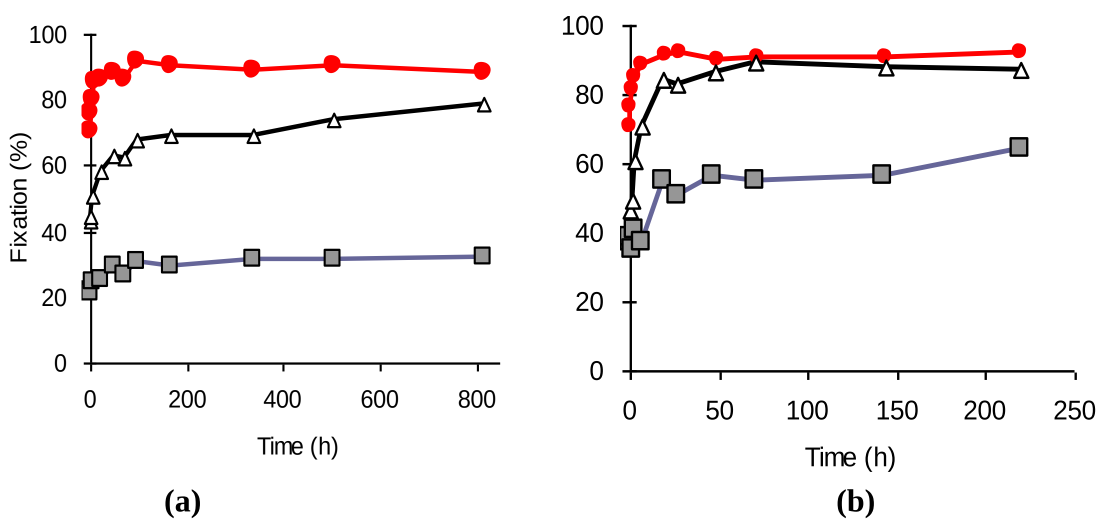


Figure 7: Effect of temperature on rate and extent of copper stabilization in ACQ treated red pine (a) 21°C, (b) 50°C (Lee and Cooper 2010a) - Red line 0.5% ACQ solution; yellow line 1.5% ACQ solution; grey line 3.0% ACQ solution.

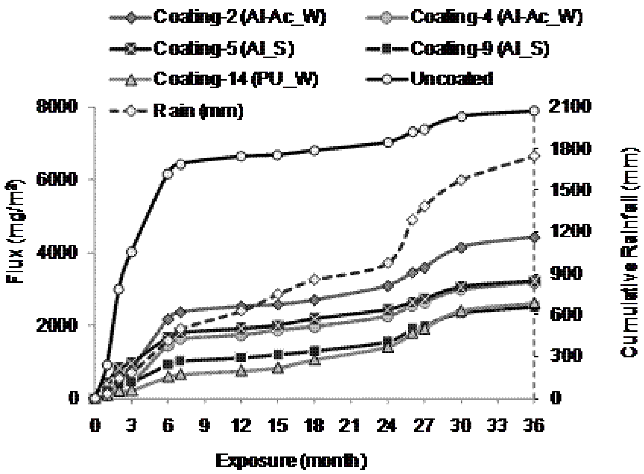
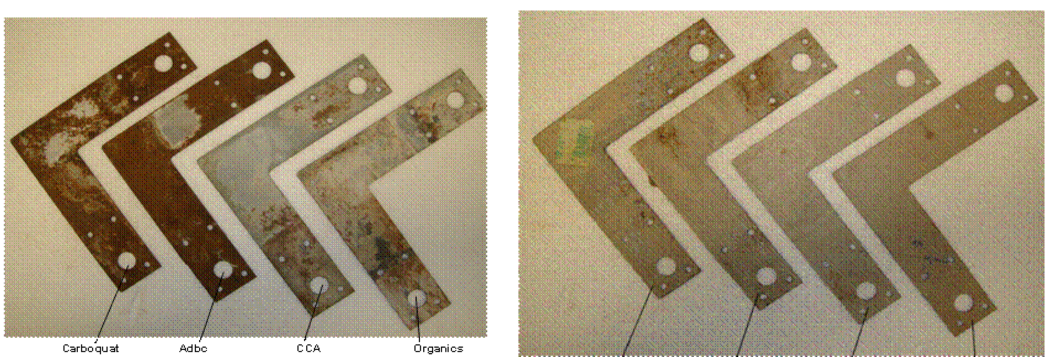


Figure 8: copper leaching from ACQ treated southern pine boards over three years, as affected by semi-transparent coating (Nejad and Cooper 2010)

The higher rate of fastener corrosion of alkaline copper treatments (e.g. Figure 9) is not greatly affected by preservative retention or stabilization conditions (Cooper and Ung 2008) and can best be addressed by use of corrosion resistant fasteners such as stainless steel, heavily galvanized products or those treated with effective barrier coats.



(a) (b)

Figure 9: Corrosion of laboratory exposed plates as affected by preservative treatment and plate material (a) G90 galvanized (b) Barrier coat (Left to right - ACQ carbonate, ACQ chloride, CCA and organic preservative) Cooper and Ung 2008)

3.3.2 Micronized copper systems

There is considerable interest in formulations that incorporate finely ground (micronized) and dispersed low solubility copper compounds with an effective co-biocide as a treatment for residential products. This treatment has the advantages of low copper leaching (e.g., Figure 10) and low corrosivity to fasteners. While these treatments are not yet approved for use in Canada, they have become a significant component of wood treated in the USA. It is my view that there are still unresolved issues to be addressed before this system is considered for the more critical industrial applications.

For example, while it appears that there is redistribution of soluble copper into wood cell walls with both amine copper systems and micronized copper systems, further confirmation is needed that the amounts are adequate to protect wood over the long term with micronized systems. Also, it was shown that in species with distinctive earlywood/latewood zones, such as southern pine, there is higher solution retention in the low density earlywood compared to dense latewood. For ACQ treatment, copper redistributes from the earlywood to latewood during post treatment conditioning, resulting in a relatively even treatment throughout the wood. In micronized copper treatments, the copper retention remains higher in the earlywood, raising the question of whether there is adequate copper in the latewood to protect it from decay (Zahora 2010). However, it should be noted that for CCA, such a redistribution does not appear to occur (Schultz et al. 2004) with no known adverse effect on the efficacy of treatment.

Another issue relates to the lower permeability of Canadian softwood species compared to southern pine, and confirmation is needed that penetration is adequate and solubility is sufficient to provide soluble copper to protect checked areas from spore germination. Many of these issues can be resolved based on performance testing of stakes and other products exposed to natural decay conditions.

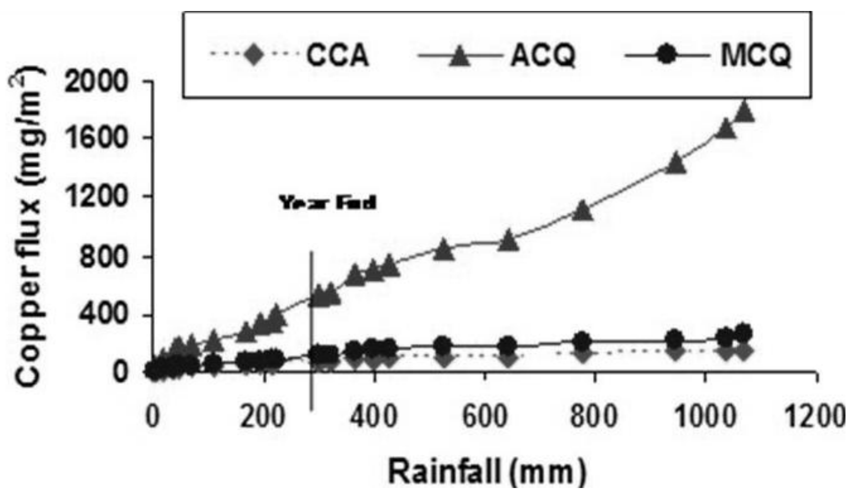


Figure 10: Comparison of cumulative copper leaching for different treatments (above ground retentions) of horizontally exposed boards over 1 year of natural weather exposure in Toronto, Canada (Cooper and Ung 2008b)

4. Issues with end of life management of industrial treated wood

Waste management of treated wood removed from service is one of the main challenges to the continued use of current preservative systems. It is estimated that about 14 million cubic feet (0.4 million m^3) of oilborne treated wood and 4 million cubic feet

(0.11 million m^3 of waterborne industrial wood is removed per year in Canada (Stephens et al. 1999).

Landfill disposal is a poor option for this material as it is a waste of a resource and potentially a source of emissions to ground water. Furthermore, the Toxicity Characteristic Leachate Procedure (TCLP) test may be applied in the future and the criteria for some preservative components cannot be met consistently (e.g., As in CCA, B(a)P in creosote). Changes to drinking water criteria may change TCLP levels to values that cannot be met for most preservative components. Perhaps more importantly, landfill disposal adversely affects the life cycle assessment profile of treated wood, since it is assumed that part of landfilled wood products is anaerobically degraded with the release of high impact greenhouse gas methane.

Options for recycling or reuse of competing materials (especially steel) are more attractive than for treated wood. However, compared to other treated wood products, industrial products have more potential for recycling and reuse because of their large size, generally good quality and the fact that infrastructure for collection and transport of products such as poles and ties is in place when they are changed out (Figure 11). Examples of reuse options are shown in Figure 12.

Another good option for the management of out-of-service treated wood, especially when treated with the oil based preservatives is energy recovery. However, as noted above, this is contingent on the ability to transport waste materials across provincial and international borders.

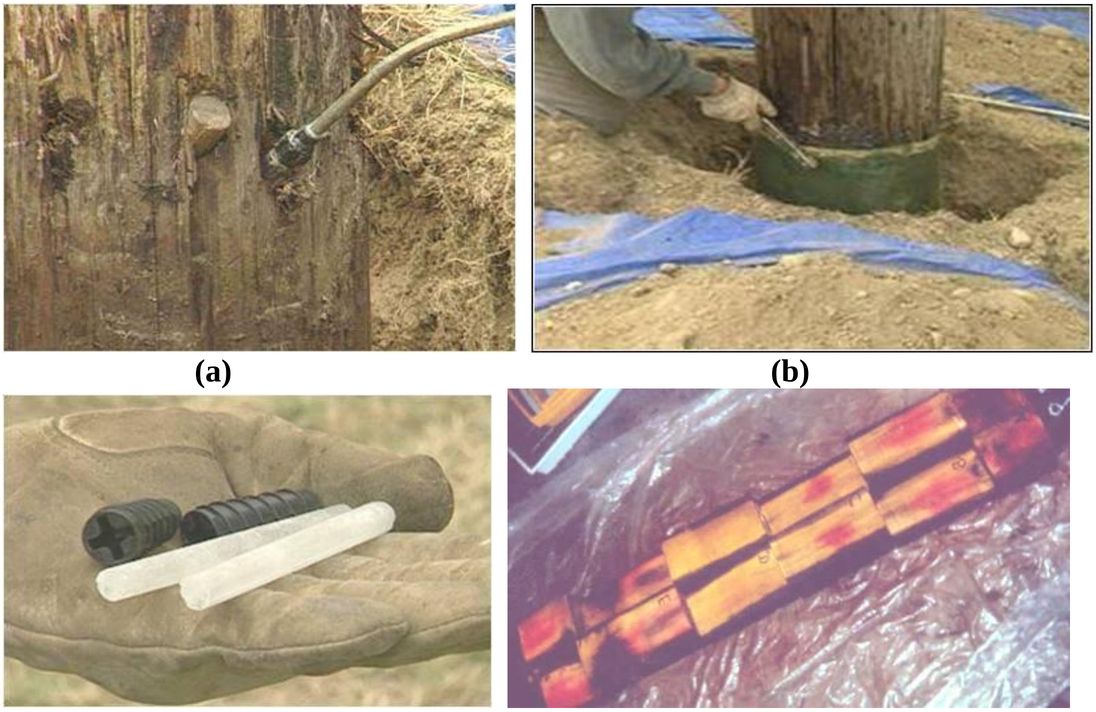
An important approach to reducing the environmental impacts associated with the management of waste treated wood is to take steps to abate, reduce or eliminate the amounts of material coming out of service. Elimination involves using other materials or approaches, but as discussed above, this may not minimize full life cycle environmental costs, and LCA is necessary to consider such options.

Figure 11: Out of service poles and ties and truck for collection of removed ties

Figure 12: Examples of reuse of industrial wood products

Another approach is to use less toxic or organic preservatives which can be burned for energy without producing toxic emissions. The potential and limitations of alternative preservatives for industrial products are discussed above. Probably the most effective way to reduce impacts is to extend the service life of products.
This requires an integrated approach that incorporates:

- Improved product design to ensure adequate strength and other performance characteristics as well as durability against deterioration.
- Well designed and considered specifications to make sure that treatments meet the end use requirements; this includes specifications on pretreatment conditioning, treatment (chemical and quality of treatment) and post-treatment conditioning.
- Reliable quality control procedures to confirm that the specifications are met.
- Appropriate inspection, assessment and remedial treatments to determine when products need supplementary treatment and to reinforce existing treatments; this may involve internal fumigant or diffusing salt treatments or surface treatments such as bandages (e.g. Figure 13).



(a) (b) (c) (d)

Figure 13: Examples of in situ treatments for poles and ties – (a) fumigant; (b) surface bandage and (c & d) borate rod treatments

There are many devices and approaches for the assessment of condition of poles, piling and ties (e.g., Figure 14) but all have limitations in terms of cost and reliability. However, many users of treated wood have developed test and treat programs that ensure extended life of the products in service. As noted, this decreases the life cycle costs and results in material with lower emissions of preservatives at the time of disposal. This latter factor reduces the likelihood of wood failing the TCLP test.

(a) **(b)**

(c) **(d)**

Figure 14: Inspection of poles in service (a) sounding; (b) drilling; (c) Resistograph; (d) acoustic/vibration device

5. Research and applied opportunities to increase the service life of products

I believe that there are research and development opportunities to develop cost-effective ways to extend the service life of poles and railway ties. Some approaches that may warrant investigation include:

- Pre-treat vulnerable zones prior to installation with diffusing salt treatments. These preservatives are not mobilized as long as the wood moisture content remains low, but as soon as conditions begin to favour decay, they will migrate into susceptible areas. Vulnerable zones include at and below ground line and near framing holes in poles and under the tie plates for ties. Application holes could be made when poles are drilled or framed and when spike holes are bored in ties. The actual treatments would be applied and plugged after preservative treatment (and in the case of water-based treatments, after drying for shipment).
- Investigate the costs and benefits of increasing the sampling intensity for preservative quality after treatment (e.g. for distribution poles, sample all poles rather than 20 per charge) and reject or retreat all substandard pieces.
- In my experience, tie failure modes (splitting, decay, plate cut and spike loosening) are all exacerbated by tie checking and splitting (Figure 15). Thus, methods of reducing the tendency to split should be investigated and applied. Proven approaches are the use of end plates to resist end splitting from natural checking and the rail crushing forces; use of glued laminated ties; and kerfing of the underside of ties (Figure 16). Other possible remedies are the development of top dressing treatments that would protect the surface from wetting and drying and bridge any checks that do develop so stones and dirt cannot wedge in the checks and promote splitting. The cost effectiveness of these treatments should be re-evaluated by factoring in the full life cycle costs and benefits, rather than focusing only on the economics of extending the life.

Figure 15: Splitting and other defects in ties and role of ballast stones in splitting

Figure 16: Check reduction strategies for ties: end plates, glulam and kerfing

6. Conclusions

Currently, the position and future of industrial treated wood products appears to be stable, given the considerable benefits of these products and the recent decision of EPA and PMRA to continue to register all of the currently used industrial wood preservatives. However, threats to their continued use are still present, such as ongoing health and environmental concerns and the shortage of good waste management options. It should be possible to ensure the viability of treated industrial wood products through the following approaches:

- Develop and confirm the suitability of alternative wood preservatives for these uses;
- Improve the serviceability of products through specifications, quality control, in service evaluation and remedial treatments;

- Continue to seek better solutions to the management of spent treated wood (keep it out of landfills!)

7. Literature

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